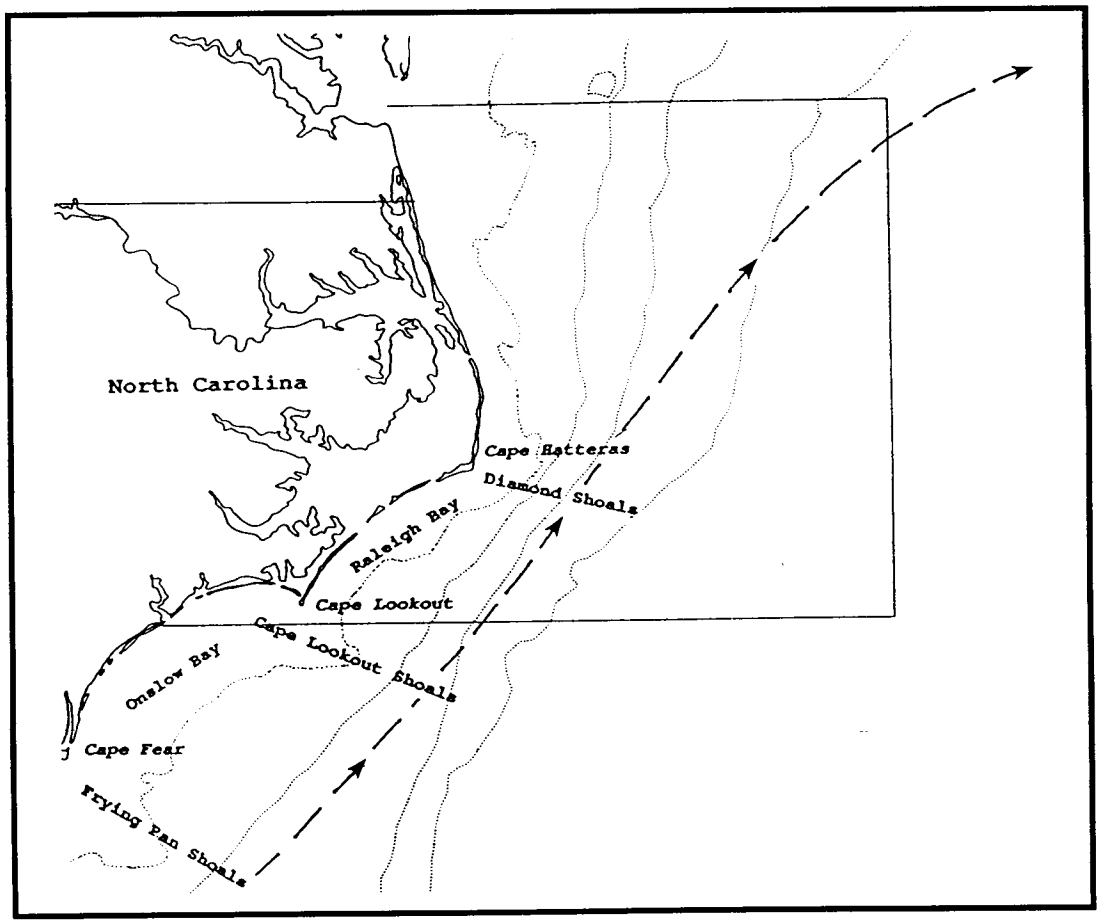
OCS Study
MMS 93/0031

A Review of the Physical Oceanography of the Cape Hatteras, North Carolina Region

Volume I Literature Synthesis
Appendix A Annotated Bibliography



Science Applications International Corporation
MMS Contract 14-35-0001-30594

Prepared for

U.S. Department of the Interior
Minerals Management Service
Atlantic OCS Region

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A Review of the Physical Oceanography of the Cape Hatteras, North Carolina Region

Volume I Literature Synthesis
Appendix A Annotated Bibliography

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October 1993

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DISCLAIMER

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Acknowledgement

The authors thank Paul Blankinship for his outstanding work in assembling this annotated bibliography. Without his dedicated and creative efforts to bring order out of chaos, the document would have been substantially more difficult to complete.

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Aaron, J.M., B. Butman, M. Bothner and R. Sylvester. 1979. Potential geologic hazards to development of the continental shelf and slope off the northeastern United States. Geol. Soc. Am. Abstr. Programs. 11(7):377.

Abstract. Identifies potential hazards including those related to physiography, current regime, circulation dynamics, and sediment character of the seafloor. Also, includes papers describing how bottom currents influence sediment transport in the North Atlantic region.

Aaron, J.M., B. Butman, M.N. Bothner and R.R. Sylvester. 1980. Maps showing environmental conditions relating to potential geologic hazards on the United States northeastern Atlantic continental margin. U.S. Geol. Surv. Misc. Field Studies Map. Map MF-1193.

Abstract. Illustrations of the geology of the northeastern Atlantic margin. Emphasis is placed on hazards such as slump features, surficial faults, and unstable bedforms along the continental slope and rise. Gloria-derived mosaics are also presented as well as near-bottom current characteristics across the study area.

Abbe, C., Jr. 1895. Remarks on the cuspate capes of the Carolina coast. Proceedings of the Boston Society of Natural History. 26:489-497.

Abstract. This paper suggests that the formation of the Carolina capes was influenced by the back-set eddies produced by the northeastward-flowing Gulf Stream.

Abel, C.E., B.A. Tracy, C.L. Vincent and R.E. Jensen. 1989. Hurricane Hindcast Methodology and Wave Statistics for Atlantic and Gulf Hurricanes from 1956-1975. Army Eng. WES Final Rep. WIS Report 19.

Adamec, D. 1985. Numerical simulations of the response of intense ocean currents to atmospheric forcing. Doctoral Thesis. Naval Postgrad. School, Monterey, CA.

Abstract. Numerical model studies response of strong ocean currents to atmospheric forcing to explain an observed 100 km southward shift in the mean position of the Gulf Stream during winter. Finds zonal wind stress more effective in displacing core of current system than gradients in surface cooling.

Adamec, D. 1989. Predictability of quasi-geostrophic ocean flow: sensitivity to varying model vertical resolution. J. Phys. Oceanogr. 19(11):1753-1764.

Abstract. Results from a set of 2- and 3-mode quasi-geostrophic simulations are used to estimate the predictability time scale of a Gulf Stream-like flow and investigate the sensitivity of the predictability time scale to changes in model vertical resolution. For this study, two simulations, which differ initially by a specified 'small' amount diverge from each other with a doubling time of approximately 16 days for simulations that are resolved by 2 modes and 13 days for simulations that are resolved by 3 modes. On average, higher vertical modes have longer predictability time scales. A spectral analysis of the differences in streamfunctions between a control simulation and a simulation with perturbed

initial conditions shows that higher modes have shorter horizontal scales of maximum growth, and the horizontal scale of maximum growth expands at later times for the baroclinic flow. An error energetics budget is calculated to show that transports of error kinetic and error potential energies are initially responsible for exponential error growth of the difference fields. (16 Refs.).

Adams, C.E., Jr. and G.L. Weatherly. 1981. Some effects of suspended sediment stratification on an oceanic bottom boundary layer. J. Geophys. Res. 86(5):4161-4172.

Addy, S.K. 1978. Mixing of the bottom sediments in the northwest Atlantic. Bull. Am. Assoc. Pet. Geol. 62(3):489.

Abstract. Analysis of trace elements in sediments from the abyssal plains and hills with emphasis on clay mineralogy. The role of bottom currents is also discussed in relation to sediment transport and resuspension of finer materials.

Aikman, F. 1984. Pycnocline development and its consequences in the Middle Atlantic Bight. J. Geophys. Res. 89(C1):685-694.

Abstract. Investigation of seasonal pycnocline development using a numerical model depicts formation of a shelf water pycnocline shallower and more intense than that over the slope due to different freshwater inputs to the two regions.

Aikman, F. 1985. Stratification and shelf-slope interaction in the Middle Atlantic Bight: A numerical study. J. Geophys. Res. 90(C3):4895-4905.

Abstract. Bulk-mixing model simulates thermohaline characteristics of shelf and slope waters in the Middle Atlantic Bight. Transition from a monotonically sloping frontal boundary of winter to the convoluted shape of summer suggests that the shelf-slope frontal shape is primarily density controlled.

Aikman, F., III. 1984. The seasonal thermohaline stratification and shelf water-slope water interaction in the Middle Atlantic Bight (mixed layer). Ph.D. Thesis. Columbia University. 139 pp. (DAI 46/02B, p.458; AAC8505942)

Abstract. The seasonal evolution of the thermohaline stratification and of the shelf water/slope water front in the Middle Atlantic Bight is examined both descriptively and numerically. The transition from a nearly vertically mixed water column of winter to the highly stratified regime of summer is accompanied by a shelf/slope frontal transformation from the baroclinic feature of winter to the thermohaline, convoluted front of summer. Identifiable cross-frontal exchange mechanisms are evaluated, and in particular, a persistent salinity maximum (S-max) intrusion is observed in the upper part of the summer pycnocline over the outer shelf, induced by a nearly isopycnal transfer of slope water shoreward. A one-dimensional, two-layer, bulk mixing model is developed to numerically investigate the formation of the seasonal stratification. The model considers the temperature, salinity and density budgets of the system a includes: turbulent diffusion and entrainment across the pycnocline separating layers; a parameterization for pycnocline shallowing; sea-surface temperature-dependent heating; and implicit "lateral fluxes". Climatic estimates of the surface inputs of heat, fresh water and wind-derived energy drive the model, which is applied

separately over the shelf and over the slope, where these inputs are different. The model simulates the predominant evolving thermohaline characteristics of the seasonal stratification over the shelf and slope, and effective coupling of these two regimes depicts the seasonal metamorphosis of the "Margules" shelf/slope front. Cross-frontal diffusive fluxes of heat and salt are evaluated in relationship to features such as the cold pool and the S-max intrusion. Sensitivity studies suggest that the model is most sensitive to parameters related to cross-pycnocline diffusion, but that the sea surface temperature is only moderately sensitive to variations in the heating.

Alexander, J.M. 1984. Gulf Stream Frontal Analysis in the Vicinity of Cape Hatteras. Master of Science Thesis. North Carolina State University. 49 pp.

Abstract. High resolution hydrographic data were acquired off the coast of Cape Hatteras on September 14-20, 1980 and February 1-8, 1981. Measured variables included conductivity, pressure, temperature, and dissolved oxygen. Gulf Stream parameters were determined by using Stommel's uniform potential vorticity and geostrophic model of the Gulf Stream. The parameters included examination of the constant density layer as a function of space and time, determination of the Rossby Length, relative vorticity, position of the 'core' of the Gulf Stream, upper level transport, and determination of a 'level of no motion' using the beta-spiral method (Stommel and Schott, 1977). The study results indicate that potential vorticity is nonuniform in the study area on the anticyclonic side of the Gulf Stream and nonuniform on the cyclonic side of the Gulf Stream. The Rossby Length, which is not represented by surface width measurements, is verified to be width scale of the Gulf Stream. A new cross-shelf velocity profile is proposed for the cyclonic side of the Gulf Stream. The position of the 'core' of the Gulf Stream fluctuates from 10 km west to 15 km east of the 100 m isobath in the vicinity of Cape Hatteras. Upper level transport was calculated at 79 Sv for the summer and 83 Sv for the winter. The maximum velocity, vmax, for the Gulf Stream was calculated at 2.6 m/sec for the summer and 2.7 m/sec for the winter. Use of the beta-spiral method indicated that the 'level of no motion', in the direction of the Gulf Stream, was at 890 m depth at a station south of Cape Hatteras and 550 m depth at a station north of Cape Hatteras.

Allen, J.S., R.C. Beardsley, J.O. Blanton, W.C. Boicourt, B. Butman, L.K. Coachman, A. Huyer, T.H. Kinder, T.C. Royer, J.D. Schumacher, R.L. Smith, W. Sturges and C.D. Winant. 1983. Physical oceanography of continental shelves. Rev. Geophys. Space Phys. 21(5):1149-1181.

Abstract. Comprehensive review paper on the physics of continental shelf flow that describes by region the tremendous increase in knowledge over the past several years.

Amein, M. and D.S. Airan. 1976. Circulation and Surge Modeling in Pamlico Sound, N.C. UNC Sea Grant Pub. UNC-SG-100:33.

Abstract. Pamlico Sound is a large semi-enclosed body of partially saline water on the coast of North Carolina separated by a narrow strip of barrier islands from the Atlantic Ocean. Freshwater inflow is from two major rivers and from Albemarle Sound. There is tidal flow across the inlets. Wind is a major factor in circulation, and there is considerable surge action during the hurricanes. A

numerical model based on the two-dimensional shallow water hydrodynamic equations is used to compute water surface elevations and currents. The model uses an explicit finite difference representation, and includes convective acceleration, and nonlinear surface and bottom stress. The time dependent water movements are computed for an observed hurricane with good success. The model can be used to predict surge heights for coastal protection, and it will provide data for water resource management and for pollution control.

Amein, M. and N.C. Kraus. 1991. DYNLET1: Dynamic Implicit Numerical Model of One-Dimensional Tidal Flow through Inlets. CERC Tech. Rep. CERC-TR-91-10:133.

Abstract. The development and verification of a simple model of inlet hydrodynamics for use in reconnaissance level quantitative studies of inlets are presented. The model, named DYNLET1 for its one dimensional modeling of the dynamic (time dependent) behavior of tidal flow at inlets, is based on the full one-dimensional shallow water equations employing an implicit finite difference technique. The model is intended for personal computer users having little or no experience in numerical modeling and facilitates minimal data entry and numerical grid generation. DYNLET1 can predict flow conditions in channels with varied geometry, and it accepts varying friction factors across an inlet channel, geometric boundary conditions. Values of water surface elevation and average velocity are computed at locations across and along inlet channels. The inlet to be modeled may consist of a single channel connecting the sea to the bay, or it can be a system of interconnected channels, with or without bays. The principal limitation of DYNLET1 is potential inaccuracy in situations where strong two dimensional flow fields, such as gyres, exist perpendicular to the major axis of channels comprising the modeled inlet. This report also includes a short review of existing, similar simple models of tidal inlet hydrodynamics. The model is illustrated with two case studies, Masonboro Inlet, North Carolina, and Indian River Inlet, Delaware.

American Meteorological Society. 1959. Glossary of Meteorology.

Amos, A.F. and E.C. Escowitz. 1971. Abyssal water circulation and spreading of Antarctic Bottom Water in the western North Atlantic. EOS, Trans. AGU. 52:241-242.

Abstract. An AGU presentation on the results of five intensive CTD transects conducted in the western North Atlantic region. The presence of hydrographic characteristics associated with ABW is detailed.

Amos, A.F., A.L. Gordon and E.D. Schneider. 1971. Water masses and circulation patterns in the region of the Blake-Bahama Outer Ridge. Deep-Sea Res. 18:145-165.

Abstract. The water masses and circulation patterns of the Blake-Bahama Outer Ridge area of the western North Atlantic were studied using a salinity/temperature/depth (STD) recording system. The dynamic method was applied to STD data in the deep ocean, revealing that the Western Boundary Undercurrent (WBUC) flows with velocities up to 26 cm/sec at the bottom on the eastern flank of the Outer Ridge. The volume transport was computed to be 22 X 10^6 m^3/sec. The high Antarctic Bottom Water (AABW) content (up to 20%) of this

current suggests that AABW flowing north into the western North Atlantic Basin is deflected by the ocean basin hills, at about 35°N merges with North Atlantic Deep Water (NADW), and returns southward along the eastern continental margin. The computed velocities and directions confirm that the WBUC in this area is a contour-following current. A layer of cold isothermal water 20-170 m thick was found on the bottom over much of the section at depths ranging from 3800 to 5400 m. In some locations the layer was capped by a comparatively steep thermal gradient. The higher AABW content of this homogeneous stratum may be a result of the confluence of NADW and AABW. The possibility that a lower turbulent boundary layer exists in the deep ocean, whose velocity field is dependent on bottom roughness, is also examined by applying relationships derived from similar phenomena in the lower atmosphere.

Amstutz, D.E. and W.B. Samuels. 1983. An oilspill risk analysis for the North Atlantic (February 1984) lease offering. Minerals Management Service Environmental Modeling Group. U.S. Geol. Surv. Open-File Rep. 83-567:177.

Anderson, D.L.T. and R.A. Corry. 1985. Ocean response to low frequency wind forcing with application to the seasonal variation in the Florida Straits-Gulf Stream transport. Prog. Oceanogr. 14(1-4):7-40.

Abstract. Investigation of linear response model to a periodic wind stress curl in the presence of bottom topography shows response varying with wave period. Strong modification occurs at shorter periods, whereas at longer periods, Rossby waves compensate for the effect of topography.

Anonymous. 1980. Physical oceanographic model evaluation for the South Atlantic OCS region. Final report, JAYCOR, Alexandria, VA, 208 pp.

Abstract. Investigates various circulation models which may be applied to the South Atlantic region. Describes advantages, limitations, and characteristics of models developed by various investigators.

Anonymous. 1984. Anticyclonic eddy census - 1984. Oceanogr. Mon. Summ. 4(12):3.

Abstract. Plots show tracks of anticyclonic Gulf Stream eddies from their formation to their absorption. Eddies generally translated westerly and southwesterly having mean duration of four months and mean speed of four km/day.

Arango, H.G. and A.R. Robinson. 1991. Primitive Equation Forecasting in the Gulf Stream Region. EOS, Trans. AGU. 72(51):18.

Abstract. Eddy resolving simulations are carried out with an open ocean Primitive Equation model to predict (hindcast/forecast) 3-D fields in the Gulf Stream region. Newly developed feature models for the stream, rings and sub-basin scale structures are used to produce the model initial fields from available IR, AXBT, and GEOSAT data. These second generation feature models include realistic vertical structures that are derived from the climatology of the Slope and Sargasso waters and from typical Gulf Stream synoptic structures. The incorporation of the sub-basin scale features (northern and southern recirculation gyres, and Deep Western Boundary Current) in the initial fields has been motivated by the need to produce continuous forecasts for longer periods of

time; to provide better adjusted fields at initialization; to allow a mechanism for the downstream increase and then decrease of the total transport by the Gulf Stream; to maintain the mean path of the Gulf Stream; and to investigate the scale-to-scale energy conversion processes. An alternative model initialization is carried out with 3-D temperature and salinity maps generated from the Navy's Optimum Thermal Interpolation System (OTIS) developed at FNOC and prepared by INO. The impact between these two different initialization methodologies on the short-term hindcast/forecast of mesoscale fields is presented as well as a comparison with quasigeostrophic model fields.

Armi, L. 1977. The Dynamics of the Bottom Boundary Layer of the Deep Ocean. pp. 153-164. In Proceedings of the International Colloquium on Ocean Hydrodynamics. 8th ed. Vol. WHOI-78-2. (NTIS Accession Number: AD-A052 016/3)

Abstract. Profiles of salinity and temperature from the center of the Hatteras Abyssal Plain have a signature that is characteristic of mixing up a uniformly stratified region: a well-mixed layer above the bottom, bounded by an interface. The penetration height of the mixed-layer varies from about 10 m to 100 m and has been correlated by Armi and Millard (1976) with the one day mean velocity, inferred from current meters located above the bottom boundary layer. Here the dynamics of such layers is discussed. A model of entrainment and mixing for a flat bottom boundary layer is outlined; this model is however incomplete because too little is known of the structure of turbulence above an ekman layer.

Armi, L. and E. D'Asaro. 1979. Flow structures of the benthic ocean. J. Geophys. Res. 85(C1):469-484.

Abstract. Three-dimensional structure of the near-bottom density field was observed with a towed yo-yoing profiler and a fixed current/temperature measuring array on the Hatteras abyssal plain. A great variety of structures were seen. Immediately above the bottom a well-mixed bottom layer extends vertically 5-60 m, with less than 1 m°C potential temperature change. This mixed layer is often capped by a region of strong vertical potential temperature gradient, with up to 100-m°C potential temperature change in about 10 m. The boundary layer may be uniform for 10 km or exhibit a bottom temperature gradient of up to 20 m°C/km. Interior layers of nearly constant potential temperature and horizontal extent of 2-100 km are seen about 25 % of the time above the bottom mixed layer. When an interior layer is present, the bottom mixed layer is thinner. On many occasions an interior layer was seen to be horizontally continuous with the bottom mixed layer, suggesting formation of interior layers by detachment of the bottom mixed layer. A benthic front was observed. Differential horizontal advection is required to explain the observed structures. Velocity fluctuations above 1 cph increase in energy near the bottom, presumably a signature of turbulence in the mixed layer; these fluctuations are modulated by the passage of structures observed in the moored record.

Arnone, R.A. and W. Elenbaas. 1991. Optical Variability off the East Coast Using CZCS Data. EOS, Trans. AGU. Suppl to 72(17):155.

Abstract. The scales of optical variability for selected East coast water masses were examined using historical Coastal Zone Color Scanner monthly composites. Monthly climatology of the diffuse attenuation coefficient k(490) was determined

from 1978 to 1986, for 1) Shelf 2) Slope 3) Gulf Stream and 4) Sargasso waters. k(490) mean and standard deviation were derived from water leaving radiance from standard NASA Goddard CZCS products (Feldman et al. 1987) and k(490) algorithms (Mueller et al., 1990). Results show well-defined differences in optical properties of these water masses; with Shelf having the highest, followed by the Slope, Gulf Stream and Sargasso having the lowest k(490) values. Minimum values were observed in summer compared with elevated values in winter and spring. Shelf waters show the strongest monthly k(490) change from 0.097 m-1 in Spring to 0.06 in Summer. Sargasso waters remain low in all months at 0.032 m-1. Inter-annual variability of these water masses was low in summer suggesting consistency of processing and high in winter. The k(490) standard deviation of these water masses is shown to be well correlated with the mean, i.e.; high mean values of the shelf waters have covarying high standard deviation. These statistics suggests methods to discriminate the water masses based on the satellite optical climatology.

Arya, S.P. 1988. Introduction to Micrometeorology. International Geophysics Series, Volume 42, Academic Press, New York, 307 p.

Abstract. Micrometeorology is a branch of meteorology which dals with the atmospheric phenomena and processes at the lower end of the spectrum of atmospheric scales, which are variously characterized as microscale, small-scale, or local-scale processes. The scope of micrometeorology is further limited to only those phenomena which originate in and are dominated by the shallow layer of frictional influence adjoining the earth's surface, commonly known as the atmospheric boundary layer (ABL) or the planetary boundary layer (PBL).

Askari, F., L. Pietrafasa, T. Curtin, C. Barans, T. Mathews, C. McClain and J. Marsh. 1983. Description of Gulf Stream frontal events from combined satellite imagery and current meter data. EOS, Trans. AGU. 64(18):237.

Abstract. AGU presentation demonstrating the usefulness of SAR in observing features masked by VHRR which allows more continuous data to augment *in-situ* data.

Atkinson, L.P. 1977. Modes of the Gulf Stream intrusions into the South Atlantic Bight shelf waters. Geophys. Res. Lett. 4:583-586.

Abstract. Presents a conceptual model which describes three basic vertical density-dependent modes of Gulf Stream intrusion into the South Atlantic Bight shelf waters.

Atkinson, L.P. 1985. Hydrography and Nutrients of the Southeastern U.S. Continental Shelf. pp. 77-92. In L.P. Atkinson, P.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, DC.

Abstract. The distribution of properties such as temperature and salinity, of nutrients such as nitrate, phosphate, and silicate, and of derived properties such as buoyancy in the South Atlantic Bight depends on complex interactions of shelf waters with rivers, coastal estuaries and sounds, atmospheric forcing, and, most importantly, the Gulf Stream. Seasonal variations in temperature depend on

the seasonal heating cycle, air-sea exchange processes, and Gulf Stream interaction. The result is extreme variations in temperature both seasonally and spatially. Salinity variations are mainly related to seasonal river flow, which peaks in the spring, and subsequent shelf circulation processes. Variations in temperature and salinity occur over shorter time scales because of Gulf Stream meanders and frontal eddies that cause intrusions of surface or subsurface water into the shelf waters. Intrusion frequency and cross-shelf excursion vary seasonally and latitudinally. The supply of nutrients mainly depends on Gulf Stream intrusions. Gulf Stream water colder than about 20°C contains significant amounts of nutrients. Such waters invade the shelf more frequently during the summer in the southern bight. Chemical tracers such as phenolic aldehydes, humic compound fluorescence, and tritium have been used successfully to trace coastal waters.

Atkinson, L.P. 1989. Proceedings of Atlantic Outer Continental Shelf Region Information Transfer Meeting (ITM) (3rd). Held in Reston, Virginia on September 11-12, 1989. U.S. Dept. Interior, MMS Rep. OCS/MMS-89/0099:168.

Abstract. The Third Atlantic Outer Continental shelf (OCS) Region Information Transfer Meeting (ITM) was held on September 11-12, 1989, in Reston, Virginia. The purpose of the 2-day meeting was to exchange results of scientific studies on the Atlantic OCS, and to discuss issues and research relative to future OCS leasing and development. The report included descriptions of benthic fauna and diversity, effects of oil and sound on marine mammals, a multi-disciplinary study of right whales off Massachusetts, ocean circulation, and Gulf Stream dynamics. The topics of risk assessment, public perception, and the role of the social scientist were new to this ITM, as was a description of Canada's OCS activities and studies program. A panel discussion on environmental conflict resolution included the issues of cooperation between State and Federal governments, public perceptions, and public interest in OCS activities. Oil and gas resource estimates were reported to have declined 63 percent from 1984 to 1987. The Mid-Atlantic region appears to be the most promising oil and gas exploration area. Present attention in the Atlantic region was focused on an exploration plan by Mobil for drilling on Block 467, a tract 45 miles northeast of Cape Hatteras, North Carolina.

Atkinson, L. 1991. South Atlantic Bight Recruitment Experiment. EOS, Trans. AGU. 72(51):59.

Abstract. SABRE is a newly funded program of the NOAA Coastal Ocean Program Office. The goal of SABRE is to "understand the relationship between variation in environmental factors and the variable recruitment of estuarine dependent fishes in the South Atlantic Bight". SABRE is directed towards obtaining a general process-oriented understanding of natural variability in specific populations by focusing on the linkage between environmental variability and variation in year class strength. The fish was the menhaden and the area chosen was the South Atlantic Bight.

Atkinson, L.P. and D.W. Menzel. 1985. Introduction: Oceanography of the Southeast United States Continental Shelf. pp. 1-9. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. The continental shelf area between West Palm Beach, Florida, and Cape Hatteras, North Carolina, known as the South Atlantic Bight (SAB), is a shallow shelf geomorphologically isolated from adjacent continental shelves by Cape Hatteras to the north and the very narrow south Florida shelf to the south. The width of the shelf varies from a few kilometers off Florida to nearly 200 km off Georgia. The SAB extends from approximately 27° to 35°N latitude, with climatic variations ranging from subtropical to temperate. The large latitudinal range results in significant latitudinal variation in weather-related physical processes. The cross-shelf variation in physical, chemical, and biological processes is also significant because of interaction with the estuaries and marshes along the coast and with the Gulf Stream at the shelf break. The interaction with coastal marshes is strongest in the central SAB where tidal range is highest. Interaction with the Gulf Stream also varies latitudinally in a more complex manner.

Atkinson, L.P. and L.J. Pietrafesa. 1980. A flushing model of Onslow Bay, North Carolina, based on intrusion volumes. J. Phys. Oceanogr. 10:472-474.

Abstract. Onslow Bay, North Carolina, is repeatedly flushed by intrusions of Gulf Stream water. An exponential dilution model based on intrusion models indicates 20-60 days are required for 50% dilution of Bay waters.

Atkinson, L.P., J.J. Singer and L.J. Pietrafesa. 1980. Volume of summer subsurface intrusions into Onslow Bay, North Carolina. Deep-Sea Res. 27A:421-434.

Abstract. Describes the summer hydrographic conditions that allow upwelled water to intrude along the bottom of the outer continental shelf and displace large amounts of shelf water in Onslow Bay.

Atkinson, L.P. and T.E. Targett. 1983. Upwelling along the 60-m isobath from Cape Canaveral to Cape Hatteras and its relationship to fish distribution. Deep-Sea Res. 30(2A):221-226.

Abstract. During a cruise north in the Gulf Stream from Cape Canaveral to Cape Hatteras several zones of upwelling were observed. Acoustic measurements suggested that fish aggregations were associated with areas of upwelling. Surface salinity and alongshore velocity observations suggest an offshore flow of shelf water in the 32 to 33°N area.

Atkinson, L.P., T.N. Lee, J.O. Blanton and W.S. Chandler. 1983. Climatology of the southeastern United States continental shelf waters. J. Geophys. Res. 88(C8):4705-4718.

Abstract. Reports temperature, salinity, and bulk stratification data from inner and outer shelf waters of the southeastern United States from 2782 hydrographic

stations. The data were sorted by each degree of latitude and by depth into three zones (0-20 m, 21-40 m, 41-60 m). Inner shelf water temperatures were similar to adjacent land air temperatures, while outer shelf temperatures were moderated by the Gulf Stream. Minimum and maximum water temperatures occurred in Georgia and South Carolina inner shelf water. Highest bulk stratification is found over the outer shelf. Stratification decreased with the approach of fall with the associated cooling and high winds. Mean flow at midshelf was northward and appears to be produced by an along-shelf slope of sea level of oceanic origin.

Atkinson, L., O. Brown, T. Curtin, P. Hamilton and T. Lee. 1984a. South Atlantic Physical Oceanography Study (Year 5). Volume 1. Executive Summary. U.S. Dept. Interior, MMS Rep. MMS/AT/ES-84/13:19.

Abstract. Between 1977 and 1984 a physical oceanographic field measurement and data interpretation and synthesis program was conducted for an area extending alongshore from approximately Cape Hatteras to Cape Canaveral and offshore across the shelf and the Blake Plateau. Emphasis was on shelf and shelf-break processes. Primary measurements made or used extensively in one or more program years include: subsurface currents/temperature, regional/seasonal hydrography, satellite thermal imagery, coastal water levels, and coastal and marine winds. The present program was closely coordinated with a concurrent DOE funded program which studied conditions on the shelf in the Georgia embayment. Program results describe Gulf Stream impacts on regional or process specific circulation patterns, e.g. Gulf Stream meanders and boundary eddies or filaments. Also described is the response of shelf currents and water level to tidal and wind-stress forcing mechanisms.

Atkinson, L., O. Brown, T. Curtin, P. Hamilton and T. Lee. 1984b. South Atlantic Physical Oceanography Study (Year 5). Volume 2. Technical Report. U.S. Dept. Interior, MMS Rep. MMS/AT/ES-84/14:244.

Abstract. Between 1977 and 1984 a physical oceanographic field measurement and data interpretation and synthesis program was conducted for an area extending alongshore from approximately Cape Hatteras to Cape Canaveral and offshore across the shelf and the Blake Plateau. Emphasis was on shelf and shelf-break processes. Primary measurements made or used extensively in one or more program years include: subsurface currents/temperature, regional/seasonal hydrography, satellite thermal imagery, coastal water levels, and coastal and marine winds.

Atkinson, L.P., D.W. Menzel and K.A. Bush. eds. 1985. Oceanography of the Southeastern U.S. Continental Shelf-Coastal and Estuarine Sciences. Vol. 2. American Geophysical Union. Washington, D.C. 156 pp.

Abstract. This monograph about the oceanography of the Atlantic continental shelf of southeastern USA consists of 12 individually authored chapters that each describe a different oceanographic topic. The present volume on the South Atlantic Bight summarizes the state of multidisciplinary knowledge on an entire continental shelf regime, providing the first comprehensive synthesis of the major new understanding acquired through a decade-long scientific campaign on a particular shelf regime. This campaign is notable for the variety of physical, chemical, and biological studies undertaken in a sustained and adaptive fashion

as the scientific investigators pursued mounting evidence for the role of Gulf Stream meanders in driving the coastal ecosystem of interest through eddy fluxes of nutrients from offshore, a striking new finding which reversed conventional wisdom.

Atkinson, L.P., T.N. Lee, J.O. Blanton and G.-A. Paffenhöfer. 1987. Summer upwelling on the southeastern continental shelf of the U.S.A. Prog. Oceanogr. 19:231-266.

Atkinson, L.P., E. Oka, S.Y. Wu, T.J. Berger, J.O. Blanton and T.N. Lee. 1989. Hydrographic variability of southeastern United States shelf and slope waters during the Genesis of Atlantic Lows Experiment: winter 1986. J. Geophys. Res. 94(C8):10699-10713.

Abstract. Continental shelf waters are particularly responsive to winter storm events mainly because of their shallow depths. Those of the southeastern United States (the South Atlantic Bight (SAB)) are especially responsive because they are broad and shallow. Also, the Gulf Stream serves as a continual source of warm water at the outer boundary. Thus the SAB receives strong meteorological (wind stress and heat loss) and oceanographic (advective) forcing. During the Genesis of Atlantic Lows Experiment (GALE) the response of shelf waters to winter storm events and Gulf Stream forcing was observed. The mean conditions showed a mixed water column with areas of stratification near the coast and at the shelf break. Onshore Ekman flow, buoyancy flux, heat budgets and air-sea heat exchange were also studied. (16 Refs.).

Aubrey, D.G. 1981. Field Evaluation of Sea Data Directional Wave Gage (Model 635-9). WHOI Tech. Rep. WHOI-81-28:58.

Abstract. A directional wave gage consisting of a two-axis electromagnetic current meter and pressure sensor, was successfully deployed during the joint NOAA/U.S. Army Corps of Engineers Coastal Engineering Research Center's Atlantic Remote Sensing Land/Ocean Experiment (ARSLOE) during November, 1980. The instrument was proven to be a viable alternative for point measurements of directional wave fields and for estimating the first five fourier coefficients in a directional wave model.

Auer, S. 1980. New daily oceanographic analyses. Mar. Weather Log. 24(60):412-414.

Abstract. Discusses the availability of oceanographic and isotherm analyses using satellites and SST for the northwest Atlantic, Gulf of Mexico, and the northeast Pacific.

Auer, S.J. 1987. Five-year climatological survey of the Gulf Stream System and its associated rings. J. Geophys. Res. 92(11):11709-11726.

Abstract. Presents climatological summary statistics for the distribution of entire Gulf Stream System including its source in the Loop Current. Additionally, the genesis and movement of rings is addressed. The data derive from 1300 Oceanographic Analysis Charts produced by the National Weather Service.

Auer, S. and J.W. Clark. 1982. East Coast ocean features. Oceanogr. Mon. Summ. 2(4):8-19.

Abstract. Satellite images delineate Gulf Stream and Loop Current boundaries by prominent SST gradients, and show location and monthly translation of anticyclonic eddies.

Baer, L. 1982. Atlantic Remote Sensing Land Ocean Experiment (ARSLOE).

Abstract. ARSLOE was a multi-organization experiment held October 6 to November 30, 1980, near Duck, North Carolina. It provided a large number of wind-wave and related measurements to intercompare and develop wave measurement systems and to evaluate and improve wave models. These sessions are the first organized public presentations for the preliminary results. This paper is an introduction to the experiment and presentation.

Baig, S., D. Gaby and J. Wilder. 1981. A provisional Gulf Stream system climatology. Mar. Weather Log. 25(5):323-326.

Abstract. NOAA's Satellite Field Services Station (SFSS) in Miami, Fla., one of seven field stations operated by NESS, was established in 1974 and began using the new imagery available from the GOES satellites. An SFSS oceanographer, together with a colleague at the NOAA Atlantic Oceanographic and Meteorological Laboratories, developed a new technique for deriving the location of the Gulf Stream using animated GOES imagery.

Baker, S. 1977. The Citizen's Guide to North Carolina's Shifting Inlets. UNC Sea Grant Pub. UNC-SG-77-08:32.

Abstract. The purpose of this volume is to reach an audience of citizens who do not have a scientific or engineering background. The writer set about preparing a graphic study sampling what has happened to barrier island inlets within the lifetimes of most readers of this publication. An aerial photograph is an impartial record of all elements of a scene visible at the time the film is exposed. Any photograph may be full of information which the layman cannot extract. It was felt, however, that most people could see and distinguish between land and water and identify inlets without special training.

Bales, S.L., W.T. Lee and J.M. Voelker. 1981. Standardized wave and wind environments for NATO operational areas. David W. Taylor Naval Ship Research and Development Center Report. DTNSRDC/SPD-0919-01:334.

Abstract. Wave statistics for North Atlantic open ocean areas are provided based on hindcasts from September, 1959, to August, 1969, with the U.S. Navy Spectral Ocean Wave Model (SOWM). Statistical information includes significant wave height and modal (peak) wave period probability distributions, significant wave height and wind speed probability distributions, significant wave height and wave direction probability distributions, significant wave height persistence, and wind speed persistence.

Bane, J.M. 1988. The Gulf Stream off the East Coast of the United States. Chinese J. Oceanol. Limnol. 6(4):334-342.

Abstract. Current and temperature data from one-year-long instrument deployment in the region just northeast of Cape Hatteras have shown the oceanic variability to be intense and quite complex. Changes in the position of the Gulf Stream's path were observed to occur following cold core Gulf Stream passages through the area. The time between these changes was a few months. The Gulf Stream jet itself was seen to meander in a manner previously observed, as long as it was not undergoing a strong ring/stream interaction. Several isolated vortices progressed through the array, with the majority of them being in the submesoscale coherent vortex class. Two mid-depth, anticyclonic warm eddies progressed through the array. It is likely the two events were caused by two different transits of the same eddy. The waters below the main thermocline oscillated as topographic Rossby waves progressed through the array area.

Bane, J.M. and D.A. Brooks. 1981. The Gulf Stream Meander Experiment: AXBT/PRT data report, R/A Project SEASCAN Flights 21-29, Nov. 1979. Rep. CMS-81-1, Univ. of North Carolina, Chapel Hill.

Abstract. Aircraft surveys were conducted between Savannah, Georgia, and Cape Hatteras, North Carolina, in order to obtain synoptic views of the three-dimensional structure of the Gulf Stream thermal frontal zone. This paper describes the aircraft temperature measurements and the vertical and horizontal temperature sections made during this survey.

Bane, J.M. and W.K. Dewar. 1983. The Gulf Stream deflection and meander energetics experiment--Current meter and bottom pressure gauge data report for the September, 1981 to April, 1982 mooring period. UNC Tech. Rep. No. CMS-83-2:481.

Abstract. The Gulf Stream Deflection and Meander Energetics Experiment was designed to study time-dependent fluctuations of the Gulf Stream and their relationship to its mean structure. Seven instrument moorings supporting 14 current meters and 2 bottom pressure gauges were deployed from mid-September 1981 to mid-April 1982 along the upper continental slope off North and South Carolina. The study area enclosed a major seafloor topographic feature known as the Charleston Bump. This region was chosen for several reasons. First, previous studies to its north and south have indicated that the bump area is a primary location for intense Gulf Stream meander 'amplification' (Hood and Bane, 1983). Second, theory has shown that irregular topography can be a major factor in the stability of a mean flow. Finally, the study in this region complements several earlier studies by completing the geographical picture of the exchanges of energy between the mean Gulf Stream and its eddies. In this technical report we document the procedures used to obtain and process the current meter and pressure data, and present the data in graphical and statistical form.

Bane, J.M. and W.K. Dewar. 1988. Gulf Stream bimodality and variability downstream of the Charleston Bump. J. Geophys. Res. 93(C6):6695-6710.

Abstract. The Gulf Stream Deflection and Meander Energetics Experiment (DAMEX) used current meters and satellite imagery to determine that the seaward

deflection of the Gulf Stream by the bump has a bimodal character and that the Gulf Stream meander field downstream of the bump differs between the two states of deflection.

Bane, J.M., L.M. O'Keefe, R.S. Ault and D.R. Watts. 1989a. The Gulf Stream Dynamics Experiment: Current Meter Data Report, January 1984 to January 1985 Mooring Period. UNC Tech. Rep. CMS89-1:253.

Abstract. The Gulf Stream Dynamics Experiment was conducted in the region northeast of Cape Hatteras, North Carolina, from April 1983 to May 1985 to study the propagation and growth characteristics of Gulf Stream meanders. Data were collected during the field experiment with inverted echo sounders, moored current meters and AXBT survey flights. This report documents the current meter data, which were collected with an array of five moorings that was in place for the one-year period beginning mid-January 1984. Instrument preparation, calibration and deployment/recovery procedures, plus data processing procedures are discussed. Basic statistics of the three-hour and forty-hour low-pass filtered time series are presented, followed by time series of currents and temperatures measured by the twenty Aanderaa current meters. Both three-hour and forty-hour low passed time series are displayed. Selected spectral calculations are given in the final section.

Bane, J.M., L.M. O'Keefe and D.R. Watts. 1989b. Mesoscale Eddies and Submesoscale, Coherent Vortices: Their Existence near and Interaction with the Gulf Stream. In J.C.J. Nihoul and B.M. Jamart, eds. Mesoscale/Synoptic Coherent Structures in Geophysical Turbulence. Elsevier, Liege.

Abstract. An array of tall current meter moorings, bottom-mounted inverted echo sounders and pressure gauges was deployed for one year in an area about 150-500 km northeast of Cape Hatteras, North Carolina. The Gulf Stream jet was observed by upper current meters in the array, and the deep western boundary current was observed by several of the deep instruments. Numerous mesoscale eddies and submesoscale, coherent vortices were observed progressing through the region. Two types of mesoscale eddies were seen. Three cold-core Gulf Stream rings were observed, two of which interacted with the Stream, ultimately coalescing with the jet within the array area. Associated with the first ring-Stream interaction was a lateral shift of the position of the Gulf Stream's axis. This shift repositioned the jet about 100 km seaward, and this new path lasted for several months. The second ring-Stream interaction was followed by another shift in the Stream's path. The bottom pressure signal observed during each ring passage through the area gave clear evidence of a vertical "tilt" to each ring's low pressure center. The second type of mesoscale eddy observed was an intriguing, subsurface, anticyclonically swirling warm eddy which moved through the array area along the seaward side of the Gulf Stream in the Sargasso Sea.

Bane, J.M., Jr. ed. 1982. Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982. The Office of Naval Research. 394 pp. (NTIS Accession Number: AD-A128 789/5)

Abstract. The Workshop on Gulf Stream Structure and Variability was held on April 1 and 2, 1982. The papers contained in this volume are written versions of

presentations made at the Workshop. These papers represent a cross-section of modern Gulf Stream physical oceanographic research. They are by no means exhaustive. This Proceedings Volume is distributed with the hope that it may serve as a source book for determining who is doing what in Gulf Stream research.

Bane, J.M., Jr. 1983. Initial observations of the subsurface structure and short-term variability of the seaward deflection of the Gulf Stream off Charleston, South Carolina. J. Geophys. Res. 88(C8):4673-4684.

Abstract. A recurring seaward deflection of the surface layer of the Gulf Stream has been observed near 32°N latitude off the coast of the southeastern United States. It has been suggested that a ridge and trough bottom feature (the so-called 'Charleston bump') on the upper continental slope off the Georgia/South Carolina coast produces the deflection through a bottom steering effect. Present data indicate that the deflection is great enough to direct the Gulf Stream's shoreward surface thermal front to the east, and even south of east, about 70% of the time. Air-deployed expendable bathythermograph surveys have been made with sufficient coverage to provide several synoptic, three-dimensional views of the Gulf Stream's thermal frontal zone in the region between Savannah, Georgia, and Cape Hatteras, North Carolina. A simple, kinematical model which incorporates growing, propagating Gulf Stream meanders is proposed to explain the deflection's short-term variability. A dome-shaped volume of cold water was observed to be located over the upper continental slope immediately downstream of the deflection. The existence and persistence of this cold dome suggest that upwelling is important in its maintenance, a hypothesis consistent with its hydrographic properties.

Bane, J.M., Jr. 1987. Final Technical Report on Office of Naval Research Control Number N00014-77-C-0354. UNC Tech. Rep. CMS-87-2:40.

Abstract. This 10 year long contract supported research on the physical oceanography of the Gulf Stream, which included several sub-projects; Research project topics included: A theoretical study of topographic Rossby Waves trapped over the continental slope in the Gulf Stream; Observations of topographic Rossby Waves and Gulf Stream meanders along the continental slope; An observational study of Gulf Stream deflection and meander energetics along the continental margin; Observations of the current structure and energetics of Gulf Stream fluctuations downstream of Cape Hatteras.

Bane, J.M., Jr. 1989. Results from the Genesis of Atlantic Lows Experiment physical oceanographic studies: Introduction. J. Geophys. Res. 94(C8):10685.

Abstract. The Genesis of Atlantic Lows Experiment (GALE) was conducted during early 1986 to investigate the rapidly developing, extratropical winter cyclones that travel across eastern North America and out over the northwestern Atlantic Ocean. Until only recently, these storms have been difficult to predict accurately. The physical oceanographic component of GALE comprised a set of studies carried out in and above the Gulf Stream and shelf waters off the southeastern United States. This research was conducted to give a better understanding of the area's air-sea exchange processes and the resulting atmospheric boundary layer and oceanic responses during winter. (7 Refs.).

Bane, J.M., Jr. and D.A. Brooks. 1979. Gulf Stream meanders along the continental margin from the Florida Straits to Cape Hatteras. Geophys. Res. Lett. 6(4):280-282.

Abstract. Discusses the deflection of the Gulf Stream off Charleston, South Carolina, with emphasis on the importance of a bottom features in producing meanders. Also shows meanders to be northward-travelling waves.

Bane, J.M., Jr. and R.V. Legeckis. 1981. Comparison of aircraft and TIROS-N satellite thermal infrared measurements of the Gulf Stream. EOS, Trans. AGU. 62(17):295.

Abstract. On November 27, 1979, an aircraft PRT and AXBT survey was made of the Gulf Stream off the Carolina coast at an altitude of 300 meters. The surface thermal infrared signatures along eight cross stream aircraft tracks are compared to coincident infrared data from the AVHRR scanner on the TIROS-N satellite. The two sets of data show remarkable similarities in the trend. The satellite temperatures tend to be smoother due to the larger AVHRR field of view (1 km). The relative temperature differences show that the satellite is about 1°C lower than that of the aircraft in the temperature range of 20 to 25°C and this is attributed to the greater atmospheric absorption of the radiation reaching the satellite. Accurate position data are critical in making the comparisons of the coincident data due to the spacial variability of the surface temperatures apparent in the satellite image. Since the aircraft measures the absolute surface temperature to 0.5°C, it is possible to use the coincident measurements to calibrate the satellite data with nearly the same uncertainty.

Bane, J.M., Jr. and K.E. Osgood. 1989. Wintertime air-sea interaction processes across the Gulf Stream. J. Geophys. Res. 94(C8):10755-10772, 11005.

Abstract. Aircraft, buoy and satellite measurements have been used to study the wintertime air-sea interaction processes across the Gulf Stream during January 25-30, 1986. The turbulent flux regime in the marine atmospheric boundary layer exhibited considerable spatial and temporal variability during this 6-day period, which was related to both the evolution of the synoptic scale atmospheric conditions and the sea surface temperature (SST) field. During the pre-storm conditions prior to January 25, the spatial structure of the SST field played an important role in generating a shallow atmospheric frontal zone along the Gulf Stream front by causing differential heating of the marine atmospheric boundary layer over the stream versus over the cooler shelf waters. As this front moved shoreward on January 25, the warm, moist, maritime air flowing northwestward behind the front induced moderate ocean-to-atmosphere heat fluxes. The subsequent outbreak of eastward flowing cold, dry, continental air over the ocean on January 27 and 28 generated high total heat fluxes as did a second, somewhat weaker outbreak which followed on January 30. (49 Refs.).

Bane, J.M., Jr., D.A. Brooks and M.J. Ignaszewski. 1980a. The Gulf Stream Meanders Experiment: Hydrographic data report. R/V ENDEAVOR cruise EN-040 and EN-045. Rep. 80-10-T, Texas A&M Univ., College Station.

Abstract. Cruise report for study to examine dynamics of Gulf Stream meanders.

Bane, J.M., Jr., D.A. Brooks, K.R. Lorenson and C.M. Seay. 1980b. The Gulf Stream Meanders Experiment. AXBT/PRT Data Report, R/A Project Birdseye Flights, 9-18 February 1979. UNC Tech. Rep. CMS-80-2:227.

Abstract. This report documents surface and subsurface ocean temperature data collected in the Gulf Stream frontal zone along the continental margin between Savannah, Georgia, and Cape Hatteras, North Carolina. The data were collected during eight flights made aboard the Project Birdseye research aircraft, a Lockheed P-3A operated by the U.S. Naval Oceanographic Office and U.S. Navy Squadron VXN-8, based at Patuxent River Naval Air Station, Maryland. These rapid, extensive and intensive surveys provided essentially synoptic, three-dimensional views of the mesoscale features (specifically meanders) within the Gulf Stream. The surveys were made in support of the observational component of the Gulf Stream Meanders Experiment (GSME), sponsored by the Office of Naval Research and the National Science Foundation. Temperature data collected during five other aircraft surveys in November, 1979 are documented in the data report by Brooks and Bane (1981). Hydrographic data from four cruises during 1979 are reported in two other data reports (Brooks et al 1980a; Bane et al 1980a). The central component of the observational study was an array of four instrument moorings which supported ten Aanderaa RCM-4 current meters. The array was deployed during two separate four-month periods during 1979. The data from the winter mooring period are documented in the report by Brooks et al. (1980b), and the summer data appear in the report by Bane and Brooks et al. (1981).

Bane, J.M., Jr., D.A. Brooks, K.R. Lorenson and C.M. Seay. 1980c. Three-Dimensional View of a Gulf Stream Meander between Savannah, Georgia and Cape Hatteras, North Carolina. Gulfstream. 5:3-7.

Abstract. Synoptic views of large regions of the ocean are difficult to obtain. Conventional shipboard techniques require such long periods of time for data collection and ship travel that severe temporal aliasing can adversely affect a data set. This is the case with measurements made in the Gulf Stream along the southeastern United States, because the Stream has significant variations with periods ranging from a few days to many weeks. Recent synoptic observations of the sea-surface temperature field, made possible through the advent of satellite-borne thermal infrared sensors, indicate that the dominant mesoscale fluctuations in the Gulf Stream in that area are wavelike meanders. They have alongshore wavelengths of about 150 km and progress in the northeastward, or downstream direction at about 40 km day (Legeckis, 1979). These properties of the surface thermal variability compare well with Webster's (1961) analysis of subsurface temperature data collected during 1 month off Onslow Bay, N.C. He showed the two dominant meander periods to be near 7 days and 4 days. The consistencies between these two sets of observations make a three-dimensional, synoptic picture of the Gulf Stream quite desirable.

Bane, J.M., Jr., D.A. Brooks and K.R. Lorenson. 1981. Synoptic observations of the three-dimensional structure and propagation of Gulf Stream meanders along the Carolina continental margin. J. Geophys. Res. 86(C7):6411-6425.

Abstract. Simultaneously measured Eulerian currents and spatially extensive subsurface temperatures have provided a time series of eight synoptic, three-dimensional views of the Gulf Stream frontal zone along the Carolina continental

margin. Two large-amplitude meanders were observed to progress through the study area between Charleston and Cape Hatteras during February 1979. Each meander had a vertically coherent, skewed wave-like subsurface structure. Included are descriptions of vertically coherent, skewed wave-like subsurface structures of each meander.

Bane, J.M., Jr., O.B. Brown, R.H. Evans and P. Hamilton. 1988. Gulf Stream Remote Forcing of Shelf Break Currents in the Mid-Atlantic Bight. Geophys. Res. Lett. 15(5):405-407.

Abstract. The "Slope Sea" is a narrow band of ocean that lies between the Gulf Stream and the continental shelf edge in the Mid-Atlantic Bight. It is composed primarily of slopewater, and a closed cyclonic gyre circulates within the upper few hundred meters of its western end. A two-year time series of current measurements in this region has shown that the southwestward flowing shelfbreak currents along the shoreward flank of the gyre are directly related to the position of the Gulf Stream, which is typically some 150 to 300 km seaward of the shelfbreak. The mean monthly shelfbreak currents are strongest, towards the southwest at about 30-40 cm/s, when the Stream is within 150 km of the shelf edge, whereas those currents are close to zero when the Stream is about 300 km away.

Barans, C.A. and W.A. Roumillat. 1976. Surface Water Drift South of Cape Lookout, North Carolina. South Carolina Mar. Res. Center Tech. Rep. 12.

Abstract. Drift bottles containing preaddressed return cards were released at total of 272 stations (5 bottles per station). An attempt was made to limit releases to surface waters inshore of the Florida Current, which was identified by its seasonal temperature and salinity characteristics. Total card recovery was 13.8% of the number of drift bottles released.

Barbieri, R.W., C.R. McClain and D.L. Endres. 1983. Methodology for Interpretation of SST Retrievals Using the Avhrr Split Window Algorithm. NASA Tech. Memo. NASA-TM-85100:57.

Abstract. Intercomparisons of sea surface temperature (SST) products derived from the operational NOAA-7 AVHRR-II algorithm and *in situ* observations are made. The 1982 data sets consist of ship survey data during the winter from the Mid-Atlantic Bight (MAB), ship and buoy measurements during April and September in the Gulf of Mexico and shipboard observations during April off the N.W. Spanish coast. The analyses included single pixel comparisons and the warmest pixel technique for 2 x 2 pixel and 10 x 10 pixel areas. The reason for using multi-pixel areas was for avoiding cloud contaminated pixels in the vicinity of the field measurements. Care must be taken when applying the warmest pixel technique near oceanic fronts. The Gulf of Mexico results clearly indicate a persistent degradation in algorithm accuracy due to El Chichon aerosols. The MAB and Spanish data sets indicate that very accurate estimates can be achieved if care is taken to avoid clouds and oceanic fronts.

Barcilon, V., P. Constantin and E.S. Titi. 1988. Existence of solutions to the Stommel-Charney model of the Gulf Stream. SIAM Journal on Mathematical Analysis. 19(6):1355-1364.

Abstract. The existence of weak solutions to the equations proposed by Stommel (1948) and Charney (1955) as a model of the Gulf Stream are established by means of the method of artificial viscosity. (17 Refs.).

Barrett, J.R. 1971. Available potential energy of Gulf Stream rings. Deep-Sea Res. 18:1221-1231.

Abstract. Study of two cyclonic eddies to determine decay rates and general behavior.

Barvenik, F.W. 1977. ERDA's oceanographic program for the Mid-Atlantic coastal region. Workshop on the Mid-Atlantic coastal oceanographic research: 137.

Abstract. Summary of ERDA sponsored programs are presented. Future research needs are also identified.

Bassinger, B.G., H. Orlin and C.H. Gray. 1970. Continental Shelf Seabottom Survey Cape Hatteras, North Carolina - Cape May, New Jersey. National Ocean Survey. NOS-DR-11:23.

Abstract. One hundred seventy three sea-floor gravity stations spaced over an area of approximately 4800 nm sq were occupied on the continental shelf between Cape Hatteras, North Carolina and Cape May, New Jersey through the cooperative efforts of the U.S. Department of Commerce, Environmental Science Services Administration and the U.S. Department of Defense, Naval Oceanographic Office. A sea-surface gravity equipment test range covering an area of approximately 500 nm sq near the Chesapeake Bay entrance was established as part of a larger continental shelf gravity program in the area of the offshore extension of the Transcontinental Geophysical Survey. Sea-floor gravity stations were occupied at 1.5 to 5 nm intervals in the test range area and at 10 nm intervals elsewhere. This report summarizes the operation and presents tabulated gravity data outside the test range. A free-air anomaly contour map of the combined areas as well as adjacent land gravity data is presented.

Battelle. 1984. Cruise Report MMS Mid-2 R/V GYRE 31 July-9 August, 1984 Study of Biological Processes on the U.S. Mid-Atlantic Slope and Rise. Final Report. Prepared for U.S. Department of the Interior, Minerals Management Service.

Battelle. 1987. Final Report on Analytical Results of Samples Collected During the 1985 North Atlantic Incineration Site (NAIS) Survey. Final Report. Prepared for the U.S. Environmental Protection Agency under Contract No. 68-03-3319. Work Assignment 5. 184 pp.

Battelle Memorial Institute. 1990. Experiment on Rapidly Intensifying Cyclones Over the Atlantic. Battelle Memorial Institute Final Report. N00014-85-C-0518:44.

Abstract. The Experiment on Rapidly Intensifying Cyclones over the Atlantic

(ERICA) field study is designed to determine physical mechanisms and processes, and their critical spatial and temporal combinations, which can account for the wintertime phenomenon of explosively-developing over-ocean atmospheric storms. The core field experiment will be supplemented by the substantial participation of many other agencies and universities from the United States and Canada. Data will be obtained over the North Atlantic Ocean from Cape Hatteras to beyond Newfoundland, centered east of Cape Cod and south of Nova Scotia. The general timing and siting is chosen through consideration of historical storm occurrence data. Measurements on individual rapidly-intensifying storms will be made from aircraft, buoys, and satellites, and by soundings and radars. Observations made during the pre-ERICA field test, January 1988, are discussed. This article describes the measurement objectives and the ways by which the field data will be collected.

Battelle. 1991. Satellite-tracked surface-layer drifters released at the 106-Mile Site: October 1989 through December 1990. A report submitted to the U.S. Environmental Protection Agency under Contract No. 68-C8-0105. Battelle Ocean Sciences Inc., Duxbury, MA., 26pp.

Abstract. This data report presents a summary of results for the satellite-tracked surface-layer drifter program at the 106-Mile Deepwater Municipal Dump Site (106-Mile Site) during the period October 1989 through December 1990. Free-drifting surface buoys attached to drogues centered at 10 m depth closely follow the movement of water within the surface mixed layer - the well-mixed near-surface water above the density interface or pycnocline.

Battisti, D.S. and A.J. Clarke. 1982. A simple method for estimating barotropic tidal currents on continental margins with specific application to the M_2 tide off the Atlantic and Pacific coasts of the United States. J. Phys. Oceanogr. 12:8-16.

Abstract. Theory is developed to describe barotropic tidal currents on "smooth" continental shelves, that is, continental shelves with longshore scales much greater than the shelf width. Two models are considered, one in which sea level does not vary significantly across the shelf and the other in which it does. Both models include longshore gradients and friction (parameterized linearly in velocity). The models were tested by calculating the M_2 tidal currents off the Atlantic and Pacific coasts of the United States and then comparing the calculated currents to those measured. Results show that theory and observation are very good agreement as far offshore as 300 km. Along the Atlantic coast, on account of the wide continental shelf, current velocities are typically O(0.10-0.15 m/s) north of Cape Hatteras and O(0.15-0.28 m/s) off Savannah, Georgia. Currents rotate anticyclonically and are highly elliptical (ellipticity E about -0.4), with the semi-major axis oriented normal to the coast. Friction is significant in the South Atlantic Bight and acts to rotate the zero-friction current ellipses in a clockwise direction. Off the Pacific coast, where the continental shelf is narrow, M_2 tidal currents are relatively weak (0.02-0.08 m/s) and strongly oriented in the longshore direction (E about 0.1). The currents rotate counterclockwise with negligible friction influence. The good agreement between calculated barotropic M_2 currents and the observed currents off the southwest Pacific coast and all along the Atlantic coast of the United States suggests that the semidiurnal tides along these coasts are largely barotropic.

Beal, R.C. 1980. The Seasat SAR Wind and Ocean Wave Monitoring Capabilities, A Case Study for Pass 1339M, 28 September, 1978. Johns Hopkins University/APL Technical Digest. JHU-APL-SIR-79U-019:66.

Abstract. One of the primary purposes of the Seasat Synthetic Aperture Radar (SAR) was to explore the possibility for synoptic monitoring of ocean wavelength and direction from space. 'Duck-X' (acronym for Duck, North Carolina Experiment) was one of only three or four major Seasat SAR wave detection experiments conducted with extensive coincident surface truth during the limited lifetime of the SAR. On the 28th of Sept., a well organized low energy 11 sec. swell system off the East Coast of the U.S. was detected with the Seasat SAR and successfully tracked from deep water, across the continental shelf, and into shallow water. In addition, a less organized 7 sec. system has been tentatively identified in the imagery. Both systems were independently confirmed with simultaneous wave spectral measurements from a research pier, aircraft laser profilometer data, and Fleet Numerical Spectral Ocean Wave Models.

Beardsley, R.C. and W.C. Boicourt. 1981. On estuarine and continental shelf circulation in the Middle Atlantic Bight. pp. 198-234. In B.A. Warren and C. Wunsch, eds. Evolution of Physical Oceanography. MIT Press, Cambridge, MA.

Abstract. Presents evidence for mean flow in the same sense as shelf wave propagation, despite movement of opposing winds.

Beardsley, R.C. and B. Butman. 1974. Circulation of the New England continental shelf: Response to strong winter storms. Geophys. Res. Lett. 1:181-184.

Beardsley, R.C., D.C. Chapman, K.H. Brink, S.R. Ramp and R. Schlitz. 1985. The Nantucket Shoals Flux Experiment (NSFE79). Part 1: A basic description of the current and temperature variability. J. Phys. Oceanogr. 15(6):713-748.

Abstract. Basic description of the moored current and temperature data from NSFE with an emphasis on the low-frequency variability.

Beardsley, R.C. and D.B. Haidvogel. 1981. Model Studies of the Wind-Driven Transient Circulation in the Middle Atlantic Bight. Part 1: Adiabatic Boundary Conditions. J. Phys. Oceanogr. 11(3):355-375.

Abstract. A numerical model of the wind-driven transient ocean circulation in the Middle Atlantic Bight is described. The model incorporates realistic topography and covers the continental shelf between the coast and the 200 m isobath from Cape Hatteras to the southern tip of Nova Scotia. The traditional shallow-water dynamics are used, i.e., the vertically integrated and linearized equations for the flow of a homogeneous fluid driven by atmospheric pressure and wind stress fluctuations and damped by a quadratic bottom stress. The equations are integrated in tim using a simple modification of Platzman's (1972) finite-difference scheme, with a 12.7 km grid spacing. At the coast, normal flow is required to vanish; at non-coastal boundaries, the equivalent surface elevation is held fixed.

Beardsley, R.C. and J. Hart. 1978. A simple theoretical model for the flow of an estuary onto a continental shelf. J. Geophys. Res. 83:873-883.

Beardsley, R.C. and C.D. Winant. 1979. On the mean circulation in the Mid-Atlantic Bight. J. Phys. Oceanogr. 9(3):612-619.

Abstract. Two possible mechanisms which may drive the observed mean alongshelf flow in the Mid-Atlantic Bight are described. Runoff from concentrated sources could conceivably force this flow; however, the one-layer homogeneous model results of Csanady (1978) and Beardsley and Hart (1978) imply that the observed shelf flow is not driven by runoff alone. On the other hand, the Semtner and Mintz (1977) numerical model of the North Atlantic strongly suggests that the shelf circulation is just a boundary layer component of the ocean circulation and thus driven by the large-scale wind stress and heat flux distributions. This model result supports Csanady's (1978) conclusion that the physical mechanism which creates the alongshelf pressure gradient thought to drive the alongshelf flow must be of oceanic origin.

Beardsley, R.C., W.C. Boicourt and D.V. Hansen. 1976. Physical Oceanography of the Middle Atlantic Bight. pp. 20-34. In M.G. Gross, ed. Middle Atlantic continental shelf and New York Bight, Special Symposia. Vol. 2. American Society of Liminology and Oceanography.

Beardsley, R.C., H. Mofjeld, M. Wimbush, C.N. Flagg and J.A. Vermersch Jr. 1977. Ocean tides and weather-induced bottom pressure fluctuations in the Middle-Atlantic Bight. J. Geophys. Res. 82(21):3175-3182.

Abstract. Five bottom pressure gages were deployed in the Middle-Atlantic Bight during the late winter of 1974. Analysis of the resulting pressure series and neighboring coastal tide gage series shows that tides are the dominant pressure signal in this section of the continental shelf. Most of the remaining pressure fluctuations appear to be forced by meteorological transients. During March 21, 1974, a developing cyclone moving up the coast excited a coherent group of sea level oscillations with characteristic periods of 5-7 hours, which are interpreted here as coastal-trapped edge waves. Spectra of the nontidal pressure series are red, however; most of the nontidal variability is caused by lower-frequency (subtidal) components. The subsurface pressure (SSP) fluctuations do appear coherent over the spatial extent of the array in the most energetic subtidal frequency bands, and estimates made of the relative horizontal SSP gradients indicate that cross-shelf gradient variations are significantly larger than alongshore gradient variations. Some consequences of these large weather-induced gradient fluctuations on the shelf circulation are discussed.

Beauchamp, R.G. 1974. Marine Environmental Planning Guide for the Hampton Roads/Norfolk Operating Area. Naval Oceanographic Office Tech. Note. NOO-SP-250:274.

Abstract. The marine environment of the Atlantic Ocean for about 180 miles east of the costs of Virginia and North Carolina is summarized and evaluated to estimate the effects of introduced pollutants. Winds, currents, waves, temperature, salinity and density of the water, geology and biology, and the marine ecosystem are discussed and summarized in charts and tables. Surface materials in the Hampton Roads/Norfolk Naval Operating Area will be moved offshore into the Gulf Stream by wind-induced surface flow during 10 months of the year. This flow is reversed during September and October and carries these

materials toward the coast - more rapidly as distance to shore decreases. A model, using an ellipse technique, predicts dispersion directions of surface or suspended material in the Area. The ellipses are closely related to the surface currents and are elongated in the direction of prevailing flow. A second model predicts the dispersion of dredge spoil or other deposits over the seabed. Orbital and forward drift velocities are sufficient during autumn, winter, and spring to erode and transport sediment, such as dredge spoil, on the Continental Shelf. Bottom transport in the area is predominantly toward the coast regardless of the season. Surface, subsurface, and bottom currents probably will least affect introduced pollutants seaward of the Continental Shelf and north of 36 deg 30 min N. Any stresses that reduce the biomass of autotrophs or cause a loss in their production efficiency will decrease the productivity of the entire ecosystem.

Bell, A. and J. Clark. 1984. December 1984 East Coast ocean features. Oceanogr. Mon. Summ. 4(12):18.

Abstract. Satellite imagery or XBT data are used to locate Gulf Stream and Loop Current boundaries. End-of-December amplitude of the Loop Current shows a slight decrease compared to the end-of-November position.

Bellis, V., M.P. O'Connor and S.R. Riggs. 1975. Estuarine shoreline erosion in the Abemarle-Pamlico region of North Carolina. UNC Sea Grant Pub. UNC-SG-75-29:67.

Abstract. Shoreline erosion within the estuaries of North Carolina is a continuing process which has been in operation for several thousand years. Actual rates of erosion range up to twenty feet per year but average 2-3 feet per year. Variables affecting rate of shoreline erosion are: bank height and composition, vegetative cover, exposure to prevailing winds and fetch, offshore topography, and various human activities. Three major shoreline types are identified on the basis of these parameters. These are: 1) Sand and Clay Banks, 2) Swamp Forest, and 3) Grass Marsh. All these shoreline types, however, can be protected by shoreline modification structures, utilization of natural protective features, or appropriate setback regulations.

Bernard, H. and J. Bowley. 1979. Summary and analysis of physical oceanographic and meteorological information on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral, Vol. 2(3), Doc. P-2904:19-138, Environ. Res. and Tech., Concord, MA.

Abstract. Comprehensive literature review summarizes the physical oceanography and meteorology of the South Atlantic Bight. Much, however, has been published since the publication of this report (especially from studies sponsored by the MMS and DOE).

Berrien, P.L., M.P. Fahay, A.W. Kendall Jr. and W.G. Smith. 1978. Ichthyoplankton from the RV 'Dolphin' Survey of Continental Shelf Waters between Martha's Vineyard, Massachusetts and Cape Lookout, North Carolina, 1965-66. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA-78061514:156.

Abstract. Data are tabulated on ichthyoplankton and concomitant physical conditions collected during a survey of Atlantic continental shelf waters. Sampling information and laboratory procedures are described. Numbers and lengths of 87 species of larval fishes are tabulated by station; egg catches for 9 of these are included. Additionally, the presence of 79 categories of larvae, presently identified only to genus or a higher taxon, is noted by station.

Betzer, P.R., P.L. Richardson and H.B. Zimmerman. 1973. Bottom currents, nepheloid layers and sedimentary features under the Gulf Stream near Cape Hatteras. Mar. Geol. 16:21-29.

Abstract. The velocities of near-bottom currents were measured at six locations on a 180-km transect of the Gulf Stream adjacent to Cape Hatteras. The average velocities indicate a southwesterly flow - the Western Boundary Undercurrent. Maximum recorded velocities at each of the six locations ranged from 15 to 47 cm/sec. Depth distributions of suspended particulate matter over the transect indicated that near-bottom nepheloid layers were present and that relatively large amounts of suspended matter were being carried to the southwest. Bottom photographs taken over the same transect, however, showed no evidence that the sediment surface was being affected by the active bottom currents. These results indicate that swift bottom currents do not always leave a record of their work on deep ocean sediment.

Bigelow, H.B. 1915. Exploration of the coast water between Nova Scotia and Chesapeake Bay, July and August, 1913, by the U.S. Fisheries Schooner GRAMPUS. Oceanography and plankton. Bulletin of the Museum of Comparative Zoology. 59:152-359.

Bigelow, H.B. 1922. Exploration of the coastal water off the northeastern United States in 1916 by the U.S. Fisheries Schooner GRAMPUS. Bulletin of the Museum of Comparative Zoology. 65:88-188.

Bigelow, H.B. 1927. Physical oceanography of the Gulf of Maine. Bulletin of the United States Bureau of Fisheries. Part 2:511-1027.

Bigelow, H.B. 1933. Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay. I: The cycle of temperature. Pap. Phys. Oceanogr. Meteorol. 2:135.

Bigelow, H. and H. Sears. 1935. Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay, II, Salinity. Pap. Phys. Oceanogr. Meteorol. 4(1):1-94.

Birkemeier, W.A. 1979. The Effects of the 19 December 1977 Coastal Storm on Beaches in North Carolina and New Jersey. Shore and Beach. 47(1):7-15.

Birkemeier, W.A., H.C. Miller, S.D. Wilhelm, A.E. DeWall and C.S. Gorbics. 1985. A User's Buide to the Coastal Engineering Research Center's (CERC's) Field Research Facility. Army Engineer Waterways Experiment Station Instruction Report. CERC-85-1.

Abstract. The U.S. Army Engineer Waterways Experiment Station (WES), thrugh its Coastal Engineering Research Center (CERC), has operated the Field Research Facility (FRF) on the coast near Duck, NC, since 1979. Facilities of the FRF and its capabilities to support nearshore coastal processes studies, and related investigations, are described in this user's guide. Assets of the FRF include its approximately 2,000 ft research pier and its capabilities to provide scientific and logistical support to measurement programs in the vicinity.

Birkemeier, W.A., C.F. Baron, M.W. Leffler, K.K. Hathaway, H.C. Miller and J.B. Strider, Jr. 1989. SUPERDUCK Nearshore Processes Experiment Data Summary CERC (Coastal Engineering Research Center) Field Research Facility. U.S. Army Engineer Waterways Expriment Station CERC Misc. Paper. CERC-MP-89-16:122.

Abstract. During September and October 1986, the US Army Engineer Waterways Experiment Station's Coastal Engineering Research Center (CERC) hosted SUPERDUCK, a nearshore processes experiment, at its Field Research Facility located at Duck, North Carolina. The objectives of SUPERDUCK were to develop an improved understanding of coastal processes (currents, waves, sediment transport, and nearshore geomorphology) under a wide variety of conditions and to collect data essential to the development of improved numerical models of coastal phenomena. Critical to the success of SUPERDUCK was the collection of a basic suite of bathymetric surveys and instrument measurements by CERC's Field Research Facility. The measurements included nearshore current, tide, incident directional wave, and meteorological data. In addition, a series of 14 surveys of the bathymetry in the experiment area was collected.

Bisagni, J.J., D.R. Kester, B.H. Ketchum and P.K. Park. 1980. Physical variability at an East Coast United States offshore dumpsite. pp. 89-107. In P.K. Park, ed. Ocean Dumping of Industrial Wastes. Plenum Pub. Co., New York.

Abstract. Describes inadvertent sampling of an established anticyclonic Gulf Stream ring, both before and after it interacted with the Gulf Stream, during a 1977 cruise to Deep Water Dumpsite 106.

Bisagni, J.J. 1983. Lagrangian current measurements within the eastern margin of a warm-core Gulf Stream ring. J. Phys. Oceanogr. 13(4):709-715.

Abstract. Two satellite-tracked buoys drogued at 10 m depth were deployed within shelf water, close to the shelf/slope front in late summer 1980. Position and sea-surface temperature data from the two buoys were combined with surface-water mass analysis based on high resolution infrared satellite imagery. Buoy trajectories and surface-water mass analysis suggest that both buoys traversed a region of shelf water while moving to the suthwest at less than 25 cm/s. Stronger currents up to 54 cm/s from warm-core ring 80-A were encountered near 38°N latitude. These currents caused the buoys to move anticyclonically along the ring's eastern margin within a well defined shelf-water entrainment. Buoy sea-surface temperatures and positions showed good correlation with frontal

boundaries based on satellite imagery. This was shown for both the ring shelf-water entrainment and another shelf-water feature located along the northern edge of the Gulf Stream.

Biscaye, P.E. and S.L. Eittreim. 1974. Variations in the benthic boundary layer phenomena: Nepheloid layer in the North American Basin. pp. 213-225. In R.J. Gibbs, ed. Suspended solids in water. Plenum Publ. Corp., New York.

Abstract. The nepheloid layer in the North American Basin is associated with the Western Boundary Undercurrent and carries a few hundred micrograms per liter at the bottom (500 to 1000 m) of the water column. The benthic nepheloid layer is best observed in nephelometer profiles.

Biscaye, P.E., R.F. Anderson and B.L. Deck. 1988. Fluxes of Particles and Constituents to the eastern U.S. Continental Slope and Rise. Cont. Shelf Res. 8:855-904.

Bishop, J.K.B. and P.E. Biscaye. 1982. Chemical characterization of individual particles from the nepheloid layer in the Atlantic Ocean. Earth Planet. Sci. Lett. 58:265-275.

Abstract. Analysis of near-bottom, 30-liter water samples collected during GEOSECS Atlantic cruise shows difference between particulates and sediment, suggesting transport by resuspension.

Bishop, J.K.B. and T.M. Joyce. 1986. Spatial distributions and variability of suspended particulate matter in warm-core ring 82B. pp. 1741-1760. In P.H. Wiebe and T.J. McDougall, eds. Workshop on Warm-Core Rings, Tokyo, 20-24 May 1985.

Abstract. Spatial distributions and variability of suspended particulate matter were determined optically during CTD/transmissometer surveys of warm-core ring 82B and surrounding waters in June 1982.

Bishop, J.K.B., R.C. Smith and K.S. Baker. 1992. Springtime distributions and variability of biogenic particulate matter in Gulf Stream warm-core ring 82B and surrounding N.W. Atlantic waters. Deep-Sea Res. 39:S295-S325.

Abstract. Distributions of particulate matter, chlorophyll and other physical/bio-optical properties were investigated during April-May 1982 in warm-core ring (WCR) 82B and surrounding Shelf, Slope, Gulf Stream and Sargasso Sea waters. Biogenic particles present in the core waters of WCR 82B were strongly influenced by the day-to-day variation in air-sea heat flux. Particles grew/accumulated in surface waters during periods of transient stratification/quiescence and were removed from the euphotic zone as deep as 400 m during periods of strong heat loss and deep convective mixing. This process enriched ring core waters below the euphotic zone compared to all other waters sampled.

Bishop, J.M. 1978. Utilization of offshore currents for improved ship efficiency. Mar. Weather Log. 22(1):9-12.

Abstract. Describes EXXON/NOAA Fuel Savings Experiment, which tests how modern Gulf Stream satellite analyses could improve navigation significantly to increase fuel savings.

Bishop, J.M. 1980. A note on the seasonal transport on the Middle Atlantic Shelf. EOS, Trans. AGU. 85(C9):4933-4936.

Abstract. Presents a field-supported analytical model capable of predicting both mean summer and mean winter transport.

Bishop, J.M. and J.E. Overland. 1977. Seasonal drift on the Middle Atlantic Shelf. Deep-Sea Res. 24(2):161-169.

Abstract. A relationship among non-tidal surface currents, seasonal density distributions, and mean wind stress is developed from the thermal wind relation and Ekman dynamics. The result can be interpreted as a simple shallow water equivalent of the dynamic method. This approach indicates that summer currents on the Middle Atlantic Shelf set southwestward on the order of 5 to 15 cm/s and are maintained by the density distribution. In winter, winds predominate over the weak contribution from the density field. Winter mean wind stress implies southward flow on the order of 15 cm/s. Drift estimates are consistent with atlas values.

Biswas, K.R. and P.V. Hobbs. 1990. Lightning over the Gulf Stream. Geophys. Res. Lett. 17(7):941-943.

Abstract. During the period 15 January-15 March 1986 the average frequency and strength of lightning flashes to the Earth's surface over the Gulf Stream off the Carolina Coast was greater than that over the adjacent land. Near the North Carolina Coast, in prefrontal situations, the mean number of flashes to the Earth's surface per lightning day per grid area (1 degrees latitude by 1 degrees longitude) was 20.9 in the vicinity of the Gulf Stream and 4.8 over the adjacent land. In postfrontal situations the corresponding numbers were 18.4 and 8.9. Most (but not all) of the lightning flashes over the Gulf Stream conveyed negative charge to the Earth's surface, and the increase in the frequency of lightning over the Gulf Stream was greater for these lightning flashes than for those that carried positive charge to the Earth's surface. The enhancement in lightning activity over the Gulf Stream is attributed to the recurrent convective rainbands that form in this region. (4 Refs.).

Blaha, J.P. 1984. Fluctuations of monthly sea level as related to the intensity of the Gulf Stream from Key West to Norfolk. J. Geophys. Res. 89(C5):8033-8042.

Abstract. Tide gauge data from Key West to Norfolk were used to identify a monthly signal in sea level that is uncorrelated with local shelf-trapped processes. Time series (1955-1975) of local winds, sea level slope, and river runoff were used in a regression model of sea level to separate a local response and a residual signal. The monthly means of the residual contribution were

investigated for their relationship to the seasonal fluctuations of the Gulf Stream. In the Florida Channel, lower sea level is found to correspond to increased flow of the Florida Current. During July and August a marked fall in residual sea level, unrelated to the coastal winds, is found from Key West to Charleston, suggesting that the transport of the Gulf Stream increases both in the north of the Florida Channel during this time. Measured long-term monthly surface currents at Diamond Shoals, Cape Hatteras, which markedly increase in summer to high velocities, tend to substantiate this claim. An additional wintertime low in residual sea level occurs north of the Florida Channel. The wintertime low does not result from steric heating within the upper 100-150 m of water, nor does it, in contrast to the summertime low, appear to coincide with increased northward surface flow. Monthly mean Sverdrup transport was computed across the North Atlantic between 15°N and 35°N. When compared at the same latitude, residual sea level and Sverdrup transport, both interpreted as indices of Gulf Stream transport, generally disagree in phase during summer. However, north of the Florida Channel they are consistent during winter, assuming that lower sea level at this time reflects increased flow in the stream.

Blaha, J. and B. Lunde. 1992. Calibrating Altimetry to Geopotential Anomaly and Isotherm Depths in the Western North Atlantic. J. Geophys. Res. 97(C5):7465-7477.

Abstract. Sixty-two temperature sections were taken to depths of 800 m by aircraft along Geosat ground tracks within 1-2 days of the satellite orbit. The sections are 500-700 km long and cross the Gulf Stream and its rings. From pairs of sections that repeat on the same ground track, collinear differences of geopotential anomaly (0/25 MPa) and the depth of the 16°C isotherm were collected as along-track signals of the change of baroclinic conditions. The difference signals, from aircraft and altimeter, were fit to one another along common ground track segments by removing residual orbit error as a tilt and bias and proportionally scaling the magnitudes of the signals. The ratio of geopotential anomaly to sea elevation by this method is 0.84 ± 0.10 dyn m/m. That is, fluctuations of geopotential anomaly which correlate to sea elevation across the Gulf Stream are smaller by this proportional value. The difference of this ratio from unity is consistent with a barotropic signal of about 0.10 m, as estimated from reported measurements of abyssal velocity under the stream. Because the uncertainties in the aircraft data are of the same order as the scatter in the calibration, it is unclear whether greater precision is impeded primarily by these uncertainties or by random barotropic signals. The ratio of the displacement of 16°C to sea elevation is 480 ± 75.

Blankinship, P.R. 1976a. A Flow Study of Drum Inlet, North Carolina. University of North Carolina Sea Grant College Publication, UNC-SG-76-13. Raleigh. 56 pp.

Abstract. A study of the flow dynamics of Drum Inlet to determine what influence it had on the salinity, tidal dynamics and circulation of Core Sound and to suggest where dredging should be done to keep the inlet open.

Blankinship, P.R. 1976b. A Flow Study of Drum Inlet, North Carolina. Master of Science Thesis. North Carolina State University. Raleigh, 56 pp.

Abstract. A study of the flow patterns in the vicinity of Drum Inlet was made during the summer of 1972. The study included measurements of currents and salinity in Core Sound. Tide measurements were not available during the period of this study but a method of determining the tides at the inlet was developed. The data was presented as a series of figures illustrating the flow pattern both in the vicinity of the inlet and in Core Sound. Salinity in the sound within the range of sampling was at a sufficiently high level to be conducive to shellfish growth.

Blanton, J.O. 1971. Exchange of Gulf Stream Water with the North Carolina Shelf Water in Onslow Bay during stratified conditions. Deep-Sea Res. 18:167-178.

Abstract. Verifies the role, characteristics, and importance of intrusions of Gulf Stream water. Describes certain summer hydrographic conditions necessary for upwelled water to intrude along the shelf bottom thereby displacing large volumes of shelf water.

Blanton, J.O. 1974. Oceanographic Research Program for the Continental Shelf off the Southeastern United States. Proceedings of the Workshop, Aiken, South Carolina, October 8--9, 1974. Department of Energy :35.

Abstract. Research programs in the following areas are discussed: physical oceanography; sediment transport; geochemical transport; and biological oceanography. The objective is a better understanding of the ocean system over the continental shelf south of Cape Hatteras in order to estimate the potential impact of nuclear power plants and other energy-related activities located on the continental shelf.

Blanton, J.O. 1975. An Oceanographic Research Program for the Continental Shelf off the Southeastern United States. Division of Biomedical and Environmental Research (USERDA):28.

Abstract. On October 8-9, 1974, forty-one oceanographers conducting research throughout the southeastern United States gathered at the Savannah River Laboratory near Aiken, South Carolina. This workshop had, as its purpose, the task of recommending the elements of a unified research program, complete with priorities, that would contribute to a better understanding of the ocean system over the continental shelf south of Cape Hatteras. Topics are discussed in the following areas: Physical oceanography; Sediment transport; Geochemical transport; Biological oceanography.

Blanton, J.O. 1981. Ocean currents along a nearshore frontal zone on the continental shelf of the southeastern United States. J. Phys. Oceanogr. 11(12):1627-1637.

Abstract. Studies of a frontal zone formed by mixing of river and estuarine discharges suggest that the force responsible for a southward flowing barotropic current must be an alongshore pressure gradient acting northward due either to wind set-up against the Florida coast or to the fall in steric sea level along

the western edge of the Gulf Stream.

Blanton, J.O. and L.P. Atkinson. 1978. Physical transfer processes between Georgia tidal inlets and nearshore waters. pp. 514-532. In M. Wiley, ed. Estuarine Interactions. Academic, Orlando.

Blanton, J.O. and L.P. Atkinson. 1983. Transport and fate of river discharge on the continental shelf of the southeastern United States. J. Geophys. Res. 88(C8):4730-4738.

Abstract. Analysis of eight years of wind and salinity data from a frontal zone indicates clear relationship between northward alongshore wind stress and a rate of loss of freshwater from the inner shelf above an established threshold of wind stress magnitude.

Blanton, J.O. and W.C. Maddox Jr. 1978. Data report on sea level fluctuations in the South Atlantic Bight, 1977, U.S. Dep. of Energy, Washington, D.C.

Blanton, J.O. and W.C. Maddox Jr. 1980. Data report on sea level fluctuations in the South Atlantic Bight, 1977. Report (TRS-80-6) Georgia Marine Sci. Center:82.

Abstract. Observes that variability of water level relates to wind events in the South Atlantic Bight.

Blanton, J.O. and L.J. Pietrafesa. 1978. Flushing of the continental shelf south of Cape Hatteras by the Gulf Stream. Geophys. Res. Lett. 5:495-498.

Blanton, J.O., L.P. Atkinson, L.J. Pietrafesa and T.N. Lee. 1981. The intrusion of Gulf Stream water across the continental shelf due to topographically-induced upwelling. Deep-Sea Res. 28(4A):393-405.

Abstract. Summer bottom temperatures along the continental shelf between Cape Hatteras and Cape Canaveral are abnormally low in regions were isobaths diverge. The regions are north of capes and shoals, which force the flow of shelf water to change vorticity and induce upwelling. Gulf Stream Water intrudes across the bottom during summer to replace the upwelled water, and accounts for the colder and more stratified water over the northern Florida and the North Carolina shelves.

Blanton, J.O., F.B. Schwing, A.H. Weber, L.J. Pietrafesa and D.W. Hayes. 1985. Wind Stress Climatology in the South Atlantic Bight. pp. 10-22. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. Fluctuations in the position of synoptic scale pressure systems largely govern mean wind patterns in the South Atlantic Bight (SAB). These winds provide the primary forcing to circulation in the broad and shallow regions of the shelf removed from direct Gulf Stream influence. Winds over the SAB originate either from the Bermuda-Azores High in the North Atlantic, or the smaller Ohio Valley High, which dominates between August and January. Monthly mean wind fields

derived from ship observations depict five seasonal wind regimes in the SAB. While these regions serve as useful indicators of month-to-month change of mean vectors, a great deal of year-to-year variability exists at a single point. Coastal wind regimes exist on three basic time scales: seasonal, synoptic weather system, and diurnal. Further offshore, the diurnal scale is insignificant. Important spatial differences occur between land and ocean observations over a distance of only 50 km. Energy data suggest a narrow lateral boundary layer separates land and sea wind regimes. Caution is needed when using over-land wind data to describe oceanic winds.

Blanton, J.O., J.A. Amft, D.K. Lee and A. Riordan. 1989. Wind stress and heat fluxes observed during winter and spring 1986. J. Geophys. Res. 94(C8):10686-10698.

Abstract. Data collected during winter from a set of offshore buoys and coastal meteorological stations on the continental shelf of the southeastern United States were analyzed as part of a meteorological and oceanographic study of the genesis of winter cyclones (Project GALE). The analyses were designed to describe the temporal and spatial variability of wind stress and heat flux over the shelf. While there were some episodes of strong spatial variations in wind stress, the wind field, on the whole, was remarkably uniform. Largest gradients were associated with times immediately preceding outbreaks of cold continental air over the shelf. Maximum heat fluxes occurred during these cold air outbreaks and reached as high as 1400 W/m^2 on the outer shelf near the Gulf Stream. (21 Refs.).

Blanton, S.L., III. 1991. Computations of Vertical Velocity in the Gulf Stream Northeast of Cape Hatteras, North Carolina. Master of Science Thesis. University of North Carolina at Chapel Hill. 84 pp.

Abstract. Two methods of computing vertical velocity based on the conservation of potential temperature are developed and applied to current and temperature data taken during the 1984 Gulf Stream Dynamics Experiment, conducted 175 kilometers downstream of Cape Hatteras, North Carolina. The first, a Single Mooring method, uses vertically adjacent time series of horizontal velocity and temperature with the thermal wind equations in the manner of Hall [1986]. The second, a method of Horizontal Finite Differencing, uses pairs of velocity and temperature time series from three different moorings in the manner of Osgood et at. [1987]. Time series of vertical velocity are computed for three levels in the water column by each method. Statistical properties of the time series are tabulated; spectral, principal component, and error analyses are conducted; a review of computational results during eddy events is presented; and similarities of, limitations of, and differences between the two methods are discussed. Compared to previous observations and estimates of vertical velocity, both methods provided reasonable time series with standard deviations of about 3.8 x 10^{-2} cm/sec. Both methods give reliable information in the vicinity of strong horizontal currents and large fluctuation phase speeds during eddy events.

Bleil, D.F. 1978. Ekman transport is a factor contributing to population variations of the Atlantic croaker, micropogon undulatus (linnaeus), in Chesapeake Bay. MS Thesis. The American University. 31 pp. (MAI 16/04, p.196; AAC1311394)

Blumberg, A.F. and L.H. Kantha. 1982. Numerical model of the shelf circulation in the Middle Atlantic Bight driven by tides, transient storms and the offshore, large-scale circulation: Formulation of proper open boundary conditions. NSF Rep. NSF/OCE-82001:198.

Abstract. Model results agree substantively with available observations of the shelf and slope circulation.

Blumberg, A.F. and G.L. Mellor. 1981. Circulation studies in the South Atlantic Bight with prognostic and diagnostic numerical models. Dynalysis. 71:103.

Blumberg, A.F. and G.L. Mellor. 1983. Diagnostic and prognostic numerical circulation studies of the South Atlantic Bight. J. Geophys. Res. 88(C8):4579-4592.

Abstract. Some of the results from a series of diagnostic and prognostic numerical simulations of the circulation in the South Atlantic Bight (SAB) are described. The numerical model developed for the study is a three-dimensional, primitive equation, time dependent, σ coordinate model with an imbedded, turbulent closure submodel which should yield realistic Ekman surface and bottom layers. An implicit numerical scheme in the vertical direction and a mode-splitting technique in time are adopted for computational efficiency. A significant portion of the paper is concerned with realistic specification of initial conditions for temperature and salinity, surface forcing, and lateral open boundary conditions. The latter are determined by a simple diagnostic (geostrophic and Ekman dynamics) model which provides dynamically consistent temperature, salinity, and velocity boundary conditions. It appears from an examination of the numerical simulations that the full model yields results that share many features in common with our general understanding of the circulation of the South Atlantic Bight; the region includes shallow shelf waters as well as deeper water dominated by the Gulf Stream. Data for synoptic skill assessment, however, are not available.

Blumberg, A.F., H.J. Herring, L.H. Kantha and G.L. Mellor. 1981. South Atlantic Bight numerical model application - executive summary. Dynalysis. 72:32.

Boc, S.J. and J. Langfelder. 1977. An analysis of beach overwash along North Carolina's coast. NCSU Center for Mar. Coastal and Studies Rep. No. 77-9:17.

Abstract. This study has a dual purpose: The first is to locate areas of overwash over a period of years; and the second is to classify the North Carolina coast with respect to it's susceptibility to overwash. The remainder of the report contains the criteria used for the classification of the areas, the method used in the classification and the results of the study.

Böning, C.W., R. Döscher and R.G. Budich. 1991. Seasonal Transport Variation in the Western Subtropical North Atlantic: Experiments with an Eddy-resolving Model. J. Phys. Oceanogr. 21(9):1271-1289.

Abstract. A high-resolution model of the wind-driven and thermohaline circulation in the North and equatorial Atlantic Ocean is used to study the structure and variability of the boundary current system at 26°N, including the Florida

Current, the Antilles Current, and the Deep Western Boundary Current (DWBC).

Boesch, D.F. 1979. Bottom sediments and sedimentary framework. Chapter 5. pp. 80. In Middle Atlantic Outer Continental Shelf Environmental Studies. Vol. II-B. Chemical and Biological Benchmark Studies, Virginia Institute of Marine Science, Gloucester Point.

Abstract. This section reports data on the grain size and organic carbon and nitrogen concentrations of sediments at all stations sampled for benthos, hydrocarbons, and trace metals over the two years of study. It is supportive of the biological and chemical studies rather than consitituting a report of sedimetology per se. However, the results are interpreted in reference to the sedimentary framework of the Middle Atlantic shelf and slope to provide the biological and chemical studies a dynamic perspective of shelf sediments.

Bohlen, W.F. and K.B. Winnick. 1984. Observations of near-bottom suspended matter concentration at the FVP site central Long Island Sound predisposal material area: 18 April 1983-29 June 1983. Prepared for Science Applications Institute, Newport, Rhode Island. :100pp.

Boicourt, W.C. 1973. The circulation of water on the continental shelf from Chesapeake Bay to Cape Hatteras. Ph.D. Thesis. The Johns Hopkins University. 197 pp. (DAI 34/01B, p.332; AAC7316636)

Abstract. Measurements from nine cruises in the southern end of the Middle Atlantic Bight have revealed significant time-dependent processes in the transverse circulation on the continental shelf and in the exchange between shelf waters and the Chesapeake Bay estuary. The mean flux of water (determined by the gravitational circulation in the estuary) out of the Bay in the upper layer is of the order 8000 m^3/s. Strong, fluctuating winds can dominate this exchange, as in November 1971, when a northwest wind drove a net outflow amounting to 25000 m^3/s from the Chesapeake Bay in a two-day interval. Enough water (nearly 10% of the Bay proper) left the Bay at this time to lower tidal heights 0.9 m in the upper reaches. Previous studies have suggested a mean southward flow at the naviface in the southern part of the Middle Atlantic Bight of the order 5 cm/s. Current-meter records and temperature and salinity observations from this study show wide, wind-driven variations about this mean. A salinity-maximum layer discovered in the seasonal thermocline on the outer shelf can provide a mechanism for return flow which compensates for an offshore drift in the Ekman layer. Support for this argument comes from an event observed in July 1971, when remarkably high (>35‰) salinities were found inshore, only 3 km from the beach. This water arrived via the salinity-maximum layer and was apparently a response to an offshore drift driven by strong southwesterly winds. There is evidence that the cold water mass which lies below the salinity-maximum layer is not only moving southward, but is also the source for the cold, low-salinity water previously observed on the north edge of the Gulf Stream, far from Cape Hatteras.

Boicourt, W.C. 1980. Circulation in the Chesapeake Bay entrance region: estuary-shelf interaction. pp. 61-78. In J.W. Campbell and J.P. Thomas, eds. Chesapeake Bay Plume Study: Superflux 1980. NASA Publication 2188.

Boicourt, W.C. 1982. Estuarine larval retention mechanisms on two scales. pp. 445-457. In V.S. Kennedy, ed. Estuarine Comparisons. Academic Press.

Boicourt, W.C. 1993. Circulation on the continental shelf of the eastern United States. In Press. In J. Milliman, ed. Physical Oceanography of the Eastern United States. Oxford University Press.

Boicourt, W.C., S.-Y. Chao, H.W. Ducklow, P.M. Gilbert, T.C. Malone, M.R. Roman, L.P. Sanford, J.A. Fuhrman, C. Garside and R.W. Garvine. 1987. Physics and microbial ecology of a buoyant estuarine plume on the continental shelf. EOS, Trans. AGU. 68(31):666-668.

Abstract. The MECCAS (Microbial Exchanges and Coupling in Coastal Atlantic Systems) Project was initiated in 1984 with support from the National Science Foundation to study the flow regime of buoyant plumes and the microbial ecology of pelagic communities that characterize these plumes. The project is interdisciplinary, with physical, chemical, and biological components. Our goal is to determine how physical and biological processes influence the production and cycling of carbon and nitrogen on time and space scales that characterize the physics of plumes and the growth of microbial populations within plumes.

Boicourt, W.L. and P.W. Hacker. 1976. Circulation on the Atlantic continental shelf of the United States, Cape May to Cape Hatteras. Mem. Soc. R. Sci. Liege. 10:187-200.

Abstract. Summarizes observations to support the dynamics model for the response of the Bight region to strong wind events.

Bothner, M.H., C.M. Parmenter and B. Butman. 1983. Resuspended sediment flux in Lydonia and Oceanographer Canyons off eastern United States. EOS, Trans. AGU. 64(52):1051.

Abstract. Provides sediment flux estimates derived from sediment trap data in Lydonia and Oceanographer Canyons. Sediment traps were deployed in conjunction with current meter moorings located within the canyons and their adjacent shelf, slope and rise.

Bothner, M.H., E.Y. Campbell, G.P. DiLisio, C.M. Parmenter, R.R. Rendigs, J.R. Gillison, W. Dangelo and J.A. Commeau. 1986. Analysis of trace metals in bottom sediments in support of deepwater biological processes studies on the U.S. Mid-Atlantic Continental Slope and Rise. Final Report. U.S. Geological Survey. Woods Hole. 64 pp.

Abstract. Sediment samples collected during the first four cruises to the continental slope and rise off the Mid-Atlantic states have been analyzed for 12 metals (Al, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, V and Zn). Because of its high concentration in drilling mud, Ba is most commonly measured to trace drilling mud in the marine environment. In the study only small changes in Ba concentrations in sediments have been noted to date in one core collected on Cruise 3 from station 1 adjacent to the drilling block 372, the concentration of Ba was 13 percent higher in the surface sediment than deeper sediment. The strongest signal from drilling mud was observed in sediment trap samples placed within the

upper 850 m of the water column on a subsurface mooring 1.8 km south-southwest of the drilling rig.

Bower, A.S. 1988. Isopycnal drifter studies in the Gulf Stream (Lagrangian). Ph.D. Thesis. University of Rhode Island. 204 pp. (Rossby, T (adviser); DAI 49/11B, p.4731; AAC8903058)

Abstract. A unique set of Lagrangian observations was collected in the Gulf Stream using the newly developed isopycnal RAFOS float. Thirty-seven drifters were launched in 1984 and 1985 in the main thermocline of the current off Cape Hatteras and tracked acoustically downstream. The isopycnal capability of this drifter allows it to follow fluid parcel pathways quite accurately along density surfaces. The RAFOS drifters revealed a striking pattern of vertical and cross-stream motion in Gulf Stream meanders. Floats were consistently observed to upwell (downwell) and move onshore (offshore) as they approached meander crests (troughs). This meander-induced circulation represents an important mechanism for cross-frontal exchange. Sixty percent of the floats launched at Cape Hatteras escaped from the Gulf Stream at least once before reaching 65°W. The trajectories were further analyzed to examine the dynamics of meanders from a Lagrangian viewpoint. Using the float data in conjunction with information on horizontal velocity shear from the PEGASUS study at 73°W, variations in planetary, curvature and shear vorticity have been estimated along the trajectories. Changes in layer thickness were then inferred assuming potential vorticity is conserved following the floats. This analysis shows that curvature vorticity changes are typically 10-20% of f (planetary vorticity) as fluid parcels travel between meander troughs and crests. Lateral shear changes on the order of 20-30% of f are common as parcels move laterally relative to the jet axis. Although changes in these two terms tend to compensate, some parcels exhibit 30% changes in thickness over several days. Sixty-one estimates of horizontal divergence were made from the average time rate of change of layer thickness between meander extreme. The sign of horizontal divergence was found to be strongly dependent on cross-stream position. On the anticyclonic side of the Stream, divergence (convergence) was indicated downstream of a trough (crest) and vice versa on the cyclonic side. Many of these results are found to be consistent with a simple gradient wind model which has previously been applied to the atmospheric jet stream.

Bower, A.S. 1989. Potential vorticity balances and horizontal divergence along particle trajectories in Gulf Stream meanders east of Cape Hatteras. J. Phys. Oceanogr. 19(11):1669-1681.

Abstract. Trajectories of 37 isopycnal RAFOS floats launched in the Gulf Stream off Cape Hatteras have been analyzed to examine the dynamics of meanders from a Lagrangian viewpoint. Using the float data in conjunction with information on the structure of horizontal velocity shear from the PEGASUS study (Halkin and Rossby), variations in planetary, curvature, and shear velocity have been estimated along the float trajectories. Changes in fluid layer thickness were then inferred assuming potential vorticity is conserved following the floats. This analysis shows that curvature vorticity changes are typically 10%-20% of f (planetary vorticity) as fluid parcels travel between meander troughs and crests. Lateral shear changes on the order of 20%-30% of f are common as parcels move laterally relative to the jet axis between meander extreme. Although changes in these two terms are usually of opposite sign and tend to compensate, significant

layer thickness changes do occur, with some parcels exhibiting 30% changes in thickness over several days. (20 Refs.).

Bower, A.S. 1991. A simple kinematic mechanism for mixing fluid parcels across a meandering jet. J. Phys. Oceanogr. 21(1):172-180.

Abstract. Recent observations of fluid parcel pathways in the Gulf Stream using isopycnal RAFOS floats revealed a striking pattern of cross-stream and vertical motion associated with meanders (Bower and Rossby 1989). In an attempt to explain the observed pattern, a two-dimensional kinematic model of a meandering jet has been developed which enables examination of the relationship between streamfunction patterns and fluid parcel trajectories. The streamfunction fields are displayed in a reference frame moving with the wave pattern so motions of fluid parcels relative to the jet can be seen more easily. (13 Refs.).

Bower, A.S. and N.G. Hogg. 1991. Energetics of the Gulf Stream at 55°W. EOS, Trans. AGU. 72(51):57.

Abstract. Current meter data from the SYNOP East Array are being analyzed to study the mean flow energetics and the energy transfer between the mean eddy fields near 55°W. Our basic goal is to determine the primary directions of energy cycling in the area (e.g., mean to eddy, eddy to mean, mean kinetic to mean potential, etc). Our results will be compared to similar analyses in numerical models.

Bower, A.S. and N.G. Hogg. 1992. Evidence of Barotropic Wave Radiation from the Gulf Stream. J. Phys. Oceanogr. 22(1):42-61.

Abstract. Highly energetic velocity fluctuations with topographic Rossby waves frequently observed over the continental slope and rise off the United States and Canadian east coast. It has been suggested that the energy source for these waves could be eastward-propagating Gulf Stream meanders, which can couple to the westward-propagating Rossby waves if the meander shape is time dependent. In this study, a historical archive of all available current meter data from the western North Atlantic has been examined for evidence of energy radiation from the Gulf Stream via barotropic/topographic Rossby waves. Maps of abyssal eddy kinetic energy (EKE) and Reynolds stress were constructed for four frequency bands (including motions with periods between 256 and 7.8 days) to examine distributions of these quantities over the largest possible geographical area. Maximum eddy kinetic energy is observed along the mean axis of the Gulf Stream at low frequencies (50-250 days), but this maximum shifts north and west with increasing frequency. The westward shift may be due to the fact that the phase speed of Gulf Stream meanders decreases with increasing downstream distance. The northward shift of maximum EKE to a position over the continental slope and rise is discussed in terms of the refraction and convergence of barotropic Rossby wave energy rays emanating from the region of the Gulf Stream.

Bower, A.S. and T. Rossby. 1989. Evidence of cross-frontal exchange process in the Gulf Stream based on isopycnal RAFOS float data. J. Phys. Oceanogr. 19(9):1177-1190.

Abstract. A unique set of Lagrangian observations has been collected in the Gulf

Stream using the newly developed isopycnal RAFOS float. Between January 1984 and October 1985, thirty-seven of these drifters were launched in the main thermocline of the current off Cape Hatteras and tracked acoustically downstream for 30 or 45 days. Temperature and pressure were also recorded along each float trajectory. The isopycnal capability of this drifter allows it to follow fluid parcel pathways quite accurately along the sloping density surfaces of the Gulf Stream. The RAFOS drifters revealed a striking pattern of vertical and cross-stream motion in Gulf Stream meanders. This meander-induced circulation represents an important mechanism for cross-frontal exchange.

Bower, A.S., R. O'Gara and H.T. Rossby. 1986. RAFOS pilot studies in the Gulf Stream: 1985-85 Tech. Report Ref. No. 86-7, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI. 110 pp.

Bowman, M.J. and L.D. Wunderlich. 1976. The distribution of hydrographic properties of the New York Bight apex. Marine Sciences Research Center Technical Report, State University of New York. Stony Brook.

Briscoe, M.E. 1975. Internal waves in the ocean. Rev. Geophys. Space Phys. 13(13):591-598.

Abstract. Progress in measuring, describing, and understanding oceanic internal gravity waves during the quadrennium 1971-1974 is reviewed. Emphasis is given to trends in techniques and ideas that hold promise for the future. An extensive bibliography is provided.

Brooks, D.A. 1976. Long waves trapped by the Cape Fear Continental Shelf Topography: A model study of their propagation characteristics and circulation patterns. NCSU Center for Mar. Coastal and Studies Rep. No. 76-2:16.

Abstract. This report deals with a physical process which may be important in determining the circulation patterns of North Carolina coastal and continental shelf waters. First, a non-technical overview of the process is given; second, some results of a computer model study of the Cape Fear continental shelf zone are presented; and third, the results are summarized and discussed in terms of practical importance to coastal zone management.

Brooks, D.A. 1977. Sea level fluctuations off the Carolina coasts and their relation to atmospheric forcing. NCSU Center for Mar. Coastal and Studies Rep. 77-6:38.

Abstract. Atmospheric pressure and wind stress fluctuations are strongly coupled to sea level fluctuations along the Carolina coasts at periods of 2.5 to 3.5 days. Sea level fluctuations in this band exhibit high coherence over a horizontal separation exceeding 500 km. Phase difference calculations indicate southward propagation of the sea level fluctuations from Beaufort to Wilmington, North Carolina; the data considered are insufficient to conclusively determine propagation direction south of Wilmington. The 2.5 - 3.5 day period sea level fluctuations are consistent with a theoretically expected first mode, barotropic continental shelf wave. It is concluded that continental shelf waves forced by the atmosphere contribute to the shelf and slope water circulation off North

Carolina.

Brooks, D.A. 1978. Subtidal sea level fluctuations and their relation to atmospheric forcing along the North Carolina coast. J. Phys. Oceanogr. 8(3):481-493.

Abstract. Coastal sea level fluctuations in Onslow Bay are selectively coupled with local atmospheric forcing variables. The coupling is strongest in period bands of 2.5-3.5 and ≥10 days, which span absolute zero group speed, barotropic continental shelf wave periods. The phase of the sea level disturbances propagated upstream from Beaufort to Wilmington, N.C., as expected for stable discrete shelf waves, consistent with earlier results by Mysak and Hamon (1969). The "barometric function", when corrected for coherent wind stresses, indicated selective, super barometric atmospheric-pressure-to-sea-level coupling in the zero group speed period bands. Stochastic models of atmospheric cold front wind stress and wind stress curl fields were found to selectively force barotropic shelf wave responses near zero group speed periods and wavelengths. A strong Onslow Bay response to the model cold front occurred near the second harmonic forcing frequency; the wind stress curl contributed importantly to the shape and the amplitude of the response spectrum. The results suggest that shelf waves forced by the atmosphere contribute to the Gulf Stream meander field off North Carolina.

Brooks, D.A. 1979a. Coupling of the Middle and South Atlantic Bights by forced sea level oscillations. J. Phys. Oceanogr. 9(6):1304-1311.

Abstract. The eastern United States continental margin is naturally divided by Cape Hatteras into the Middle and South Atlantic Bights. The margin depth profile is relatively uniform throughout the Middle Atlantic Bight, but in the South Atlantic Bight it bifurcates into inner and outer slope regions. Coastal tide gage records indicate that long period (1-2 weeks) sea level oscillations propagate southward as continental shelf waves in both Bights, thereby providing a coupling mechanism between the Bights. However, short-period (several days) oscillations appear to be confined to the South Atlantic Bight, and may result from backscattering of long-wave energy by the variable topography and the Gulf Stream. The coastal sea level short-period phase data are not easily attributable to monochromatic propagating waves; rather, it appears that wave group properties may lead to a more consistent explanation of the phases. Cross-shelf and longshelf wind stress components were both strongly coupled to sea level fluctuations for long periods; short-period motions were more closely associated with nonstatic atmospheric pressure fluctuations.

Brooks, D.A. 1979b. Long wave coupling of the Mid and South Atlantic Bights - forced by the atmosphere. Texas A&M Univ., Rep. 79-3-T:131.

Abstract. Discusses the role and importance of wind forcing in long wave coupling of the two regions.

Brooks, D.A. 1979c. Shelf waves: Do they modulate the Gulf Stream? Mar. Sci. Directorate, Ottawa, Canada, Ms. Rept. Series (53):162-172.

Abstract. Examines the interaction of coastally-trapped waves and the Gulf

Stream.

Brooks, D.A. 1982. Gulf Stream fluctuations and their relation to the winds off North Carolina. In Proceedings of the Workshop on Gulf Stream structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982, AD-A128 789. 16 pp.

Abstract. Summary analysis results from the Gulf Stream Meanders Experiment (GSME) show no significant coherence between the wind or its curl or divergence and the weekly-scale current fluctuations typical of Gulf Stream meanders.

Brooks, D.A. 1986. Doing the Charleston Bump. EOS, Trans. AGU. 67(1):3-4.

Abstract. Gives a historical review of literature describing current fluctuations downstream of the Charleston Bump and the origin of the name.

Brooks, D.A. and J.M. Bane Jr. 1978. Gulf Stream deflection by a bottom feature off Charleston, South Carolina. Science. 201(4362):1225-1226.

Abstract. A topographic feature on the continental slope off Charleston at 32°N persistently deflects the Gulf Stream seaward, with the inshore surface thermal front deflected east or south of east in 27 of the 39 cases examined. Meanders often form downstream of the deflection, suggesting that the "Charleston bump" induces Gulf Stream fluctuations.

Brooks, D.A. and J.M. Bane Jr. 1981. Gulf Stream fluctuations and meanders over the Onslow Bay upper continental slope. J. Phys. Oceanogr. 11(2):247-256.

Abstract. Gulf Stream fluctuations at the 200 m and 400 m isobaths off Onslow Bay, North Carolina have a prominent weekly time scale. The principal fluctuations observed during the 4-month winter experiment are consistent with Webster's (1961) description of downstream propagating, skewed, lateral meanders of the Gulf Stream over the upper continental slope. The subtidal velocity fluctuations were highly coherent over the vertical extent (about 120 m) and over the horizontal extent (64 km) of our array. The implied downstream propagation speed was about 30 km/day for the weekly period meanders. Concurrent satellite images of a sea surface temperature (SST) meander pattern indicate that subsurface temperature, salinity, velocity and relative-vorticity maxima occurred as meander crests (shoreward SST-front excursions) passed over the experiment site. The meandering currents were not coherent with nearby wind stress of coastal sea level fluctuations. Eddy-flux extimates indicate energy conversion from the fluctuations to the mean Stream.

Brooks, D.A. and J.M. Bane Jr. 1982. Seasonal Comparison of Gulf Stream Fluctuations off North Carolina. pp. 17-47. In J.M. Bane Jr., ed. Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982. The Office of Naval Research. (NTIS Accession Number: AD-P001 040/5)

Abstract. The Gulf Stream Meanders Experiment (GSME) was conducted off North Carolina in 1979. Instruments were moored in the Stream over the 200 m and 400 m isoabaths on the continental slope for two 4-month periods, one in the winter

and one in the summer. In both seasons, the downstream current speed typically fluctuated between -50 cm/s and +100cm/s about a 30 cm/s mean. The velocity, temperature, and salinity fluctuations had a prominent 7- to 10-day period in the winter, and a less prominent 5- to 7-day period in the summer. The fluctuations, which were nearly in-phase vertically and propagated down-stream at approx. 40 km/d, apparently resulted from lateral, wavelike excursions or meanders of the Gulf Stream front, as first described by Webster (1961a). The observed structure is complicated along the shoreward edge of the Stream, where shallow surface filaments of warm water often trail southwestward from meander crests. The warm filaments are usually separated from the Stream by a band of cool surface water, which is a manifestation of deeper uplifting or upwelling associated with the meander process. Strong cyclonic circulation around the uplifted cool water pool is a characteristic feature of meanders. In both seasons, the leading term in the energy equation indicated that part of the fluctuation kinetic energy was converted to mean Stream kinetic energy, with an implied doubling time of a few weeks. Direct forcing by the wind was found to be ineffective during the GSME. The seasonal persistence of meanders in the GSME area thus indicates an upstream source of their kinetic energy.

Brooks, D.A. and J.M. Bane Jr. 1983. Gulf Stream meanders off North Carolina during winter and summer 1979. J. Geophys. Res. 88(C8):4633-4650.

Abstract. Meanders produced most of the subtidal variability in the Gulf Stream off North Carolina during 1979. Recording instruments were moored in the lower half of the water column over the 200-m and 400-m isobaths for two periods of 4 months, one in the late winter and one in the late summer. In both seasons, the middepth current speed typically fluctuated between -50 cm/s and +100 cm/s about a 30 cm/s downstream mean. The velocity, temperature, and salinity fluctuations had a prominent weekly scale in the winter, caused by the meandering stream. In the summer the weekly time scale was less prominent within a generally energetic 3- to 10-day period band. In both seasons, the meandering currents were nearly in phase vertically, and the meanders propagated downstream at about 40 km/d. Shallow, in-shore filaments of warm water, separated from the main stream by bands of cooler surface water, are often extruded from the Gulf Stream front during the shoreward-most phase (crest) of meanders. Countercurrents, or upstream flow reversals, often occur under the filaments, forming the shoreward limb of cyclonic frontal eddies which are associated with uplifted cool water found upstream of meander crests. The energy source of the meanders off North Carolina remains obscure. The meandering currents locally transferred their kinetic energy to the mean stream, at about the same rate in each season. The loss of energy is consistent with an asymmetry or skewness of the meander process, often seen in satellite images of the surface temperature. The meandering currents were unrelated to the local wind, or to its curl or divergence, in either season. These results collectively point to an upstream source of meander energy, most probably made available by an instability of the Gulf Stream.

Brooks, D.A. and C.N.K. Mooers. 1977. Wind-forced continental shelf waves in the Florida Current. J. Geophys. Res. 82(18):2569-2576.

Abstract. Yearlong records of sea level, oceanic temperature, winds, and atmospheric pressure provide evidence of atmospherically induced subinertial

frequency fluctuations in the Florida current. The dominant subinertial responses occurred at periods of 7-10 days in winter and 12-14 days in summer. Consistent with the theory of long stable continental shelf waves (CSW) in the Florida current, a sea level array indicated southward propagation of disturbances. The propagating disturbances had alongshore coherence scales of a few hundred kilometers and wavelengths of the order of 1000 km. The sea level and temperature fluctuations were strongly coupled, and they were coupled to both components of the wind stress. It is concluded that wind-forced southward propagating CSW's account for a significant fraction of the subinertial frequency fluctuations of the Florida current.

Brooks, D.A., J.M. Bane, R.L. Cohen and P. Blankinship. 1980a. The Gulf Stream Meanders Experiment: Current meter, atmospheric, and sea level data report for the January to May, 1979 mooring period. Rep. 80-7-T, Texas A&M Univ., College Station, TX.

Abstract. Summarizes current meter and hydrographic data in the Gulf Stream off North Carolina. The hydrographic data were obtained from hydrographic cruises as well as air-dropped expendable bathythermographs (AXBT).

Brooks, D.A., J.M. Bane Jr. and M.J. Ignaszewski. 1980b. The Gulf Stream Meanders Experiment: Hydrographic data report, R/V ENDEAVOR cruises EN-031 and EN-037, Rep. 80-1-T, Texas A&M Univ., College Station.

Abstract. Summary of hydrographic data collected in the Gulf Stream off the coast of North Carolina.

Brooks, D.A., J.M. Bane Jr., R.L. Cohen and P. Blankinship. 1981. The Gulf Stream Meanders Experiment. Current Meter and Atmospheric Data Report for the August to November, 1979 Mooring Period. Texas A&M Univ. Rep. A&M-REF-81-3-T:194.

Abstract. The principal objective of the Gulf Stream Meanders Experiment was to kinematically and dynamically describe the nature of meanders. The upper continental slope region off Onslow Bay, North Carolina was chosen for the experiment site because several previous investigations in that area provided a baseline data set giving some ideas about time and space variability scales within and a several-month mean view of the Stream. In addition, earlier observations ranging from reports in centuries-old ship logs to recent satellite infrared imagery made it apparent that Gulf Stream meandering was more intense between Charleston, South Carolina and Cape Hatteras, North Carolina.

Brooks, R.M. and W.D. Corson. 1984. Summary of Archived Atlantic Coast Wave Information Study Pressure, Wind, Wave, and Water Level Data. Army Eng. WES Final Rep. WIS-13:57.

Abstract. This report is a summary of seven data sets produced and archived by the Wave Information Study (WIS) for the Atlantic coast: (1) surface pressure fields, (2) Phase I hindcast wind fields, (3) Phase I deepwater wave data, (4) Phase II hindcast wind fields, (5) Phase II hindcast wave data, (6) Phase III nearshore wave data, and (7) water level data. The wave parameters from the data sets listed in 2, 5, and 6 have been incorporated into WIS's computer-based data system, the Sea-State Engineering Analysis System (SEAS), which is available to

all Corps of Engineers personnel. These data sets, except for 1 and 7, have been transferred to the National Climatic Data Center (NCDC) in Asheville, North Carolina. These data may be obtained through Customer Service at NCDC (reference Tape Deck 9787).

Broome, S.W., E.D. Seneca and W.W. Woodhouse Jr. 1981. Planting Marsh Grasses for Erosion Control. UNC Sea Grant Pub. UNC-SG-81-09:15.

Abstract. Transplanting salt marsh vegetation is an alternative erosion control method which is relatively inexpensive and proven to be effective on some shorelines. A fringe of marsh grasses, whether volunteer or transplanted, serves as a natural erosion barrier. The aerial plant parts dissipate waves reducing their impact on the bank, and they act as a living groin by accumulating sediment which widens the beach and increases the elevation. The tough mat of roots and rhizomes which develops helps stabilize the substrate and prevents loss due to wave action. There are many shorelines in North Carolina where environmental conditions (tide range, salinity, wave action, etc.) are unfavorable for a marsh fringe to exist. However, in many cases the natural marsh fringe has been destroyed by severe storms, dredging, filling or foot traffic.

Brown, O.B., P.C. Cornillon, S.R. Emmerson and H.M. Carle. 1986. Gulf Stream warm rings: A statistical study of their behavior. Deep-Sea Res. 33(11/12):1459-1473.

Abstract. A 10-year series of NOAA polar-orbiter satellite infrared-based determinations of Gulf Stream warm-core ring (WCR) locations, is used to derive mean loci, lifetime and size, and movement statistics in the Slope water region off the northeast United States east coast. This time series, produced by the NOAA/NMFS Atlantic Environmental Group, is validated against precision observations of WCR frontal loci by investigators at the Universities of Miami and Rhode Island: an r.m.s. error of ± 15 km in latitude and longitude between the two sets is determined. We find that the ensemble of WCR lifetimes is bi-modal with the split at 140 days. Rings are formed with a semi-major axis of about 75 km. Longer-lived rings show a reduction in size over their lifetime to about 35 km, shorter-lived rings do not. Ring movement shows some dependence on location, but mean motions are never <1.6 cm/s; averaged translation speed is 6.5 cm/s. Longer-lived rings tend to be located farther away from the climatological Gulf Stream north wall than shorter-lived rings east of 66°W. The mean loci are compared with Warm Core Ring Experiment results for 82B. We find similar changes in track corresponding to topographic variation, similar translation speed, size, decrease in size over time, etc., leading us to conclude that the kinematics observed for 82B are representative of those for a long-lived warm-core ring.

Brown, W.S. and J.D. Irish. 1992. The annual evolution of geostrophic flow in the Gulf of Maine: 1986-1987. J. Phys. Oceanogr. 22(5):445-473.

Abstract. The annual evolution of the geostrophic flow structure in the Gulf of Maine was studied with a combined set of moored pressure time-series measurements and five hydrographic surveys from August 1986 through September 1987. A series of quasi-synoptic dynamic height maps depicts a gulf flow structure whose typical spatial scales decrease from order 100 km during the winter to about half that in the summer, when the evolution of surface, intermediate, and deep water masses

is most rapid and complex. The unusually large amount of freshwater in the gulf during 1987 was partially responsible for the establishment of a north-south across-gulf front during the summer. Year-long time series of bottom pressure and internal pressure (derived from temperature and conductivity measurements in Georges and Jordan basins) have been differenced with coastal synthetic subsurface pressures (SSP) to yield a history of the basin-scale geostrophic flow variability. The basin-scale geostrophic transport was dominated by cyclonic flow (>0.5 X 10^6 m^3/s) through the gulf during autumn 1986. During early January 1987, the flow around Jordan Basin became anticyclonic as relatively fresh Scotian shelf water flowed into the eastern gulf. Though temporarily disrupted during April and May, the Jordan Basin anticyclone persisted through July. Inflows of slope water to Georges Basin helfped to establish a robust (0.5 X 10^6 m^3/s) cyclonic flow around Beorges Basin in June and July. Though somewhat weakened (≈0.3 X 10^6 m^3/s), the cyclonic gyre migrated with the flow of slope and Maine bottom water to Jordan Basin in August. The delay in the establishment of the cyclonic gyre in Jordan Basin in 1987 appears to have been related in part to the effects of the anomalously large amount of freshwater in the gulf during 1987. A conceptual model of the annual evolution of gulf-scale flow, based on a hypothesized interplay of pressure gradient forcing produced by variable inflows (outflows), thermohaline forcing, and, to a lesser extent, wind forcing, is presented.

Bryan, G.M. 1970. Hydrodynamic model of the Blake Outer Ridge. J. Geophys. Res. 75:4530-4537.

Abstract. Model proposes sediment deposition on the Blake Outer Ridge is due to the interaction between the Florida Current and the Western -Boundary Undercurrent.

Brzezinski, M.A. and D.M. Nelson. 1989. Seasonal changes in the silicon cycle within a Gulf Stream warm-core ring. Deep-Sea Research, Part A [Oceanographic Research Papers]. 36(7A):1009-1030.

Abstract. The silicon cycle within Gulf Stream warm-core ring 82-B was examined before and after spring stratification using silicon isotope tracers. In April, before stratification, the ring was isothermal and isohaline to 400 m. Ambient silicic acid concentrations were ca 3 mu mol/l and biogenic silica concentrations ranged from 80 to 100 nmol/l throughout this depth range. Net silica production occurred from the surface to 300 m on 25 April. By June, a seasonal pycnocline had developed and silicic acid concentrations were depleted to ≤0.2 mu mol/l in the upper 20-30 m. Siliceous biomass was concentrated in the upper 40 m, with a subsurface maximum of ca 1000 nmol Si/l within the seasonal pycnocline. The percentage of silica production that could be supported by *in situ* dissolution increased from ≤30% for the upper 110 m during April/May to 68% for the upper 80 m in June. This transition from a 'new production' cycle to a 'regenerated production' cycle is the first observation of a seasonal trend in the silicon cycle. (66 Refs.).

Bue, C.D. 1970. Streamflow from the United States into the Atlantic Ocean during 1931-60. U.S. Geol. Surv. Water-Supply Paper 1899-I:36.

Bulfinch, D.L., M.T. Ledbetter, B.B. Ellwood and W.L. Balsam. 1982. The high-velocity core of the Western Boundary Undercurrent at the base of the U.S. continental rise. Science. 215:970-973.

Abstract. The Western Boundary Undercurrent is a high-velocity, contour-following bottom current that flows southwesterly on the U.S. Atlantic continental margin. A high-velocity core of the Western Boundary Undercurrent is delineated by an analysis of underlying sediments, which are characterized by coarse particle sizes and efficiently aligned magnetic grains in a zone from 4440 meters at the base of the rise to 5200 meters on the adjacent abyssal plain.

Bumpus, D.F. 1955. The circulation over the continental shelf south of Cape Hatteras. EOS, Trans. AGU. 36:601-611.

Abstract. Discusses transient nature of southerly-flowing coastal current on a narrow portion of shelf.

Bumpus, D.F. 1965. Residual drift along the bottom on the continental shelf in the Middle Atlantic Bight area. Limnol. Oceanogr. Suppl. 10:50-53.

Abstract. Describes southward coastal current as being caused by the density distribution of sloping isopycnals over the continental shelf due to marked stratification of the water column.

Bumpus, D.F. 1969. Reversals in the surface drift in the Middle Atlantic Bight area. Deep-Sea Res. Suppl. 16:17-23.

Abstract. Reports that surface drift reversals are found during periods of strong southerly winds and low runoff.

Bumpus, D.F. 1973. A description of the circulation on the continental shelf of the East Coast of the United States. Prog. Oceanogr. 6:111-157.

Abstract. A summary of a ten-year program of drifters which demonstrated a mean longshore flow from Cape Cod to Cape Hatteras. The circulation on the continental shelf of the east coast of the United States is discussed, including the historical development of the concepts, and the surface and bottom circulation based on drift-bottle data and sea-bed drifter data. Suggestions for future research to futher our understanding of the circulation problem are offered.

Bumpus, D.F. and E.L. Pierce. 1955. The hydrography and the distribution of chaetognaths over the continental shelf off North Carolina. Deep-Sea Res. Suppl. 3:92-109.

Abstract. Occasional strong northeast winds drive a small amount of Mid-Atlantic Bight water southward around Cape Hatteras. The distribution relation with chaetognaths is also discussed.

Bumpus, D.F., R.E. Lynde and D.M. Shaw. 1973. Physical oceanography. pp. 1-72. In Coastal and offshore environmental inventory: Cape Hatteras to Nantucket Shoals. Mar. Publ. Ser. No. 2, Univ. of R.I. 1-1.

Abstract. Literature review which summarizes the physical oceanography of the North and Middle Atlantic regions. Provides descriptions of current flow and hydrography for the entire study region.

Burckle, L.H., K. Poferl-Cooke and J. Maloney. 1975. Southward flowing Antarctic Bottom Water off Cape Hatteras. Evidence from displaced Antarctic diatoms. Northeastern section, 10th Annual Meeting. Geol. Soc. Am. Abstr. 7(1):34.

Abstract. Analysis of floral associations confirms that the Antarctic Bottom Water joins the North Atlantic Deep Water off Cape Hatteras and turns southward.

Burrage, D.M. 1986. Dynamics and short term variability of the Middle Atlantic Bight shelfbreak front (geostrophy, ekman forcing, internal waves, thermohaline). Ph.D. Thesis. University of Delaware. 408 pp. (DAI 47/09B, p.3690; AAC8629268)

Abstract. Shelfbreak front dynamics in the MAB during spring and summer involve nonlinear processes (Rossby no. R(,0) (TURN) 0.2) in the high subtidal, tidal and supertidal frequency bands. Models based on simplified momentum balances, such as Ekman dynamics or the thermal wind, might explain shelfbreak flows qualitatively, but are not quantitatively accurate and can be misleading. Little simplification of the momentum equation is possible and 3-D numerical models having all terms in the governing equations, with time-dependent stratification, realistic topography, and spatially variable wind forcing are needed. Summertime frontal dynamics are dominated by the seasonal pycnocline which partially decouples the surface layer from the interior, and provides a waveguide for supertidal internal solitons generated by interaction of the M2 barotropic tide with the shelfbreak. The tidal frequency band couples nonlinearly to the subtidal motion through bottom stress enhancement, and indirectly through generation of supertidal internal waves which can enhance interfacial and bottom stress, while contributing to vertical mixing and across-self salt migration. Internal displacements due to supertidal interfacial waves and tidal body waves reaching 12 m and 30 m, respectively, can alias hydrographic and current measurements. In summer, when the front is weak relative to the seasonal pycnocline, and isopycnal exchange above the front is possible, a combination of supertidal wave-induced vertical mixing and nonlinear advection might explain the persistence of the S-max (a warm saline intrusion frequently found in summertime hydrography), its diapycnal component, and its location above the seasonal pycnocline. In winter and spring the front resists warm saline intrusions which can only penetrate the front if there is strong onshore flow of slope water, as when warm core rings interact with the shelfbreak.

Burrage, D.M. and R.W. Garvine. 1988. Summertime hydrography at the shelfbreak front in the Middle Atlantic Bight. J. Phys. Oceanogr. 18:1309-1319.

Abstract. We present results from a study of the shelfbreak front in the Middle Atlantic Bight during summer when we obtained the best resolved hydrography in time and space yet published for that structure. Repeated transects enabled us

to treat the hydrography data statistically. While the general features of our mean fields are not new, their statistical basis is new. A principal result is the firm basis for two features of the shelfbreak front density field: the near absence of across-shelf density gradients above the pycnocline and the presence of only weak gradients in subsurface front. No published models exist that treat the front with this density structure. Consistent with the weakness of the frontal baroclinic field, we found that the alongshelf transport was dominated by the barotropic component, the baroclinic component being only about 20% of the total. We report a new finding that much of the subtidal frequency variability at the front is best explained by the alongshelf advection of alongshelf transport for the summertime front are unreliable, even when based on transects repeated at 6 h intervals and with adequate spatial resolution, as ours were. We ascribe this unreliability to the aliasing of energetic isopycnal displacements by supertidal internal waves present in summer. We found large values of across-shelf shear in the near-surface currents at the shelfbreak by tracking large arrays of drifters. As large as 15 m in amplitude, these displacements impose powerful constraints on the conduct of proper sampling for the shelfbreak front. During summer, when supertidal internal waves are present, these constraints become even more daunting.

Burroughs, L.D. 1982. Analyses of elements of the marine environment for the Atlantic Remote Sensing Land Ocean Experiment (ARSLOE), an atlas for October 22 through October 27, 1980. NOAA, NWS Tech. Rep. NWS 29:.

Abstract. Contains detailed analyses of sea surface temperatures, wind streamlines and isotachs, and surface air temperatures for two significant meteorological events, a cold front and a nearby extratropical cyclone, that occurred during the Atlantic Remote Sensing Land Ocean Experiment (ARSLOE).

Bush, K. and S.L. Kupferman. 1980. Wind stress direction and the alongshore pressure gradient in the Middle Atlantic Bight. J. Phys. Oceanogr. 10(3):469-471.

Abstract. We find that the alongshore transport in winter calculated using a circulation model based on Ekman and geostrophic dynamics (Csanady, 1976) for a shelf region similar to the Middle Atlantic Bight is sensitive both to the alongshore component of the wind stress and the alongshore pressure gradient. If the total alongshore transport in the region remains uniform along the shelf at -2.5×10^5 m^3/s (positive poleward) as indicated by current meter measurements, our calculations show that the alongshore pressure gradient must decrease from 1×10^{-3} Pa/m off Montauk Point to zero south of Cape Henry, as a consequence of the change in orientation of shelf to wind stress.

Bush, K.A., J.O. Blanton and L.P. Atkinson. 1985. Summary and Future Plans for South Atlantic Bight Oceanography. pp. 153-156. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Buss, B.A. 1972. Suspended sediments in continental shelf waters off Cape Hatteras, North Carolina. Master's Thesis. University of Illinois, Chicago.

Buss, B.A. and K.S. Rodolfo. 1972. Chapter 12 Suspended Sediments in Continental Shelf Waters Off Cape Hatteras, North Carolina. pp. 263-280. In D.J.P. Swift, D.B. Duane and O.H. Pilkey, eds. Shelf Sediment Transport: Process and Patterns. Dowden, Hutchinson and Ross, Inc., Stroudsburg.

Abstract. Suspended sediment and salinity samples were taken at 46 stations over the Cape Hatteras shelf area from August 26 to 28, 1970. Analyses of these samples provide data on the Cape Hatteras plume seen in Apollo 9 photographs. Relatively high suspensate (> 2 mg/liter) and low salinity (< 3.2‰) waters from Pamlico Sound are issuing onto the shelf through Ocracoke and Hatteras Inlets. A portion of this outflow is moved southward by coastal currents. In the shoal waters off the cape itself, wave and current mixing causes suspensions of between 0.5 and 1.0 mg/liter. Seaward, suspension are gradually diluted to less than 0.10 mg/liter on the outer shelf and slope with salinities generally between 3.5 and 3.6‰.

Butman, B. 1981. Dynamics of the surface sediments along the United States East Coast continental shelf. International Geol. Congress, Paris, Abstracts, 2:446.

Abstract. Sediment transport on the Atlantic outer continental shelf is described utilizing results from bottom moored instrumented tripod systems. Sediment transport is strongly related to near-bottom currents and in shallow waters is observed to respond to storms.

Butman, B. 1987. Physical processes causing surficial sediment movement, pp. 147-162. In R.H. Backus, ed. Georges Bank. MIT Press, Cambridge, MA.

Butman, B. 1988. Downslope Eulerian mean flow associated with high-frequency current fluctuations observed on the outer continental shelf and upper slope along the northeastern United States continental margin: implications for sediment transport. Cont. Shelf Res. 8(5-7):811-840.

Abstract. Eulerian current measurements made 5-7 m above bottom at six stations along the United States east coast continental margin show a net downslope flow of 1-5 cm/s. Although the scalar current speed decreases with water depth and toward the bottom, fluctuations in the cross-isobath flow were stronger and increasingly asymmetric near the bottom. Maximum downslope flow exceeded maximum upslope flow by a factor of two to three. The strength of the low-passed downslope flow was proportional to the upslope Reynolds flux of density as well as to the amplitude of the current fluctuations that have periods shorter than 30 h. These flow characteristics may be caused by differential vertical mixing in the bottom boundary layer where a stratified fluid flows upslope (unstable) and downslope (stable). The asymmetry in current strength clearly favors net downslope transport of sediments that move as bedload.

Butman, B. and R.C. Beardsley. 1987. Physical Oceanography. pp. 88-98. In R.H. Backus and D.W. Bourne, eds. Georges Bank. The MIT Press, Cambridge, Massachusetts.

Abstract. A long-term objective of physical oceanographers interested in Georges Bank is to relate its physical oceanography to its biology, chemistry, and

geology. The circulation, the exchange of water and material on and off the bank, the rate and extent of vertical and horizontal mixing, the location of hydrographic fronts, and the frequency and extent of sediment movement all clearly affect the bank's biology and chemistry.

Butman, B., R.C. Beardsley, B. Magnell, D. Frye, J.A. Vermersch, R. Schlitz, R. Limeburner, W.R. Wright and M.A. Noble. 1982. Recent observations of the mean circulation on Georges Bank. J. Phys. Oceanogr. 12(6):569-591.

Abstract. A clockwise circulation around Georges Bank was measured by means of moored current meters, aircraft-tracked surface drifters, and satellite-tracked drifters drogued at 10 m. The strongest flow was in a narrow jetlike current (30 cm/s) along the northern flank of the bank. The flow of shelf water on the southern flank was westward (10 cm/s) toward the Middle Atlantic Bight; some of this water flowed northward through the eastern side of Great South Channel and recirculated around Georges Bank. The satellite-tracked drifters and the moored observations indicate that the circulation around the bank was not completely closed and considerable variability occurs in the trajectory of an individual water particle.

Butman, B., J.W. Loder and R.C. Beardsley. 1987. The seasonal mean circulation: Observation and theory. pp. 125-138. In R.H. Backus and D.W. Bourne, eds. Georges Bank. The MIT Press, Cambridge.

Abstract. The currents in the Georges Bank region can be divided conceptually into a seasonal mean current, low-frequency currents (associated with winds, topographic waves, or meanders of the Gulf Stream), energetic tidal currents, and higher-frequency currents associated with surface or internal waves. The mean circulation, sometimes called the residual circulation, is the current averaged over a long period of time, so that short-term motions caused by the higher-frequency phenomena are removed. This circulation is important because it plays a major role in determining the direction and speed at which water and material in the water are transported over long periods of time. In this chapter the seasonal mean circulation on Georges Bank and the processes that may drive the circulation are described. In addition, the results of existing dynamical theories of the seasonal mean circulation are compared with observation in an attempt to explain dynamically the observed current pattern. Because the circulation and the strength and direction of the various forces that drive the circulation in the Georges Bank region change during the year, the current pattern will be described on a seasonal basis.

Butman, B. and J.A. Moody. 1983. Observations of bottom currents and sediment movement along the U.S. east coast continental shelf during winter. pp. 7.1-7.60. In B.A. McGregor, ed. Environmental geologic studies on the United States Mid and North Atlantic outer continental shelf area. Vol. 2. final report to the U.S. Bureau of Land Management,

Butman, B. and M. Noble. 1979. Bottom currents and bottom sediment mobility in the offshore middle Atlantic Bight, 1976-1977. Chapter 2. pp. 46. In Middle Atlantic Outer Continental Shelf Environmental Studies. Geologic Studies. Vol. III. Virginia Institute of Marine Science, Gloucester Point.

Butman, B., M. Noble and D. Folger. 1977. Long term observations of bottom current and bottom sediment movement on the Middle Atlantic continental shelf. pp. 2-1 - 2-61. In R. Miller, P. Cousins, W. Dillon et al. (eds.). Middle Atlantic Outer Continental Shelf Environmental Studies. Vol. III. Geologic studies prepared for Bureau of Land Management. Virginia Institute of Marine Science (BLM-st-78-29).

Abstract. Presents data obtained from bottom-moored tripod systems instrumented to measure bottom currents for speed and direction. Documents bottom flows sensitive to storm events and active with respect to sediment movement. Supportive data are provided by mounted time-lapse cameras and transmissometers for measurement of resuspended materials.

Butman, B., D.W. Folger and S. Pfirman. 1980. Bottom currents and bottom sediment mobility in the offshore Georgia Embayment. Part I. An instrument system for long-term sediment transport studies on the continental shelf. Part II. Observations of bottom current and bottom sediment movement in the southeast Georgia Embayment. In P. Popenoe, ed. Final Report. Environmental studies of the southeastern United States Atlantic outer continental shelf. 1977. Open-File Rep. 80-146:4-I-1--4-II-29 ed. Geology. U.S. Geol. Surv.

Abstract. Results from a relatively short-term deployment of a bottom-moored tripod system in the South Atlantic are presented. Bottom sediment movement was found to be seasonal in a seaward direction and related to near-bottom currents in the region.

Butman, B., M. Noble and J. Moody. 1982a. Observations of near-bottom currents at the shelf-break near Wilmington Canyon. pp. 3.1-3.58. In J.M. Robb (ed.). Environmental geologic studies in the Mid-Atlantic outer continental shelf area: Results of 1978-1979 field seasons, U.S. Geol. Surv. Final Report to U.S. Bureau of Land Management.

Abstract. Identifies warm-core Gulf Stream rings as the dominant source of low-frequency variability in Lydonia Canyon, although the rings appear to have little influence upon deep flow (below 800 m). Records a polarization of velocity fluctuations toward the head of the canyon due to surface and internal tides.

Butman, B., M.A. Noble, J.A. Moody and M.H. Bothner. 1982b. Lydonia Canyon dynamics experiment. Progress Report. U.S. Geol. Surv. Rep. 91:91.

Abstract. Interim report describes the Lydonia Canyon Experiment. Current meter moorings (in some cases with pressure gauges and transmissometers) are located within Lydonia Canyon as well as on the adjacent slope and rise. Preliminary results indicate currents to be strongly related to canyon bathymetry, while at the canyon head they are more consistent with observations recorded on the shelf. On the continental slope, currents are observed to be influenced by Gulf Stream eddies.

Butman, G., M. Noble and D.M. Folger. 1979. Long-term observations of bottom currents and bottom sediment movement on the Mid-Atlantic continental shelf. J. Geophys. Res. 84(C3):1187-1205.

Abstract. Long-term *in situ* observations made at three locations on the mid-Atlantic continental shelf during 1975-1976 clearly show intermittent movement of bottom sediment caused by currents, waves, and other forcing mechanisms. In winter, storm-associated bottom currents greater than 30 cm/s resuspended and transported sediments. Net water particle excursions during storms were about 20-30 km longshelf and 5-10 km cross-shelf. Wave-induced bottom currents also resuspended sediments during periods of low mean flow. Sediment motion was observed in summer, although bottom conditions were generally tranquil. Significant changes in suspended matter concentration were observed that were only partially related to bottom currents. These changes may have been caused by biological activity or advection. Bottom currents on the mid-Atlantic region of the continental shelf were characterized by a coherent, primarily cross-shelf tidal flow of 5-10 cm/s and a low-frequency longshelf component of 5-20 cm/s. The longshelf current was coherent over length scales of 100 km at tidal frequencies and for motions with periods greater than 50 hours. For these longer periods the longshelf flow was coherent with wind stress, which implies that winds were a major driving force of the longshelf current. The cross-shelf current was not coherent at stations separated by 100 km except at tidal frequencies. Packets of high-frequency internal waves were observed during stratified conditions in summer with bottom currents as large as 20 cm/s.

Byrnes, M.R. 1989. Superduck Beach Sediment Sampling Experiment. Report 1. Data Summary and Initial Observations. CERC Tech. Rep. CERC-89-18:56.

Abstract. This report provides a summary of grain size data collected during Phase II (October 1986) of the SUPERDUCK field experiment. The objective of the study was to collect and analyze data on changes in beach sedimentology and morphology associated with major storm event. Average median grain size provided useful information for identifying trends in sediment texture associated with variations in nearshore wave climate. During storm events, finer-grained sand was removed from the subaerial beach profile, producing a coarser average median grain size. Post-storm recovery involved landward migration of the nearshore bar system and a net decrease in average median grain size.

Cacchione, D.A. and D.E. Drake. 1982. Measurements of storm-generated bottom stresses on the continental shelf. J. Geophys. Res. 87(C3):1952-1960.

Abstract. Large values of bottom friction velocity, u_*, and roughness length, z_0, determined from burst-averaged speed data taken on the continental shelf in outer Norton Sound, Alaska, with the GEOPROBE tripod during a storm in September 1977 are correlated with extremely large valued of near-bottom concentration of total suspended particulate matter (TSM). Combined wind-driven and tidal currents exceeding 30 cm/s at 1 m above the bottom and intense oscillatory bottom currents with maxima above 45 cm/s were associated with the largest measured values of TSM at 2 m above the sea floor. The valure of u_* and z_0 obtained from the 'law of the wall' velocity-depth relationship are diminished substantially throughout the storm period (average reduction of 44 %) when the turbulence-reducing effects of the vertical concnetration gradient of TSM are considered.

Cacchione, D.A., W.D. Grant, D.E. Drake and S.E. Glenn. 1987. Storm-dominated bottom boundary layer dynamics on the northern California continental shelf: measurements and predictions. Journal of Geophysical Research. 92(C12):1817-1827.

Abstract. Measurements of near-bottom velocity profiles in 85 m of water during a storm on the continetal shelf off northern California using the GEOPROBE tripod in Decenber 1979 provided estimates of shear velocities, u_*, and roughness lengths, z_0, when the near-bottom velocity profiles were logarithmic. These estimates agree within 90% confidence intervals with values computed from a simple near-bottom combined wave-current model that includes movable bed effects. The reasonably good comparison between model and profile estimates of u_* suggests that such models can be used to predict bed shear stresses (or shear velocities) under combined flows of waves and currents typical of stormy conditions on continental shelves if stratification corrections to the velocity profile resulting from suspended sediment are small.

Cahill, M.L. and K. Drinkwater. 1991. Warm Eddies and Cross-Shelf Exchange. EOS, Trans. AGU. 72(51):87.

Abstract. Satellite images suggested that a large volume of cold water was drawn from the Scotian shelf in spring 1991, apparently by warm Gulf Stream eddies. A large interdisciplinary field program on the Scotian Shelf in late April permitted opportunistic sampling of this feature. Biological samples indicated high densities of redfish larvae and the hydrographic observations showed that the feature was at least 50 m deep and consisted of cold, fresh water that probably originated from the eastern part of the Scotian Shelf. The surface area of the entrained shelf water was in the order of 10% of the surface area of the Scotian Shelf and so there is little doubt that warm eddies have a profound effect on both the biology and hydrography of the Scotian Shelf. We are currently using Haidvogel's semi-spectral primitive equation model (SPEM) to investigate the dynamics of the exchange and following a description of the observations, preliminary results from an idealized ocean-shelf model will be presented.

Calliari, L.J. 1990. Cross-shore and longshore sediment size distribution on southern Currituck Spit, North Carolina. Ph.D. Thesis. College of William & Mary. 279 pp.

Campbell, B., E. Kern and D. Horn. 1977. Impact of Oil Spillage from World War II Tanker Sinkings. NOAA Tech. Rep. NOAA-77030211:96.

Abstract. The overall effects of spilled oil are studied through available data on tankers sunk along the East Coast of the United States during World War II. The baseline data of ships sunk, cargo, locations and data on sinkings was established through an extensive literature and archives search. Cape Hatteras, North Carolina and its surrounding area was chosen as the primary site of the investigation on the basis of the volume of spilled oil. A computer model was developed to estimate the trajectory of oil released from each ship. In addition, the Asbury Park area of New Jersey was investigated on the merit of substantial documentation of spills in that area. Interviews were conducted in both areas to obtain first hand information on visible effects of the oil. Newspapers and

records of marine activities were analyzed to determine environmental and other oil related effects for the selected regions. Results indicated that effects of the oil spills, as observed by residents of the areas under investigation, were negligible. In both cases, regional wildlife and economy survived with minimal difficulty.

Campbell, J.W. and J.E. O'Reilly. 1988. Role of satellites in estimating primary productivity on the northwest Atlantic continental shelf. Cont. Shelf Res. 8(2):179-204.

Abstract. Variance in primary productivity over the northwest Atlantic continental shelf has been studied to determine its dependence on variables amenable to satellite remote sensing. A large data set consisting of ^{14}C uptake rates, chlorophyll concentrations, incident and underwater light (PAR) and sea surface temperatures was analyzed for empirical and theoretical relationships. These data were obtained at 1047 stations surveyed by the National Marine Fisheries Service between 1977 and 1982 as a part of the MARMAP program. Empirically, we bound a well-defined seasonal pattern in the ratio of integral productivity to surface layer chlorophyll; its annual maximum occurred in August, lagging the maximum insolation by about 30 days, and coinciding with maximum surface water temperature.

Campbell, N.J. 1973. Summary of hydrographic conditions in the International Commission for the North Atlantic Fisheries Area in 1971. Ann. Biol. 28:10-11.

Abstract. Hydrographic measurements from ICNAF surveillance cruises are summarized. Measurements are taken within the "Banana Zone" as part of ICNAF monitoring of commercial fish catches.

Campos, E.J.D. and D.B. Olson. 1991. Stationary Rossby Waves in Western Boundary Current Extensions. J. Phys. Oceanogr. 21(9):1202-1224.

Abstract. The existence of temporally growing, spatially damped long waves in western boundary current extensions is suggested by various authors from both an observational and theoretical point of view. Here the nature of such waves is reconsidered based on both a local analysis of a simple analytical model and numerical experiments. The analytical calculation consists of an investigation of the possible solutions of the quasi-geostrophic equation in a barotropic ocean, when a spatially constant zonal mean flow and Laplacian lateral dissipation are considered. In numerical experiments, in addition to an investigation on the realizability of the analytical solutions, effects of a tilting western boundary on the wind-driven circulation are explored. It is found that the tilt of the western boundary has a very strong effect on the penetration scale of the zonal midlatitude jet.

Carson, S.R. 1989. The use of radon-222 as a tracer of mixing in the waters of the continental shelf and slope of the Middle Atlantic Bight (radon-222). Ph.D. Thesis. Columbia University. 497 pp. (DAI 50/10B, p.4410; AAC9005842)

Abstract. Production of Radon 222 by the surface sediments of the shelf generally increases with increased fraction of fine-grained sediments. Unusually high radon

production found in some areas of shelf sands appears to be the result of mineralogically-controlled coatings on grain surfaces that contain radium in association with manganese. Radon fluxes from the shelf sediments are enhanced relative to fluxes expected from molecular diffusion alone. The flux enhancement from the largest body of high-production sands is greater than that from normal-production sands and is variable with season and/or current strength. On the slope the production of radon by the surface sediments tends to increase with water depth. Excess radon standing crops in the waters of the lower slope are consistent with fluxes from the underlying sediments due to molecular diffusion alone, while on the upper slope excess radon standing crops indicate enhanced fluxes. The seasonally variable vertical distributions of radon in the shelf waters show a general association between radon gradients and density gradients. Horizontal distributions of radon in the shelf waters are tied to the laterally inhomogeneous sediment source with some redistribution due to horizontal advection. Short term variability of radon distributions is lowest in the waters of the middle shelf and highest on portions of the outer shelf. Modelling of both vertical and horizontal radon distributions is limited by the time variability of those distributions and by the sensitivity of the models. During stratified periods the vertical eddy diffusion coefficients in the lower pycnocline of the middle shelf average 0.025-0.050 cm^2/sec. During winter the vertical eddy diffusion coefficients in well-mixed, middle shelf waters are probably greater than the 100 cm^2/sec upper limit on sensitivity of the model. The waters of the middle slope are characterized by a zone in which excess radon concentrations, standing crops and gradients are lower than those found on both deeper and shallower parts of the slope and lower than those expected from molecular diffusion of radon from the sediments. This low-radon zone is found in all seasons and all along the slope of the Middle Atlantic Bight. The low-radon zone is most likely caused by isopycnal mixing that rapidly transports radon away from the sloping bottom.

Carter, E.F. 1989. Assimilation of Lagrangian data into a numerical model (of Gulf Stream). Dynamics of Atmospheres and Oceans. 13(3-4):335-348.

Abstract. During 1983 and 1984, approximately 40 neutrally buoyant (isopycnal) floats were released into the Gulf Stream. These floats, which were released at approximately weekly intervals, measured their location and depth three times a day for 30-45 days. The basic statistics of these floats are briefly described. This float data set has been applied to the important problem of assimilation of Lagrangian information into a numerical model of the oceanic mesoscale. The assimilation method is a Kalman-filter type technique. Since the processed float data consists of a time series of position, velocity and depth it is natural to use a dynamical model that uses these variables directly. For this purpose a simple shallow-water model utilizing a Lax-Wendroff numerical scheme is used. This type of numerical model has been successfully used in meteorological data assimilation studies. Some results using both one- and two-dimensional versions of this model are described. (15 Refs.).

Carver, R.D. and D.D. Davidson. 1983. Jetty Stability Study, Oregon Inlet, North Carolina. Hydraulic Model Investigation. CERC Tech. Rep. CERC-TR-83-3:449.

Abstract. An undistorted-scale hydraulic model study was conducted to provide input for design optimization of a rubble-mound jetty system proposed for Oregon

Inlet, North Carolina. Two-dimensional (trunk) tests consisted of (a) developing stable stone and dolos sections (base designs) for a depth-limited breaking wave of 15 sec, 13.6 ft at a design swl of +5.5 ft; (b) subjecting the stable base designs obtained at the +5.5 ft swl to storm-surge hydrographs with peak levels of +6.5, +7.5, +8.5, +9.5, +10,5. and +11.5 ft NGVD and obtaining damage as a function of swl; (c) redesigning the armoring schemes for stable sections of +7.5 ft swl with a depth-limited breaking wave of 15 sec, 15.5 ft and subjecting these plans to storm-surge hydrographs of +8.5, +9.5, +10.5, and +11.5 ft NGVD and again determining damage as a function of swl; and (d) redesigning both the stone and dolos sections for stability at an swl of +9.5 ft with a depth-limited breaking wave of 15 sec, 17.2 ft. Three-dimensional tests were conducted to determine stable stone and dolos head sections for 15-sec, 17.6 ft waves at angles of wave attack equal to 0, 22.5, 45, 67.5, and 90 deg.

Casagrande, C. and P. Hamilton. 1988. Study of Deep Ocean Currents Near the 3800 m Low-Level Radioactive Waste Disposal Site. May 1984-May 1986. EPA Rep. EPA/520/1-88/007:62.

Abstract. The report presents the results of a two-year study of a U.S. 3800 m low-level radioactive waste disposal site near the mouth of the Hudson Canyon. The program objectives were to describe the currents, including their source and variability, and deduce from the data the potential for, and direction of, transport of contaminants from the disposal area. The results show that the currents in the disposal area range in strength from a few to 62 cm/sec and are principally due to the presence of low frequency topographic Rossby waves having periods of approximately two to four weeks. The currents generally flow towards the southwest, in line with the general topography of the mid-Atlantic region. The canyon acts to distort the southwest flow, resulting in currents below the canyon rim which are aligned with the canyon onshore-offshore axis. The direction of currents along the canyon axis appears to be determined by the proximity of both the Gulf Stream and the Western Boundary Undercurrent.

Celone, P.J. and J.L. Chamberlin. 1980. Anticyclonic warm-core Gulf Stream eddies off the northeastern United States in 1978. ICES Annals of Biology. 35:50-55.

Celone, P.J. and J.W. Clark. 1991. Satellite Observations of a Cold, Thin, Wedge-Shaped Filament Embedded in the Gulf Stream. EOS, Trans. AGU. Suppl to 72(17):155.

Abstract. Analysis of NOAA Polar Orbiter satellite imagery in late 1990 revealed a thin cold filament interacting with and embedding itself into the Gulf Stream at the surface. An AVHRR image obtained from the NOAA 10 satellite on October 30, 1990 revealed a thin, 4 kilometers wide, strip of relatively cool, possibly shelf-type water interacting with the north edge of the Stream several hundred kilometers northeast of Cape Hatteras, North Carolina. This filament appeared to flow in an easterly direction until reaching about 70 degrees West Longitude. At this point, the easterly flow stopped, and a westerly flow apparently developed, crossing the Stream, and interrupting the flow at least at the surface. This feature was monitored by satellite imagery for three days until cloud contamination precluded a good view. Cloud cover had decreased enough by the middle of November to view the northern edge of the Gulf Stream again, revealing a cold, wedge shaped filament near 65 degrees West Longitude inside the

Stream. We hypothesize that a cold, narrow, wedge-shaped filament became embedded in the Stream at the surface, and propagated downstream at about 0.5 m/sec. The authors intend to document this evidence with satellite imagery, and if available, XBT, CTD, and velocity data.

Center for Natural Areas, ME. 1977a. A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras (1977). Volume III. Appendix A, B, and C. U.S. Dept. Interior, BLM Rep. No. BLM-YL-SR-77-05:511.

Abstract. The Literature survey analyzes published, unpublished, and raw data from 1972 to 1977. Topics presented in the report are geology (nearshore and offshore), meteorology, physical oceanography, chemistry (hydrocarbons, trace metals, nutrients, pesticides, and radioactivity), phytoplankton, zooplankton, neuston, nekton, benthos, commercial fisheries, sport fisheries, benthic flora, marine mammals, marine birds, threatened or endangered species, microbiology, OCS uses, unique and endangered environments, and toxicity. The literature review also identifies data gaps and recommends studies to fill those gaps.

Center for Natural Areas, ME. 1977b. A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras (1977). Volume II. Master Bibliography, Index, Acknowledgements. U.S. Dept. Interior, BLM Rep. No. BLM-YL-SR-77-04:516.

Abstract. The Literature survey analyzes published, unpublished, and raw data from 1972 to 1977. Topics presented in the report are geology (nearshore and offshore), meteorology, physical oceanography, chemistry (hydrocarbons, trace metals, nutrients, pesticides, and radioactivity), phytoplankton, zooplankton, neuston, nekton, benthos, commercial fisheries, sport fisheries, benthic flora, marine mammals, marine birds, threatened or endangered species, microbiology, OCS uses, unique and endangered environments, and toxicity.

Center for Natural Areas, ME. 1977c. A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras (1977). Volume 1. Book 3. Chapters XV-XX. U.S. Dept. Interior, BLM Rep. No. BLM-YL-SR-77-03:990.

Abstract. The Literature survey analyzes published, unpublished, and raw data from 1972 to 1977. Topics presented in the report are geology (nearshore and offshore), meteorology, physical oceanography, chemistry (hydrocarbons, trace metals, nutrients, pesticides, and radioactivity), phytoplankton, zooplankton, neuston, nekton, benthos, commercial fisheries, sport fisheries, benthic flora, marine mammals, marine birds, threatened or endangered species, microbiology, OCS uses, unique and endangered environments, and toxicity.

Center for Natural Areas, ME. 1977d. A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras (1977). Volume I. Book I. Chapters I-V. U.S. Dept. Interior, BLM Rep. No. BLM-YL-SR-77-01:879.

Abstract. The Literature survey analyzes published, unpublished, and raw data from 1972 to 1977. Topics presented in the report are geology (nearshore and

offshore), meteorology, physical oceanography, chemistry (hydrocarbons, trace metals, nutrients, pesticides, and radioactivity), phytoplankton, zooplankton, neuston, nekton, benthos, commercial fisheries, sport fisheries, benthic flora, marine mammals, marine birds, threatened or endangered species, microbiology, OCS uses, unique and endangered environments, and toxicity.

Center for Natural Areas, ME. 1979a. A Summary and Analysis of Environmental Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral (1977). Volume III. Appendix A: Ongoing Research and Programs. Appendix B: Data Gaps. Appendix C: Raw Data and Unworked Samples. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-79-28:370.

Abstract. A 12-month study by the Center for Natural Areas (CNA) was conducted to collect and analyze published, unpublished, and raw data as well as ongoing research programs from 1974 to present, relative to the marine environment of the outer continental shelf (OCS) and the Blake Plateau from Cape Hatteras, North Carolina to Cape Canaveral, Florida. The report is to be used to assess adequacy of the regional data base, and may be used in the design of environmental studies that the Bureau of Land Management (BLM) will direct in an attempt to assess and predict the possible effects of oil and gas development on the marine life and environment.

Center for Natural Areas, ME. 1979b. A Summary and Analysis of Environmental Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral (1977). Volume II. Master Bibliography, Index, Acknowledgements. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-79-27:382.

Abstract. A 12-month study by the Center for Natural Areas (CNA) was conducted to collect and analyze published, unpublished, and raw data as well as ongoing research programs from 1974 to present, relative to the marine environment of the outer continental shelf (OCS) and the Blake Plateau from Cape Hatteras, North Carolina to Cape Canaveral, Florida.

Center for Natural Areas, ME. 1979c. A Summary and Analysis of Environmental Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral (1977). Volume I, Book 2. Chapters VIII thru XIII. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-79-24:637.

Abstract. A 12-month study by the Center for Natural Areas was conducted to collect and analyze published, unpublished, and raw data as well as ongoing research programs from 1974 to present, relative to the marine environment of the outer continental shelf and the Blake Plateau from Cape Hatteras, North Carolina to Cape Canaveral, Florida. The report is to be used to assess adequacy of the regional data base, and may be used in the design of environmental studies that the Bureau of Land Management will direct in an attempt to assess and predict the possible effects of oil and gas development on the marine life and environment.

Center for Natural Areas, ME. 1979d. A Summary and Analysis of Environmental Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral (1977). Volume I, Book 1, Chapters I thru VII. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-79-23:734.

Abstract. A 12-month study by the Center for Natural Areas was conducted to collect and analyze published, unpublished, and raw data as well as ongoing research programs from 1974 to present, relative to the marine environment of the outer continental shelf and the Blake Plateau from Cape Hatteras, North Carolina to Cape Canaveral, Florida. The report is to be used to assess adequacy of the regional data base, and may be used in the design of environmental studies that the Bureau of Land Management will direct in an attempt to assess and predict the possible effects of oil and gas development on the marine life and environment.

Cerone, J.F. 1984. Satellite observed climatology of Warm Core Gulf Rings and Discussion of their Possible Biological Effects. Master of Science Thesis. Univ. of Rhode Island, Kingston. 180 pp.

Chamberlin, J.L. 1977. Monitoring effects of Gulf Stream meanders and warm core eddies on the continental shelf and slope. ICNAF Sel. Pap. 2:145-153.

Abstract. Hydrographic measurements taken in conjunction with monitoring commercial fish catches are used to identify meanders and eddies in the western North Atlantic. These events are also examined with respect to fishery productivity in the region.

Chamberlin, J.L. 1978. Unusual offshore distribution of cold Atlantic shelf water during the spring and summer of 1978. Coastal Oceanography and Climatology News. 1:1-3.

Chao, S.-Y. 1984. Bimodality of the Kuroshio. J. Phys. Oceanogr. 14(1):92-113.

Abstract. A barotropic ocean model is used to study the bimodal behavior of the Kuroshio to the south of Japan. By considering the combined effects of the beta plane, the Kyushu coast perturbation, the Izu Ridge and the SW-NE tilted coastline, the two frequently observed meander patterns have been numerically verified as the two quasi-steady solutions contained in the model. The small-meander state is identified as an upstream disturbance largely forced by the Izu Ridge; its width decreases as the strength of the current increases. The large meander state is forced by the presence of both the Kyshu wedge and the Izu Ridge topography. For small volume transports the large meander state behaves like the small meander state, in that the meander width decreases as the current speed increases; for large volume transports it behaves like a lee Rossby wave, in that the width of the meander increases as the current speed increases. The birth of the large meander state occurs as a consequence of the ocean spin-down. Prior to the generation of the large meander state, the Kyshu wedge excites small meanders and eddies which propagate eastward at a speed of several miles a day. This model result agrees well with observations. The bimodality of the Kuroshio is identified as an example of multiple equilibrium states (Charney and Flierl). Below a volume transport of 30 Sv, only the small meander state exists. The large meander state and the small meander state coexist in a range of volume transports from 30 to 60 Sv. Beyond 60 Sv, a strongly nonstationary solution

develops and the structure of the meander can no longer be determined by the present model.

Chao, S.-Y. 1990. Instabilities of fronts over a continental margin. J. Geophys. Res. 95(C3):3199-3211.

Abstract. Over a continental slope, a negatively buoyant density forcing from the coastline generates a 'Gulf Stream front' if the receiving water is initially homogeneous and a coastal upwelling front if the receiving water is stratified. A positive buoyancy forcing produces density-driven coastal currents whether the ambient water is stratified or not. The four types of fronts are analyzed and compared to lowest order. (20 Refs.).

Chao, S.-Y. and W.C. Biocourt. 1986. Onset of Esturarine Plumes. J. Phys. Oceanogr. 16(12):2137-2149.

Abstract. The onset of esturarine plumes is numerically studied here, using a three-dimensional, primitive-equation model. The model ocean consists of a narrow estuary that is connected to an otherwise enclosed ocean ocean basin. The basin is initially filled with saline water. Subsequently, freshwater is pumped in near the surface and the saline water is withdrawn from below at the head of the estuary. To maximize the chance of development for a baroclinic flow field, a rigid-lid and a flat bottom are assumed, and the inflow-outflow profile has no barotropic component. The plume expands in the direction of propagation of the coastally trapped waves after the freshwater release. The intrusion speed inside the estuary is consistently higher than that along the shelf. Energy is therefore accumulated near the estuary mouth, forming a bulge of anticyclonic surface flow. The far-field flow consists of a bore intrusion along the shelf. The transitional zone between the near-field and far-field flows is characterized by strong cyclonic surface flow and also strong downwelling. For reasonable amounts of vertical mixing and bottom drag, two-layer opposite flows are confined inside the bulge and the far-field bore intrusion is unidirectional. In the limit of small vertical mixing and vanishing bottom drag, the difference in intrusion speeds in and out of the estuary is reduced. The seaward expansion of the bulge decreases, and the undercurrent leaks out of the bulge and propagated behind the nose of the bore. The three-dimensional structures of the density-driven estuarine circulation and also of the bore intrusion along the shelf have been identified.

Chao, S.-Y. and G.S. Janowitz. 1979. The effect of a localized topographic irregularity on the flow of a boundary current along the continental margin. J. Phys. Oceanogr. 9:900-910.

Abstract. A model for the effect of a localized topographic irregularity on a barotropic sheared current flowing along a continental margin with shallow water to the left of the current is developed.

Chao, S.-Y. and T.W. Kao. 1987. Frontal instabilities of baroclinic ocean currents with applications to the Gulf Stream. J. Phys. Oceanogr. 17(6):792-807.

Abstract. The frontal instability of major baroclinic ocean currents such as the

Gulf Stream is numerically studied here, using a three-dimensional, primitive-equation model. The model current is driven by a buoyant discharge near the surface from the light water side of the front. Subsequent geostrophic adjustment produces a baroclinic current that closely resembles the Gulf Stream. The model is to be distinguished from the conventional stability analysis in which a prescribed mean current is subject to eddy dissipation with no provision for its maintenance. At low latitudes small-amplitude unstable waves are generated. The eddy fluxes are shown to be largely up-gradient and responsible for the maintenance of the front. At higher latitudes the model produces anticyclonic rings. The ring genesis consumes the cyclonic shear of the mean current near the front, and apparently involves barotropic instability. The triggering mechanism for instability is related to the outward surge of the front during the initial stage of geostrophic adjustment, which in turn is related to the inertial oscillations of surface isopycnals. The outward surge is surface-trapped. To trigger instability, the surge must be shallow and intense in lower latitudes, and becomes deeper and weaker in higher latitudes. The Richardson number decreases below 0.25 shortly before and after onset of instability, and increases again after unstable waves have fully developed. The instability is initially of grid scale, and subsequently evolves into larger scales through nonlinear cascading processes, rendering themselves to baroclinic instability.

Chao, S.-Y. and L.J. Pietrafesa. 1980. The subtidal response of sealevel to atmospheric forcing in the Carolina Capes. J. Phys. Oceanogr. 10:1246-1255.

Abstract. The subtidal frequency response of sea level to atmospheric forcing along the coastal region between Cape Hatteras and Charleston is investigated for a four-month period: 1 September-31 December, 1974. It is found that low-frequency sea level fluctuations are preferentially forced by wind stress components which are aligned with the local topography. Also, a localized, one-dimensional model of sea surface response to a clockwise rotating wind for the Charleston coastal regime is developed. The phase spectrum of the alongshore wind component versus sea level as predicted by the model is shown to compare favorably to that derived from actual observations at Charleston, an open ocean coastal site. The model results and observations also suggest that wind-induced fluctuations of coastal sea level are trapped within 40 km of the coast by the combined effects of friction, Coriolis force and bottom topography. The outer shelf is dominated by fluctuations which are less related to wind stress and are attenuated rapidly in the shoreward direction. A reasonable estimate of bottom frictional coefficient, r=0.05 cm/s, is also established.

Chao, Y.-Y. 1974. Wave refraction phenomena over the continental shelf near the Chesapeake Bay entrance. U.S. Army Corps of Engr., CERC. Technical Memorandum No. 47:53.

Chapman, D.C. 1986. A Simple model of the formation and maintenance of the shelf/slope front in the Middle Atlantic Bight. J. Phys. Oceanogr. 16(472-474):1273-1279.

Abstract. The strong salinity and temperature gradients across the shelf/slope front in the Middle Atlantic Bight often compensate such that the cross-front density gradient is nearly eliminated. This suggests that the density field may not be as dynamically important as has been assumed in previous models.

Hypothesizing this to be the case, a simple steady barotropic model, which allows no density variations, is used to demonstrate that a strong tracer gradient may form near the shelf break. The velocity is such that an initially smooth tracer distribution develops a sharp front within a relatively short downstream distance. Essential features of the model are 1) the velocity convergence near the shelf break which acts to sharpen the front on the shelf side, and 2) the increase in bottom slope and depth seaward of the shelf break which leads to rapid diffusion of tracer into the deep ocean. The result is that the front is maintained for a large alongshelf distance despite both diffusion effects and the frictional decay of the alongshelf velocity.

Chapman, D.C. and R.C. Beardsley. 1989. On the origin of Shelf Water in the Middle Atlantic Bight. J. Phys. Oceanogr. 19(3):384-391.

Abstract. Based on a limited set of available oxygen isotope measurements, it is hypothesized that the mean flow in the Middle Atlantic Bight is part of a 5000 km-long buoyancy-driven, coastal current which originates along the southern coast of Greenland. This idea is consistent with most features of the known circulation of the region.

Chapman, D.C., J.A. Barth, R.C. Beardsley and R.G. Fairbanks. 1986. On the continuity of mean flow between the Scotian Shelf and the Middle Atlantic Bight. J. Phys. Oceanogr. 16(4):758-772.

Abstract. Oxygen-isotope tracer data combined with results from models are used to argue that the equatorward mean alongshelf flow in the Middle Atlantic Bight is a downstream extension of the mean alongshelf flow over the Scotian Shelf.

Chapman, R.D. 1987. The cooling and sinking of warm-core rings (Gulf Stream). Ph.D. Thesis. The Florida State University. 84 pp. (DAI 48/03B, p.688; AAC8713308)

Abstract. Intense cooling of a warm-core ring can cause the ring to sink under the surrounding fluids. A simple model of this process in a two and one-half layer (two active and one passive layer) ocean consisting of an inviscid Boussinesq fluid on an f-plane is presented. The model assumes that the cooling is limited to just the ring and occurs in such a way as to maintain a uniform density throughout the ring. This special cooling allows the results for various ring densities to be connected through the conservation of potential vorticity. The analytic solution that is derived for this model is examined to establish the physical processes accompanying the cooling and sinking of a ring. Results show that warm-core rings can sink in a matter of days when exposed to typical cold air outbreaks of 500 to 1000 W/m^2. The model predicts that when the ring sinks it is overwashed completely, but this overwashing layer is very thin near the center of the ring. Thus the overwashing fluid would slow (but not eliminate) the cooling of the ring. Further analysis of the system assuming that the ring continues to be cooled after sinking shows that the overwashing fluids spiral in towards the center of the ring. These spiral trajectories steepen as the cooling rate increases, achieving spiral angles approaching those observed in Gulf Stream rings for cooling rates of about 1000 W/m^2. It is proposed that this mechanism can lead to the formation of streamers when one portion of the overwashing fluid has been passively marked with a visible tracer such as temperature or

chlorophyll. It is shown that the fluid that initially overwashes the ring originates under the ring, and not from outside the ring. When the ring sinks, this fluid is pushed out to the edge of the ring and spun up in the process. The theory further provides a mechanism for the entrainment of shelf-water organisms that are observed in warm-core rings.

Chase, J. 1971. Oceanographic observations along the east coast of the United States. Oceanogr. Rep. 38(CG 373-38):1.

Chase, J. 1972. Oceanographic observations along the East Coast of the United States. Gov. Rep. Ann. B-213-06154P.

Chen, H.S. 1981. A finite element model of storm surge and circulation for Chesapeake Bay and its Atlantic nearshore. Oceans 81 Conference Record 2:815-819.

Abstract. A two-dimensional depth-integrated storm surge model has been developed for calculating water elevation and circulation in a bay-ocean system subject to the forcing of a hurricane.

Chenard, S. 1991. Pictures of the oceanic planet. Ciel et Espace. (254):44-49.

Abstract. The role of the hydrosphere in global climatic equilibrium is highlighted and its structure and movements are illustrated by colour photographs computed from satellite-borne multifrequency scanning microwave radiometry and medium-resolution spectroradiometry. Attention is drawn to underwater forestry (where 'deserts' are defined in terms of chlorophyll concentration per m^3 of seawater), phytoplankton migration, and the seabed mountain ranges discerned by Seasat and Geosat imagery. A wind map of the Atlantic and Indian oceans and peripheral seas (compiled from only three days' satellite observations), and a thermal map of the Gulf Stream showing how it redistributes tropical heat and CO_2 into the Arctic atmosphere, are particularly striking. (0 Refs.).

Cheney, R.E. 1974. The Observed Decay of a Cyclonic Gulf Stream Ring. Master of Science Thesis. Univ. of Rhode Island, Kingston. 132 pp.

Cheney, R.E. 1975. A census of rings in the Gulf Stream system. EOS, Trans. AGU. 56(12):1007-1008.

Abstract. Although it is clear that Gulf Stream rings play a significant role in the circulation and physical properties of the western North Atlantic, estimates of their number and distribution vary widely. Between March and July 1975 a series of cruises by the U.S. Naval Oceanographic Office and Woods Hole Oceanographic Institution provided near synoptic data coverage over most of the Gulf Stream system between 55°W and 80°W. These observations together with satellite infrared imagery allowed a census to be made of the rings in this region. A total of thirteen different rings were found: ten cyclonic and three anticyclonic. Diameters (15°C at 500 m) of the cyclonic rings ranged from 50 to 200 km and their probable ages, based on known histories and temperature structures, varied from a few months to almost two years. Three cyclonic rings, which were significantly larger than the others, are believed to have originated east of 60°W and may be a separate class. Preliminary observations of these

larger rings indicate that they may be characterized by anomalously high salinities between 5°C and 7°C, suggesting Mediterranean Water influence. Only one of the three anticyclonic rings was studied in detail. However, with a diameter (15°C at 100 m) of 130 km and a downward thermocline displacement of 500 m, it is one of the most pronounced warm rings ever observed. These observations are consistent with five cyclonic rings forming per year, each with a lifetime of two years. Since anticyclonic rings are known to have shorter lifetimes (less than one year) an equal number of this type may also form during a year.

Chernyakova, A.M., S.G. Poyarkov, S.O. Borodkin and E.A. Akhmet'eva. 1986. Hydrochemical water structure of the Gulf Stream frontal zone., Gidrokhimicheskaya struktura vod frontal'noj zony Gol'fstrima. Oceanol. 26(5):768-777.

Abstract. Soviet investigation shows that hydrochemical parameters can be used as reliable indicators of different types of water masses.

Chew, F. 1977. The advection effect of planetary vorticity on sea level slope in a western boundary current. Mar. Geod. 1(1):103-116.

Abstract. Western boundary currents, such as the Gulf Stream, are often modeled as flows in near cross-stream geostrophic balance with paths that are straight or nearly straight. The effect of planetary vorticity advection on the downstream sea-level slope in these rectilinear flows is re-examined and found negligible. Instead, the re-examination reveals a much greater effect of the ageostrophic component of the horizontal divergence in determining the downstream slope. Overlooked in previous studies is the geostrophic component of the horizontal divergence because of a hidden assumption of parallel flow. To avoid this pitfall, we employ a natural coordinate system to follow precisely the downstream direction. Further, we differentiate between weak geostrophic flows with small accelerations and flows in cross-stream geostrophic balance where downstream acceleration might be appreciable. Two Rossby numbers are employed: a small cross-stream number (≤ 0.01) to describe the near cross-stream balance, and a large downstream number (≤ 0.1) to describe the large downstream accelerations that are found in western boundary flows. Finally, by means of a scale analysis we show that over the whole range of possible Rossby numbers, the advection effect of planetary vorticity on downstream sea level slope is negligible compared to the effect of the ageostrophic component of the horizontal divergence. Some new data on the nearshore gradient of the Reynolds stress are also included.

Chew, F. 1981. Shingles, spin-off eddies and an hypothesis. Deep-Sea Res. 28(4A):379-391.

Abstract. Presents a hypothesis for the growth of an anticyclonic eddy.

Chew, F. and G.A. Berberian. 1970. A Determination of Horizontal Divergence in the Gulf Stream off Cape Lookout. J. Phys. Oceanogr. 1(1):39-44.

Abstract. A horizontal divergence of 2 x 10 to the -5th power/sec was determined by tracking three shallow drogues in the speed axis of the Gulf Stream. Concurrent bathythermograph soundings along a drogue track support this

magnitude. The data also provide estimates of the strength of turbulence encountered. In terms of the neighbor diffusivity, they amount to 2 x 10 to the 5th power cm squared/sec for a drogue separation scale of 4 km, and 4 x 10 to the 4th power cm squared/sec for the 2-km scale.

Chou, S.-H. and M.P. Ferguson. 1991. Heat fluxes and roll circulations over the western Gulf Stream during an intense cold-air outbreak. Boundary-Layer Meteorology. 55(3):255-281.

Abstract. An intense cold-air outbreak, with the sea surface temperature (SST) warmer than the 70-m level air temperature by approximately 19-24 degrees C occurred offshore of the Carolinas in the GALE area on 28 January 1986. The GOES visible image shows that cloud streets, with axes nearly parallel to the mean marine atmospheric boundary layer (MABL) wind directions, prevailed over the Gulf Stream. The purpose of the paper is to study the turbulence structure in the MABL for this case and the significance of roll vortices to heat fluxes. Mixed-layer scaling has generally been used to investigate the turbulence, diffusion, and dominant eddies in a convective boundary layer (e.g. Deardorff, 1972, 1985; Willis and Deardorff, 1974; Kaimal et al., 1976; Lenschow et al., 1980, hereafter LWP; Chou et al., 1986). The same scaling is also adopted to analyze the data in the present study. (45 Refs.).

Chuang, W.-S. and W.C. Boicourt. 1989. Resonant seiche motion in the Chesapeake Bay. J. Geophys. Res. 94(C2):2105-2110.

Abstract. Chesapeake Bay is a long and narrow estuary in which seiche motions are common phenomena. These motions are generally driven by the longitudinal (N-S) wind at 2- to 3-day time scales and are characterized by a node at the mouth and an antinode at the head of the bay. Recent observations revealed a burst of seiche activity which was, however, related to the lateral (E-W) wind. The amplitude of current fluctuations was about 50 cm/s and was not simply related to the winds. The period was about 1.6 days, which was less than the natural period of the whole bay. Since the optimum wind was aligned with only a small portion of the bay (the lower reaches of the bay, about 40 km long), the primary wind effect may be active only at the entrance region. Nevertheless, it appeared that the wind-driven current was able to trigger a resonant seiche motion in the rest of the bay. The coupled response was modeled through a two-section conceptual model, and the results compare well with the observations.

Churchill, J.H. 1985. Properties of flow within the coastal boundary layer off Long Island, New York. J. Phys. Oceanogr. 15(7):898-916.

Abstract. Properties of flow within the nearshore waters off the southern coast of Long Island are established by statistical analysis of data from a moored current meter array and by concurrent hydrographic information. Upwelling-downwelling episodes dominate subdiurnal frequency fluctuations of the flow within a coastal boundary layer of about 10 km width. The structure of the boundary layer appears to be baroclinic during the presence of a pycnocline, and is also influenced by frictional effects because of the increase of bottom depth with distance from shore. Significant mean offshore flow is evidenced by measurements taken in autumn and late summer, despite negligible mean wind stress during the same periods. This flow is most likely related to the large longshore

density gradients which are consistently inferred from hydrographic data taken in the vicinity. During events of roughly constant wind heading, the cross-shore flow of a particular directions is often confined within a distinct density band. This has made it possible to infer cross-shore flow which was otherwise unresolved by the current meter array.

Churchill, J.H. 1989. The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. Cont. Shelf Res. 9(9):841-864.

Abstract. Numerous field observations have revealed that turbulence created in the wake of trawl doors can generate large and highly turbid clouds of suspended sediment. Time-averaged concentrations of sediment resuspended by trawls from various areas of the Middle Atlantic Bight continental shelf have been estimated using a simple mathematical model and National Marine Fisheries Service records of commercial trawling activity. Mean concentratins of sediment put into suspension by currents have also been computed using a modified form of the Glenn and Grant model. The results indicate that sediment resuspention by trawling can be a primary source of suspended sediment over the outer shelf, were storm-related bottom stresses are generally weak. The concentration estimates further suggest that sediment resuspended by trawls makes a sizeable contribution to the total suspended sediment load over the heavily trawled central shelf area of Nantucket Shoals during all times except winter and early spring. The level of trawling activity declines dramatically going seaward across the outer shelf. This decline coupled with cross-shore water motins in the area appears to result in a net offshore transport of sediment of sediment across the shelf edge. However, the estimated magnitude of this transport indicates that trawling does not produce significant short-term erosion of outer shelf sediments.

Churchill, J.H. and P.C. Cornillon. 1991a. Gulf Stream water on the shelf and upper slope north of Cape Hatteras. Cont. Shelf Res. 11(5):409-431.

Abstract. By examining sea surface temperature distributions and hydrographic data collected over an 11-yr period, the authors have found that water discharged from the Gulf Stream often appears over the shelf and upper slope north of Cape Hatteras. For example, in the band between 36 and 38 degrees N, roughly 80-300 km north of the tip of Cape Hatteras, Gulf Stream water was detected 13-27% of the time at sites on the upper slope and 3-9% of the time at locations on the shelf. (30 Refs.).

Churchill, J.H. and P.C. Cornillon. 1991b. Water Discharged From the Gulf Stream North of Cape Hatteras. J. Geophys. Res. 96(C12):22227-22243.

Abstract. Satellite radiometer-derived sea surface temperature images together with moored instrument and hydrographic survey data indicate that water ejected from the Gulf Stream often occupies the upper 200 m of the water column over the continental slope between Cape Hatteras and Hudson Canyon. At times this water resembles the energetic Gulf Stream frontal eddies commonly seen to the south of Cape Hatteras. However, many of the observed parcels of this water differ markedly from frontal eddies and Gulf Stream warm-core rings and so appear to form a class of discharged Gulf Stream water distinct from any previously reported. These parcels generally cover a broad area (compared with frontal

eddies), contain relatively weak currents (generally <40 cm/s at 100 m), and are remarkably long-lived (sometimes distinguishable for more than 2 months). Salinity anomaly distributions indicate that despite their persistence, these water masses contain intrusions of and mix with surrounding lower-salinity water, particularly in the upper 50 m. Continuity of various tracers along σ_θ surfaces reveals that the discharged Gulf Stream water observed near the sea surface originated within the nutrient-gearing stratum of the Gulf Stream, having upwelled hundreds of meters along density surfaces. As a result, it tends to enhance nutrient concentrations over the continental slope, to a significant extent at 100 m depth but only marginally at 50 m depth. By contrast, this water does not carry unusually large kinetic energy densities into the slope region, but apparently gives up a good deal of kinetic energy, on the order of 10^4 cm^2/s^2 per unit mass, while leaving the Gulf Stream.

Churchill, J.H., P.C. Cornillon and G.W. Milkowski. 1986. Cyclonic eddy and shelf-slope water exchange associated with a Gulf Stream warm-core ring. J. Geophys. Res. 91(C8):9615-9623.

Abstract. Warm-core ring (WCR) 83D passed through a linear array of moored temperature, conductivity and velocity sensors during October 1983. Satellite-derived thermal imagery combined with data from the moored sensors have revealed a cold-core cyclonic eddy, of approximately 80-km diameter, traveling in advance of ring 83D. This cyclone, whose angular momentum magnitude was about 1/3 that of the WCR, evolved either during or shortly after the WCR's formation. Hydrographic and moored sensor data suggest that the WCR brought about a subsurface exchange of shelf and slope water, with near-surface slope water moving onshore and near-bottom shelf water being drawn offshore and around the ring. Examination of 308 cross-shelf hydrographic sections from the Middle Atlantic Bight has indicated that such exchange commonly occurs in the presence of a WCR. This apparent ring-induced exchange may significantly affect the overall salt balance of Middle Atlantic Bight shelf water. As an example, the volume of slope water within a well-surveyed intrusion, which lay onshelf of WCR 79B, was 16% of Wright's (1976) estimate of the annual slope water transport to the Middle Atlantic Bight shelf.

Churchill, J.H., E.R. Levine, D.N. Connors and P.C. Cornillon. 1992. Mixing of shelf, slope and Gulf Stream water over the continental slope of the Middle Atlantic Bight. Deep-Sea Res. In press.

Abstract. A combination of water masses was observed over the continental slope between Cape Hatteras and Hudson Canyon following the passage of a Gulf Stream meander. It is largely made up of fluid discharged from the Gulf Stream in the wake of the menader and also contained intrusions of Middle Atlantic Bight (MAB) shelf water and slope water. Its most prominent dynamical feature was an anticyclonic eddy that had an initial diameter of about 100 km but contained relatively weak currents, not greater than 30 cm/s in magnitude. Discharged Gulf Stream water made up the eddy's core, and a band of entrained shelf water circulated at its margin. This band was connected with another entrained shelf water band that flowed along the northern margin of the Gulf Stream. Transport of the shelf water at the edge of the eddy was estimated to be 1.3×10^5 m^3/s, which is comparable with the estimated alongshore transport of water over the MAB

shelf. Vigorous mixing of both shelf water bands with surrounding discharged Gulf Stream water is indicated by the large differences of the latter's T/S properties from those found within the Gulf Stream. These differences were used to estimate salt fluxes into the shelf water band at the edge of the anticyclonic eddy, with results in the range of 1.9-6.6 X 10_6 gm salt/cm^2/s. Density ratios and Richardson numbers determined from hydrographic data suggest that these salt fluxes were primarily the result of mixing by double diffusive processes, and that shear-induced turbulence combined with double diffusion to effect vertical mixing at the margins of the shelf water band next to the Gulf Stream.

Churchill, J.H., P.E. Biscaye and F. Aikman III. 1988. The character and motion of suspended particulate matter over the shelf edge and upper slope off Cape Cod. Cont. Shelf Res. 8(5-7):789-809.

Abstract. Time series of suspended particulate matter (SPM) concentration made by transmissometers deployed on the shelf edge and upper slope off New England are examined together with data from companion sensors. At the shelf-edge instrument cluster (on the 125-m isobath) the highest SPM concentrations were apparently due to sediment resuspended further onshore and advected to the transissometer by offshore motion of the shelf-edge density front. This was due to a tendency for more frequent episodes of high bottom stress, and thus more sediment resuspention, progressing onshore from the outer shelf. The decrease of surface wave current amplitude with depth was primarily responsible for this cross-shelf gradient in bottom stress.

Churchill, J.H., P.D. Cornillon and P. Hamilton. 1989. Velocity and Hydrographic Structure of Subsurface Shelf Water at the Gulf Stream's Edge. J. Geophys. Res. 94(C8):10791-10800, 11009-11010.

Abstract. Relatively cool and fresh water, originating from the Middle Atlantic Bight continental shelf, has often been found along the northwestern margin of the Gulf Stream. In this paper measurements of temperature, salinity, and velocity are made within subsurface filaments of entrained shelf water adjacent to the Gulf Stream. The data indicate that vertical mixing within and near these filaments is effected by double-diffusive processes and shear-induced turbulence. The measurements also reveal a complex velocity and hydrographic structure within the filaments and show that the character of individual filaments differed considerably.

Churchill, J.H., C.D. Wirick, C.N. Flagg and L.J. Pietrafesa. 1992. Sediment resuspension over the continental shelf east of the Delmarva Peninsula. Cont. Shelf Res. In press.

Abstract. Resuspension of sediment over the continental shelf east of the Delmarva Peninsula has been examined using records of light-beam attinuation, near-bottom current speed and surface-wave height spectra collected during 1988 and 1989. These data given evidence of a factor of three variation in the bottom stress threshold required for sediment resuspension at the outer shelf. This appears to be related to resuspension history as the largest thresholds are observed after lengthy periods without resuspension. Episodes of shelf-wide sediment resuspension are evidenced only during very intense atmospheric storms. A 7-month-long set of records from the 90 m isobath show storm-induced sediment

resuspension on only three occasions. The failure of storms of modest intensity to effect resuspension at the outer shelf is largely due to the decline of surface-wave currents with depth. High-frequency currents, presumably due to internal waves, are shown to be an important agent in initiating sediment motion at the shelf edge. On a number of occasions, supertidal currents pushed the near-bottom current speed measured near the seafloor at the 131 m isobath above the estimated level required for sediment resuspension. Numerous clouds of turbid water detected by the light-beam attenuation records could not be attributed to local sediment resuspension. A probability analysis indicates that some, but not all, of these could have resulted from sediment resuspension by bottom fishing.

Churgin, J. and S.J. Halminski. 1974. Temperature, salinity, oxygen, and phosphate in waters off United States, Volume I. Western North Atlantic: 171.

Abstract. Primarily a historical accounting of hydrographic and nutrient values for waters off the coasts of the United States. Provides comparative values for each of the regions.

Cione, J.J. 1992. The effects of surface forcing on mid-Atlantic winter cyclones. Master of Science Thesis. North Carolina State University. 120 pp.

Abstract. Mid-latitude cyclones develop off the Carolinas during winters and move north producing gale force winds, ice and heavy snow. It is believed that boundary layer and air-sea interaction processes are very important during the pre-cyclonic and development stages of these east coast storms. Due to the presence of the Gulf Stream, the marine boundary layer just offshore is highly baroclinic caused by warmer sea surface temperatures relative to the coastal waters. The offshore flow during cold air outbreak (CAO) periods initiates a strong heat flux distribution in the Western Atlantic Ocean that, over time, acts to vertically warm and moisten the atmosphere from below (Wittman, 1982; Vukovich et. al., 1991; Wayland and Raman, 1989; Holt and Raman, 1990). This airmass modification has been observed to substantially reduce regional stabilities over a time scale of 36 to 48 hours. This thesis looks into the effects the presence of the Gulf Stream off the Virginia and Carolina coastlines during the pre-storm environment potentially has on the intensification of coastal cyclones. The examination of nine years of data on the Gulf Stream position and east coast winter storms seems to indicate that the degree of low level baroclinicity and modification existing prior to a cyclonic event significantly affects the rate of cyclonic deepening off the mid-Atlantic coastline.

Cione, J.J., L.J. Pietrafesa, S. Raman and J. Churchill. 1991. The influence of Gulf Stream Location on Offshore Storm Intensification. EOS, Trans. AGU. 72(51):87.

Abstract. It has been observed that many east coast winter storms develop rapidly off the Cape Hatteras region and travel northward along the eastern seaboard. These storms are referred to as "bombs"; cyclonic disturbances that exhibit central pressure decreases greater than 24 millibars over a 24 hour period. However, these storms may also have a preferred region of localized deepest intensification. It is believed that the diabatic nature of the offshore atmospheric boundary layer acts in conjunction with upper level dynamic forcing

mechanisms to rapidly intensify these cyclones. The extreme wintertime baroclinic conditions occasionally existing off North Carolina may be the main reason for such localized deep intensification. A detailed storm data base of over 110 cyclones that traveled from the Carolinas to Delaware are used to address this hypothesis with particular emphasis on two of these storms which occurred during the SEEP-II field program.

Clarke, A.J. 1991. The dynamics of barotropic tides over the continental shelf and slope (Review). pp. 79-108. In B.B. Parker, ed. Tidal Hydrodynamics. John Wiley and Sons, Inc., New York.

Abstract. Because the continental shelf and slope form a large perturbation to the nearly constant-depth deep-sea bottom topography, the deep-sea ocean tide can be severely distorted over this topography. The basic interaction of the barotropic tide with a quasi-straight continental shelf and slope (i.e., one in which alongshore variations in coastline and bottom topography are large compared to the shelf width) can be described by simple analytical models. For the diurnal and semidiurnal tides, frictional effects are dynamically small and for $\omega > f$ (ω=tidal frequency, f=Coriolis parameter) inertia-gravity waves can propagate over the topography and constructively interfere. As a result, strong tidal amplification and even resonance can occur across wide continental shelves in mid and low latitudes. At resonance the coastal tidal sea level is large and there is a sharp change in sea level tidal phase. When $\omega < f$ no waves are available to propagate across the shelf and constructive interference cannot occur. Consequently, if alongshore effects are negligible, the tide's amplitude decreases from the shelf edge toward the coast. On very wide continental shelves this decay can be significant.

Clarke, T.L., B. Lesht, R.A. Young, D.J.P. Swift and G.L. Freeland. 1982. Sediment resuspension by surface-wave action: an examination of possible mechanisms. Mar. Geol. 49:43-59.

Abstract. Detailed spectral and coherence analyses of both nephelometer data and near-bottom acoustic concentration profiles support the conclusion of Lesht et al. (1980) that surface-wave activity is the most important input to the sediment resuspension process. The sand-sized fraction is suspended primarily by bursts of turbulence which are related to peak values of the envelope of surface waves. Two mechanisms for the resuspension of fine sediment are considered. When the bed is bimodal sand and silt, pore-water motion induced by wave-pressure fluctuations may carry fine particles into the boundary layer where they are suspended. Motion of the sand matrix as bedload will also expose fine particles to the flow so that they become suspended. The combination of these two mechanisms accounts for the observed quasi-linear relation between wave orbital velocity and suspended sediment concentration for the Long Island data. The second mechanism is also consistent with observations of near-bottom fluid velocity and suspended sediment concentration in Norton Sound, Alaska.

Coastal Engineering Research Center, MS. 1991. Data Summary for 1989 CERC Field Research Facility. Volume 1. Main Text and Appendixes A and B. CERC Tech. Rep. CERC-TR-91-9-Vol-1:123.

Abstract. This report provides basic data and summaries for the measurements made

during 1989 at the US Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) in Duck, NC. The report includes comparisons of the present year's data with cumulative statistics from 1980 to the present. The report summarizes meteorological and oceanographic data, monthly bathymetric survey results, samples of quarterly aerial photography, and descriptions of 17 storms that occurred during the year. The year was highlighted by a severe storm in March that destroyed or damaged over 100 ocean front structures. Waves with 4-m significant height were measured 6 km form shore. This report is eleventh in a series of annual summaries of data collected at the FRF that began with Miscellaneous Report CERC-82-16, which summarizes data collected during 1977-1979.

Coastal Plains Center for Marine Development Services. 1972a. An Environmental Inventory for the Coastal Plain and Adjacent Atlantic Waters of the Southeastern States, Part II, An index to coastal marine observations off the Carolinas and Georgia, Pub. 72-5, 191 pp.

Abstract. Inventory of data collected off N.C., S.C. and GA.

Coastal Plains Center for Marine Development Services. 1972b. An Environmental inventory for the Coastal Plain and Adjacent Waters of the Southeastern States, Part III, An index to hydrographic surveys for coastal and inshore waters of the Carolinas and Georgia, Pub. 72-6, 71 pp.

Abstract. Summary of hydrographic surveys.

Colucci, S.J. 1976. Winter cyclone frequencies over the eastern United States and adjacent western Atlantic, 1964-1973. Bull. Am. Meteorol. Soc. 57(5):548-553.

Abstract. Analyses of winter cyclone frequency and deepening rates are presented for a 10-year period over the eastern United States and western Atlantic Ocean. Results are presented for 1° latitude-longitude quadrangles. The analyses reveal a concentration of storms in a band from Cape Hatteras to New England, over the northern edge of the Gulf Stream current, and over the eastern Great Lakes. In addition, distinct minimums of winter cyclones are evident over the Appalachian Mountain range and, to a lesser degree, over the Florida peninsula. Analysis on a similar scale of 3 h pressure changes in these cyclones indicates that deepening was most favorable over the southern Appalachians, immediate Carolina coastal strip, the northern edge of the Gulf Stream, and the eastern Great Lakes. Significant positive or negative departures from normal winter precipitation along the East Coast of the United States may be attributed to anomalies in adjacent sea surface temperatures, as evidenced by investigation into precipitation data and offshore sea surface temperatures of three regions exhibiting such departures.

Condon, C. 1971. North Atlantic tropical cyclones, 1970. Mar. Weather Log. 15(1):5-12.

Abstract. Summarizes the statistics of four tropical storms and three hurricanes, including occurrence, location, and damages incurred.

Connors, D.N., E.R. Levine and H.T. Rossby. 1983. The isopycnal Swallow float: a tool for studying bathymetric influences on the Gulf Stream. EOS, Trans. AGU. 64(18):237.

Abstract. The preliminary field experiments in the upper main thermocline of the Gulf Stream North Wall were conducted using isopycnal-following Swallow Floats to tag water parcels. These instruments were converted into passive isopycnal followers by the addition of a spring-backed piston in a cylinder designed to give the float the compressibility of seawater. During August 1981, a spherical float was deployed 200 km downstream from Cape Hatteras and was tracked for approximately 100 km. Equilibrating in the oxygen minimum near 380m, the float tracked the $\sigma_t = 27.12 \pm .01$ as determined from CTD data during its passage through a mini-meander. During September 1982, a cylindrical float was tracked for approximately 100 km east of Cape Hatteras in the transition region between the Blake Plateau and the Hatteras Abyssal Plain. Deployed in the Gulf Stream near the 250m level, the float tracked the $\sigma_t = 26.74 \pm 0.1$ isopycnal surface during a gradual descent of 60m, and down-stream motion from a bottom depth of 2400m to 3200m over the 24 hour sampling period. The float telemetered temperature increased by 0.5°C indicating advection along isopycnal surfaces into the warmer water that was observed cross-stream.

Continental Shelf Associates, Inc. 1983a. North Carolina fisheries and environmental data search and synthesis study, Final Report, 21 June 1983, Executive Summary. (Contract No. AA851-CT-68) Continental Shelf Associates, Inc. Jupiter, FL. 18 pp.

Continental Shelf Associates, Inc. 1983b. North Carolina fisheries and environmental data search and synthesis study. (Contract No. AA851-CT1-68) Continental Shelf Associates, Inc. Jupiter, FL. 363 pp.

Abstract. Available information on the marine resources and habitats of the North Carolina OCS, from shore to a depth of 200 m (656 ft), was collected, annotated, and synthesized. Over 1,450 published and unpublished data sources were reviewed. Written synthesis chapters summarized the geology, oceanography, biological communities, commercial and sport fisheries, endangered and threatened species. and sensitive biological areas and unique habitats. Data gaps were identified, implications to OCS development were discussed, and suggestions for additional research were provided. In addition, a computer program was designed to catalog and sort all of the pertinent annotated information sources. The purpose of this computer program is to provide the MMS with a useful and viable method of maintaining, updating, and expanding the data base. The North Carolina OCS is a transition zone between the South and Middle Atlantic Bight. The climate, proximity and behavior of the Gulf Stream, and the presence of cuspate projecting shoals and capes influence unique oceanographic and biological features. Extensive hard/live bottom areas are present within Onslow Bay and along the North Carolina continental shelf edge. Upwelling along the North Carolina continental shelf edge and the intrusion of nutrient rich eddies into middle-and inner-shelf waters occur frequently along this coast. The upwelling-eddy, formation-intrusion phenomenon is not well understood and its ecological implications are just beginning to be studied. The present lack of knowledge in this area makes risk assessment for OCS development activities difficult. Additional studies of the coupling of physical and biological processes along the

North Carolina continental shelf are needed in order to formulate effective OCS management policies for that area.

Continental Shelf Associates, Inc. 1991. Ichthyoplankton in the vicinity of Manteo Area Block 467 from June to November 1990--Final Report--19 March 1991. Jupiter. 172 pp.

Cook, S.K. 1985. Temperature Conditions in the Cold Pool 1977-81: A Comparison between Southern New England and New York Transects. NOAA Tech. Rep. NOAA-TR-NMFS-24:29.

Abstract. Expendable bathythermograph data collected by the Ships of Opportunity (SOOP)-Ocean Monitoring Program are analyzed for seasonal and inter-annual variations of the cold pool. Two major SOOP transects within the Middle Atlantic Bight (Southern New England and New York) have been analyzed for the years common to both (1977-81). During the years 1977-81, over 200 transects were occupied, and almost 3,000 XBT's were dropped. Results show that the cold pool is formed with the onset of spring warming and persists until fall overturn, is consistent year to year in both area and weighted average annual temperature, and advects water from the northeast to the southwest.

Cooper, A.L., S.R. Chubb, J.R. Bennett and J.-S. Lee. 1991. Simulations of Radar Images of Modeled Gulf Stream Meanders. EOS, Trans. AGU. Suppl to 72(17):148-149.

Abstract. Simulated SAR and RAR images are computed numerically for a number of modeled Gulf Stream meanders. The Gulf Stream meanders are modeled by means of a Gaussian surface jet profile which is transversely displaced by a hyperbolic tangent function of streamwise distance. Realistic two-dimensional meanders of differing curvature are generated by varying the amplitude and the streamwise scale of the transverse displacement. The modulated spectral density of the ocean surface due to wave-current interaction is computed and SAR and RAR images are constructed for these meanders. The images are generated by means of an integrated hydrodynamic-electromagnetic model (EOM^2) which combines a full-spectrum numerical solution of the wave action equation with a two-scale composite backscattering model. The effects of wind direction and intensity, Gulf Stream intensity and curvature, look direction of the radar, and radar frequency are investigated.

Copeland, B.J. and J. Gray. eds. 1989. Albemarle-Pamlico Estuarine System, Preliminary Technical Analysis of Status and Trends. (Report 89-13A) UNC Sea Grant College Program and UNC Water Resources Research Institute. Raleigh. 341 pp.

Abstract. Study of North Carolina's sounds and estuaries.

Cordova, L. 1982. The Gulf Stream's western surface temperature front in the Atlantic Bight, 1976-78: Preliminary results from an empirical orthogonal function analysis. EOS, Trans. AGU. 63(45):983.

Abstract. Preliminary results from a study of 105 weekly Experimental Ocean Frontal Analysis Charts, produced by the U.S. Naval Oceanographic Office between

2 June 1976 and 31 May 1978, are reported. Basic statistics of the excursions of the front (as measured from a 64-week mean axis extending Cape Canaveral to Cape Hatteras) show appreciable changes between year-long subsets of the data. Estimates of standard deviations as well as extreme of the frontal amplitudes are presented. Empirical Orthogonal Function Analysis has provided 6 basic components of the front which account for 85% of the original variance. Their associated eigenvectors off a more compact assessment of the spatial variability and are used to generate time series whose spectra contain significant peaks in frequency bands centered near periods of 2.3, 3.2, 4.4, 6.0 and 17 weeks. A yearly band seems also present in the first five principal components.

Cordova, L. 1984. The Gulf Stream's Western Surface Temperature Front Between Cape Canaveral and Cape Hatteras, 1976-1978: Basic Statistical and Principal Component Analysis. Master of Science Thesis. University of North Carolina at Chapel Hill. 158 pp.

Abstract. A set of 105 weekly EOFACs (Experimental Ocean Frontal Analysis Charts, U.S. Naval Oceanographic Office, 02 June 1976 - 31 May 1978) has been used to generate maximal and minimal descriptions of the Gulf Stream's frontal shapes in the region between the Straits of Florida and Cape Hatteras, N. Carolina, known as the South Atlantic Bight (SAB). Both datasets have been processed in parallel to test for sensitivity of the analyses to sampling schemes. Small secular, oceanward trends of up to 10 km/year are detected in most of the original time series. The basic statistics show significant changes in frontal activity between year-long subsets of the data. Principal component analysis of the data matrices provides sets of five eigenvectors (containing waveforms with length scales of 200-400 km) that reduce the temporal description to five component series in each case, accounting for about 80 % of the original variances. These principal components have frequency spectra with dominant bands centered near periods of 2.4, 3.4, 4.6 and 6.1 weeks. An annual signal is presented in most of the series. Spacetime autocorrelations scales are O(100 km) and O(1 week), possibly related to Gulf Stream meanders; they also hint at motions with phase speeds of 40-140 km/week downstream and 37 km/week upstream. These results suggest that topographic waves may contribute to the variability scales observed. Manifest differences in the results overall point to a possible partition of the SAB into two dynamical subdomains, separated by the region off Charleston (S. Carolina).

Cornillon, P. and D.R. Watts. 1987. Satellite thermal infrared and inverted echo sounder determination of the Gulf Stream northern edge. J. Atmos. Oceanic Technol. 4(4):712-723.

Abstract. The northern edge of the Gulf Stream off Cape Hatteras, North Carolina was located in 155 AVHRR-derived maps of sea surface temperature (SST) using five different methods. One method was subjective location of the northern edge by an analyst; the other four involved objective location of the edge by computer using various statistics of the SST field. Specifically, the quantities considered were: maximum SST gradient (calculated over a 3 X 3 pixel box), maximum SST (on a pixel-pixel basis), maximum variance (calculated over a 7 X 7 pixel box), and change in the skewness of the SST distribution (calculated over a 5 X 5 pixel box). The resulting locations were compared with the location of the 15°C isotherm at 200 m (T_{15}) determined from inverted echo sounders (IESs)

moored on the sea floor. The best method, which yielded the smallest rms difference from the IES-derived T_{15}, was the subjective one; the surface front was located 9.0 km shoreward of T_{15} with a rms difference of 14.3 km. The best objective technique used the skew of the SST distribution: Each pixel in the image was replaced by the skew of the distribution of the twenty-five SST values obtained from a 5 X 5 pixel square centered on that pixel. The skew changes sign when a step in the SST data, such as the Gulf Stream northern edge, is crossed. The Gulf Stream northern edge located in the skew images was found to be 14.0 km shoreward of T_{15} in the mean with a rms difference of 18.2 km. In general, the more spatial information used the better the estimate.

Corson, W.D. and B.A. Tracy. 1985. Atlantic Coast Hindcast, Phase II Wave Information: Additional Extremal Estimates. Army Eng. WES Final Rep. WIS Report 15.

Abstract. Additional information about extreme wave conditions than that in earlier reports for the U.S. Army Corps of Engineers Wave Information Study (WIS) North Atlantic hindcast is provided.

Corson, W.D., D.T. Resio, R.M. Brooks, B.A. Ebersole, R.E. Jensen, D.S. Ragsdale and B.A. Tracy. 1981. Atlantic Coast hindcast, deepwater, significant wave information. U.S. Engineer Waterways Experiment Station Technical Report. Hydraulic Laboratory, Report No. WES-2:15.

Abstract. Hindcast deepwater statistics are provided based on the U.S. Army Corps of Engineers Wave Information Study (WIS) North Atlantic hindcast for the twenty year period, 1956-1975. Seasonal statistics covering significant wave heights computed from hindcast spectra, peak wave periods, and peak wave directions are provided for thirteen locations along the U.S. Atlantic coast. Provided results include percent occurrence tables, percent exceedance diagrams, wave height duration tables, wave rose diagrams, histograms of wave parameters (height, period, direction), return period diagrams, wave steepness diagrams, and mean and largest wave height tables.

Corson, W.D., D.T. Resio, R.M. Brooks, B.A. Ebersole, R.E. Jensen, D.S. Ragsdale and B.A. Tracy. 1982. Atlantic Coast Hindcast, Phase II, Significant wave information. Army Eng. WES Final Rep. WIS Report 6:1179.

Abstract. Report presents various analyses of the ACWIA Phase II hindcast, significant wave data using 20 years of data from 33 stations.

Craddock, J.E., R.H. Backus and M.A. Daher. 1992. Vertical distribution and species composition of midwater fishes in warm-core Gulf Stream meander/ring 82-H. Deep-Sea Res. 39:S203-S218.

Abstract. The integrated abundance and vertical distribution of midwater fishes in the upper 1000m of warm-core Gulf Stream ring 82-H show that the fauna of the ring was very similar to that of the northern Sargasso Sea. The data indicate that warm-core rings have a large impact on the fauna of the Slope Water even though only a small fraction of the volume of rings is mixed into the Slope Water and the fishes (mostly non-migratory) are located in the "unreactive" parts of the ring.

Crawford, K. ed. 1989. 1989 Marine Expo, The Natural Resources Associated with Mobil's Proposed Drill Site, October 6, 1989, Coastline Convention Center, Wilmington, North Carolina. N.C. Outer Continental Shelf Office, N.C. Department of Administration. Raleigh. 64 pp.

Abstract. The Marine Expo is a bi-annual event that features both commercial and non-profit educational exhibits to increase citizen awareness of how coastal resources affect people's lives and vice-versa. On Friday, October 6, the Expo sponsored a seminar on the marine resources that exist at the site of Mobil Oil's proposed test well. The workshop, coordinated by Dr. James Merritt at UNC-Wilmington, featured speakers from universities, state agencies and federal agencies with expertise on the geology, oceanography and biology of the site.

Cronin, M. and D.R. Watts. 1991. Energetics of the Gulf Stream at 68°W. EOS, Trans. AGU. 72(51):57.

Abstract. From June 1988 to August 1990 twelve tall, high-performance, current meter moorings measured the velocity and temperature fields at nominal depths of 400m, 700m, 1000m, and 3500m along three lines centered at 68°W. Two of these lines spanned the mean Eulerian Gulf Stream, making it possible to compute the full energy budget for the Gulf Stream flow at 68°W. In the preliminary analysis, at each level, local planes were fit to groups of moorings to represent the mean temperature and velocity fields and Reynolds stress and temperature flux fields. These fields were then used to estimate the 1) advection of the kinetic energy the mean flow (MKE), 2) advection of the eddy kinetic energy (EKE), 3) advection of the eddy potential energy (EPE), 4) the radiation of MKE, 5) the conversion of MKE into EKE (due to barotropic instability) and 6) the conversion of MPE into EPE (due to baroclinic instability).

Cronin, M., E. Carter and D.R. Watts. 1991. Prediction of the Gulf Stream path from upstream parameters. J. Geophys. Res. 97(C5):7257-7269.

Abstract. A linear Wiener (least squares optimal) filter is used to predict the path of the Gulf Stream in the region between Cape Hatteras and 70°W using upstream ("Inlet") conditions as filter inputs. Although positions, angle, curvature, geostrophic velocity, and curvature vorticity (*kv*) measured at 73°W were tested as multiple Inlet parameters, it was found that Inlet position alone was the best predictor. With Inlet position as the predictor, this filter is equivalent to propagating meanders downstream with a typical phase speed and growth rate. Forecasts of the downstream path position are produced, more accurate than persistence, 12 days in advance at 140 km from the Inlet, 24 days in advance at 240 km from the Inlet, and 28 days in advance at 340 km from the Inlet.

Cronin, M., E. Carter and D.R. Watts. 1992. Prediction of the Gulf Stream Path From Upstream Parameters. J. Geophys. Res. 97(C5):7257-7269.

Abstract. A linear Wiener (least squares optimal) filter is used to predict the path of the Gulf Stream in the region between Cape Hatteras and 70°W using upstream ("Inlet") conditions as filter inputs. Although position, angle, curvature, geostrophic velocity, and curvature vorticity measured at 73°W were tested as multiple Inlet parameters, it was found that Inlet position alone was

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Crowson, R.A., W.A. Birkemeier, H.M. Klein and H.C. Miller. 1988. SUPERDUCK Nearshore Processes Experiment: Summary of Studies, CERC (Coastal Engineering Research Center) Field Research Facility. CERC Tech. Rep. :115.

Abstract. During September and October 1986, the US Army Engineer Waterways Experiment Station's Coastal Engineering Research Center (CERC) hosted SUPERDUCK, a nearshore processes experiment, at its Field Research Facility located at Duck, North Carolina. The objectives of SUPERDUCK were to develop an improved understanding of coastal processes (currents, waves, sediment transport, and nearshore geomorphology) under a wide variety of conditions and to collect data essential to the development of improved numerical models of coastal phenomena. SUPERDUCK benefited from the cooperative efforts and resources of engineers and scientists from CERC, 6 other government agencies, 10 universities, 3 foreign countries, and 15 Corps of Engineers district and division offices. This report describes the 30 experiments that comprised SUPERDUCK and summarizes the data sets collected. SUPERDUCK was organized into three phases: a nonstorm wave phase conducted during September, a storm wave phase carried out during October, and an all-weather phase. This is the first in a series of reports which will be published summarizing the data and findings of this unique effort.

Csanady, G.T. 1976. Mean circulation in shallow seas. J. Geophys. Res. 81:5389-5399.

Abstract. Summarizes the classical mixing-length theory, combining it with observations to produce an estimate of vertical eddy viscosity that is proportional to water depth in a well-mixed region.

Csanady, G.T. 1978. The arrested topographic wave. J. Phys. Oceanogr. 8:47-62.

Csanady, G.T. 1979a. The pressure field along the western margin of the North Atlantic. J. Geophys. Res. 84(C8):4905-4915.

Abstract. The surface elevation field over a shelf-slope region is subject to a parabolic differential equation, the timelike coordinate being longshore distance in the direction of propagation of vorticity waves. Two source terms in this equation contain long-isobath and cross-isobath density gradients. In the absence of long-isobath variations the particular solution of the equation containing the cross-isobath density gradient source term describes a steric setup distribution, which represents a plausible extension of the dynamic height method to shallow water. When long-isobath variations of density are also present, the steric setup solution is complemented by a residual field, which is essentially a diffusive smoothing out of the steric setup distribution. The steric setup distribution calculated for the shelf-slope region of the Northwest Atlantic from Cape Hatteras to the Grand Banks shows two major features: a mound of water associated with the St. Lawrence outflow and a rapid drop at the shelf

break associated with an upper slope mean current having a surface velocity of the order of 20 cm/s. The effects of the St. Lawrence outflow are felt mainly over the Scotian Shelf and in the Gulf of Maine. The shelf break current is apparently a boundary layer component of the cyclonic gyre between the Gulf Stream and the North American mainland.

Csanady, G.T. 1979b. What drives the waters of the continental shelves? Oceanus. 22(2):28-35.

Abstract. Reviews the hydrography of the East Coast continental shelf for application to power plant siting issues.

Csanady, G.T. 1982. Circulation in the Coastal Ocean. D. Reidel Publishing Company. Dordrecht, Holland. 279 pp.

Csanady, G.T. 1984a. Circulation induced by river inflow in well-mixed water over a sloping continental shelf. J. Phys. Oceanogr. 14(11):1703-1711.

Abstract. The pressure field over a sloping continental shelf subject to freshwater runoff at the coast can be resolved into a nearly two-dimensional dynamic height field and a residual field, the latter arising from the interaction of baroclinity and topography. The residual field is essentially three-dimensional and so constituted as to supply the fluid for the baroclinic alongshore flow off a coastal source of buoyancy associated with the cross-isobath density gradients. The intensity of the induced residual circulation (its total transport in m^3/s) varies directly with the buoyancy input and bottom slope, and inversely with the zero-order alongshore flow velocity and Coriolis parameter. Over the Mid-Atlantic Bight continental shelf the runoff-induced residual circulation makes a generally weak contribution to the observed mean flow field. It could, however, be more important over a low-latitude shelf subject to high runoff.

Csanady, G.T. 1984b. Influence of wind stress and river runoff on a shelf front. J. Phys. Oceanogr. 14(8):1383-1392.

Abstract. Runoff from land gives rise to the formation of a front-jet system separating fresher coastal waters from more saline waters offshore, over some continental shelves, notably in the Mid-Atlantic Bight in winter. Three first-order characteristics of such fronts are the anchor depth H, where the front intersects the bottom, the stretch l, i.e., the distance between its surface and bottom intersections, and the buoyancy contrast b across the front. The three characteristics may be determined from the cross-front property transfer rate, the along-front momentum balance, and the turbulence-energy dissipation rate. Key independent variables are the horizontal buoyancy transport B_x, the friction velocity u_* and direction θ of the wind, and the Coriolis parameter f.

Csanady, G.T. 1988. Radiation of topographic waves from Gulf Stream meanders. Cont. Shelf Res. 8(5-7):673-686.

Abstract. In a two-layer model of the Gulf Stream and underlying cold water mass, meander formation and pinch-off generates substantial pressure torque on the interface. This transfers vorticity to the lower layer and acts, over a sloping

sea floor, as a source term for topographic waves. The source intensity is proportional to the Jacobian of surface pressure and interface elevation. Other possible source terms (interfacial or bottom shear stress curl or horizontal momentum flux divergence) are dwarfed by the pressure torque. Model calculations show that individual meander pinch-off events radiate topographic waves with characteristics very much as observed. The radiation field is quite unlike a plain monochromatic wave: the perceived frequency of oscillations varies in proportion to distance from the source.

Csanady, G.T. 1989. Energy dissipation and upwelling in a western boundary current. J. Phys. Oceanogr. 19(4):462-473.

Abstract. Energy dissipation in a western boundary current begins with the conversion of mean potential energy into kinetic energy of 'primary' eddies. The rate of this energy conversion is taken to equal the total energy dissipation rate, in analogy with the energy cascade of laboratory turbulence. The growth of primary eddies is due to baroclinic instability, and implies the rising of relatively light fluid, sinking of heavy fluid. An inviscid, nondiffusive model adequately describes this process and yields a quantitative relationship between the dissipation rate and upward-downward motions. In statistically steady flow, an eddy mass transport arises from the correlation of cross-stream velocity and isentropic layer thickness which is proportional to the energy dissipation rate. In this manner, the rate of upwelling of upper thermocline fluid and/or the downwelling of heavier fluid comes to determine the energy dissipation rate. Conversely, a given energy dissipation rate implies upwelling or downwelling of specific intensity. A simple parameterization scheme for eddy mass transport similar to that suggested by Green for the atmospheric jet stream gives results in accord with the meager experimental evidence on western boundary upwelling. (26 Refs.).

Csanady, G.T. and P. Hamilton. 1988. Circulation of Slope Water. Cont. Shelf Res. 8(5-7):565-624.

Abstract. The recently conducted Mid-Atlantic Slope and Rise (MASAR) experiment yielded much new information on the structure and behavior of slopewater, the water mass occupying the upper "Slope Sea", a narrow band of ocean between the Gulf Stream and the continental shelf from Cape Hatteras to the Grand Banks. The results of this experiment, combined with earlier evidence, have been used to construct empirical schema of slopewater circulation. Key features are:(1) inflow of Coastal Labrador Sea Water (CLSW) across the Grand Banks at the rate of 4 X 10^6 m^3/s, and isopycnal advection from the Gulf Stream thermocline at the rate of 6 X 10^6 m^3/s, the total draining eastward; (2) a closed cyclonic gyre in the western Slope Sea, transporting approximately 3 X 10^6 m^3/s along the New Jersey coast southward; and (3) seasonal formation of pycnostad by convective overturn and its flushing in approximately 6 months.

Csanady, G.T. and P.-T. Shaw. 1983. The "insulating" effect of a steep continental slope. J. Geophys. Res. 88(C12):7519-7524.

Abstract. Geochemical evidence shows that the midcontinental slope off the Mid-Atlantic Bight constitutes an important sink for substances attached to fine particles, partially explained by the weakness of the near-bottom current which

allows settling out and incorporation of fine particles into permanent sediment.

Csanady, G.T., J.H. Churchill and B. Butman. 1988. Near-Bottom Currents over the Continental Slope in the Mid-Atlantic Bight. Cont. Shelf Res. 8(5-7):653-671.

Abstract. From a set of 28 current meter records we have found that near-bottom currents faster than 0.2 m/s occur frequently over the outer continental shelf of the Mid-Atlantic Bight (bottom depth <210 m) but very rarely (<1% of the time) between bottom depths of 500 m and 2 km over the slope. The rarity of strong near-bottom flow over the middle and lower slope allows the accumulation of vine-grained sediment and organic carbon in this region. Fast near-bottom currents which do occur over the slope are invariably associated with topographic waves, although it is often superimposed inertial oscillations which increase current speed above the level of 0.2 m/s. Episodes of intense inertial oscillations occur randomly and last typically for 10-20 days. Their energy source is unknown. Topographic wave energy exhibits a slight, but statistically significant, minimum over the mid-slope. These waves appear irregularly and vary both along isobaths and in time. The irregularity is presumably a consequence of random topographic wave generation by Gulf Stream instability. The current regime within sea-floor depressions in the slope (canyons and gullies) is distinctly different from that of the open slope; most notable is the near absence of topographic wave motion within depressions.

Curtin, T.B. 1979a. Oceanographic Field Observations Off North Carolina-Fall Survey-1-11 November 1977, Ocean Outfall Waste Water Disposal Feasibility and Planning Study, Report Number 79-5. Department of Marine Science and Engineering, North Carolina State University. Raleigh. 248 pp.

Abstract. The objectives of the oceanographic field observations within the overall Ocean Outfall Feasibility and Planning Study (Langfelder, et al., 1979) were both to provide input data for boundary condition initialization and to provide reference data for diagnostic testing of a series of coastal numerical circulation models under development. The data acquisition program was designed to parallel the model development in that a series of successive scales of variability were addressed. Of particular overall interest in this project, with its ultimate focus on the nearshore coastal environment, was the interaction of the larger regional scale processes with those on smaller or local scales.

Curtin, T.B. 1979b. Oceanographic Field Observations Off North Carolina-Spring Survey-12-22 May 1978, Ocean Outfall Waste Water Disposal Feasibility and Planning Study, Report Number 79-4. Department of Marine Science and Engineering, North Carolina State University. Raleigh. 241 pp.

Abstract. The objectives of the oceanographic field observations within the overall Ocean Outfall Feasibility and Planning Study (Langfelder, et al., 1979) were both to provide input data for boundary condition initialization and to provide reference data for diagnostic testing of a series of coastal numerical circulation models under development. The data acquisition program was designed to parallel the model development in that a series of successive scales of variability were addressed. Of particular overall interest in this project, with its ultimate focus on the nearshore coastal environment, was the interaction of the larger regional scale processed with those on smaller or local scales.

Curtin, T.B. 1979c. Oceanographic Field Observations Off North Carolina-Summer Survey-2-12 August 1977, Ocean Outfall Waste Water Disposal Feasibility and Planning Study, Report Number 79-2. Department of Marine Science and Engineering, North Carolina State University. Raleigh. 303 pp.

Abstract. The objectives of the oceanographic field observations within the overall Ocean Outfall Feasibility and Planning Study (Langfelder, et al., 1979) were both to provide reference data for diagnostic testing of a series of coastal numerical circulation models under development. The data acquisition program was designed to parallel the model development in that a series of successive scales of variability were addressed. Of particular overall interest in this project, with its ultimate focus on the nearshore coastal environment, was the interaction of the larger regional scale processes with those on smaller or local scales.

Curtin, T.B. 1979d. Oceanographic Field Observations Off North Carolina-Winter Survey-2-12 February 1978, Ocean Outfall Waste Water Disposal Feasibility and Planning Study, Report Number 79-3. Department of Marine Science and Engineering, North Carolina State University. Raleigh. 148 pp.

Abstract. The objectives of the oceanographic field observations within the overall Ocean Outfall Feasibility and Planning Study (Langfelder, et al., 1979) were both to provide input data for boundary condition initialization and to provide reference data for diagnostic testing of a series of coastal numerical circulation models under development. The data acquisition program was designed to parallel the model development in that a series of successive scales of variability were addressed. Of particular overall interest in this project, with its ultimate focus on the nearshore coastal environment, was the interaction of the larger regional scale processes with those on smaller or local scales.

Curtin, T.B. and L.J. Pietrafesa. 1978. Oceanographic observations across the northern Gulf Stream. Sci. Engr. Rep. 78(3):388.

Curtin, T.B., L.J. Pietrafesa and N.E. Huang. 1978. Concurrent satellite and ship observations across the Gulf Stream north of Cape Hatteras. Unpubl. manuscript.

Abstract. Temperature values obtained by satellite and ship provide the surface thermal structure for a section of the Gulf Stream. Brief comparison of the data is provided.

Cushman-Roisin, B. 1987. On the Role of Heat Flux in the Gulf Stream-Sargasso Sea Gyre System. J. Phys. Oceanogr. 17(12):2189-2202.

Abstract. In contrast with the traditional view of midlatitude circulation driven by winds in the ocean interior and regulated by friction along the western boundary, it is hypothesized that some control can be attributed to surface cooling acting primarily in a recirculation region off the western boundary current. Several arguments suggest that this mechanism and the generation of eddies are the two major reactions of the midlatitude ocean under the action of the surface winds.

Daifuku, P.R. and R.C. Beardsley. 1983. The K_1 tide on the continental shelf from Nova Scotia to Cape Hatteras. J. Phys. Oceanogr. 13(1):3-17.

Abstract. A description is given of the K_1 tide over the northeast continental shelf off North America from Nova Scotia to Cape Hatteras. Analyzed pressure data obtained from W. Brown and J. Irish (University of New Hampshire) have been used to draw up the K_1 cotidal map and existing current data have been analyzed to give the associated velocity map. Offshore, there is a sweep of the tide from north to south, in general agreement with what is known of the oceanic K_1 tide in the North Atlantic. On the shelf, there is a trapping of phase lines to the coast, creating, in particular, a virtual amphidrome south of Cape Cod. Maximum amplitudes of around 15 cm are found in the Gulf of Maine, lowest around 7 cm south of Cape Cod. The K_1 currents are generally barotropic and current ellipses are aligned with the local topography. Maximum currents of about 10 cm/s are found south of Cape Cod. A simple model from the K_1 pressure field is developed using the free and forced inviscid barotropic waves on a two-dimensional shelf. The theoretical solutions are fitted to the K_1 pressure data using a least-squares method. The model results confirm that the K_1 tide is composed of both a Kelvin wave and a shelf wave, with the Kelvin wave dominating the pressure field, and the shelf wave dominating the current field. The two free waves account for 99% of the variance of the difference of the observed pressures and the calculated forced wave, but unfortunately some of the observed features are not accurately reproduced. Possible model improvements should include the addition of bottom friction and longshore topographic variations (especially the changes in shelf geometry associated with the Gulf of Maine).

Davis, C.W. 1979. Bottom-Water Temperature Trends in the Middle Atlantic Bight during Spring and Autumn, 1964-76. NOAA Tech. Rep. NOAA-TR-NMFS-SSRF-739:21.

Abstract. Annual variations of bottom-water temperatures on the continental shelf between Cape Cod and Cape Hatteras were examined for the spring and autumn from 1964 to 1976. Temperatures generally were highest since 1972 during both seasons. For waters between Cape Cod and Hudson Canyon, maximum temperatures occurred in the spring of 1976 (8.3C) and autumn of 1972 (12.8C); between Cape Hatteras and Hudson Canyon, temperatures peaked in the spring of 1974 (9.0C) and the autumn of 1972 (15.7C).

Dean, R.G. and M. Perlin. 1986. Intercomparison of near-bottom kinematics of several wave theories and field and laboratory data. Coastal Engineering. 9:339-437.

DeAngelis, R.M. and W.T. Hodge. 1972. Preliminary Climatic Data Report Hurricane Agnes June 14-23, 1972. NOAA Tech. Memo. NOAA-TM-EDS-NCC-1:67.

Abstract. The report gives a preliminary description of Hurricane Agnes June 14-23, 1972, and its disastrous consequences. Hurricane Agnes caused one of the worst natural disasters in United States history. Record-breaking rains caused floods from North Carolina to New York. Hardest hit were Pennsylvania, New York, Virginia, and Maryland. Florida was beset with storm tides and tornadoes. Details are given concerning the storm history, the climatology, weather records from ship land and aircraft reconnaissance reports, and from remotely sensed observations (radar and satellite). Data are given on extremes of pressure, wind,

tides and rainfall. New records were established. Appendixes provide a chronology of the hurricane, maps of rainfall, surface weather maps, and preliminary flood stage and crest data.

Deaver, J.W. 1975. Aerial Oceanographic Observations, July 1969 - June 1970, Cape Cod, Massachusetts to Miami, Florida. USCG Oceanogr. Rep. USCG-373-68:32.

Abstract. Sea surface temperatures (SST) for July 1969 to June 1970 from Cape Cod, Massachusetts to Miami, Florida were measured during Coast Guard Airborne Radiation Thermometer (ART) monthly surveys. A total of 12 airborne surveys were conducted along more than 6,800 kilometers of transects covering approximately 130,000 square kilometers of Atlantic coastal waters each month. Twelve monthly SST isotherm charts are presented which were contoured from these data. The coastal SST distribution and seasonal variation is analyzed on a time-space grid. The thermal front associated with the Gulf Stream between Cape Hatteras, North Carolina and Miami, Florida was tracked by ART and appeared to parallel the 183 meter isobath. Distributions of certain marine animal are presented as a function of temperature and latitude.

Deibel, D. 1985. Blooms of pelagic tunicate, Dolioletta gegenbauri: Are they associated with Gulf Stream frontal eddies? J. Mar. Res. 43(1):211-236.

Abstract. Satellite-directed sampling was used to determine whether blooms of Dolioletta gegenbauri are associated with warm filaments of Gulf Stream frontal eddies. Radio-transmitting drogues were used to mark the center of the bloom so that physical and biological covariables could be measured inside and outside of bloom waters.

DeRycke, R.J. and P.K. Rao. 1973. Eddies along a Gulf Stream boundary viewed from a very high resolution radiometer. J. Phys. Oceanogr. 3(4):490-492.

Abstract. Pronounced eddies along the western edge of the Gulf Stream were observed by the Very High Resolution Radiometer aboard the NOAA-2 satellite. Similar eddies were seen on one previous occasion. In each case, there was an apparent relationship between the occurrence of the eddies and strong westerly winds. These eddies can also be attributed to the bottom topography of the region and the baroclinic instability along the Gulf Stream boundary.

Dewar, W.K. and J.M. Bane Jr. 1989a. Gulf Stream Dynamics. Part I: Mean flow dynamics at 73°W. J. Phys. Oceanogr. 19(10):1558-1573.

Abstract. During 1984, five current meter moorings measured velocity and temperature in the Gulf Stream anticyclonic flank at a location approximately 250 km downstream of Cape Hatteras. The data are used to analyze the energy budgets of the Gulf Stream mean flow with a view towards examining Gulf Stream vertical structure and inertial character.

Dewar, W.K. and J.M. Bane Jr. 1989b. Gulf Stream Dynamics, Part II: Eddy energetics at 73°W. J. Phys. Oceanogr. 19(10):1574-1587.

Abstract. Pointwise energy balances in the Gulf Stream system at 73°W (downstream of Cape Hatteras) are examined. Five current meter mooring and temperature data

at four different depths for approximately one year. The data were used to estimate eddy kinetic and potential energy flux divergences and the rates of energy conversion between the eddy and mean fields in both the Gulf Stream and the Deep Western Boundary Current. A hypothesis of eddy field dynamics in the vicinity of the Gulf Stream from the Florida Straits through the Gulf Stream extension is proposed.

Dewar, W.K. and G.R. Flierl. 1985. Particle trajectories and simple model of transport in coherent vortices. Dyn. Atmos. Oceans. 9(3):215-252.

Abstract. Particle trajectories and transport effects of coherent vortices are computed and a number of advection and diffusion experiments using a time-dependent dynamical ring model are analyzed. Loss rates from the ring trapped zone are also estimated, which permits calculation of cross-Gulf Stream chemical and biological fluxes due to ring formation.

Dickson, S.M. 1985. Late Quaternary Evolution of the Northern Hatteras Abyssal Plain. Master of Science Thesis. Univ. of Rhode Island, Kingston. 230 pp.

Dirks, R.A., J.P. Kuettner and J.A. Moore. 1988. Genesis of Atlantic Lows Experiment (GALE): An Overview. Bulletin of the American Meteorological Society. 69(2):148-160.

Abstract. The field phase of the Genesis of Atlantic Lows Experiment (GALE) was conducted from 15 January to 15 March 1986. The objectives of GALE were to study mesoscale and air-sea interaction processes in East Coast winter storms, with particular emphasis on their contributions to cyclogensis. The project area, special observing systems, and field operations are described. There were thirteen special observing periods during the field phase including eight cases of cyclogensis. Meteorological and oceanographic phenomena on which special observations were collected include: cyclogensis, rainbands, cold fronts, coastal fronts, cold-air outbreaks, lightning and marine boundary layer interactions with Gulf Stream and mid-shelf oceanic fronts. Preliminary research findings and operational implications are presented. GALE data documents are listed. The GALE data set is open to all interested scientists.

Doebler, H.J. 1966. A Study of Shallow Water Wind Drift Currents at Two Stations Off the Coast of the United States. Master of Science Thesis. Univ. of Rhode Island, Kinston. 78 pp.

Douglas, B.C., R.E. Cheney and R.W. Agreen. 1983. Eddy energy of the northwest Atlantic and Gulf of Mexico determined from GEOS 3 altimetry. J. Geophys. Res. 88(C14):9595-9603.

Abstract. From May 1975 to October 1978 the GEOS 3 satellite altimeter made numerous repeated observations of sea surface topography in the northwest Atlantic and Gulf of Mexico. By comparing members of about 1000 collinear pairs of altimeter profiles, we have determined mesoscale sea height variability and eddy kinetic energy in these ocean regions. Our results agree qualitatively with estimates made from traditional oceanographic surveys, but significant quantitative differences exist in certain areas, especially in the Gulf Stream between Florida and Cape Hatteras where the altimetric results show less

variability. The reason for this appears to be due to differences in spatial sampling. Historical oceanographic measurements are relatively sparse and must be aggregated into small geographic boxes to compute variability statistics. Results therefore represent a combination of temporal and spatial variability. In contrast, repeated satellite altimeter tracks provide point measurements of changes of sea height and slope. This enables determination of temporal variability alone, a quantity more representative of eddy energy. It is important to make this distinction between space and time because in regions of strong horizontal gradient such as the Gulf Stream, spatial variability can exceed the temporal component. In mid-ocean where spatial variability is negligible, altimetric and oceanographic results are in excellent agreement.

Doyle, J.D. 1991. An observational and numerical investigation of mesoscale coastal processes during GALE IOP 2 (Genesis of Atlantic Lows Experiment, coastal processes). Ph.D. Thesis. The Pennsylvania State University. 272 pp. (Advisor: Warner, TT; DAI 52/04B, p.2095; AAC9127316)

Abstract. A detailed analysis of the conventional and special observations taken during Intensive Observation Period 2 (IOP 2) of the Genesis of Atlantic Lows Experiment (GALE), and results from one- (1-D), two- (2-D), and three-dimensional (3-D) numerical model simulations using idealized and observed data are used to examine the structure, evolution, dynamics, and interactions of the coastal low-level jet (LLJ), marine atmospheric boundary layer (MABL), coastal front, and coastal cyclone, during a 72-h period between 23-26 January 1986. In one series of experiments, the Penn State/National Center for Atmospheric Research (PSU/NCAR) mesoscale model is initialized with idealized data to study the MABL near the Gulf Stream. Important contributors to the MABL response and frontal structure are the horizontal resolution of the sea surface temperature analysis, latent heat release in the lower troposphere, sea-surface fluxes of moisture, and high wind speeds near the MABL front. During GALE IOP 2, a diurnally varying, low-level northeasterly jet was observed along the Carolina Coastal Plain. Results from a 3-D real-data simulation and from a 1-D planetary boundary layer model show that the LLJ is a manifestation of strong low-level geostrophic forcing, with its strength and direction modulated by inertial accelerations. A large daytime speed reduction results from a rapid increase in the frictional stress at the jet level. Coastal frontogenesis takes place near the eastern edge of the Gulf Stream, coincident with a preexisting low-level coastal trough. Large sensible heat and moisture fluxes, present along the Gulf Stream, contribute directly to the trough formation. The ageostrophic deformation associated with the coastal trough formation may initiate the coastal frontogenesis. In the formative stage of the coastal front, the frontogenetical deformation over the Gulf Stream is opposed by the frontolytical differential diabatic effects. As the coastal front moves near the coastline, the deformation and differential diabatic terms act in concert to intensify the baroclinic zone. Along the coastal front, the frontogenetical deformation over the Gulf Stream is opposed by the frontolytical differential diabatic effects. As the coastal front moves near the coastline, the deformation and differential diabatic terms act ln concert to intensify the baroclinic zone. Along the coastal front, a small-scale, shallow, warm-core cyclone develops in a region of weak quasi-geostrophic forcing. The baroclinic zone to the rear of the cyclone is substantially weakened and embedded in an environment less conducive for subsequent rapid cyclogenesis.

Drake, D.E. 1976. Suspended sediment transport and mud deposition on continental shelves. pp. 127-158. In D.J. Stanley and D.J.P. Swift, eds. Marine Sediment Transport and Environmental Management. John Wiley and Sons, New York.

Drijfhout, S.S. 1992. Ring Genesis and the Related Heat Transport. Part II: A Model Comparison. J. Phys. Oceanogr. 22(3):268-285.

Abstract. Various ocean circulation models have been compared with respect to their performance in the genesis of rings and the subsequent heat transport. Emphasis has been placed on the role of the spurious diapycnal fluxes of heat and momentum in Cartesian models, arising when the horizontal dissipation mixes through sloping isopycnals. Quasigeostrophic, isopycnal coordinate, and Cartesian primitive equation models in a two-layer periodic channel domain have been used to simulate the process of eddy detachment from an eastward-flowing jet. This jet is modeled after the Gulf Stream east of Cape Hatteras. On this jet a small sinusoidal disturbance is superimposed, which, through the release of available potential energy, grows until it ultimately has developed into ringlike eddies. Simulations with the Cartesian primitive equation model appear to suffer from spurious diapycnal mixing of both heat and momentum. This retards the process of Rossby wave breaking and prolongs the growth of the meander, thus causing a double heat transport at 10-km resolution, compared to a 5-km resolution experiment. The isopycnic model does not show this degree of overshoot in heat transport. In general, the Cartesian model is much more sensitive to both resolution and closure formulation than the isopycnic model. The quasigeostrophic model does not simulate the small-scale processes of Rossby wave steepening and breaking correctly. However, as a consequence the diapycnal mixing of heat and momentum hardly affects these processes. For this reason, the quasigeostrophic model does not show an overshoot in heat transport.

Duane, D.B. 1962. Petrology of recent bottom sediments of the western Pamlico Sound region, North Carolina. Ph.D. Thesis. University of Kansas, Lawrence. 108 pp.

Duane, D.B., M.E. Field, E.R. Meisburger, D.J.P. Swift and J.S. Williams. 1972. Linear shoals on the Atlantic inner continental shelf, Florida to Long Island. pp. 477-498. In D.J.P. Swift, D.B. Duane and O.H. Pilkey, eds. Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Ross, Stroudsburg.

Abstract. The inner Atlantic continental shelf from Long Island to Florida is characterized by fields of linear, northeast trending shoals. The shoals exhibit up to 30 ft of relief, have side slopes of a few degrees and extend for tens of miles. Clusters of linear shoals merge with the shoreface in water as shallow as 10 ft. Most of the shoals out to depths of 120 have been examined by means of seismic profiling, presicion depth profiling, grab sampling, coring; current monitoring has been conducted on a few shoals. These inner-shelf sand bodies or shoals can be grouped as arcuate (inlet and cape-associated) and linear. Linear shoals sand may radiate from estuary mouths, as a second order structure on arcuate, inlet-associated shoals, or may orrur on the open coast. Linear shoals on the open coast may be shoreface-connected or isolated. All linear shoals of the open coast form a small angle (most < 35°) with the coast line; most open northward regardless of presumed direction of net littoral drift. Seismic

reflection profiles show the linear and arcuate cape associated shoals to be plano-convex features, some exhibiting internal inclined bedding structures, resting upon a featureless, nearly horizontal stratum.

Dunstan, W.M. and L.P. Atkinson. 1976. Sources of new nitrogen for the South Atlantic Bight. pp. 69-78. In M. Wiley, ed. Estuarine Processes. Academic, Orlando.

Earle, M.D. 1975. Oceanographic design conditions for Diamond Shoals Light Tower. Naval Oceanographic Office Tech. Note. No. 6110-3-75:47.

Abstract. An extreme event numerical wave hindcast of all severe extratropical storms and hurricanes that affected Cape Hatteras between 1944 and 1973 was performed. Wave directional spectra and extreme event statistics are provided at Diamond Shoals Light Tower. Results include estimated design waves, storm surges, and currents. Storm surges and currents were calculated with a simplified bathystrophic storm surge model. Typical wave conditions are summarized based on ship wave observations.

Earle, M.D. and D.A. Burns. 1975. Oceanographic design conditions for offshore light towers. Naval Oceanographic Office Tech. Note. No. 6110-3-75:47.

Abstract. An extreme event numerical wave hindcast of all severe extratropical storms and hurricanes that affected the U.S. east coast between 1944 and 1973 was performed. Wave directional spectra and extreme event statistics are provided at Chesapeake Bay, Frying Pan Shoals, Ambrose, and Buzzards Bay Light Towers. Results include estimated design waves, storm surges, and currents. Storm surges and currents were calculated with a simplified bathystrophic storm surge model. Typical wave conditions are summarized based on ship wave observations.

Ebbesmeyer, C.C. 1988. Frontal Eddy Dynamics (FRED) Experiment off North Carolina: Volume 2. U.S. Dept. Interior, MMS Rep. OCS/MMS-89/0028-Vol-2:323.

Abstract. In preparation for oil and gas lease sales on the outer continental shelf offshore of North Carolina, the Minerals Management Service was requested to investigate the potential transport and impacts of oil spilled offshore. Of particular concern is estimating the movement of spilled oil, especially the probability of shoreward transport and/or beaching of the floatable fraction. Although the speed and location of the Gulf Stream are well known, knowledge of the meanders of the Gulf Stream is limited. How the circulatory structure and movement of associated frontal eddies and filaments affect the North Carolina coastal waters is not clear. The present study investigates the interactions of these circulatory elements and follows the evolution of frontal eddies as they migrate along the North Carolina coast.

Ebbesmeyer, C.C. 1989. Frontal Eddy Dynamics (FRED) Experiment off North Carolina: Volume 1. Executive Summary. U.S. Dept. Interior, MMS Rep. OCS/MMS-89/0028-Vol-1:19.

Abstract. In preparation for oil and gas lease sales on the outer continental shelf offshore of North Carolina, the Minerals Management Service was requested to investigate the potential transport and impacts of oil spilled offshore. The

Gulf Stream and associated eddies are an important aspect of the transport. Although the speed and location of the Gulf Stream are reasonably well known, knowledge of the meanders of the Gulf Stream is limited. How the circulatory structure and movement of associated frontal eddies and filaments affect the North Carolina coastal waters is not clear. The present study investigates the interactions of these circulatory elements and follows the evolution of frontal eddies as they migrate along the North Carolina coast.

Ebbesmeyer, C.C. and B.A. Taft. 1979. Variability of potential energy, dynamic height and salinity in the main pynocline of the western North Atlantic. J. Phys. Oceanogr. 9:1073-1089.

Abstract. Hydrographic data in the upper 2 km from the period 1914-73 have been analyzed in the western North Atlantic (22-36°N, 66-74°W). Expendable bathythermograph (XBT) data were also analyzed and compared with the hydrographic data. Means and standard deviations of the 15 and 17°C depths are comparable for the two data sets if only those XBT's reaching 700 m depth are used. Biased statistics result from use of a mixture of deep (T-7) and shallow (T-4) XBT's.

Ebersole, B.A. and S.A. Hughes. 1987. DUCK85 Photopole Field Experiment. CERC Misc. Paper. CERC-MP-87-18:162.

Abstract. A field study was conducted at the Coastal Engineering Research Center's Field Research Facility in Duck, North Carolina, during the fall of 1985. The photopole experiment was one component of the overall study. Synchronized 16 mm movie cameras were used to film the propagation of waves past a shore-perpendicular transect of brightly painted poles. The film was developed and the photographic images were digitized to obtain the time variation of the free surface at each pole location. Time series data of free surface elevation were analyzed to compute information for characterizing the short-period incident wave field. Data collection and analysis techniques are documented as are results of the data analysis.

Egentowich, J.M. 1989. Inland Evolution of the Coastal Front During IOP-2, January 25, 1986. Master's Thesis. Air Force Institute of Technology. 97 pp. (NTIS Accession Number: AD-A217 443/1/XAB)

Abstract. A unique case of mid-Atlantic coastal frontogenesis on 25 January 1986 is examined through mesoscale analysis to illustrate various stages of it's evolution. This analysis suggests that as the coastal front moves onshore and passes over Pamlico Sound in eastern North Carolina, the front breaks down to form two separate boundaries. The inland boundary is characterized by a strong temperature gradient, while a second weaker front remains along the coast. The Barnes analysis scheme is applied to data from the PAM network to obtain wind fields and areas of convergence. Two identifiable areas of convergence are associated with the two fronts. The importance of vertical mixing is examined and a numerical finite-difference scheme is used to evaluate the magnitude of individual terms of the frontogenesis equation. Lastly, an error analysis is performed to determine the level of reliability of the frontogenesis analysis.

EG&G Environmental Consultants. 1983. Environmental description of Norfolk Submarine Canyon - draft final report. Prepared for Sanctuary Programs Div. Office of Coastal and Ocean Resource Management, NOAA, Washington, D.C., under contract No. NA-82-AAA-03887.

Abstract. Environmental review of Norfolk Submarine Canyon. Descriptions are provided for biological communities in the canyons as well as the suspected current and hydrographic structure.

Elrod, J.A. and D.R. Kester. 1986. Chemical Anomalies in a Cold Core Gulf Stream Ring. Deep-Sea Res. 33(10):1313-1325.

Abstract. Changes occurring in a cold core ring were examined using anomalies of salinity, oxygen, nitrate, phosphate and silicate as a function of sigma sub theta for April and August 1977 stations. Sargasso Sea Water was used as the reference for the anomalies. All property anomalies diminished in intensity over the time interval, with stronger changes observed for the nonconservative properties than for salinity. The Slope Water core was readily identifiable by the property anomalies, but the outer region, originally Gulf Stream Water, lost most of its characteristic anomalies by August. Nitrate and phosphate showed similar anomaly distributions, but each of the other three properties showed different distributions within the ring.

Embley, R.W. 1980. The role of mass transport in the distribution and character of deep-ocean sediments with special reference to the North Atlantic. Mar. Geol. 38(1-3):23-50.

Abstract. The distribution and character of mass flows, particularly on the North Atlantic margin, are described. On seismic records, mass-flow characteristics range from internal reflectors and a hummocky surface to acoustically transparent lens-shaped deposits. The acoustic character also partly depends on the degree of lithification of the sediment; lithified or semi-lithified material will form more irregular deposits than will unconsolidated muds even though translated over the same slopes and distances.

Emery, K.O. and E. Uchupi. 1972. Western North Atlantic Ocean: Topography, rocks, structure, water, life and sediments. Am. Assoc. Petrol. Geol. Mem. 17:532.

Abstract. A comprehensive report on the geology and water masses of the western North Atlantic. Provides generalized biological assemblages associated with the geology and water characteristics.

Emery, W.J. 1983. On the geographical variability of the upper level mean and eddy fields in the North Atlantic and North Pacific. J. Phys. Oceanogr. 13:269-291.

Abstract. All available historical expendable bathythermograph data are used to compute means and standard deviations in temperature for the upper 500 m in the North Atlantic and North Pacific. To take advantage of marked spatial differences in data coverage a variable grid scheme is employed. Both surface and subsurface annual mean temperature distributions agree well with published maps of these quantities. Climatological mean temperature-salinity and salinity-

depth curves are used infer salinities for the mean temperature profiles in order to compute 0/500 db inferred dynamic height and its standard deviation. These mean curves are also used to compute eddy potential energy at 300 m. The maps of mean annual inferred dynamic height agree well with traditional dynamic height maps and appear similar to the maps of mean temperature at 400 m. The North Atlantic eddy potential energy distribution is similar to an earlier calculation. Maps of the standard deviations in inferred dynamic height also represent the geographical variability in mesoscale activity and compare well with a recent global map of mesoscale variability based on satellite altimetry from SEASAT.

Environmental Protection Agency. 1992. Final report on current-meter measurements at the 106-Mile Site in support of municipal waste disposal. U.S. Environmental Protection Agency, Office of Water. Washington, D.C. EPA 82-S-92-012.

Environmental Research and Technology, Inc. 1979. Summary and analysis of physical oceanographic and meteorological information on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. 3 volumes, Document No. P-2904, Contract No. AA550-CT7-16.

Abstract. Literature review sponsored by the Bureau of Land Management. Summarizes the physical oceanography and meteorology for the South Atlantic Bight in anticipation of OCS oil and gas sales in the area. Identifies information needs relevant to offshore oil and gas exploration.

Evans, H.E., K.S. Baker, O.B. Brown and R.C. Smith. 1985. Chronology of warm-core ring 82B. J. Geophys. Res. 90(C5):8803-8811.

Abstract. A chronology constructed from satellite-derived thermal imagery is presented to describe the formation and life history of warm-core ring 82B. This overview provides insight into a classification of features and discrete events associated with Gulf Stream warm-core rings and allows these events, as well as our limited shipboard observations, to be placed in a broader spatial and temporal context than would otherwise be possible without the satellite data. Events influencing the evolution of 82B include environmental factors, such as meteorological influences and Gulf Stream interactions, as well as those stimulated by encounters with changes in bottom topography. The interactions of the ring with surrounding waters are especially noteworthy, and the existence of vortex-vortex interactions is shown to be a significant cause of local water advection through streamer activity. Ring events are documented by following changes in ring size, shape, translation, and surface thermal structure. Our satellite observations are supported by extensive contemporaneous shipboard observations, including XBT, CTD, BOPS (biooptical profiling system) temperature profiles, and along-track sea surface temperature measurements. In addition, acoustic velocity profiling and drifter trajectories have been used to corroborate hydrographic features of the ring and environs. these ship and satellite data form a coherent space/time overview of the ring and its environment and show them to be closely related and continually interacting.

Everts, C.H., J.P. Battley Jr. and P.N. Gibson. 1983. Shoreline Movements. Report 1. Cape Henry, Virginia, to Cape Hatteras, North Carolina, 1849-1980. CERC Tech. Rep. CERC-83-1-1:278.

Abstract. Shoreline position changes between about 1850 and 1980 along the ocean coastal reach from 12 km west of Cape Henry, Virginia, to 8 km west of Cape Hatteras, North Carolina, are documented in this report. In places where the ocean shoreline is on an island or spit, shoreline changes in the sound or bay are also given. Shoreline movement maps at a scale of 1:24,000 constitute the basic data set included in the report. Composite reproductions of these maps are shrinkwrapped separately. In addition, ocean and sound shoreline changes averaged for 1-minute-latitude- (or longitude-) distance increments are provided. Consistent alongshore trends in the shoreline change rate are evident only from Virginia Beach south to the Virginia-North Carolina border and for about 15 km north of Cape Hatteras. Other areas experienced variable rates of shoreline change. The highest average shoreline change rate, about -2.0 m/year, occurred between 1917 and 1949. From about 1850 to 1917, the shoreline change rate averaged -0.1 m/year, and for the past 30 years it has averaged about -0.8 m/year.

Ezer, T. and G.L. Mellor. 1992. A Numerical Study of the Variability and the Separation of the Gulf Stream, Induced by Surface Atmospheric Forcing and Lateral Boundary Flows. J. Phys. Oceanogr. 22(6):660-682.

Abstract. A primitive equation regional model is used to study the effects of surface and lateral forcing on the variability and the climatology of the Gulf Stream system. The model is an eddy-resolving, coastal ocean model that includes thermohaline dynamics and a second-order turbulence closure scheme to provide vertical mixing. The surface forcing consists of wind stress and heat fluxes obtained from the Comprehensive Ocean-Atmosphere Data Set (COADS). Sensitivity studies are performed by driving the model with different forcing (e.g., annual versus zero surface forcing or monthly versus annual forcing). The model climatology, obtained from a five-year simulation of each case, is then compared to observed climatologies obtained from satellite-derived SST and hydrocast data.

Ezer, T., G.L. Mellor and D.-S. Ko. 1992. Using Thermal Analysis Fields and Geosat Altimetry Data for Initialization and Data Assimilation Studies of the Gulf Stream and the U.S. Eastern Coast. EOS, Trans. AGU. 73(14):170.

Abstract. Numerical model studies as well as observations have indicated the important effect that the Gulf Stream forcing has on the variability of the coastal water. This interaction can be simulated with a realistic three-dimensional, coastal ocean model, which includes the Gulf Stream area. In the coastal region the quality of satellite altimetric data is usually poor, and the ocean signal is not much higher than the altimeter noise level. However, if Gulf Stream meanders and rings are obtained from data assimilation in the open ocean, then coastal water variability can be inferred through the model dynamics. To study the usefulness of altimetric data for data assimilation, we compare synoptic sea surface height fields obtained from the Geosat altimeter, using an optimal interpolation method, to those obtained from diagnostic calculations using the OTIS analysis fields. Although both fields clearly resolve many of the Gulf Stream features, significant differences in the natural variability of the

two data types are found. In the dynamic assimilation, the OTIS analysis fields are used as initial condition and verification, while Geosat altimetry data are continuously assimilated into the numerical ocean model.

Falkowiski, P.G., J. Vidal, T.S. Hopkins, G.T. Rowe, T.E. Whitledge and W.G. Harrison. 1983. Summer nutrient dynamics in the Middle Atlantic Bight: Primary Production and Utilization of Phytoplankton Carbon. Journal of Plankton Research. 5(4):515-557.

Abstract. In the late summer, production and utilization of carbon in the stratified water of the Middle Atlantic Bight appears to approach steady-state conditions. In the euphotic zone there is a particulate organic carbon (POC) pool of about 6000 mg C/m^2.

Fecher, M.P. 1970. Gulf Stream Transport at 31° 41'N. Master of Science Thesis. Univ. of Rhode Island, Kingston. 111 pp.

Fields, E. and D.R. Watts. 1990. The SYNOP Experiment: Inverted Echo Data Report for May 1988 to August 1989. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 90-2:233.

Fields, E. and D.R. Watts. 1991. The SYNOP Experiment, Inverted Echo Sounder Data Report for Jun 1989 to Sep 1990. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 91-2:255.

Fine, R.A., E. Johns and R.L. Molinari. 1991. Deep Western Boundary Current Structure in the Region of the Blake Bahama Outer Ridge. EOS, Trans. AGU. 72(51):32.

Abstract. Chlorofluorocarbon (CFC) and hydrographic data are used to examine the structure of the Deep Western Boundary Current (DWBC) in the subtropical North Atlantic. The region surveyed in June-July 1990 lies between 30 and 24°N and extends eastward to 71°W. The region has a varied bottom topography, which included the Blake Bahama Outer Ridge (BBOR). The tracers show a complicated watermass and transport structure. The bottom waters have low CFCs, salinity, oxygen and potential vorticity. These properties suggest a Circumpolar Deep Water source. Above there are two cores of high CFCs, centered at 4.4°C (1500 m) and 2.2-1.9°C (3500 m). The high CFCs correlate with high oxygen and geostrophic velocities. The tracer properties indicate a northern hemisphere source. The highest tracer values in the DWBC cores are observed along the western boundary and at the crest of the BBOR. Earlier studies have shown a large deep cyclonic eddy in this region. The detailed 1990 survey shows that the flow in the two CTC cores is more complex and is strongly influenced by the bottom topography. These smaller scale features may be an effective means for ventilating some areas of the western subtropical North Atlantic.

Fischer, H.B. 1980. Mixing processes on the Atlantic continental shelf, Cape Cod to Cape Hatteras. Limnol. Oceanogr. 25(1):114-125.

Abstract. Data from moored current meters and airborne and satellite observations are used in conjunction with analyses of shear flow dispersion to estimate the dispersion of dissolved substances in the Middle Atlantic Bight during

unstratified periods. The long-shelf dispersion coefficient is estimated to be of the order of 10^4-10^5 cm^2/s, and the cross-shelf dispersion coefficient of the order of 3 X 10^5 cm^2/s at midshelf. The cross-shelf estimate is a factor of 10 less than previous ones, which were based on the assumption that the cross-shelf flux of freshwater is equal to the inflow from tributary rivers within the bight itself.

Fisher, A., Jr. 1972. Entrainment of shelf water by the Gulf Stream northeast of Cape Hatteras. J. Geophys. Res. 77(18):3248-3255.

Abstract. Observes the entrainment process off Cape Hatteras which results in the formation of cold shelf-water filaments carried northeast by the Gulf Stream. Reports the temperature of the entrapment region dropped well below that of the slope water and the Gulf Stream.

Fisher, A., Jr. 1973. Environmental Guide to the Virginia Capes Operating Area. NOO Spec. Pub. NOO-SP-211:66.

Abstract. The general oceanography of the Virginia Capes (VACAPES) area is discussed with particular emphasis on near-surface thermal structure of water masses and oceanic fronts. Warm, saline Gulf Stream-Water, identified by temperature equal to or greater than 15°C at the 200-meter (m) level, is characterized by mean monthly sea surface temperature (SST) and sonic layer depth (SLD) ranging from 21°C and 78 m, respectively, in winter to 28°C and 25 m in summer. Slope Water, identified by temperatures between 9° and 15°C at the 200-m level, is characterized by a temperature inversion in spring and mean monthly SST and SLD ranging from 11°C and 203m, respectively, in winter to 25°C and 6m in summer. Relatively fresh Shelf Water, found on the Continental Shelf between the 30-m and 200-m isobaths, is characterized by a positive in-layer temperature gradient in winter and mean monthly SST ranging from 7°C in winter to 25°C in summer. SLD is at the bottom in winter and is 3m in summer. Two major oceanic fronts occur in the VACAPES area: the northern edge of the Gulf Stream separating Gulf Stream Water from Slope Water and the slope front separating Shelf Water from Slope Water.

Fisher, A., Jr. 1977. Historical limits of the northern edge of the Gulf Stream. Gulfstream. 3(7):7.

Abstract. Defines the northern limits of the Gulf Stream by utilizing statistical methods and historical data.

Fisher, A., Jr. and G.A. Gotthardt. 1970. Aerial Observation of Gulf Stream Phenomena Virginia Capes Area, October 1968-May 1969. Naval Oceanographic Office Informal Report. ASWEPS Report No. 17:23.

Abstract. Thermal structure of a rectangular area, approximately 220 kilometers on a side and contiguous to the Continental Shelf northeast of Cape Hatteras was investigated by aircraft between 9 October 1968 and 16 May 1969 with the object of formulating an analysis and prediction model. Major features in the area included warm water northwest of the Gulf Stream, entrainment of Shelf Water into the Gulf Stream system, lateral displacement of the northern edge of the Gulf Stream, and a thermal gradient adjacent to the Continental Slope during winter.

A simplified model of thermal structure describes interaction of observed water masses.

Fitchko, R.M. 1976. Topography, shallow structure, and sedimentary processes of the Atlantic continental slope off the Carolina coast. Master's Thesis. Old Dominion University.

Fitzgerald, J.L. and J.L. Chamberlin. 1983. Anticyclonic warm-core Gulf Stream rings off the northeastern United States in 1980. Ann. Biol. 37:41-47.

Abstract. Summarizes warm-core rings occurring off the northeastern United States in 1980. Derivations and implications of the warm-core rings are also discussed.

Flagg, C.N. 1988. Internal waves and mixing along the New England shelf-water/slope-water front. Cont. Shelf Res. 8(5-7):737-756.

Abstract. a 48-day early spring data set from the outer continental shelf south of New England is used to describe the internal wave climate of the shelf-slope front. Current data from three near-bottom and one mid-depth instruments in water depths between 80 and 120 m indicate that internal waves provided a significant portion of the near-bottom current variance in the frontal zone. The data show that the internal wave energy was enhanced in the frontal zone relative to the shelf. At these depths, at least during the observational program, surface waves did not generally cause noticeable near-bottom water motions. Spectra describe an internal wave field of low vertical mode propagating perpendicular to the isobaths onto the shelf. This suggests significant refraction of the waves as they propagated onshore from the isotropic internal wave field of the continental slope. There appeared to be very little along-shelf variation in internal wave energy over distances on the order of 100 km. Onshore, however, there was a factor of two decrease in internal wave energy density over a distance of about 15 km. Assuming frictional dissipation within a bottom boundary layer, this decrease in energy translates into a friciton velocity of about 2 cm/s. Thus, internal wave dissipation could result in bottom stress levels comparable to values deduced for shallower waters under the influence of storm-driven surface waves. This dissipation rate is shown to produce a significant bottom mixed layer which can, under some circumstances, result in sizeable cross-frontal exchange of shelf and slope waters.

Flagg, C.N., R.H. Houghton and L.J. Pietrafesa. 1991a. Summertime Cross-Frontal Intrusions in the Mid-Atlantic Bight. EOS, Trans. AGU. 72(44):277.

Abstract. Cross-frontal intrusions of shelf and slope water are a well known phenomena of the Mid-Atlantic Bight having appeared in numerous hydrographic transects (Wright, 1976). Because the intrusions were observed in this manner, it is natural to assume that they were stationary, or at most, slowly evolving features. This view has changed as a result of the SEEP-II program in which bottom-moored ADCPs were deployed in conjunction with vertical thermistor arrays providing a highly resolved description of the joint temperature and velocity distribution. The picture that emerges is of a highly dynamic region in which on- and offshore intrusions have cross-frontal velocities of 10 to 20 cm/sec and lifetimes of one to several days. There appear to be two distinct types of intrusions, one that occurs within the seasonal thermocline, which is the most

energetic, and another below the thermocline. The lifetime of the subthermocline intrusions is typically longer than those within the thermocline. What's more, the two varieties of intrusions are not usually coherent and apparently are driven by different forces. The thermocline intrusions appear to be driven by along-shore winds in a manner that is similar to a near bottom upwelling/downwelling response. The forcing for the sub-thermocline intrusions is not apparent at this stage.

Flagg, C.N., C.D. Wirick and S.L. Smith. 1991b. Zooplankton, Phytoplankton, and Current Interactions in the Shelf/Slope Front of the Mid-Atlantic Bight. EOS, Trans. AGU. 72(51):86.

Abstract. Fifteen months of data from an acoustic Doppler current profiler (ADCP) and fluorometers obtained during the SEEP-II program provide a unique view of the seasonal progression of zooplankton and phytoplankton biomass and their response to water currents, or lack thereof. Several items are of immediate interest. First, the biomass records are highly variable with a continuum of energy at all frequencies and substantial interannual variation. Second, the zooplankton and phytoplankton spring blooms are more or less coincident, that is the increase in zooplankton biomass does not lag behind that of phytoplankton. Third, the spring blooms are not dominant events of the records, rather, the largest fluctuations are linked with currents, although not always in the same manner. Fourth, the seasonal succession of zooplankton and phytoplankton species together with changes in stratification lead to significant differences in the vertical distribution of biomass and its response to physical forcing. Considerable effort was made to understand the link between physical forcing and the biological communities without coming to any general conclusions.

Flierl, G.R. 1983. Impact of Gulf Stream rings upon the slope water. pp. 241-263. In: Aha Huliko'a Hawaiian Winter Workshop on the Role of Eddies in the General Ocean Circulation, Univ. of Hawaii, Jan. 5-7, 1983, Proceedings.

Abstract. Argues that the contributions of four or five rings formed each year can be important to the heat, salt, and vorticity balance in the slope water.

Flierl, G.R. and J.S. Wroblewski. 1985. The possible influence of warm core Gulf Stream rings upon shelf water larval fish distribution. Fish. Bull. 83:313-330.

Flood, R.D. and C.D. Hollister. 1974. Current-controlled topography on the continental margin off the eastern United States. pp. 197-205. In C.A. Burke and C.L. Drake, eds. The geology of continental margins. Springer-Verlag, New York.

Abstract. Describes the influence of topography on currents along the eastern continental margin. Major topographic features are thought to influence current flow, for example, through submarine canyons along the continental margin.

Fofonoff, N.P. 1981. The Gulf Stream System. pp. 112-139. In A. Warren and C.I. Wunsch, eds. Evolution of physical oceanography, scientific surveys in honor of Henry Stommel. MIT Press, Cambridge.

Abstract. Reviews the current nomenclature of the Gulf Stream System. Discusses the relationship between the well-defined Florida current over the Blake Plateau and the Gulf Stream.

Fofonoff, N.P. 1982. Energy and mass flux in the Gulf Stream. pp. 7. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982, AD-A128 789.

Abstract. Estimates of the kinetic energy and momentum fluxes of the Gulf Stream are obtained from the meridional hydrographic sections taken during the Gulf Stream '60 surveys.

Folger, D.W. 1977. Submersible observations of the bottom in and near petroleum lease areas and two dumpsites on the continental shelf off the Middle Atlantic states. pp. 40. In Middle Atlantic outer continental shelf environmental studies, Vol. III, Geologic studies 8(1-1).

Abstract. Submersible observations taken as part of the BLM Middle Atlantic Benchmark Program, including a description of the surficial characteristics of the sea floor. Observations are limited to the continental shelf.

Folger, D.W. and H.J. Knebel. 1978. Environmental studies of the Mid-Atlantic outer continental shelf. U.S. Geol. Surv. Prof. Pap. 1100:147-148.

Abstract. Summary of the U.S. Geological Survey's environmental program conducted in the Middle Atlantic for the Bureau of Land Management. Research topics include: sediment mineralogy, sediment trace metal chemistry, sediment movement, sediment characteristics, and measurements of near-bottom currents.

Folger, D.W. and S. Needell. 1983. U.S. Geological Survey program of offshore resource and geoenvironmental studies, Atlantic-Gulf of Mexico region, from September 1, 1976, to December 31, 1978. U.S. Geol. Surv. Circ. 870:67.

Abstract. Summary of U.S. Geological Survey's environmental programs in the Gulf of Mexico and along the Atlantic coast. Much of the USGS program is in response to anticipated offshore oil and gas sales in these areas and is conducted for the Bureau of Land Management. Emphasis is on the geologic hazards associated with drilling in lease sale areas.

Ford, W.L. and A.R. Miller. 1952. The surface layer of the Gulf Stream and adjacent waters. J. Mar. Res. 11:267-280.

Abstract. Early description of the Gulf Stream and characterization and analysis of the shelf water, including detached parcels of shelf water that become entrained with slope water.

Ford, W.L., J.R. Longard and R.E. Banks. 1952. On the nature, occurrence, and origin of cold low salinity water along the edge of the Gulf Stream. J. Mar. Res. 11:281-293.

Abstract. Discusses the Gulf Stream and detached parcels of shelf water as sources of the upper layer of continental slope water.

Forder, E.B., D.J. Stanley, W.B. Sawyer and K.L. Slagle. 1981. Sediment transport in Washington and Norfolk Submarine Canyons. Appl. Ocean Res. 3(2):59-62.

Abstract. Summary of a petrologic study suggests that downslope sediment dispersal does occur in Washington and Norfolk Canyons although there is little evidence to suggest that transport of coarse-grained sediment exists.

Fox, D.N. and O.M. Smedstad. 1991. Assimilation of Ocean Features in a 2-Layer Primitive Equation Model of the Gulf Stream. EOS, Trans. AGU. 72(51):79.

Abstract. Information about the ocean surface is the most abundant data type available today for assimilation into general circulation models of the oceans, and will likely remain so for the next several years. Altimetry measures the topography of the sea surface, and satellite MCSSTs measure the sea surface temperature. The development of techniques to optimally use this information in ocean circulation is an area of active research.

FRED Group. 1989. Frontal Eddy Dynamics (FRED) Experiment off North Carolina. C.C. Ebbesmeyer, ed. Prepared by Evans-Hamilton, Inc. OCS Study MMS 89-0028 Vol 2 Technical Report, March 1989. U.S. Dept. of Minerals Management Service, Herndon, VA, 325pp.

Abstract. During May to November, 1987, oceanographic measurements were made off North Carolina to examine the effects of Gulf Stream frontal eddies on the circulation over the continental shelf. Satellite images were collected daily, and currents were measured at eight moorings containing 21 current meters. During a 2-week time period in May, three eddies were intensively examined using satellite imagery, drifting buoys, aircraft and survey vessel launched temperature probes, and an Acoustic Doppler Current Profiler. The Gulf Stream appears to behave in two distinct modes. 1) Small meander mode, the Gulf Stream lies at the shelf break and meanders of the Front have smaller amplitudes. Frontal eddies and associated warm water filaments are smaller and farther from shore during this mode. 2) Large meander mode, the Gulf Stream Front is displaced offshore of the shelf break and meanders of the Front have large amplitudes. Frontal eddies and associated warm water filaments are larger and closer to shore during this mode, with some of the filaments nearly reaching the Barrier Islands. Eddies migrate past locations off the North Carolina coast approximately once every five days. After an eddy passes, parts of the filament may stagnate on the Shelf for approximately a week before dissipating or moving northward out of the study area.

French, T.J., J.L. Machemehl and N.E. Haung. 1974. A new technique for beach erosion control. NCSU Center for Mar. Coastal and Studies Rep. No. 74-3:70.

Abstract. An experimental study of a new technique for beach erosion control was conducted in a wave channel facility in the Civil Engineering Department, North Carolina State University. The primary objective of the study was to determine the effects of a sub-sand filtering system on the stability of a beach profile.

Friedlander, A.I., K.L. Tracey and D.R. Watts. 1986. Gulf Stream dynamics Experiment: Inverted echo sounder data report for the July 1982 to April 1983 deployment period. Univ. R.I., Grad. School Oceanogr. Tech. Rep. URI/GSO-TR-86-5:107.

Abstract. Echo sounder data from experiment conducted northeast of Cape Hatteras to study the propagation and growth characteristics of Gulf Stream meanders.

Friedman, J.M. 1975. Atlantic offshore oil: The need for planning and regulation. Oceanus. 19(1):22-31.

Abstract. Overview of the legislation governing oil and gas exploration and development on the outer continental shelf. The need for proper planning, regulation, and active monitoring of offshore activities is discussed.

Frost, C.C., H.E. LeGrand Jr. and R.E. Schneider. 1990. Regional Inventory for Critical Natural Areas, Wetland Ecosystems, and Endangered Species Habitats of the Albemarle-Pamlico Estuarine Region: Phase 1. (A/P Study Project No. 90-01) N.C. Natural Heritage Program. Raleigh. 448 pp.

Abstract. The rapid development of North Carolina's coastal and tidewater regions has caused an urgent need to protect significant natural resources in this part of the state. However, before protection of natural resources and natural areas can be accomplished, it is important to have background information about these resources, such as locations of endangered and rare species and delineation and description of critical natural areas. The North Carolina Nature Preserves Act delegates responsibilities to the N.C. natural Heritage Program for maintaining the statewide inventory of important natural areas and rare species habitats. Funding from the Albemarle-Pamlico Estuarine Study has allowed a reconnaissance inventory to identify, describe, map, prioritize, and make protection recommendations for special natural areas, exceptional wetland exosystems, and endangered and rare species habitats in 10 counties -- Bertie, Camden, Chowan, Currituck, Gates, Hertford, Martin, Pasquotank, Perquimans, and Washington -- adjacent to Albemarle Sound. Biologists contracted by the N.C. Natural Heritage Program have consulted other biologists familiar with these counties, in addition to reviewing soil maps, topographic maps, aerial photos, and other sources to determine sites for survey work for sites that appear to contain significant or critical natural resources. Approximately 300 sites were identified from these various sources during the preliminary screening. After a visitation to over 100 of these sites, a total of 96 have been identified as containing biological or physiographical significance at the national, state, or regional level. This report is a compilation of critical natural areas, both those already under protection and those lacking protection, in addition to a discussion of endangered and rare species, wetland ecosystems and other natural communities,

and the geomorphology of the 10-county region. Data from the project will be recorded in the Natural Heritage Program's central inventory management system, which is used by many other agencies for environmental impact assessment, land use planning, resource management decisions, and conservation planning. It is hoped that this report will lead to increased protection of the natural heritage of the Albemarle Sound region.

Fu, L.-L., J. Vazquez and M.E. Parke. 1987. Seasonal variability of the Gulf Stream from satellite altimetry. J. Geophys. Res. 92(C1):749-754.

Abstract. The nearly continuous 3.5 years of altimeter data in the western North Atlantic Ocean from the GEOS 3 mission (April 1975 to November 1978) have been used to study the seasonal variability of the Gulf Stream. The differences between altimetric measurements of sea surface height made at satellite ground track intersections, called crossovers, are utilized to construct time series of sea level variations. The results indicate that the Gulf Stream in the region off Cape Hatteras has a pronounced seasonal variability. The peak-to-peak amplitude of the seasonal cycle in terms of cross-stream sea level difference is about 15 cm, with a maximum in April and a minimum in December. The result is in good agreement with historic hydrographic observations and recent direct measurements of the Gulf Stream. The mechanisms responsible for the observed seasonal variability are discussed.

Fuglister, F.C. 1960. Atlantic Ocean atlas of temperature and salinity profiles and data from the International Geophysical Year of 1957-1958. WHOI Tech. Rep. Atlas 1:209.

Abstract. Summary of temperature and salinity values found along the U.S. Atlantic coast using data collected in 1957 and 1958.

Fuglister, F.C. 1984. Account of the usefulness of new techniques of measurement in study of the Gulf Stream. J. Mar. Tech. Soc. 17(4):13-18.

Abstract. General overview of how the introduction of new instruments has led to a growth in knowledge of the Gulf Stream.

Fuglister, F.C. and L.V. Worthington. 1951. Some results of a multiple ship survey of the Gulf Stream. Tellus. 3:1-14.

Abstract. Reports the first observation of the formation of a cold-core ring from a meander. Notes that cold-ring generation is common near the New England seamounts, which are associated with large meanders and a semi-permanent ring-meander.

Fukumori, I. and C. Wunsch. 1991. Efficient representation of the North Atlantic hydrographic and chemical distributions. Prog. Oceanogr. 27:111-195.

Abstract. The large-scale temperature, salinity, oxygen and nutrient distributions of the North Atlantic Ocean are explored with the aim of identifying the minimum data set necessary to describe the general circulation and to identify the dominant physical characteristics. A form of empirical orthogonal function (principal component analysis) based upon the singular value

decomposition is used. Six modes are capable of describing 92% of the variance of the full hydrographic fields. A second singular value decomposition applied to the horizontal property modes shows that there are only two independent tracers among the six used. The modal reconstruction satisfactorily reproduces the large-scale transport properties of the original data. A clear physical interpretation of the modes has not been found, but they are obviously connected to the large-scale water mass characteristics of the ocean. Much remains to be learned about how to use such descriptions.

Fukumori, I., F. Martel and C. Wunsch. 1991. The hydrography of the North Atlantic in the early 1980s. An Atlas. Prog. Oceanogr. 27(1-2):1-110.

Abstract. Atlas includes hydrographic data from various cruises taking sections in the north Atlantic, the plotted sections, horizontal property charts(surface nutrient and deep) and the distributed data set.

Gagosian, R.B. and G.E. Nigrelli. 1979. The transport and budget of sterols in the western North Atlantic Ocean. Limnol. Oceanogr. 24(5):838-849.

Abstract. A general correlation exists between total free sterols, particulate organic carbon, particulate organic nitrogen, and chlorophyll a in the upper 300 m of the water column in the western North Atlantic Ocean. High values are found in shelf waters and in the subsurface chlorophyll a maximum in the Sargasso Sea, lower values at a Gulf Stream meander or ring fringe station.

Gagosian, R., A. Gaines, T. Joyce, W. Schmitz and B. Tucholke. 1984. Environmental Summary of the U.S. Atlantic Continental Slope and Rise, 28-42°N. U.S. Dept. Interior, MMS Rep. 1(Final rept. 1982-84):446.

Abstract. This report is a synthesis and evaluation of environmental information concerning the continental slope and rise off the eastern United States, Atlantic Continental Slope and Rise (ACSAR). The ACSAR region of the eastern United States is defined as the area between latitudes of 28 and 42 N and between water depths of 200 and 4,000m. Environmental data and information were collected from published papers and reports, unpublished reports, reported but unpublished data, and personal communication from scientific colleagues. The topics covered in the document include meteorology and air-sea interactions, physical oceanography, geology, and chemistry.

Galvin, C. 1989. Barrier island growth by longshore transport consistent with J. J. Fisher's Outer Banks data. Geol. Soc. Am. Abstr. Programs. 21(2):17.

Abstract. All the sand in the Atlantic coast barrier island chain could have accumulated by longshore growth of spits in 2000 to 3000 years at rates typical of recent growth of Fire Island, Sandy Hook, or Assateague (about 400,000 m^3/yr). A typical barrier island has a mean cross-sectional area of 4900 m^2, assuming a prograding spit advancing into 8 m of water, with a crest 3 m high, 300 m wide, and appropriate side slopes. With that section, a barrier island chain 160 km long will contain 784 million cubic meters of sand. Divided by 2000 years, the growth rate of the barrier island chain is 392,000 m^3/yr, close to the estimated net longshore transport rates. Such a rate could be maintained by 1 m/yr erosion of a source shore 30 km long from +3 to -10 m elevation for 2000 years. The 1

m/yr assumes that the proportion of non-sand in the source shore is the same as the proportion in the barrier island cross section. This longshore transport estimate incorporates present day rates of spit growth and shore erosion to quantitatively support J.J. Fisher's (1967) observations along the 350 km of Outer Banks barrier islands. He found that 56% of the Outer Banks shore had clear geomorphic or sedimentologic evidence of accumulation by the longshore prograding of the distal ends of spits, and that the absence of evidence on the remaining 44% could be attributed to erosion and former inlets. Fischer's non-radiometric dating suggested that the Outer Banks formed since 2400 BP, Cape Hatteras since 1200 BP.

Gangopadhyay, A. 1990. Wind forcing of the Gulf Stream: a space-time analysis. Ph.D. Thesis. University of Rhode Island. 190 pp. (Advisor: Cornillor, P; DAI 52/02B, p.1007; AAC9120419)

Abstract. This study considers the effect of wind forcing on the behavior of the Gulf Stream downstream of Cape Hatteras for different temporal and spatial scales. Three specific areas have been investigated in this dissertation: (A) Since satellite data is used throughout this study and such datasets are 'gappy' due to clouds, and finite in space, a suitable spectral analysis technique is warranted to obtain the relevant spatial and temporal scales of the meanders of the Gulf Stream northeast of Cape Hatteras. The applicability of the Autoregressive modeling for such data sets have been shown by comparative analysis with the Fourier Transform. It is shown that as the length of the time series becomes shorter, the resolving power of the AR approach as compared with that of the Fourier Transform improves. (B) The Parsons-Veronis hypothesis related to the separation of the Gulf Stream from the coast at Cape Hatteras has been tested against observations. This hypothesis predicts the separation latitude based on a reduced gravity balance between the basin-wide Ekman wind drift and the net geostrophic transport across the basin which is expressed as the difference of the square of the thermocline depths at the eastern and western ends of the basin. Using twelve years (1977-1988) of satellite, wind, and CTD data, we found that the predicted separation latitude by the Parsons-Veronis hypothesis agrees well with the observed latitude over long baroclinic time scales on the order of three years. (C) Lastly, this study investigates the variability of the curvature, local winds, and latitudinal position. Comparing satellite-derived surface front locations with the IES-derived subsurface front locations over 1983-1985, we found that the local winds seem to have no effect on the variability of the offset. The latitudinal position of the stream and curvature variability together explain 85% of the geophysical variability, whereas position seems to account for about 75% of the long-term decrease in the offset.

Gangopadhyay, A.P., P. Cornillon and D.R. Watts. 1991. A test of the Parsons-Veronis hypothesis on the separation of the Gulf Stream. J. Phys. Oceanogr. Accepted.

Gardner, W.D. 1989a. Baltimore Canyon as a modern conduit of sediment to the deep sea. Deep-Sea Res. 36(3):323-358.

Abstract. An integrated study using moored current meters, transmissometers and sediment traps revealed that sediment in Baltimore Canyon was resuspended

regularly when energy from internal tides was focused along the canyon axis. Such focusing occurred primarily during late winter and early spring. Currents outside the canyon walls quickly dilute and dissipate sediment moving out of the canyon. Submarine canyons can act as conducts of sediment to the deep ocean not only by channeling turbidity currents, but also by focusing internal tides that resuspend sediment, after which it is advected to deeper water.

Gardner, W.D. 1989b. Periodic resuspension in Baltimore Canyon by focusing of internal waves. Journal of Geophysical Research. 94(C12):18185-18194.

Abstract. High concentrations of particulate matter are frequently reported in submarine canyons. This study demonstrates that in Baltimore submarine canyon, elevated concentrations result from periodic resuspension events. The sloping bottom and V-shaped topography of submarine canyons could accelerate tidal flows in the canyon axis sufficiently to cause resuspension, which occurs predominantly at tidal frequencies. However, current meter and transmissometer data show that resuspension events are often associated with a borelike intrusion of cold water moving upslope near the canyon head; an event that is consistent with the focusing of internal wave energy toward the canyon head at tidal frequencies. Hydrographic conditions for the focusing of energy are most favorable in late winter and most pronounced resuspension events occur during those seasons. Bottom stresses generated in the canyon are sufficient to resuspend sediment along the axis at least between 200 and 800 m, with little resuspension occurring deeper along the axis, on the canyon walls, adjacent slope, or shelf. During a resuspension event, the sediment-laden water is forced upcanyon, then sloshes back down the canyon until it reaches a layer of higher-density water, detaches from the canyon floor, and moves seaward along a density surface. This is a means of transferring sediment and associated pollutants intercepted at the canyon head to deeper water, across the shelf-slope front. Over geologic time, frequent resuspension and seaward transport may aid in the headward erosion of submarine canyons, or at least inhibit their infilling during interglacial times.

Garfield, N., III and D.L. Evans. 1987. Shelf Water Entrainment by Gulf Stream Warm-Core Rings. J. Geophys. Res. 92(C12):13003-13012.

Abstract. Examination of 7 years of satellite advanced very high resolution radiometer imagery demonstrates that shelf water removal by entrainment adjacent to warm-core rings is a common phenomenon, representing an important process for shelf water budgets. South of Georges Bank, streamer entrainment occurred 69 ± 20% of the time. In addition, 9 ± 6% of the time more than one streamer was active. The data show little mean seasonal variability but large interannual variability in streamer occurrence. Most of the variability is related to the passage of warm-core rings south of Georges Bank. An instantaneous streamer transport value of 2.5×10^5 m^3/s was determined from ship-tracked drogues and hydrographic data. Reducing this value to 70% gives an estimated mean annual shelf water removal by streamer entrainment of 1.8×10^5 m^3/s (5700 km^3/yr) for this segment of the shelf. A balanced Gulf of Maine transport budget can not be obtained when this value is compiled with transports across the other boundaries of the gulf; instead a net export of 16×10^4 m^3/s of water results. This lack of a balance emphasizes the uncertainty of the existing transport measurements. The fate of streamers includes incorporation into the warm-core ring and detrainment from the ring with either the formation of cold cyclonic rings in the

slope water or entrainment into the northern edge of the Gulf Stream. In addition to streamer entrainment, the satellite imagery reveals that a number of different phenomena are occurring which move shelf water across the shelf-slope front. In 86 ± 13% of the images, some type of offshore transport is observed.

Garvine, R.W. 1982. A steady-state model for buoyant surface plumes in coastal waters. Tellus. 34:293-306.

Gawarkiewicz, G.G. 1988. A linear stability analysis of the summer configuration of the shelfbreak front in the Middle Atlantic Bight. EOS, Trans. AGU. 69(44):1283.

Abstract. The cross-frontal exchange of heat and salt at the shelfbreak front in the Middle Atlantic Bight primarily takes place during the summer. This was shown during both the Shelf Edge Exchange Precesses (SEEP) and Mid-Atlantic Shelf and Rise (MASAR) programs. A linear stability analysis was performed for the summer frontal configuration using the geostrophic momentum approximation in a manner similar to Flagg and Beardsley (1978). For typical frontal conditions, the front is baroclinically unstable with e-folding scales of roughly 5 days. The most unstable wave has a wavelength of 20 km. Observations from the summer of 1984 show a wave of 35 km eventually developing into a shelfbreak eddy. This analysis indicates that the summer front is considerably more unstable than the winter front. This strengthens the idea that summer exchange processes dominate over winter processes.

Gawarkiewicz, G.G. 1989. Linear stability models of shelfbreak fronts. Ph.D. Thesis. University of Delaware. 181 pp. (Garvine, RW (adviser); DAI 50/11B, p.4957; AAC9010406)

Abstract. The linear inviscid stability of frontally trapped waves along a shelfbreak is examined to determine whether frontal instabilities may contribute to the alongfront variability frequently observed. Three different basic states with increasingly complex stratification are treated. The first basic state consists of an infinitesimally thin shear layer located at the shelfbreak, with no stratification. The shear waves are stable for the velocity shear and topography typical of observed fronts. Next a two layer front in geostrophic balance situated over a linearly sloping bottom is considered, similar to Flagg and Beardsley (1978). The linearly sloping bottom is assumed to extend offshore beyond the frontal region unlike the previous analysis in which the bottom offshore of the front was assumed to be flat. Parameters typical of the Middle Atlantic Bight in winter are chosen. The most unstable wave is surface trapped with typical e-folding time scales for growth of ten days. At the most unstable wavelength, 25 km, it is roughly twenty per cent more unstable using the sloping topography seaward of the front versus using the flat topography. The third case simulates the summer configuration of the shelfbreak front in the Middle Atlantic Bight. A subsurface two layer front in geostrophic balance is overlain by a uniformly buoyant surface layer containing an infinitesimally thin shear region. Pycnocline trapped waves with offshore motion concentrated in the surface layer are the most unstable for all parameter ranges examined. The model predicts regional differences in stability characteristics within the Middle Atlantic Bight. For the region south of New England the wavelength of the most unstable wave is 20 km and the e-folding time scale for growth is 4.5 days. This is half

the time scale for growth of the winter front. Observed summertime wavelengths are roughly 30 km with e-folding time scales for growth of 1.5 days. The model also indicates that frontal regions to the north and south are less unstable. This simple model indicates that shelfbreak frontal instabilities have seasonal and regional biases. Implications for cross-frontal exchange are discussed.

Gawarkiewicz, G. 1991. Linear Stability Models of Shelfbreak Fronts. J. Phys. Oceanogr. 21(4):471-488.

Abstract. The stability of inviscid frontally trapped waves along a shelfbreak is examined to determine whether frontal instabilities may contribute to the alongfront variability frequently observed. Three different basic states with increasing complex stratification are treated. In each case, the shelfbreak occurs where a constant depth shelf meets a slope region with linearly increasing depth.

Gawarkiewicz, G., R.K. McCarthy, K. Barton, A.K. Masse and T.M. Church. 1990. A Gulf Stream-derived pycnocline intrusion on the Middle Atlantic Bight shelf. J. Geophys. Res. 95(C12):22305-22313.

Abstract. Saline intrusions from the upper slope onto the outer shelf are frequently observed at the pycnocline along the shelfbreak front in the Middle Atlantic Bight during the summer. A brief cruise was conducted in July, 1986 between Baltimore and Washington Canyons to examine alongshelf variability of pycnocline salinity intrusions. A particularly saline intrusion of 35.8 Practical Salinity Units (PSU) was observed between 20 and 40 m in a water depth of 70 to 80 m. The along-shelf extent was at least 40 km. The cooler, sub-pycnocline outer shelf water was displaced 15 km shoreward of the shelfbreak. A Gulf Stream filament was present in the slope region prior to the hydrographic sampling, but was not visible in thermal imagery during the hydrographic sampling. Temperature-salinity characteristics of the intrusion suggest that it was a mixture of Gulf Stream water and slope water, possibly from the filament. (15 Refs.).

Gawarkiewicz, G., T.M. Church, G.W. Luther III, T.G. Ferdelman and M. Caruso. 1992. Large-scale penetration of Gulf Stream water onto the continental shelf north of Cape Hatteras. Geophys. Res. Lett. 19(4):373-376.

Abstract. A hydrographic cruise on the continental shelf between Chesapeake Bay and Cape Hatteras on the east coast of the United States during the summer of 1990 revealed the presence of a large volume of Gulf Stream water. Gulf Stream Water was normally observed on the shelf between the depths of 10 m to 30 m, and penetrated the shelfbreak front which normally separates the shelf water from slope water and Gulf Stream water. The layer of Gulf Stream water on the shelf extended 60 km north of Cape Hatteras, and reached at least as far shoreward as the 25 m isobath. Velocities of Gulf Stream water in the upper 110 m of the water column along the 1000 m isobath indicated a flow of 18 to 25 cm/s directed toward the northwest. The Gulf Stream water on the shelf was associated with low values of fluorescence, transmissivity, and nutrient concentrations relative to adjacent shelf water. The presence of the seasonal stratification during the summer may allow for mid-level penetration of Gulf Stream water onto the continental shelf north of Cape Hatteras.

General Oceanics, Inc. 1983. Blake Plateau: Mid-depth and bottom current measurements. Second year Rep. 87 pp. and Appendices.

Abstract. Interim report describing the Minerals Management Service-sponsored South Atlantic Deep Water Physical Oceanography Program. Preliminary results of the program are provided with emphasis on the design of the program.

Geyer, W.R. and R. Signell. 1991. Measurement and modeling of the spacial structure of nonlinear tidal flow around a headland. pp. 403-418. In D.B. Parker, ed. Tidal Hydrodynamics. John Wiley and Sons, Inc, New York.

Abstract. A shipboard acoustic current profiler (ADCP) was used to obtain detailed measurements of the horizontal structure of the tidal flow around a headland in Vineyard Sound, Massachusetts, where the nonlinear generation of residual currents and overtides is pronounced. Repeated ship tracks extending through a tidal cycle provide information about the structure of the semidiurnal tide, the principal overtides (M_4 and M_6) and the residual circulation. The semidiurnal tidal flow was found to be relatively uniform in space, roughly following the bathymetry around the headland, while the overtides and residual flow showed cinsiderable spatial structure, indicative of local nonlinear transfer of energy from the tidal flow. The vertical, relative vorticity was found to vary considerably during the tidal cycle from zero to several times the planetary vorticity. A high-resolution, vertically integrated numerical model was used to simulate the tidal flow around a headland, to provide a comparison with the observations and to explore the sensitivity of the flow to variations in bottom friction, bathymetry and tidal velocity. The numerical results are consistent with the observations, showing similar tidal characteristics and vorticity variations. The numerical simulations indicate a pronounced flow separation and formation of a transient eddy at the tip of the headland, with a strong shear zone extending from the shore to the center of the eddy.

Gezentsvey, A.N. and I.D. Lozovatskiy. 1987. Statistics of finestructure spectra of temperature and salinity fields in the energy active zone of the Gulf Stream. Oceanol. 27(6):691-695.

Abstract. The ranges of temporal and spatial variability in the levels of normalized (to the squares of the mean gradients) spectra of temperature and salinity for the upper part of the main pycnocline and the layer of 18 degrees C water are estimated. The temporal variability of the spectral structure in each of the layers over 1.5 months, expressed in mean-square form, was approximately an order of magnitude smaller than the spatial variability over the study area. (10 Refs.).

Giannini, J.A. 1988. Variability of the Diffuse Attenuation Coefficient in Waters Off the US East Coast. pp. 1395-1397. In ESA, Proceedings of the 1988 International Geoscience and Remote Sensing Symposium (Igarss) '88 on Remote Sensing: Moving Towards the 21st Century. Vol. 3. (NTIS Accession Number: N89-18738/9/XAB)

Abstract. The seasonal variability of ocean color is examined using Coastal Zone Color Scanner (CZCS) data. The CZCS provided direct measurement of the upwelled radiance at wavelengths in the visible regime, from which the diffuse attenuation

coefficient, K, at 490 nm was derived. Thirteen scenes are chosen from the mid-Atlantic Bight region off the east coast of the United States (38°N and 70°W) from 1979 to 1982, showing the seasonal variability in the ocean color on scales of 30,000 sq km. The distributions show a shift in the peak K value and a change in their width as functions of season.

Giese, G.L., H.B. Wilder and G.G. Parker Jr. 1979. Hydrology of major estuaries and sounds of North Carolina. USGS Water Res. Investigations. 79-46:175.

Abstract. Hydrology-related problems associated with North Carolina's major estuaries and sounds include contamination of some estuaries with municipal and industrial wastes and drainage from adjacent intensively-farmed areas, and nuisance-level algal blooms. In addition, there is excessive shoaling in some navigation channels, saltwater intrusion into usually fresh estuarine reaches, too-high or too-low salinities in nursery areas for various estuarine species, and flood damage due to hurricanes.

Gilman, C.S. 1988. A Study of the Gulf Stream Downstream of Cape Hatteras, 1975-1986. Master of Science Thesis. Univ. of Rhode Island, Kingston. 75 pp.

Gilman, C. and L. Rothstein. 1991a. Gulf Stream Warm Surges: Thermal and Potential Vorticity Anomalies in the Stream. J. Geophys. Res. Submitted.

Gilman, C. and L. Rothstein. 1991b. Numerical Simulations of a Gulf Stream Warm Surge. EOS, Trans. AGU. 72(51):58.

Abstract. Analyses of satellite IR images have revealed a Gulf Stream feature, that we have labelled a 'warm surge'. These features are visible as a 'jet' of warm surface water that is advected down the major axis of the Gulf Stream, maintaining a 1-3°C temperature difference with the surrounding Gulf Stream water. The formation of a warm surge event has been observed to sequentially encompass all of the following processes: (1) Mesoscale eddy interaction with the Gulf Stream between Florida and Cape Hatteras causes the warm surface layers to be detrained out of the Stream. (2) Due to a sudden loss of this surface water, the SST of the Gulf Stream downstream of Cape Hatteras decreased 1-3°C over a few days. (3) The Stream/eddy detrainment process diminishes, and the warm surface water flowing through the Florida Straits resumes its uninterrupted flow past Cape Hatteras, with this return of warm water being the warm surge observed in the satellite data.

Glenn, S.M. and W.D. Grant. 1987. A suspended sediment stratification correction of combined wave and current flows. J. Geophys. Res. 92:8244-8264.

Glenn, S.M., G.Z. Forristall, P. Cornillon and G. Milkowski. 1990. Observations of Gulf Stream ring 83-E and their interpretation using feature models. J. Geophys. Res. 95(C8):13043-13063, 13557.

Abstract. Analysis techniques were developed to track and estimate the propagation velocity, size shape, orientation, and swirl velocity of Gulf Stream warm core rings. The methods involve fitting idealized warm core ring feature models to observed surface fronts in the satellite imagery, to expendable bathythermograph survey data, and to satellite-tracked drifting buoy data. The

ring feature models are analytic structure functions with adjustable parameters. Use of the feature models is illustrated with data collected from warm core ring 83-E. A comparison of the time series of ring 83-E feature model parameters indicates that not only is the feature model analysis of the buoy track an effective method for tracking and monitoring the evolution of Gulf Stream rings, it also provides useful forecasts of ring locations based simply on a persisted propagation velocity. (44 Refs.).

Goldsmith, V., W.D. Morris, R.J. Byrne and C.H. Whitlick. 1974. Wave climate model of the Mid-Atlantic shelf and shoreline (Virginian Sea). Model development, shelf geomorphology, and preliminary results. NASA. Report No. NASA SP-358, VIMS SRAMSOE No.38:146.

Abstract. Numerical wave refraction analyses were performed between Cape Hatteras, NC, and Cape Henlopen, DE. Waves were refracted for 122 sets of incedent wave conditions. Wave ray diagrams show directions of propagation and where wave energy is concentrated and not concentrated. Numerous wave parameters were calculated along each refracted wave ray.

Goodman, L. and E.R. Levine. 1990. Vertical motion of neutrally buoyant floats. J. Atmos. Oceanic Technol. 7(1):38-49.

Abstract. The vertical motion of a neutrally buoyant float is determined from the solution to the nonlinear forced harmonic oscillator equation originally set forth by Voorhis (1971). Float response to forced vertical oscillations is characterized by the response ratio, $r = \xi_r/\xi_w$, where ξ_r is the vertical displacement of an isopycnal relative to the float, and ξ_w is the vertical displacement of an isopycnal relative to its initial equilibrium position. For isopycnal displacements with frequencies much less than the resonant frequency of the float, the float can be considered to be near dynamic equilibrium. Data obtained from a float deployment in a Gulf Stream meander result in an observed r value close to the predicted value. (26 Refs.).

Gopalakrishnan, T.C. and J.L. Machemehl. 1978. Numerical Flow Model for an Atlantic Coast Barrier Island Tidal Inlet. UNC Sea Grant Pub. UNC-SG-78-02:64.

Abstract. A numerical model for computation of flow in inlets with junction is developed. The Galerkin technique is coupled with a finite element analysis in the flow model. The vertically integrated equations of momentum and mass conservation are used with appropriate boundary and initial conditions. The junction conditions are introduced by the time rates of change of energy and mass flux at the junction. A 'double sweep' approach is used in solving for the dynamics of flow. A parabolic shape function is adopted in the model to satisfy the requirement of linear independence. The numerical flow model is verified with field data for Carolina Beach Inlet, North Carolina. The tidal fluctuations in the inlet gorge and tidal velocities in the Atlantic Intracoastal Waterway were used as initial and boundary conditions respectively. The tidal velocities in the inlet gorge and tidal fluctuations in the Atlantic Intracoastal Waterway were computed with the numerical simulation flow model and compared with field data. The Galerkin finite element flow model performed well considering the complex nature of flow in a tidal inlet.

Gordeichev, D.O., A.S. Kaz'min, R. Legekis and K.N. Fedorov. 1990. Frontal surface inclination in a cyclonic Gulf Stream meander: analysis of ship and satellite data. Soviet Journal of Remote Sensing. 8(2):193-204.

Abstract. The paper studies the dependence of the inclination of a frontal surface on the curvature of the front in a cyclonic Gulf Stream meander, based on synchronous data acquired by the NIS 'Academician Kurchatov' and the NOAA-9 satellite in October 1986. It is shown that, in a cyclonic meander, for a constant current component velocity along the front, the inclination of the frontal surface increases as the curvature of the front increases, as follows from the condition of cyclostrophic equilibrium. However, this dependence may be infringed due to the effect of factors complicating the dynamic structure of the current.

Gordon, A.L. and F. Aikman. 1981. Salinity maximum in the pycnocline of the Middle Atlantic Bight. Limnol. Oceanogr. 26(1):123-130.

Abstract. A persistent salinity maximum is observed in the upper part of the pycnocline in summer-autumn over the outer shelf of the New York Bight, induced by a nearly isopycnal transfer of slope water to the outer shelf. The transfer is possible only in the stratified seasons when isopycnals are continuous across the shelf-slope front. Estimates of the slope-shelf salt flux required to produce the pycnocline S-max suggest that it may provide about half of the salt required annually in the shelf region to balance input of river water.

Gordon, A.L., A.F. Amos and R.D. Gerard. 1975. New York Bight water stratification-October 1974. Presented at Am. Soc. Limnol. Oceanogr. Conf. on Middle Atlantic Continental Shelf and the New York Bight, Nov. (3-5) 75:45.

Abstract. Deepwater stratification observed off the shelf in the New York Bight.

Gordon, H.R., D.K. Clark, J.W. Brown, O.B. Brown, R.H. Evans and W.W. Broenkow. 1983. Phytoplankton pigment concentrations in the Middle Atlantic Bight: Comparison of ship determinations and CZCS estimates. Appl. Optics. 22(1):20-36.

Abstract. The processing algorithms used for relating the apparent color of the ocean observed with the Coastal-Zone Color Scanner on Nimbus-7 to the concentration of phytoplankton pigments (principally the pigment responsible for photosynthesis, chlorophyll *a*) are developed and discussed in detail. These algorithms are applied to the shelf and slope waters of the Middle Atlantic Bight and also to Sargasso Sea waters. In all, four images are examined, and the resulting pigment concentrations are compared to continuous measurements made along ship tracks. The results suggest that over the 0.08-1.5 mg/m^3 range the error in the retrieved pigment concentration is of the order of 30-40% for a variety of atmospheric turbidities. In three direct comparisons between ship-measured and satellite-retrieved values of the water-leaving radiance the atmospheric correction algorithm retrieved the water-leaving radiance with an average error of about 10%. This atmospheric correction algorithm does not require any surface measurements for its application.

Gornitz, V. and P. Kanciruk. 1989. Assessment of Global Coastal Hazards from Sea Level Rise. Department of Energy. CONF-8907104-1:15.

Abstract. A global coastal hazards data base that contains topographic, geologic, geomorphic, erosional and subsidence information is being developed in order to predict the coastal segments at greatest risk to a rise in sea level caused by future climate warming. High risk areas are characterized by low coastal relief, an erodible substrate, past and present evidence of subsidence, extensive shoreline retreat and high wave/tide energies. Data have been assembled for the USA and are being extended to the rest of North America. Several high risk areas have been tentatively identified and include the central Gulf Coast, South Florida, the North Carolina Outer Banks, southern Delmarva peninsula, and the San Francisco Bay area. 24 refs., 3 figs., 4 tabs.

Gorsline, D.S. 1963. Bottom Sediments of the Atlantic Shelf and Slope off the Southern United States. J. Geol. 71:422-440.

Gotthardt, G.A. 1973. Observation of a cyclonic Gulf Stream eddy. EOS, Trans. AGU. 54(4):312.

Abstract. The formation of a large cyclonic Gulf Stream eddy was observed near the region of the New England Seamount Arc. During a five day period in November 1972 a Gulf Stream meander with a wavelength of over 400 kilometers isolated a cyclonic eddy with a diameter of 150 kilometers. The eddy was subsequently surveyed through January 1973 at 2 - to 3-week intervals by ship and aircraft. During this period the eddy moved south-southwest and maintained much of its initial size and temperature gradient strength in levels below the effects of surface winds. Translation slowed considerably from initial separation speed to less than half in a one month period. Shipboard STD measurements indicated a strong, deep cyclonic circulation. Comparison of this eddy with others observed indicates many similarities in the life cycle of these features.

Gotthardt, G.A. and G.J. Potocsky. 1974. Life cycle of a Gulf Stream anticyclone eddy observed from several oceanographic platforms. J. Phys. Oceanogr. 4(1):131-134.

Abstract. Combined use of satellite infrared imagery, and shipboard and aircraft bathythermograms provided near-synoptic observations of the movement and subsequent recapture of a Gulf Stream anticyclonic eddy by a large meander northeast of Cape Hatteras. The eddy drifted westward for over four months along the continental slope at speeds of 4-5 cm/sec before rejoining the Gulf Stream, coalescing with a large meander northeast of Cape Hatteras. The meander was subsequently observed for an additional month after recapture translating eastward at 15 cm/sec. Meander movement resembles that of a similar feature observed in 1970 which resulted in formation of a cyclonic Gulf Stream eddy.

Govoni, J.J. In Press. Flux of larval fishes across frontal boundaries: examples from the Mississippi River plume front and the western Gulf Stream front in winter. Contributions in Science Natural History Museum of Los Angeles County.

Abstract. Boundaries between water masses, frontal zones, are neither static nor impervious; they are dynamic. There is exchange of water across frontal zones and, as a consequence, there is flux of biota. The spatial distribution of larval gulf and Atlantic menhaden (Brevoortia patronus and B. tyrannus), presumed indicators of larval fish assemblages, in and about two well defined, but vastly different frontal zones, serve as examples of the flux of larval fishes across water mass boundaries. Across the Mississippi River plume front in the Gulf of Mexico bight of the United States, mixing and stirring can account for flux of larval fishes. The consequences of the flux for the larvae of these indicator species is their shoreward transport, or the reciprocal, their expatriation from coastal populations.

Grant, W.D. and O.S. Madsen. 1979. Combined wave and current interaction with a rough bottom. Journal of Geophysical Research. 84(C4):1797-1808.

Abstract. An analytical theory is presented to describe the combined motion of waves and currents in the vicinity of a rough bottom and the associated boundary shear stress. Characteristic shear velocities are defined for the respective wave and current boundary layer regions by using a combined wave-current friction factor, and turbulent closure is accomplished by employing a time invariant turbulent eddy viscosity model which increases linearly with height above the seabed.

Grant, W.D. and O.S. Madsen. 1986. The Continental-Shelf Bottom Boundary Layer. Ann. Rev. Fluid Mech. 18:265-305.

Abstract. Many aspects of the flow of air or water in the vicinity of boundaries have been studied both theoretically and experimentally. Well-known examples occurring in nature include the atmospheric boundary layer, the upper-ocean mixed layer, and shallow-water tidally driven bottom boundary layers. Although the boundary layers for these geophysical flows have many features in common, it has become increasingly obvious that the detailed understanding of each particular type of boundary layer depends on knowledge of the role played by specific processes in determining the boundary-layer scales and the mean and turbulent flow structure.

Grant, W.D., A.J. Williams and S.M. Glenn. 1984. Bottom stress estimates and their prediction on the northern California shelf during CODE-1: The importance of wave-current interaction. Journal of Physical Oceanography. 14:506-527.

Abstract. High quality near-botom boundary layer measurements obtained at a midshelf location (90 m water depth) in the CODE region off Northern California are described. Bottom tripod velocity measurements and supporting data obtained during typical spring and early summer conditions (June 1981 during CODE-1) are analyzed to obtain both velocity profiles and mean bottom stress and bottom roughness estimates.

Gray, I.E. and M.J. Cerame-Vivas. 1963. The circulation of surface waters in Raleigh Bay, North Carolina. Limnol. Oceanogr. 8(3):330-337.

Abstract. Returns from helicopter-released drift bottles over Diamond Shoals, in April and August 1962, revealed a definite southwesterly coastal flow from Cape Hatteras, North Carolina. Influenced by northeast winds the flow was more pronounced in late summer than in late spring, some of the bottles rounding Cape Lookout. Recovery of drift bottles from Onslow Bay and Bogue Sound strongly supports the theory that the temporary winter populations of distinctly northern species in the Beaufort, North Carolina, area become established from planktonic larvae that originated north of Cape Hatteras and were transported around the capes. A postulated circulation, involving the influences of Diamond and Lookout shoals, runoff, northeasterly and southwesterly winds, and back eddies from the Florida Current and from wind-induced currents, is presented for Raleigh Bay.

Gregg, W.W. and J.J. Walsh. 1992. Simulation of the 1979 Spring Bloom in the Mid-Atlantic Bight: A Coupled Physical/Biological/Optical Model. J. Geophys. Res. 97(C4):5723-5743.

Abstract. A coupled physical/biological/optical model was developed to investigate the causes of phytoplankton variability in the spring 1979 Mid-Atlantic Bight (MAB) as observed in Coastal Zone Color Scanner (CZCS) imagery, and to estimate the magnitude and variability of primary production. The model incorporated advection, mixing, sinking, growth as a function of light, temperature, and nutrient availability, and death as a function of ingestion. These variables were assumed to determine the large-scale, low-frequency variability of phytoplankton distributions. The model also contained two phytoplankton groups, netplankton and nanoplnakton, which differed in maximum growth rate, sinking rate, and specific light absorption. The model produced chlorophyll concentrations within the first attenuation depth within 1 standard deviation of CZCS imagery on large scale (i.e., over regions about 50 km in width). This suggested the model represented the physical/biological coupling often observed in imagery. The two phytoplankton groups used in the model were initialized to equal distributions throughout the model domain and organized in the course of the model run into distributions corresponding to long-term observations in the MAB; netplankton dominated the coast and nanoplankton dominated the slope. This suggested that the model incorporated the mechanisms causing these distributions in the real ocean, namely, the interaction between mixing, differential growth rates, and differential sinking rates. Finally, primary production estimates were within reasonable agreement with those measured *in situ*, suggesting the applicability of the model in estimating regional-scale primary production.

Grosskopf, W.G. 1980. Calculation of Wave Attenuation due to Friction and Shoaling: An Evaluation. CERC Tech. Paper. CERC-TP-80-8:17.

Abstract. An evaluation of the Bretschneider and Reid (1954) technique for calculating wave attenuation due to friction and shoaling is presented. Data used in this evaluation were collected at CERC's Field Research Facility (FRF), Duck, North Carolina. The results, using Kamphuis' (1975) friction factor diagram, show slightly underpredicted wave heights with an average deviation of 6 percent. Poor correlation with observed wave heights is illustrated when bottom contours are

not straight and parallel, indicating the presence of other mechanisms.

Grossman, R.L. and A.K. Betts. 1990. Air-sea interaction during an extreme cold air outbreak from the eastern coast of the United States. Mon. Weather Rev. 118(2):324-342.

Abstract. The area east of the coast of North Carolina chosen for enhanced observations during the Genesis of Atlantic Lows Experiment (GALE) has one of the highest average wintertime energy transfers from ocean to atmosphere. A substantial part of this transfer occurs in the aftermath of winter storms as cold, dry air flows off of the continent over the warm Gulf Stream. The authors report on an aircraft investigation of boundary layer mean and turbulent structure and evaluate the Lagrangian budgets of temperature and moisture in the subcloud layer following a streamline during an extreme cold air outbreak. (45 Refs.).

Gutman, A.L. 1976. Delineation of a wave climate for Dam Neck, Virginia Beach, Virginia. Virginia Institute of Marine Science Report. SRAMSOE No. 125:.

Abstract. Data from ship wave observations (1948-1973), Chesapeake Lightship wave observations (1970-1972), Corps of Engineer-Coast Guard surf observations (1954-1965), a Virginia Beach wave gage (1964-1969), and Virginia Institute of Marine Science-Corps of Engineers wave observations (1974-1976) are statistically summarized by season. Extreme waves are discussed.

Guza, R.T. and E.B. Thornton. 1982. Swash oscillations on a natural beach. J. Geophys. Res. 87(C1):483-491.

Abstract. Run-up (swash) oscillations were measured on a gently sloping beach face for a variety of incident wave conditions. Run-up energy spectra at wind wave frequencies show an f^{-3} dependence and energy levels that are independent of incident wave height. This suggests saturation. In contrast, run-up energy at surf beat periods increase approximately linearly with increasing incident wave energy. Thus, in the inner surf zone, where wave breaking limits the energy at wind wave frequencies, the principal manifestation of large incident wind waves is energetic surf beat.

Guza, R.T. and E.B. Thornton. 1985a. Observations of Surf Beat. J. Geophys. Res. 90(C2):3161-3172.

Abstract. The magnitudes of cross-shore velocity and elevation oscillations at surf beat frequencies observed on three ocean beaches are significantly correlated with the significant height of incident wind waves. Measured surf beat run-up spectra are coupled with numerical integrations of the long wave equations to predict the energy spectrum at offshore sensors, and the coherence and phase between offshore sensors and run-up meter. As in previous studies, valleys in the observed surf beat energy spectra at offshore sensors, and jumps in the relative phase between sensors, occur at the nodal frequencies of simple standing wave (either leaky or high mode edge wave) models. The variance observed in the surf beat cross-shore velocity field is between 10 and 100 times larger near the shoreline than in 5 m depth, and decays more rapidly with increasing offshore distance than the variance in the surf bveat elevation field.

The standing wave model is qualitatively consistent with this structure.

Guza, R.T. and E.B. Thornton. 1985b. Velocity moments in nearshore. American Society of Civil Engineers Journal of Waterway, Port and Coastal Ocean Engineering. 111:235-256.

Abstract. Recent models for nearshore sediment transport suggest the importance of various moments of the fluid velocity field in determining transport rates. Using two days of field data from a low slope beach with moderate wave heights (*H* approximately 70 cm), some low order, normalized moments are compared to results from simple monochromatic and linear random wave models. Not surprisingly, the random wave model is substantially more accurate than the monochromatic model. However, wave breaking and other nonlinearities introduce effects not explained by either formalism. The observed cross-shore velocity variance is decomposed into wind wave and surf beat components. The surf beat contribution is maximum at the shoreline, while the wind wave component is maximum offshore. The total variance is nearly constant across the surf zone. This observation contradicts assumptions that are fundamental to many models of surf zone dynamics and sediment transport. Analysis of a wider range of wave conditions is needed to assess the generality of these preliminary results. Using field data in the sediment transport model of Bailard (1981) suggests that both bed and suspended load are significant cross-shore transporting mechanisms on this low slope beach with moderate wave energy. Asymmetries in the oscillatory wave field tend to transport sediment shoreward, while the interaction of the offshore mean flow sith waves produces an offshore sediment flux.

Hager, J.G. 1977. Kinetic energy exchange in the Gulf Stream. J. Geophys. Res. 82(12):1718-1724.

Abstract. Ship drift data are utilized in studying the velocity field associated with the Gulf Stream system by computing three quantities suggested by the theory of turbulence; the mean kinetic energy, the eddy energy, and the energy exchange between the mean and fluctuating portions of the flow field (called dE/dt). Contours of the mean kinetic energy demonstrate that the mean velocity field is well defined and contains the major accelerations and decelerations described in the literature. Eddy energy contours show a smaller range of variance in comparison with the mean kinetic energy and a minimum situated along the center of the flow axis. The distribution of the dE/dt quantity is somewhat puzzling, although it is certainly contourable and nonrandom. It is suggested that downstream, cross-stream, and vertical components all may play important roles in its composition, whereas previous authors have made the assumption that only the cross-stream component is significant.

Hagerman, G., B. Zickefoose and T. Heller. 1989. Wave energy resource and technology assessment for coastal North Carolina. pp. 755-760. In Proceedings of the 24th Intersociety Energy Conversion Engineering Conference IECEC-89. Vol. 2. IEEE, New York.

Abstract. A preliminary assessment is presented of ocean wave energy conversion as an energy source for North Carolina. It considers the state's wave climate, the cost and performance of wave generating technologies now under development,

and the potential impacts that these devices may have on the marine environment. It is the first evaluation that combines these three aspects for a specific coastal area of the United States. It is concluded that wave energy can supply significant amounts of electricity to North Carolina without disruption of natural environmental processes, other uses of coastal sea space, or the scenic beauty of the coastline.

Haidvogel, D.B. 1983. The dynamics of the Gulf Stream System: Observations and models. EOS, Trans. AGU. 64(52):1027.

Abstract. Drawing on recent observational evidence, theoretical studies, and eddy-resolving general circulation models, we review our present understanding of Gulf Stream dynamics. Topics include: eddy and ring generation mechanisms, interaction with bottom topography, and potential vorticity conservation and homogenization. It is noted in particular that recent investigation of the Gulf Stream system using SOFAR floats, and their analogues in numerical models, presently allows the examination of these processes in the Lagrangian frame. As a result, considerable conceptual simplicity and sampling efficiency can be achieved.

Haight, F.J. 1942. Coastal currents along the Atlantic coast of the United States. U.S. Geol. Surv. Special Publication No. 230.

Hakansson, B. 1990. On the stability properties of an oceanic jet stream. J. Phys. Oceanogr. 20(10):1638-1643.

Abstract. The instability of oceanic jets such as the Gulf Stream and the Kuroshio appears to be dependent upon the distribution of potential vorticity. The formal argument favoring this state of affairs is generally based on linear quasi-geostrophic dynamics from which it can be shown that the necessary condition for instability is that the gradient of the potential vorticity changes sign. In the present investigation the consequences of this result are further investigated by extending the validity of the analysis to the regime of finite but small Rossby numbers. Hereby, the interpretation of the criterion can be generalized to also take into account effects due to a steeply sloping interface, and the relative vorticity of the geostrophically balanced basic state. (22 Refs.).

Halasi-Kun, G.J. and K. Widmer. 1975. Proceedings of University Seminar on Pollution and Water Resources (Selected Papers on Special Problems in Ocean Engineering). Volume VIII: 1974-1975. New Jersey Bureau of Geology and Topography Final Report. :176.

Abstract. Understanding the impact of outer continental shelf development approaches to design of environmental studies; Thermal plume field measurements in three dimensions; Recent progress in wave refraction studies and its application in the Mid-Atlantic Bight; Beach dynamics and sediment mobility on Sandy Hook, New Jersey; Phytoplankton bioassays for industrial pollutants in the Hackensack meadowlands; Sedimentary dynamics of a disturbed estuary-entrance sand shoal: the Shrewsbury entrance area of Sandy Hook Bay, New Jersey; Future energy resources including outer continental shelf development; Recent developments in the law of the sea.

Halkin, D. 1984. The Structure and Transport of the Gulf Stream at 73°W. Master of Science Thesis. Univ. of Rhode Island, Kingston. 87 pp.

Halkin, D. and H.T. Rossby. 1985. The Structure and Transport of the Gulf Stream at 73°W. J. Phys. Oceanogr. 15:1439-1452.

Abstract. Between September 1980 and May 1983, 16 sections of temperature and velocity were obtained with the Pegasus instrument along a transect crossing the Gulf Stream at 73°W. The mean temperature and velocity fields of the upper 2000 meters were calculated. The transport above 2000 meters calculated from the sections had a mean of 87.8 (± 17.3) X 10^6 m^3/s. A comparison with mass flux measurements obtained by previous investigators at Cape Fear indicated that the addition to the transport of the Stream in the region was uniform above 800 meters and to decrease substantially below this depth. The increase in transport at the line estimated from the mean cross-stream velocity field was 15.4 (± 5.8) X 10^6 m^3/s per 100 km downstream distance. The temporal fluctuation of the Pegasus transport measurements was consistent with an annual cycle with a maximum in April. The mean eddy kinetic energy at the surface was 1500 cm^2/s^2, of which 1000 cm^2/s^2 was due to the meandering of the current. The velocity structure of the front was remarkably constant: the eddy kinetic energy attributable to structural changes of the front was 500 cm^2/s^2, only three times as great as midocean values.

Hall, N.M. 1991. Depth Dependence and Mass Transport of Recirculating Midlatitude Gyres. J. Phys. Oceanogr. 21(6):824-842.

Abstract. The study is diagnostic, concentrating on numerical inversions of idealized quasi-geostrophic potential vorticity distributions in a vertical, meridional section through a free inertial gyre. An iterative approach is used to find the "bowl" of circulation: the free boundary between the deep recirculating homogenized water and the stagnant water below.

Halliwell, G.R. 1978. The space-time structure and variability of the shelf water/slope water and Gulf Stream surface thermal fronts and warm core eddies, off the northeast United States. CMS-C-2-78, College of Marine Studies, Univ. of Delaware.

Halliwell, G.R., Y.J. Ro and P. Cornillon. 1991. Westward-propagating SST Anomalies and Baroclinic Eddies in the Sargasso Sea. J. Phys. Oceanogr. 21(11):1664-1680.

Abstract. Previous studies have documented the existence of a zonal band of strong, persistent, westward-propagating sea surface temperature (T_s) anomalies with zonal wavelengths of ≈800 km and periods of ≈200 days that are confined to the subtropical convergence zone (STCZ, roughly 26°-32°N). Two years of satellite-derived sea surface temperature (T_s) and sea surface anomaly maps of the Sargasso Sea (22.5°-33.5°N, 71.5°-59.5°W) are analyzed to determine how these anomalies are forced and why they are confined to the STCZ. A simple anomaly model forced by horizontal eddy currents and damped by a linear feedback mechanism explains many properties of the anomaly response. At wavelengths exceeding several hundred kilometers, forcing by horizontal eddy currents becomes less important relative to atmospheric forcing with increasing wavelength. A

simple linearized reduced-gravity model is used to demonstrate that interaction between eddies and zonal mean currents can qualitatively account for the change in dispersion properties south of the STCZ, but not to the north within the Gulf Stream recirculation region.

Halliwell, G.R., Jr. and C.N.K. Mooers. 1979. The space-time structure and variability of the shelf water-slope water and Gulf Stream surface temperature fronts and associated warm-core eddies. J. Geophys. Res. 84(C12):7707-7725.

Abstract. The space-time structure and variability of three thermal features on the surface of the Northwest Atlantic--the shelf water-slope water front; and warm-core, anticyclonic eddies--were examined between September 1, 1975, and August 31, 1977, using weekly satellite-derived charts of surface temperature fronts. The temporal and spatial correlation scales of both the shelf-slope and Gulf Stream fronts were about 2 weeks and 80 km, respectively. The rms amplitude of both fronts increased from about 25 to 80 km in the first 1,000 km southeastward from Cape Hatteras. The dominant Gulf Stream meanders had wavelengths of about 320 km and periods of 7-8 weeks, and they propagated downstream at a speed of about 6 cm/s. The results of this study agree with earlier, more limited estimates, and they extend the statistical analyses to the space-time continuum of long waves and meanders with the aid of wave number-frequency spectra and empirical orthogonal functions. These analyses quantify the broadbanded nature of the various perturbations and their interactions. Thus a holistic view of the principal surface thermal features of the Northwest Atlantic, and their interactions, is provided.

Halliwell, G.R., Jr. and C.N.K. Mooers. 1980. Atmospheric and offshore forcing of shelf circulation at sub-synoptic periods from Cape Hatteras through Georges Bank. Subcontract Rep. to EG&G.

Abstract. Compares current measurements to atmospheric forcing variables measured at coastal stations. Fluctuations of wind stress and temperature were found to change dramatically between coastal locations, and the offshore changes in these fluctuations have a large annual cycle.

Halliwell, G.R., Jr. and C.N.K. Mooers. 1983. Meanders of the Gulf Stream downstream from Cape Hatteras, 1975-1978. J. Geophys. Res. 13(7):1275-1292.

Abstract. Time series data from the U.S. Navy Ocean Frontal Analysis is examined for positioning of the Gulf Stream and for associated features. The Ocean Frontal Analysis is a weekly facsimile product derived from polar orbiter infrared imagery along with ship observations.

Halliwell, G.R., Jr., P. Cornillon and D.A. Byrne. 1991. Westward-propagating SST Anomaly Features in the Sargasso Sea, 1982-88. J. Phys. Oceanogr. 21(5):635-649.

Abstract. Sea surface temperature maps of the region from 59.5° to 75.5°W, 22.5° to 33.5°N containing the western North Atlantic Subtropical Convergence Zone (STCZ) were derived from AVHRR/2 images. The 7-year mean annual cycle was removed and the maps were filtered in space and time to represent anomaly

variability with wavelengths ≥ 220 km and periods ≥ 50 days. Warm and cold anomaly features were observed east of 71°W between 26° and 32°N that propagated westward at 3-4 km/day and that occasionally exceeded ±1°C in amplitude.

Hamilton, P. 1982. Analysis of current meter records at the northwest Atlantic 2800 meter radioactive waste dumpsite. EPA Tech. Rep. 520/1-82-002.

Hamilton, P. 1984. Topographic and inertial waves on the continental rise of the Mid-Atlantic Bight. J. Geophys. Res. 89(C1):695-710.

Abstract. Analysis of an array of four closely spaced moorings instrumented by near-bottom current meters was performed with a view to isolating coherent wave motions in the low-frequency and inertial bands.

Hamilton, P. 1987. The Structure of Shelf and Gulf Stream Motions in the Georgia Bight. Prog. Oceanogr. 19:329-351.

Abstract. The structure of the current and temperature fields along 30°N over the mid-shelf and western Blake Plateau in the South Atlantic Bight has been investigated by combining two moored instrument experiments in the summer of 1981. The shelf moorings were part of the second Georgia Bight Experiment (GABEX-II) and the Gulf Stream mooring data on the Blake Plateau have been described by Lee and Waddell (1983). Empirical Orthogonal Functions (EOF) in the frequency domain are used to extract shelf and Gulf Stream coherent current and temperature fluctuations in the two-to 14-day period band. Three modes are found, of which the first two are interpreted as Gulf Stream meander and frontal eddy circulations. The difference between them is chiefly in the shelf motions; the first mode is primarily restricted to the shelf edge, whereas the second mode penetrates to the 40m isobath. The third mode dominates at mid-shelf and is the only mode that shows strong coherence with the windstress and local sea-level fluctuations. The relationship of the modes to the occurrence of mid- and inner-shelf cold sub-surface intrusions, generated by shelf-edge Gulf Stream frontal eddies, is examined. All three modes are found to play a role in the initiation, growth and decay of these structures.

Hansen, D.V. 1970. Gulf Stream meanders between Cape Hatteras and the Grand Banks. Deep-Sea Res. 17:495-511.

Abstract. The position of the Gulf Stream between Cape Hatteras and approximately 60°W was delineated at intervals of a few days to a month using the 15°C isotherm at 200 m depth as an indicator for the thermal front associated with the stream. The dominant pattern inferred from the sequence of observations is a quasi-geostrophic wave pattern of 200-400 km wave length moving to the east with phase speeds of 5-10 cm/sec, and amplitudes generally increasing steadily to the east, except for a breakdown in summer when very large amplitude meandering between 69°W and 64°W led to extremely complicated thermal conditions in this region. Evaluation of topographic and Coriolis effect variations along the paths indicates that for plausible current structure the mean path of the stream is consistent with the topographic control hypothesis advanced by Warren (1963). Although the meanders too must be strongly influenced by topographic variations, these variations are in general insufficient to account for the curvature of meanders in the observed paths. Comparison of unstable wave properties inferred

from the observations with results from several investigations of dynamic instability as a possible cause of the meanders shows that baroclinic instability theories yield good estimates of wave length of the fastest growing wave component, and a baroclinic theory with some topographic influences yields a good approximation to the phase speed as well. An equivalent spatial growth rate computed from the disturbance group velocity and the temporal growth predicted by all the theories is generally larger than that of the observed meanders.

Hansen, D.V. and G.A. Maul. 1970. A note on the use of sea surface temperatures for observing ocean currents. Remote Sens. Environ. 1:161-164.

Abstract. Utilizing satellite data, this study suggests that surface and the deeper structures of the Gulf Stream are fairly coherent. This paper attempts to connect surface with subsurface flow using satellite images.

Harrington, C.L. 1981. Responses of benthic macrofauna to the dynamics of a Gulf Stream front on the continental shelf near Cape Hatteras, North Carolina. Ph.D. Thesis. The University Of Wisconsin - Madison. 149 pp. (DAI 42/02B, p.526; AAC8112541)

Abstract. A 10C front between Virginian and Gulf Stream water masses oscillates across the inner shelf near Cape Hatteras North Carolina, a region recognized as a major zoogeographic barrier. This thesis evaluates the importance of the Gulf Stream front in determining (1)the geographic distributions of echinoderms, (2)the seasonal persistence and species richness, and (3)the aggregations of benthic fishes, decapod crustaceans, and echinoderms in this region. Samples were collected in June, August, and October 1977, and January 1978 with a bottom trawl in the area most influenced by the Gulf Stream front, in two sites directly off Cape Hatteras, and in northern and southern reference sites relatively uninfluenced by the movements of the front. All sites were located along the 30m depth contour. Nine species of echinoderms exhibit two distribution patterns, terminated and discontinuous, in the Cape Hatteras region. Two sea stars which have discontinuous distribution patterns appear to recruit to the southern sites only. Differences in larval dispersability and adult mobility among the species assemblage may explain the distributions observed. Lower seasonal persistence was observed for fishes in the three sites influenced by the seasonal dynamics of the front. For decapods, seasonal persistence was lower only at the site most influenced by the front. Seasonal persistence was high for echinoderms at all sites. Species richness of all three faunal groups was highest at the southern site, with most substrate types, and declined to the north. Lower seasonal persistence at the front did not lead to increased species richness as predicted by Connell's intermediate disturbance hypothesis. Mobile species migrating from southern and offshore populations may contribute to the species richness of the sites near Diamond Shoals. We test the hypothesis that frontal aggregations resulted from organisms response to the front itself rather than to a geographically fixed feature of the region. For fishes, two areas contained more species and individuals when the front was present. Atlantic croaker, weakfish, and spot left when the front left. Decapods exhibited some response to the front especially at night. During day, fewer echinoderms were caught when the front was present. During the day all three groups were more abundant in the northern than in the southern area. This thesis is part of a team research project conducted near Cape Hatteras, North Carolina in 1977-78. The significance of the project

lies in its focus (1)on the dynamics of the Gulf Stream front, (2)on the benthic community, (3)on faunal groups differing in many aspects of life history, and (4)in its rigorous sampling design. Smith-McIntyre grab samples were also collected from each sampling site. Analyses still in progress include (1)zonation and resource partitioning of fishes living in the front, (2)life history and its role in the distribution of selected decapods near Cape Hatteras, (3)community dynamics of a zoogeographic barrier, (4)biogeographic guilds of mid-Atlantic shelf fishes and seasonal dynamics of the faunal boundary near Cape Hatteras, and (5)comparative zoogeography and ecology of the infauna near Cape Hatteras. A study of the effects of temperature and dispersal on echinoderm recruitment to the continental shelf near Cape Hatteras, based on Chapter I, is proposed.

Harrison, W., J.J. Norcross, N.A. Pore and E.M. Standley. 1965. Circulation of shelf waters off the Chesapeake Bight: surface and bottom drift of continental shelf waters between Cape Henlopen, Delaware and Cape Hatteras, North Carolina, June 1963 - December 1964. ESSA Professional Paper. No. 3:81.

Harrison, W.G., D. Douglas, P.G. Falkowski, G.T. Rowe and J. Vidal. 1983. Summer Nutrient Dynamics in the Middle Atlantic Bight: Nitrogen Uptake and Regeneration. Journal of Plankton Research. 5(4):539-556.

Abstract. Nitrate and ammonium uptake and ammonium regeneration rates (by zooplankton, microplankton and benthos) were measured on the Atlantic continental shelf (Middle Atlantic Bight) during the summer, 1980. Euphotic zone profiles of NO_3^- and NH_4^+ regeneration rates, although measured less frequently, also showed a relatively consistent vertical structure; rates were positively correlated with uptake rates.

Hastenrath, S.L. and R.M. Hayes. 1981. Detection of the Gulf Stream. pp. 146-160. In R.C. Beal, P.S. DeLeonibus and I. Katz, eds. Spaceborne Synthetic Aperture Radar for Oceanography. The John Hopkins University Press, Baltimore.

Hathaway, J.C. 1971. Data file continental margin program Atlantic coast of the United States, Volume 2 samples collection and analytical data. WHOI Tech. Rep. WHOI-71-15:496pp.

Abstract. The purpose of the data file presented below is twofold: the first purpose is to make available in printed form the basic data relating to the samples collected as part of the joint U.S. Geological Survey - Woods Hole Oceanographic Institution program of study of the Atlantic continental margin of the United States; the second purpose is to maintain these data in a form that is easily retrievable by modern computer methods. With the data in such form, repeated manual transcription for statistical or similar mathematical treatment becomes unnecessary. Manual plotting of information or derivatives from the information may also be eliminated. Not only is handling of data by the computer considerably faster than manual techniques, but a fruitful source of errors, transcription mistakes, is eliminated.

Haung, C.-Y. and S. Raman. 1991. Numerical simulation of January 28 cold air outbreak during GALE II. The mesoscale circulation and marine boundary layer. Boundary-Layer Meteorology. 56(1-2):51-81.

Abstract. A two-dimensional (2-D) mesoscale numerical model is applied to simulate the January 28 cold-air outbreak over the Gulf Stream region during the 1986 Genesis of Atlantic Lows Experiment (GALE). The model utilizes a turbulence closure which involves the turbulent kinetic energy (TKE) and dissipation (in) equations. The modeled marine boundary layer (MBL) is in good agreement with the observations, showing a low-level jet west of the Gulf Stream warm core and a constrained boundary layer due to the middle-level (2-4.5 km) stable layer. The MBL-induced single cloud and rain band first appears east of the Gulf Stream boundary, and then moves offshore at the speed of the circulation front. The results also indicate that the observed high cloud streets propagating downwind of the Gulf Stream may be related to upper-level baroclinic lee waves, triggered by an elevated density mountain.

Haung, N.E., C.D. Leitao and C.G. Parra. 1978. Large-scale Gulf Stream frontal study using GOES-3 radar altimeter data. J. Geophys. Res. 83(C9):4673-4682.

Abstract. From data obtained by the Geos 3 radar altimetry, sea surface heights are found by both editing and filtering the raw sea surface height measurements and then referencing these processed data to a 5' X 5' geoid. Any trend between the processed data and the geoid is removed by subtracting out a linear fit to the residuals in the open ocean. Data from individual passes are further processed by applying a minimum variance technique at the subsatellite crossing points to produce surface topography maps for the 6 months and an overall mean map which reveal important details about the Gulf Stream system. The differences between the monthly mean and the overall mean are calculated for each of the 6 months to show the temporal and spatial changes of the Gulf Stream front and spawned eddies. The standard deviation map is even more informative and shows preferred locations of Gulf Stream meanders.

Haung, R.X. 1990. On the structure of inertial western boundary currents with two moving layers. Tellus, Series A [Dynamic Meteorology and Oceanography]. 42A(5):594-604.

Abstract. The structure of inertial western boundary currents with two moving layers is studied using a streamfunction coordinate transformation. This transformation converts the equation system, a stiff system over a semi-infinite domain in physical coordinates, into a non-stiff system over a finite domain in streamfunction coordinates. For simplicity, the interfacial slopes of the interior solution are assumed constant. The structure of the solutions can be classified into three categories in a phase plane which consists of two regions joining along a critical line. Within each region, solutions of the system appear in the form of two unconnected branches. As parameters approach values corresponding to those at the critical line, the two branches of the solution join at a movable critical point to form a continuous solution. Although changes in the vorticity profile of the incoming flow or other parameters can alter the position and shape of the critical line, the general features of the system remain unchanged. (10 Refs.).

Haupt, S.E. 1988. Solving nonlinear wave problems with spectral boundary value techniques. Ph.D. Thesis. The University of Michigan. 167 pp. (BOYD, JP (adviser); DAI 49/05B, p.1765; AAC8812905)

Abstract. Solitary waves are important in modeling geophysical flows. They have been the basis for successful models of coherent structures, such as the persistent high pressure systems in the atmosphere, Gulf Stream rings, and the Great Red Spot of Jupiter. Most previous numerical studies have solved the nonlinear evolution equations as initial value problems. Here, they are approached as spectral boundary value problems. One technique used is to analytically expand the equation in powers of an amplitude parameter via the Stokes' perturbation expansion, which is accurate for small amplitude. The solution may then be extended to larger amplitude using a Newton-Kantorovich iteration. We have applied these techniques to several problems. The first problem addressed is wave resonance; the phase speeds of two wave components are equal and the traditional Stokes' expansion fails. The situation is rectified by adding the resonant wave into the expansion at the appropriate lower order. The coefficient of the resonant wave is determined at higher order in the expansion, resulting in a modified expansion which agrees well with the numerical solution. The case of near resonance is treated by expanding the resonance parameter in terms of the amplitude as well. A second problem is computing double conoidal waves (two independent waves on each period) of the integrable Korteweg de Vries equation and the nonintegrable Regularized Long Wave (RLW) equation. The nonlinear evolution equation is written in terms of two phase dimensions and the techniques described above are applied. The KdV solution compares well to the exact solution in the soliton limit. Although we cannot prove the double conoidal waves of the RLW exist, the results agree well with initial value solutions for moderate amplitudes.

Haustein, J.R. 1981. Effects of shoaling bottom topography on the dynamics of Gulf Stream cyclonic rings. Ph.D. Thesis. Texas A&M University. 273 pp. (DAI 42/07B, p.2756; AAC8128894)

Abstract. A two-layer, rigid-lid model of a Boussinesq, quasi-geostrophic ocean, based on the vertically-integrated equations of motion, is used on a beta-plane to study the processes involved as an initially-Gaussian cyclonic ring translates into a continental shelf. Initial tests of geostrophy, rotation, nonlinearity, lateral frictional effects and topography yield values of energy decay and partitioning and centroid propagation speeds in close proximity to those predicted by and extrapolated from linear theory. A series of six 60-day simulations, based on the parameterization of an actual Gulf Stream-derived ring, are used to study the combined effects of baroclinicity (defined as the ratio of maximum lower layer velocity to maximum upper layer velocity) and topography as a ring propagates up a numerical parameterization of the Blake Plateau. Model results are compared to actual ring measurements and subsequent data analyses. Nonlinear terms in the equations of motion are found to have a stabilizing effect on ring decay. A greater slope results in an increased westerly and decreased northerly component of motion. Baroclinicity yields an increase in both northerly and westerly translation. Slope inhibits the propagation of the barotropic mode and appears to stabilize ring spin-down. Velocities tend to converge to a common value with initially-different values of baroclinicity. Increased baroclinicity decreases ring lifetime. An anomalous behavior results in the case where

velocities in the upper and lower layers are initially opposite in direction.

Havens, J.M., D.M. Shaw and E.R. Levine. 1973. Offshore weather and climate. pp. 43. In S.B. Saila, ed. Coastal and offshore environmental inventory of Cape Hatteras to Nantucket Shoals. URI (Marine Publ. Series No. 3)11.

Abstract. A literature review which summarizes the Middle Atlantic region. Provides summary of weather/climate statistics from predominantly onshore stations up to 1972.

Hayden, B.P. 1975a. The annual cycle of wave climates along the East Coast of the United States. Proceedings of the Coastal Society, November 1975, Arlington, VA. 225-231.

Abstract. Visual surf observations from the Cooperative Surf Observation Program (COSOP) were processed into running means to define summer and winter wave climates at six U.S. east coast locations including Virginia Beach (VA).

Hayden, B.P. 1975b. Storm Wave Climates at Cape Hatteras, North Carolina: Recent Secular Variations. Science. 190:981-982.

Abstract. Mid-Atlantic coastal wave climates have undergone significant change within the last three decades. The duration and frequency of storms generating high waves and the length of the winter storm wave season have increased. These changes may, in part, account for the observed trend in shoreline erosion along the east coast of the United States.

Hayden, B.P. 1980. Atlantic Coast extratropical cyclones: Characteristic frequency patterns and their secular variation. Presented at 2nd Conference on Coastal Meteorology, Los Angeles, CA (USA) 30 Jan. 1980. Am Meteor. Soc. p. 192-197.

Abstract. Provides summary of extratropical cyclones which have traversed the Middle Atlantic region. Their seasonality, frequency, and historical paths are presented.

Hayden, B.P. 1981. Secular variation in Atlantic coast extratropical cyclones. Mon. Weather Rev. 109(1):159-167.

Abstract. Areal distribution and climatology of the most common storms off the eastern U.S. coast.

Hayden, B.P. and R. Dolan. 1975. Classification of coastal environments of the world. Coastal wave climates of the Americas. University of Virginia, Department of Environmental Sciences. Final Report prepared under contract number N00014-69-0060-0006:169.

Abstract. A classification of U.S. east coast wave climate regimes was developed based on characteristics of large scale semi-permanent wind systems such as those depicted in climatological atlases.

Hayden, B. and R. Dolan. 1977. Classification of Coastal Environments (Technical Reports Number 13 through 18). University of Virginia, Department of Environmental Sciences. TR-13; TR-14:101.

Abstract. Crescentic Coastal Landforms; Classification of Coastal Landforms of the Americas; Recent Secular Variations in Mid-Atlantic Winter Extratropical Storm Climate; Storm Wave Climates at Cape Hatteras, North Carolina: Recent Secular Variations; Multivariate and Spectral Analyses of Some Seasonal Aspects of Wave Climates; and January-Thaw Singularity and Wave Climate Along the Eastern Coast of the USA.

Hayes, J. and W. Mihok. 1981. SEASAT Shallow Water Wave and Ocean Current Refraction Analysis. NOAA, NESS Rep. NOAA-82012007:100.

Abstract. This study evaluates the use of SEASAT Synthetic Aperture Radar (SAR) as an ocean wave and current measuring device. The ERT Shallow Water Wave Model (SWAM) was used to model refraction due to both bathymetry and Gulf Stream Interaction. Initial conditions are the deep water direction and period of waves observed from Revolution No. 974 of the SAR on September 3, 1978. Output from the model are compared with data from the SAR in shallow water, ERIM FFT's, NOAA data buoys and the Duck, North Carolina Experiment (Duck-X).

Hayes, J.G., P.H. Kirshen, C.J. Bowley, H.R. Bernard and C.S. Welch. 1978. The value of remote sensing in studying the physical oceanography and meteorology of the South Atlantic OCS area. Presented at 10th Annual Offshore Tech. Conf. (OTC 3275) Houston, TX: 1937-1946.

Abstract. Publication resulting from BLM contract as part of South Atlantic OCS Environmental Studies Program. Demonstrates advantages of remote sensing to augment conventional data for climatology of the study area (South Atlantic OCS). In particular, an analysis of the interaction of the Gulf Stream with the continental shelf and Blake Plateau is provided.

Hayes, R.M. 1975. Oceanographic Observations: Nova Scotia to Cape Hatteras, North Carolina (October-November 1969 and May-June 1970). USCG Rep. USCG-373-66:248.

Abstract. A volumetric statistical (T-S) analysis of water masses is presented for two Coast Guard oceanographic cruises in support of the International Commission for the Northwest Atlantic Fisheries, from 25 Oct-22 Nov 1969 and 19 May-9 June 1970. The fall cruise data exhibited a 54% greater volume of Gulf Stream water in the survey area than the spring cruise, a result of a Gulf Stream meander which brought large volumes of tropical water into the slope region. Effectively the Gulf Stream meanders resulted in an exchange of water masses bringing oceanic water into the coastal zone and vice versa. Seasonal changes in the geostrophic conditions shoreward of the Gulf Stream may influence the extent of intrusion of that water mass into the continental shelf region.

Hayes, R.M. 1981. Detection of the Gulf Stream. pp. 146-160. In . Johns Hopkins Univ. Press, Baltimore.

Abstract. Provides overview of the Gulf Stream in terms of characteristics and methods for collection information regarding path, features and associated hydrography.

Hazelworth, J.B. 1976. Oceanographic variations across the Gulf Stream off Charleston, South Carolina during 1965 and 1966. NOAA Tech. Rep. ERL 383-AOML 25:73.

Abstract. A physical oceanographic program across the Gulf Stream was conducted off Charleston, South Carolina. The project consisted of a series of cruises, one every two weeks, from August 1965 to July 1966. The primary objectives of the program were to investigate the variability of the physical properties and to record the dynamic variability of the Gulf Stream over a period of one year. This report describes the measurements taken and the methods applied to correct and analyze the hydrographic station data. Cross-sections of each physical property for each cruise are presented. Geostrophic currents and volume transport calculations are presented. Results of water mass analysis by use of the T/S curve and also by use of the oxygen-density relationship are given.

Hebert, P.J. 1974. North Atlantic tropical cyclones, 1973. Mar. Weather Log. 18(1):1-16.

Abstract. Summary of hurricane statistics by the National Hurricane Center in Coral Gables, FL.

Hebert, P.J. 1976. North Atlantic tropical cyclones, 1975. Mar. Weather Log. 20(2):63-73.

Abstract. Continuation in series of regular summaries of hurricane seasons by the National Hurricane Center.

Hebert, P.J. 1977a. Annual data and verification tabulation Atlantic tropical cyclones 1975. National Hurricane Center, Coral Gables, FL, Tech. Memo. 67.

Abstract. Continuation of series of regular summaries for 1975 hurricane season.

Hebert, P.J. 1977b. Annual data and verification tabulation Atlantic tropical cyclones 1976. National Hurricane Center, Coral Gables, FL, Tech. Memo. 70.

Abstract. Continuation of series of regular summaries for 1976 hurricane season.

Hebert, P.J. 1979. Annual data and verification tabulation Atlantic tropical cyclones 1978. National Hurricane Center, Coral Gables, FL, Tech. Memo. 67.

Abstract. Continuation of series of regular summaries for 1978 hurricane season.

Hebert, P.J. 1980a. Annual data and verification tabulation Atlantic tropical cyclones 1979. National Hurricane Center, Coral Gables, FL, Tech. Memo. 84.

Abstract. Continuation of series of regular summaries for 1979 hurricane season.

Hebert, P.J. 1980b. North Atlantic tropical cyclones, 1979. Mar. Weather Log. 24(2):88-103.

Abstract. Summary of tropical cyclones for the 1979 hurricane season for the North Atlantic region. The 1979 tropical cyclone season showed some signs of returning to what is considered normal; that is, lower latitude origins and tracks, more U.S. landfalls, and more intense hurricanes striking land areas in the western North Atlantic. There were eight named storms, five of which became hurricanes, and one subtropical storm this season.

Hebert, P.J. and N.L. Frank. 1974. Atlantic hurricane season of 1973. Mon. Weather Rev. 102(4):280-289.

Abstract. The general overview of the 1973 hurricane season in the North Atlantic is presented together with detailed accounts of all named tropical storms.

Hecker, G.M. 1980. Coherence between wind and current events in a nearshore, shallow water, wave dominated environment. Ph.D. Thesis. Old Dominion University. 124 pp. (DAI 41/12B, p.4433; AAC8111390)

Abstract. Five days of observation were made of the current at four depths in a water depth of eight meters, and accompanying record of local wind one-half Kilometer from shore at the U.S. Army Corps of Engineers Coastal Engineering Research Center field facility at Duck, North Carolina beginning five May 1978. The current was measured with a state-of-the-art electromagnetic current meter having a 0.2-second response time and an accuracy of ± 2 centimeters per second. At each depth a ten-minute record was made each hour with a sampling interval of one-eighth second. The frequency components of the record were analyzed and found to be essentially free from noise and bias. The record of one hundred and twenty (less five lost due to loss of amplifier power supply) ten-minute averages was also analyzed for frequency components. Semidiurnal and diurnal tidal components and quadratic curve trends were identified. Analyses by fast fourier transform revealed that the component of the wind perpendicular to the coast had significant coherence with the alongshore component of the current.

Hendry, R.M. 1982. On the Structure of the Deep Gulf Stream. J. Mar. Res. 40(1):119-142.

Abstract. The zonal and temporal structure of the mean and low-frequency flow beneath the Gulf Stream at 55W is explored in an analysis of 17 months of current ant temperature measurements at 4000 m depth. The data were obtained from a zonal array of four moorings along 40° 30'N with a maximum separation of 90 km. Current speeds of up to 0.5m/s are observed, with r.m.s. speeds of 0.17 m/s and a mean flow of about 0.05 m/s toward the northwest. The temperature variability is skewed toward warm events, suggesting that the array is located near the edge of a deep zonal temperature front. Current and temperature events show a dominantly westward propagation tendency, with meridional velocity components and

temperature exhibiting propagations speeds of about 15 km/day but zonal current fluctuations propagating more than twice as fast. This suggests that there are several organized modes of variability present in the deep water. There is a statistically significant deep eddy heat flux, of uncertain origin, which is directed toward the southeast.

Herstein, P.D., R.K. Dullea and S.R. Santaniello. 1979. Hatteras Abyssal Plain Low Frequency Bottom Loss Measurements. NUSC Tech. Rep. NUSC-TR-5781:105.

Abstract. Bottom-loss measurements were made for frequencies less than 800 Hz at three stations in the Hatteras Abyssal Plain. The stations were each separated approximately 55 km along 70 deg. 30'W longitude. The data acquisition procedure was to launch two self-recording submersibles (AUTOBUOYS) and then maneuver from and to the launch site detonating explosives as the AUTOBUOYS recorded data. Because of the experimental geometry, the direct and bottom-interacting signals were time-separated as they arrived at the AUTOBUOYS. Thus, a 'self-calibrating' processing procedure could be used to compute bottom loss values. Bottom loss versus grazing angles (5-66 deg) was obtained over a wide bandwidth (90-790 Hz) and for a number of narrow bandwidths (1/3 octave and less). Broadband results were found to be homologous between stations, whereas the narrowband results were less correlated. Negative bottom loss values were also observed. Analyses of the impulse responses for the southern station also aided in developing a geophysical description of the sediment structure. The derived structure consists of a thin (21 m), constant sound-speed layer overlaying a thick layer having a linear depth-dependent sound speed. This structure is representative of a class of documented subbottom sediment structures that can support the propagation of low-frequency acoustic signals traversing non-plane wave reflected and refracted acoustic paths.

Hill, S. and H.W. Ducklow. 1983. Bacterial biomass variability in warm core ring systems. EOS, Trans. AGU. 64(52):1074.

Abstract. During the Warm Core Rings program we sampled bacterial abundance and biomass in four rings (81-D, 82-B, 82-E, 82-H) during spring, summer, and fall. We have been able to examine variability in these properties over time scales ranging from hours to months and space scales of meters - 100's of km. Equal variability was observed over all these scales and is related to physical and biological variability which is also manifested at all scales. We suggest that sources of large-scale variability such as ring rotation and translation, and of mesoscale variability (storms) may destroy covariability between phytoplankton and bacteria, which is manifested at smaller scales (meters-kilometers). Mean cell sizes were 3.7, 9.2, and 10.3 fgC/cell at ring center, high velocity, and Slope Water regions, respectively. Bacterial biomass, but not necessarily abundance, increased sharply away from ring center.

Hitchcock, G.L. and A.J. Mariano. 1991. Pigment Distributions in a Gulf Stream Meander Trough, April 1989. EOS, Trans. AGU. 72(51):58.

Abstract. In April, 1989 six sections across the Gulf Stream examined chlorophyll a (chl a), temperature, and salinity gradients about an anticyclonic Gulf Stream meander in conjunction with the Anatomy of a Meander study of T. Rossby and E. Carter. Repeated sections in a meander trough over 3 weeks revealed the pigment

field evolved as surface waters at the northern edge of the Stream destratified and the trough interacted with a cold-core ring. Analysis of all available data indicates that seasonal factors have a major influence on pigment distributions. By late April the upper pycnocline surfaces (25.8 - 26.2 σ_θ) had shoaled into the surface mixed layer on the cyclonic edge of the current. Chl a levels increased to > 1 μg/l, with highest concentrations associated with the 26.2 - 26.4 σ_θ surfaces. A pigment 'front' with chl a > 0.4 μg/l extended seaward from the Slope Water to the Stream core. In general, the cross-Stream pigment gradients and near-surface density structure had sharper gradients in the meander trough (spring, 1989) than previously seen in a meander crest (fall, 1988). It is concluded that seasonal factors physical and biotic) determine the magnitude of the mesoscale cross-Stream pigment gradient, while the dynamical structure of Gulf Stream meanders and ring-Stream interactions regulate the spatial gradient.

Hitchcock, G.L., E.J. Lessard, D. Dorson, J. Fontaine and T. Rossby. 1989. The IFF: the isopycnal float fluorometer. J. Atmos. Oceanic Technol. 6(1):19-25.

Abstract. An isopycnal float has been developed which provides a description of water parcel motion and simultaneous measurements of chlorophyll a fluorescence, pressure and temperature along a chosen isopycnal surface. The device consists of a modified Swallow float with a 'compressee' to match the compressibility of the float to that of seawater, so that pressure-induced buoyancy changes are removed. The solid-state fluorometer, modified from a preexisting design, provides a measure of the temporal variability in chlorophyll a fluorescence. A pilot deployment of the float was made in September 1986 within a shelf water entrainment feature along the northern edge of the Gulf Stream near 37°N, 73°W. A primary application of the float is to measure upwelling velocities and the concurrent changes in the chlorophyll a fluorescence field. (17 Refs.).

Hitchcock, G.L., A.J. Mariano and T. Rossby. 1991. Mesoscale pigment fields in the Gulf Stream. J. Geophys. Res. Submitted:.

Ho, F.P. and R.J. Tracey. 1975a. Storm Tide Frequency Analysis for the Coast of North Carolina, North of Cape Lookout. NOAA Tech. Memo. NOAA-TM-NMS-HYDRO-27:54.

Abstract. Storm tide height frequency distributions are developed on the coast of North Carolina, north of Cape Lookout, for the National Flood Insurance Program. Storm tides are computed from a full set of climatologically representative hurricanes using the National Weather Service numerical-dynamic storm surge model. Winter storm effects are estimated from tide gage records. Storm tide levels from all storms are shown in coastal profile between annual frequencies of 0.10 and .002. The report is intended for use in estimating actuarial risk to buildings from coastal floods and in land use management.

Ho, F.P. and R.J. Tracey. 1975b. Storm Tide Frequency Analysis for the Coast of North Carolina, South of Cape Lookout. NOAA Tech. Memo. NOAA-TM-NWS-HYDRO-21:52.

Abstract. Storm tide height frequency distributions are developed on the coast of North Carolina, south of Cape Lookout, for the National Flood Insurance Program by computing storm tides from a full set of climatologically

representative hurricanes, using the National Weather Service hydrodynamic storm surge model. Tide levels are shown in coastal profile between annual frequencies of 0.10 and .002. The report is intended for use in estimating actuarial risk to buildings from coastal floods and in land use management.

Hobbie, J.E. 1970. Hydrography of the Pamlico River Estuary, N.C. North Carolina Water Resources Research Institute. OWRR-B-004-N.C. (5):80.

Abstract. The Pamlico River Estuary extends some 35 miles from Washington, N.C. to Pamlico Sound. It is shallow, from 2 to 6 miles wide, naturally productive, and has from 0.5 to 15 or 20 ppt salinity. The salinity regime is determined chiefly by the quantity of inflowing freshwater and changes in salinity of up to 10 ppt are common at any station. Lunar tides are small (less than 0.5 ft) but wind and wind tides can have important effects on the salinity distribution. In addition, the Coriolis Force causes much of the freshwater to flow along the south side of the estuary. The temperatures range from 3°C (37°F) to 34°C (93°F), although temperatures above 31C (89F) are unusual. On any given day, there could be horizontal temperature differences of up to 4°C or 7°F. The estuary stratifies irregularly; when this happens in the summer complete deoxygenation may occur. This condition may last for only a week and then be destroyed by wind. The benthic animals (bottom dwelling) are completely eliminated from large stretches of the river by the low concentrations of oxygen.

Hoffman, R.F., R.K. Jeck and R.L. Clark. 1984. Conditions Governing the Formation of Stratocumulus Clouds over the Western Atlantic during Cold Air Outbreaks. Naval Research Laboratory. NRL-MR-5428:48.

Abstract. Extensive stratocumulus (Sc) clouds from frequently in the winter months over the western North Atlantic Ocean during episodes of cold air advection off the continent. During a four month study period (November 1981 through February 1982), 25 separate episodes resulted in varying extents and amounts of maritime cloud cover during 36 days, or 30% of the time during the study period. An examination of satellite imagery and surface analysis charts shows that these offshore Sc formations occur primarily following the passage of a cold front offshore, or in the southwest quadrant of a passing cyclone, or with the development of a high pressure ridge over the Atlantic coastal states. Data from four buoys between Cape Hatteras and Maine were used to look for thresholds in air-sea temperature difference (delta tan) and surface windspeed for the initiation and maintenance of these Sc formations. For locations from 25 to 200 miles (40 to 300km) east of Cape Hatteras, thresholds of 5°C and 5 m/s at a given at-sea location seem to be a good predictor for the existence of Sc overhead. The reliability of this rule decreases rapidly within 50 miles (80km) of the shoreline where the fetch may be inadequate. For locations 150 miles (240km) or so east of Cape Cod and in the Gulf of Maine, these rules break down and the air sea temperature difference and windspeed do not appear to have any useful predictor capability.

Hofmann, E.E. 1982. A model of biological response to Gulf Stream induced upwelling. EOS, Trans. AGU. 63(45):983.

Abstract. Several recent studies have shown that the Gulf Stream provides, via cold-core frontal eddies, almost continual input of nutrient-rich water to the

shelf break region of the South Atlantic Bight. Biological measurements made during these events indicate increased primary and secondary production. To investigate the biological response to these upwelling events, a system of biological equations is coupled to a flow field derived from current meter observations made in the outer shelf region of the South Atlantic Bight, February-June, 1980. The effect of the flow field on the biological system is better represented from current meter data than from a theoretically derived flow field. The resultant model is used to investigate what percentage of the upwelled nutrients is converted into biomass and what portion of this production is retained on the shelf. Model results are compared to hydrographic and biological data collected during an upwelling event in April 1980.

Hofmann, E.E., L.J. Pietrafesa, J.M. Klinck and L.P. Atkinson. 1980. A time-dependent model of nutrient distribution in continental shelf waters. Ecological Modelling. 10:193-214.

Hofmann, E.E., L.J. Pietrafesa and L.P. Atkinson. 1981. A bottom water intrusion in Onslow Bay, NC. Deep-Sea Res. 28A:329-345.

Abstract. Examines causes of upwelling in Onslow Bay, North Carolina, using data obtained during July and August, 1976.

Hogg, N.G. 1981. Topographic waves along 70°W on the continental rise. J. Mar. Res. 39:627-649.

Abstract. Topographic waves are derived through analysis of current and temperature data using empirical orthogonal functions.

Hogg, N.G. 1991. The State of the Gulf Stream at 55°W. EOS, Trans. AGU. 72(51):57.

Abstract. Observations from a recent moored array across the Gulf Stream will be presented. Emphasis will be on the time and space scales and on vertical structure. By using information from previous moored arrays it will be shown that there exists a near universal form of the spatially lagged autocorrelation function in this region of the Northwest Atlantic.

Hogg, N.G. Accepted. On the transport of the Gulf Stream between Cape Hatteras and the Grand Banks. Deep-Sea Res.

Hogg, N.G. and H. Stommel. 1985. Relation between the Deep Circulation and the Gulf Stream. Deep-Sea Res. 32(10):1181-1193.

Abstract. A kinematic argument is used to estimate the direction and amplitude of the recirculating gyre in the deep water associated with the Gulf Stream.

Holland, W.R. 1983. Mesoscale eddy activity as part of the large-scale ocean circulation. World Meteor. Org., Geneva, WCRP Publications Series No. 1, June 1983 2:135-146.

Abstract. Models are used to reveal three important regions of eddy generation: the Gulf Stream (mixed instability), the recirculation regime (mainly baroclinic

instability), and the shallow Sverdrup flow on the southern flank of the subtropical gyre.

Hollister, C.D. 1973. Atlantic continental shelf and slope of the United States - Texture of surface from New Jersey to southern Florida. U.S. Geol. Surv. Prof. Pap. 529-M:22.

Abstract. A study of more than 800 both-sediment samples collected from the continental margin between New Jersey and Florida shows that sand covers almost the entire continental shelf. The sand is mainly unimodal, is well sorted, and has a symmetrical grain-size distribution curve. Mean grain size generally increases toward the shelf break. Shelf sands containing an appreciable amount of calcium carbonate on the continental shelf south of Cape Hatteras are texturally similar to the sands consisting mainly of quartz and feldspar does not influence grain-size distribution. The continental slope off the Carolinas is covered by sand; north of there, the slope is covered by clayey and sandy silt. The upper continental rise is veneered by silty clay.

Hollister, C.D. and B.C. Heezen. 1972. Geologic effects of ocean bottom currents: western North Atlantic. pp. 37-66. In A.L. Gordon, ed. Studies in physical oceanography - a tribute to George Wust in his 80th birthday. Gordon and Breach, New York.

Abstract. Demonstrates use of bottom photographs, sediment cores, and echograms to supplement earlier studies of the relationship between circulation and deep sediment bodies.

Hollister, C.D., E.T. Bunce and R.S. Chandler. 1979. Identification of Generic Study Areas for the Disposal of Low Level Radioactive Waste: Western North Atlantic Ocean. WHOI Tech. Rep. WHOI-79-82:50.

Abstract. Two sites have been identified in the western North Atlantic as deserving further study as potential low level radioactive waste repositories. This study examines those two areas, one north of Puerto Rico and the other east of Cape Hatteras, because of various physical and geological parameters, including topography, seismicity, sediment characteristics and deep water circulation. A detailed topographic analysis is offered based on seismic reflection studies and recommendations for confirmatory research are outlined for each site.

Hollister, C.D., A.R.M. Nowell and J.D. Smith. 1980. The third annual report of the high-energy benthic boundary layer experiment. WHOI Tech. Rep. 80-32:48.

Abstract. Describes characteristics, composition, and structure of the benthic boundary layer occurring in the western North Atlantic region.

Hollyfield, N.W., J.W. McCoy and W.C. Seabergh. 1983. Hydraulic Model Investigation: Functional Design of Control Structures for Oregon Inlet, North Carolina. U.S. Engineer Waterways Experiment Station Technical Report. WES/TR/HL-83-10:462.

Abstract. Oregon Inlet, the northernmost inlet through North Carolina's barrier islands known as the Outer Banks, is a natural channel conducting flow between the Atlantic Ocean and extensive open bay sounds. As is typical of many natural inlets, navigation through the inlet can be dangerous due to shallow shifting sand shoals. The necessity of continued maintenance dredging and the exposure of commercial and private craft to shoaling and breaking waves indicate that inlet stabilization by jetties is desirable and should be investigated. The design study for the Manteo (Shallowbag) Bay Project included construction and testing of a physical model of Oregon Inlet. Model testing included the study of jetty alignment, length, and spacing and the effects of the jetty structures on tidal exchange and on the flow through Bonner Bridge. It was concluded that the plan 2 jetty alignment with 2,500-, 3,500-, or 5,000-ft spacing would not negatively impact the tidal exchange, storm surge flows, or flow through Bonner Bridge. However, the larger spacings may permit bifurcation of the entrance channel or a more curvilinear channel.

Holman, R.A. 1981. Infragravity Energy in the Surf Zone. J. Geophys. Res. 86(C7):6442-6450.

Abstract. Field measurements of onshore and longshore velocities in the surf zone have been obtained on Martinique Beach, Nova Scotia, for the purpose of investigating the dynamics of the infragravity band (0.003-0.03 Hz) of the spectra. A total of 35 data runs were obtained during a 1-week period. Of particular interest is the response of the infragravity energy to the changing incident waves, which increased considerably in size during the latter half of the week due to an approaching hurricane. It is shown theoretically, using equilibrium arguments, that the infragravity amplitude should vary approximately linearly with incident wave amplitude. This is supported from the field data if significant wave height is used as a measure of incident amplitude. The incident band of spectra observed by instruments in the surf zone is limited by breaking. Thus the infragravity band appears to dominate these spectra during storms. The analysis is carried out in terms of a spectral transformation, the spectrum which would be observed at an offshore velocity the transformation predicts the observed spectral structure in the infragravity band, showing the structure did not represent any true frequency selection. The match of theory and data also implies that the onshore motions are free waves, forced near resonance. The longshore spectra are red and show no structure which would be associated with free waves. This is consistent with the theoretical prediction that many edge wave modes, including high modes, would be forced given the broad directional spread of the storm waves. It is noted that further field experiments would be simpler on the Pacific coast where the typical, narrow-band, incident swell should force only a few, low edge wave modes, a more accommodating situation to observe and analyze.

Holman, R.A. and A.J. Bowen. 1982. Bars, bumps, and holes: Models for the generation of complex beach topography. J. Geophys. Res. 87(C1):457-468.

Abstract. In shallow water, any two waves of the same frequency are shown to produce complex patterns of drift velocity above the sea bed. If the longshore components λ_1, λ_2 of wave numbers of the two waves are different, these steady flow patterns exhibit a longshore periodicity of wave number ($\lambda_1 - \lambda_2$) irrespective of whether the waves propagate in the same direction (say λ_1, λ_2 positive) or in opposite directions (λ_2 negative). The interaction of two edge wave modes is examined in detail. The drift velocities are calculated and a simple sediment transport model is used to predict the beach topography that would be in equilibrium with these flow patterns. As expected, crescentic sand bars are produced by the special case of standing edge waves ($\lambda_1 = -\lambda_2$). Intriguingly, for all other cases a combination of complex transverse bars plus meandering or straight offshore bars result, patterns that are surprisingly reminiscent of many published descriptions of complex, rhythmic topography. The extension of the model to three or more waves produces topography that appears to be very irregular. Although the pattern should repeat over sufficiently long distances along the beach, even with only three waves these distances may be very large compared to the scale of the bars.

Holt, T. and S. Raman. 1990. Marine boundary-layer structure and circulation in the region of offshore redevelopment of a cyclone during GALE. Mon. Weather Rev. 118(2):392-410.

Abstract. Marine boundary-layer structure and circulation is documented for the 24 February 1986 case of offshore redevelopment of a cyclone during the Genesis of Atlantic Lows Experiment (GALE) Intensive Observing Period (IOP) 9. Mesoscale and satellite information emphasize that the onshore cyclone is not well organized as it moves offshore to the cold shelf waters with redevelopment occurring later over the Gulf Stream region. Within hours of redevelopment, low-level aircraft data were obtained in the region. (30 Refs.).

Holt, T.R. and S. Raman. 1992. Three-dimensional mean and turbulence structure of a coastal front influenced by the Gulf Stream. Mon. Weather Rev. 120(1):17-39.

Abstract. The interaction of oceanic fronts in the vicinity of the Gulf Stream with an atmospheric coastal front during the Genesis of Atlantic Lows Experiment (GALE) is examined using aircraft, satellite, and ship data. The nearshore, midshelf, and Gulf Stream oceanic fronts are readily discernible from low-level aircraft radiometer and satellite imagery data. The three-dimensional (3D) structure of the coastal front is extensively mapped by low-level aircraft transects through the frontal boundary. Results confirm the existence of the coastal front as a very shallow (depth less than 200 m), spatially inhomogeneous, undulating material surface. Aircraft observations from 2000 to 2200 UTC show a surface location of the coastal front that is aligned over the Gulf Stream oceanic front under conditions of very weak onshore flow, but is observed to migrate shoreward for stronger onshore flow. Ahead of the front in the warm air, the marine atmospheric boundary layer is characterized as well mixed with broken cumulus and stratocumulus cloud bases observed near 500 m, and tops varying from 1300 to 1900 m.

Holthuijsen, L.H. and H.L. Tolman. 1991. Effects of the Gulf Stream on ocean waves. J. Geophys. Res. 96(C7):12755-12771.

Abstract. A third-generation numerical wave model is used to study effects of a straight Gulf Stream and a Gulf Stream ring on ocean waves in swell and storm conditions. The model accounts for all relevant processes of propagation, generation, and dissipation of the waves (including current effects) without imposing a priori restraints on the spectral development of the waves. The dominating mechanism affecting the waves appears to be current-induced refraction even though the short-crestedness of the incoming waves tends to mask its effects (also in swell conditions). Refraction may trap locally generated waves in the straight Gulf Stream or it may reflect wave energy back to the open ocean. (65 Refs.).

Hope, J.R. 1975a. North Atlantic tropical cyclones, 1974. Mar. Weather Log. 19(1):8-18.

Abstract. Individual summaries of seven tropical cyclones, four of which were hurricanes.

Hope, J.R. 1975b. North Atlantic tropical cyclones, hurricanes, and tropical storms: 1974. In U.S Defense Mapping Agency, Hydrographic Center:12.

Abstract. Summary of cyclone, hurricane and tropical storms occurring in 1974. Characteristics are provided for each occurrence.

Hope, J.R. 1976. Annual data and verification tabulation of Atlantic tropical cyclones 1974. National Hurricane Center, Coral Gables, FL, Tech. Memo. 58.

Abstract. Tabulation of Atlantic cyclones occurring in 1974. Continuation of a series summarizing yearly cyclone events in the Atlantic.

Hopkins, T.S. 1982. On the sea level forcing of the Mid-Atlantic Bight. J. Geophys. Res. 87(C3):1997-2006.

Abstract. The Mid-Atlantic Bight circulation is discussed with particular comment directed toward the role of the parabathic pressure gradient. A distinction is made between external and local sea level forcing. External forcing consists of an oceanic boundary condition on the sea level gradient. The shelf response to this is geostrophic: the diabathic component drives the parabathic flow, and the parabathic component drives diabathic flow. The latter, together with the bottom stress generated by the former and the physical dimensions of the shelf, determine the degree of convergence or divergence within the shelf volume, which, in turn, determines the sea level dependence required to satisfy continuity over the shelf. Local forcing due to the wind stress, the internal field of mass, and the total bottom stress, in conjunction with local bathymetry, determines the extent of local convergence or divergence, and as a consequence, generates additional sea level distortion. Conceptually, local and external forcing can be considered as independent although they are, in fact, coupled through bottom stress and internal field of mass adjustment.

Horton, C.W. 1986. Inferring the subsurface paths of fronts from surface observations (Gulf Stream, Atlantic Ocean). Ph.D. Thesis. The Florida State University. 170 pp. (DAI 47/07B, p.2817; AAC8625780)

Abstract. The separation between the surface and subsurface fronts of the Gulf Stream can change due to (a) changes in the curvature of the subsurface front as the Stream meanders, (b) wind-driven Ekman advection of the surface front, and (c) ageostrophic instabilities of the surface front. Combining observational field experiments, and theoretical and numerical modeling efforts, we showed that wind-driven Ekman advection of the Stream's surface front is not responsible for most of the observed variability in the Stream's surface-subsurface frontal separation. Our field experiments verified earlier ones when they demonstrated that part of the variability in the Stream's surface-subsurface separation is due to changes in the path of the Stream's surface front. To explain the observations an analytical expression was obtained which relates changes in separation to path curvature and shows that the strength of the curvature effect is proportional to the frontal separation at path inflection points. It was concluded that the majority in the variability in the frontal separation is due to instabilities of the surface front.

Hotchkiss, F.L. and C. Wunsch. 1982. Internal waves in Hudson Canyon with possible geological implications. Deep-Sea Res. 29(4A):415-442.

Abstract. Data from an array of instruments in Hudson Submarine Canyon for 15 weeks are qualitatively consistent with theoretical and laboratory results concerning the concentration of internal wave energy by canyon topographies. Internal wave energy was intensified at the head and near the floor of the canyon, with phase lags suggestive of propagation of internal waves up the canyon from the deep sea. Significant diurnal and semidiurnal internal tides were present, indicating their generation at the topographic relief around the canyon. Internal wave energy is apparently dissipated by mixing at the head of the canyon. A major storm during the experiment induced strong currents in the canyon. These currents are probably more important than internal waves as carriers of sediment except in the very head of the canyon.

Houghton, R.W., R. Schlitz, R. Beardsley, B. Butman and J.L. Chamberlin. 1982. The Middle Atlantic Bight cold pool: Evolution of the temperature structure during summer 1979. J. Phys. Oceanogr. 12:1019-1029.

Abstract. Temperature data spanning the entire Middle Atlantic Bight (MAB) during 1979 are used to study the structure and evolution of the cold pool. The Nantucket Shoals and New England Shelf appear to be the source of the coldest water found in the MAB in late winter. During the spring and summer, water within the cold pool in the New York Bight north of Hudson Canyon remains colder than any shelf water either to the northeast or southwest. Thus the coldest cold-pool water persists there as a remnant of winter-cooled water rather than being replenished by a colder upstream source, and south of Hudson Canyon, cold-pool temperatures decrease in June and July as colder water from upstream is advected southwestward along the coast. Both temperature data and direct current measurements suggest that the mean alongshore current has a minimum between Nantucket Shoals and Hudson Canyon. The alongshore variation of shelf topography appears to be responsible for the spatial variation in both the alongshelf drift

speed and the thermal structure of the cold pool.

Howd, P.A. and W.A. Birkemeier. 1987. Beach and Nearshore Survey Data: 1981-1984 CERC (Coastal Engineering Research Center) Field Research Facility. CERC Tech. Rep. CERC-87-9:143.

Abstract. This report presents 4 years of highly accurate, approximately biweekly surveys of four selected beach profiles collected at the USAEWES, CERC's Field Research Facility (FRF) in Duck, North Carolina. These data are unique because they cover the most active region of the nearshore, from the dune out to a depth where net bottom changes appear to be negligible, and were collected coincident with detailed measurements of waves and water levels. The data were collected between 1981 and 1984 using the FRF's CRAB, A 10-m-tall motorized tripod, which, combined with an electronic 'total station' surveying instrument, is capable of accuracies of a few centimeters in both elevation and position. The report discusses the data-collection methods, the sources of errors and data editing procedures, and a brief summary of the actual profile data. Appendices contain the listings and plots of the survey data along with the tables and plots of the wave and water level data.

Howd, P.A. and W.A. Birkemeier. 1987. Storm-induced morphology changes during DUCK85. pp. 834-847. In N.C. Kraus, ed. Coastal Sediments '87. American Society of Civil Engineers, New York.

Abstract. In September 1985, the second of a series of three (DUCK82, DUCK85, and SUPERDUCK) nearshore processes experiments was held at the Coastal Engineering Research Center's Field Research Facility (FRF) of the Waterways Experiment Station, U.S. Army Engineers. For a 17-day period the nearshore morphology of a 470-m long stretch of beach was monitored on a near-daily basis during periods of change. The results of the survey program definitively show for the first time the rapid morphological change associated with the passage of a storm. The pre-storm morphology was characterized by a terrace with incised rip channels. With the onset of the storm, a linear sand bar was formed, which migrated offshore as the storm intensified. As the waves began to decrease, the bar rapidly became three-dimensional, showing a classic crescentic morphology. Interestingly, the pattern of morphological change was very similar to the changes seen and inferred during the DUCK82 experiment. The three-dimensional changes observed occurred much more rapidly than previously reported.

Howd, P.A., J. Oltman-Shay and R.A. Holman. 1991. Wave Variance Partitioning in the trough of a barred beach. J. Geophys. Res. 96(C7):12781-12795.

Abstract. The wave-induced velocity field in the nearshore is composed of contributions from incident wind waves, surface infragravity waves and shear waves. Using an alongshore array of current meters located in the trough of a nearshore bar (mean depth ≈ 1.5 m), we investigate the bulk statistical behaviors of these wave bands over a wide range of incident wave conditions. The behavior of each contributing wave type is parameterized in terms of commonly measured ore easily predicted variables describing the beach profile, wind waves, and current field. Over the 10-day period, the mean contributions (to the total variance) of the incident, infragravity, and shear wave bands were 71.5%, 14.3% and 13.6% for the alongshore component of flow (mean rms oscillations of 44, 20, and 19

cm/s, respectively). However, the values varied considerably. The contribution to the alongshore (cross-shore) component of flow ranged from 44.8-88.4% (58.5-95.8%) for the incident band, to 6.2-26.6% (2.5-32.4%) for the infragravity band, and 3.4-33.1% (0.6-14.3%) for the shear wave band. Incident wave oscillations were limited by depth-dependent saturation over the adjacent bar crest and varied only with the tide. The infragravity wave rms oscillations on this barred beach are best parameterized by the offshore wave height, consistent with previous studies on planar beaches. Comparison with data from four other beaches of widely differing geometries shows the shoreline infragravity amplitude to be near-constant ratio of the offshore wave height. The magnitude of the ratio is found to be dependent on the Iribarren number. Shear waves are significantly correlated with a prediction of the seaward facing shear of the longshore current.

Howden, S., K. Tracey, D.R. Watts and H.T. Rossby. 1991. Inverted Echo Sounder Telemetry System Report. Univ. R.I., Grad. School Oceanogr. Tech. Rep. GSO-TR-91-8:44.

Abstract. From August 1989 until August 1990, a simple acoustic telemetry system was used for obtaining real-time data from 5 Inverted Echo Sounders (IESs) deployed in the SYNOP inlet array in the Gulf Stream east of Cape Hatteras. Every 24 hours, each IES calculated a representative travel time from a set of 48 measurements (Tr), and telemetered that value to a listening station on Bermuda. From the received data, a daily time series of the depth of the 12°C isotherm (our proxy for main thermocline depth) over each IES was calculated. The position of the Gulf Stream North Wall through the IES array was calculated on a daily basis from the thermocline depth information at each IES site.

Hsu, S.A. 1984. Sea-breeze-like winds across the north wall of the Gulf Stream: an analytical model. J. Geophys. Res. 89(C2):2025-2028.

Abstract. Sea-breeze-like winds have been observed on the warmer side of the Gulf Stream when synoptic-scale winds blow from cool shelf water toward a warm water surface (Sweet et al., 1981). It is shown that a simple, thermally driven analytical model can explain satisfactorily the increase in wind speed from the cold to the warmer water side as resulting from horizontal temperature gradient across the Gulf Stream.

Huang, C.-Y.A. 1990. A mesoscale planetary boundary layer numerical model for simulations of topographically induced circulations. Ph.D. Thesis. North Carolina State University. 268 pp. (Advisor: RAMAN, S; DAI 51/04B, p.1877; AAC9023385)

Abstract. A mesoscale planetary boundary layer (PBL) numerical model is developed to investigate airflow over complex topography. The model physics includes PBL turbulent transfer, atmospheric longwave and shortwave radiation, diurnal energy budgets over ground, cloud microphysics and subgrid cumulus parameterization. The model utilizes a new fourth order Crowley advection scheme which preserves phase and amplitude much better than other Crowley schemes. Turbulence closures using the turbulent kinetic energy (TKE) and dissipation equations are investigated with the level 2.5 scheme of Mellor and Yamada (1982) to better determine eddy diffusivities. One-dimensional (1-D) model results show that the PBL flows under

various stability conditions are not significantly sensitive to the modified Blackadar's and Kolmogorov's eddy mixing lengths in the entrainment region of the upper PBL. With the same prognostic TKE equation, the model results show insensitivity of the 1-D flow to the details of diagnostic formulations in the closures and to eddy Prandtl numbers. A 2-D model is used to stimulate January 28 cold-air outbreak over the Gulf Stream region during the OIP-2 (Intensive Observation Period) of the 1986 Genesis of Atlantic Lows Experiment (GALE). The modeled 2-D circulation system is found to be sensitive to Prandtl number, in contrast to the 1-D model results. Prandtl number becomes increasingly important as the clouds begin to interact with the marine boundary layer (MBL). Using the closure, the model predicts the observed MBL structure that includes a low level jet west of the Gulf Stream warm core and a constrained boundary layer height due to the middle-level stable layer. Two cases with 3-D idealized flow are also simulated for the same GALE IOP. For the easterly onshore ambient flow, a confluence zone appears near the coastline in response to the strong oceanic baroclinicity due to the Gulf Stream. With the increased coastal confluence, a shallow coastal front (below 2 km) begins to form. Stationary rainbands are produced along the coastal front. For the northerly offshore ambient flow, the rainband first appears along the eastern edge of the Gulf Stream and moves slowly downstream. The model is also applied to simulate the 3-D airflow past Taiwan mountains. For both north-westerly and the south-westerly prevailing winds (with a Froude number of about 0.3), a mesoscale low pressure center occurs at the south-eastern (downstream) slopes of the steep mountains. The role of the PBL effects in changing the flow separation and stagnation points is found to be more important for the upstream flow than the downstream flow.

Huang, C.-Y. and S. Raman. 1988. A numerical modeling study of the marine boundary layer over the Gulf Stream during cold air advection. Boundary-Layer Meteorology. 45(3):251-290.

Abstract. A two-dimensional mesoscale model has been developed to simulate the air flow over the Gulf Stream area where typically large gradients in surface temperature exist in the winter. Numerical simulations show that the magnitude and the maximum height of the mesoscale circulation that develops downwind of the Gulf Stream depends on both the initial geostrophic wind and the large-scale moisture. As expected, a highly convective planetary boundary layer (PBL) develops over this area and it was found that the Gulf Stream plays an important role in generating the strong upward heat fluxes causing a farther seaward penetration as cold air advection takes place. Numerical results agree well with the observed surface fluxes of momentum and heat and the mesoscale variation of vertical velocities obtained using Doppler Radars for a typical cold air outbreak. (43 Refs.).

Huang, C.-Y. and S. Raman. 1990. Numerical simulations of cold air advection over the Appalachian Mountains and the Gulf Stream. Mon. Weather Rev. 118(2):343-362.

Abstract. Cold air advection over the Gulf Stream off the Carolinas and the Appalachian Mountains is studied using idealized two-dimensional cases for the Genesis of Atlantic Lows Experiment (GALE) IOP 2 conditions. An inelastic hydrostatic mesoscale model is used. Turbulent transfer in the planetary boundary layer, diurnal heating, cloud dynamics, atmospheric longwave and shortwave

radiation and subgrid cumulus parameterization are included in the model. (49 Refs.).

Huang, N.E., C.D. Leitao and C.G. Parra. 1978. Large-scale Gulf Stream frontal study using Geos 3 radar altimetry data. J. Geophys. Res. 83(C9):4673-4682.

Abstract. From data obtained by the Geos 3 radar altimeter, sea surface heights are found by both editing and filtering the raw sea surface height measurements and then referencing these processed data to a 5' X 5' geoid. Any trend between the processed data and the geoid is removed by subtracting out a linear fit to the residuals in the open ocean. Data from individual passes are further processed by applying a minimum variance technique at the subsattellite crossing points to produce surface topography maps for the 6 months and an overall mean map which reveal important details about the Gulf Stream system. The differences between the monthly mean and the overall mean are calculated for each of the 6 months to show the temporal and spatial changes of the Gulf Stream front and spawned eddies. The standard deviation map is even more informative and shows preferred locations of Gulf Stream meanders.

Huang, R.X. 1990. Does atmospheric cooling drive the Gulf Stream recirculation? J. Phys. Oceanogr. 20(5):750-757.

Abstract. A two-layer model for the recirculation is studied. Initially, a narrow jet of the upper layer moves eastward with the lower layer remaining stagnant. The model uses both initial velocity and pressure perturbation in order to examine how the barotropic current and the high pressure center is established through cooling events. (12 Refs.).

Hubertz, J.M. 1981. Prediction of Wave Refraction and Shoaling Using Two Numerical Models. CERC Tech. Rep. CERC-CETA-81 12:16.

Abstract. Two numerical models to predict wave refraction and shoaling in shallow water are described. One model is formulated in terms of wave rays, the other in terms of wave spectra. Output from each model is illustrated and compared to observations made at CERC's Field Research Facility at Duck, North Carolina.

Hubertz, J.M. 1982. Prediction of Nearshore Wave Transformation. CERC CETA Rep. CERC-CETA-82-7:14.

Abstract. The DHI System 21 Mark 8 numerical model for the prediction of both long and short waves is being used in certain studies of coastal engineering problems. Procedures are discussed for using the model to predict nearshore short wave transformations. An example is presented showing the combined effects of refraction, shoaling, reflection, and diffraction. Predicted model results are compared to measured wave heights at the Coastal Engineering Research Center's Field Research Facility in Duck, North Carolina.

Hubertz, J.M. 1986. Observations of local wind effects on longshore currents. Coastal Engineering. 10(3):275-288.

Abstract. Two sets of nearshore current data are available from measurements made at the Coastal Engineering Research Center's (CERC) Field Research Facility

(FRF). These data are examined to characterize the nearshore currents at the FRF site and to identify the processes which contribute to the total current vector. The data indicate that local winds and atmospheric pressure fields can be important factors contributing to nearshore currents. Quantitative evidence is presented which shows a direct relationship between the mean longshore current and mean longshore wind speed. For coastal engineering studies which require estimates of nearshore currents, it is recommended that meteorological factors be included in the estimation techniques.

Hubertz, J.M., C.E. Abel and R.E. Jensen. 1988. A Hindcast of Winds, Waves, Water Levels and Currents During Hurricane Gloria. pp. 411-426. In Proceedings of the International Symposium on Natural and Man-Made Hazards 3-9 August 1986.

Hubertz, J.M., R.M. Brooks, W.A. Brandon and B.A. Tracy. 1992. Hindcast Wave Information for the US Atlantic Coast. Army Eng. WES Final Rep.

Abstract. The U.S. Army Corps of Engineers twenty year, 1956-1975, wave hindcast was repeated using an improved version of the Wave Information Study (WIS) numerical wave model. The new hindcast utilizes previous wind fields, but employs a finer grid resolution over continental shelf regions and includes shallow water effects. Statistics for wave heights, periods, and directions are provided for locations along the U.S. Atlantic coast including fourteen locations that are applicable to the Cape Hatteras region. Characteristics of maximum hindcast wave heights are provided for each month during the hindcast. Using extremal analysis, wave heights as functions of return period were determined and are provided.

Hughes, R.L. 1990. On the general character of coastal flow. Pure Appl. Geophys. 133(4):665-676.

Abstract. It is well-known that some coastal currents such as the Florida Current have a recirculating region on their coastal side, while other currents such as the East Australian Current have no such region. Under the hypothesis that the form drag on a coastal current by an irregular coastal topography reduces the momentum transport of the current to a minimum for the given flow within the current, the hydraulic theory of coastal currents is used to explain this behavior. (6 Refs.).

Hughes, S.A. 1984. Spatial Variability in the Nearshore Wavefield. CERC Misc. Paper. CERC-MP-84-7:73.

Abstract. The Coastal Engineering Research Center, under sponsorship from the Naval Civil Engineering Laboratory, collected wave data for 25 days from a closely spaced array of five wave gages moored in 17 m of water offshore of the North Carolina coast. The objective of the collection was to determine the spatial variability of the wave field under a variety of incident wave conditions to aid the NCEL in planning ship mooring tests. The spatial variability of the wave field was examined in terms of the coherence function measured between pairs of wave gages. The primary factor affecting the coherence function is the spatial separation between the gages. Coherence was found to rapidly decrease as spatial separation increased, particularly in the along-crest direction (right-angle to the direction of wave travel). The effect of spatial separation was quantified

as nondimensional coherence contours which provide a first rough estimate of the wave coherence which would be expected between two gages.

Hunkins, K. 1988. Mean and tidal currents in Baltimore Canyon. Journal of Geophysical Research. 93(C6):6917-6929.

Abstract. The mean and tidal current fields within Baltimore Canyon and on the shelf and slope around it were observed with instrumented moorings at 12 sites. Currents on the shelf are similar to those observed elsewhere over the northeastern U.S. outer shelf with mean flow southwestward at 10 to 15 cm/s parallel to the shelf break. Tidal current velocity in the direction of the major axis of the M_2 ellipse over the shelf is about 9 cm/s. Currents within the canyon are complex. Mean flow near the bottom along the canyon axis is downcanyon at 5 cm/s at a depth of 275 m, but upcanyon at 7 cm/s at 600-m depth and negligible at depths of 1000 m and 1500 m. At 50 m above the bottom, mean flow at each of these sites is less than it is at 6 m above the bottom. The M_2 tidal currents in the canyon tend to be aligned with topography and have velocities ranging up to 22 cm/s. Maximum instantaneous current speeds were found near the bottom in the canyon axis with a peak speed for the entire survey of 106 cm/s near the bottom at the 275-m level.

Huntley, D.A. and D.M. Hanes. 1987. Direct measurement of suspended sediment transport. pp. 723-737. In N.C. Kraus, ed. Coastal Sediments '87. American Society of Civil Engineers, New York.

Abstract. Fast response measurement of suspended sediment concentrations at five heights within 18cm of the seabed were made by miniature optical backscatter sensor (MOBS) placed seaward of a narow surf zone at Pte. Sapin, New Brunswick in October 1983. Concurrent measurements of horizontal velocities 21cm above the bed were also made. The cospectrum between the cross-shore velocity and the concentration at each height provides an estimate of the contributions from different frequencies to the mean cross-shore sediment transport. A strong onshore transport due to incident waves and a weaker offshore transport due to long period motion are observed near the sea bed. Higher in the water column the offshore transport due to long period flow becomes relatively less important due to an increasing time lag between the flow and the sediment concentration response. Close to the sea bed the onshore transport due to the incident waves dominates, but above about 5cm above the bed the mean transport is offshore due to the dominance of an offshore mean flow. These preliminary results show the value of fast-response suspended sediment measurements for improving our understanding of the nature of nearshore sediment transport.

Huntsman, A.C. 1924. Oceanography. pp. 274-290. In Handbook of the British Association for the Advancement of Science. University of Toronto Press, Toronto.

Hwang, S.-M. 1983. The Interaction of Short Surface Gravity Waves with the Gulf Stream. Ph.D. Thesis. North Carolina State University. 168 pp. (DAI 45/10B, p.3194; AAC8428991)

Abstract. There are two basic parts to this study; theoretical derivations and the comparison of theory with field data. In the first part, theory related to

the variation in wave kinematics and dynamics were derived under the slowly-varying assumption (i.e., the scales over which the current characteristically varies are much larger than those which characterize the oscillatory (wave) part of the motion). Theory was then simplified to the case of deep water and the changes of wave length, amplitude, vertical acceleration, two orthogonal wave slopes, wave particle velocity and spectra were discussed. The behavior of the waves near the critical layer and turning points also were examined. In the second part, field data recorded by pitch/roll buoys (PRB) were analyzed to obtain directional spectra to examine the existing linear theory of wave-current interaction. The results showed excellent agreement between the field data and existing theory in three comparisons: (1) the same swell train recorded by PRB1 in the current and by PRB2 east of the current were used to fix the current, with results that showed the estimated current speed and direction were consistent with the results estimated by ship set and drift, (2) the same train of wind-waves crossing the current under conditions where no net change in either energy or direction was expected gave good agreement with theory, and (3) under steady wave and current conditions, data from PRB1 inside the current, where the waves should show an active refraction and a reduction in spectral density, agreed remarkably well with theory.

ICES. 1979a. Inventory of oceanographic investigations at North Atlantic ocean weather stations in 1975. ICES Oceanographic Data Lists, Inventory 45, 50pp.

Abstract. Summary of oceanographic research conducted at weather stations in 1975 are presented. Brief descriptions for each investigation are presented with location of each.

ICES. 1979b. Inventory of oceanographic investigations at North Atlantic ocean weather stations in 1976. ICES Oceanographic data Lists, Inventory 46, 42pp.

Abstract. Similar to ICES (1979). Research conducted in 1976 by weather station is presented.

Ichiye, T. 1972. Power spectra temperature and salinity fluctuations in the slope water off Cape Hatteras. Pure Appl. Geophys. 96:205-216.

Abstract. Vertical wave number spectra computed from eleven CTD stations yield power law coefficients consistent with the influence of both stratification and turbulence.

Ierley, G.R. and W.R. Young. 1991. Viscous Instabilities in the Western Boundary Layer. J. Phys. Oceanogr. 21(9):1323-1332.

Abstract. The stability of the western boundary layer is studied by idealizing it as a parallel flow and solving the Orr-Sommerfeld equation, generalized to include the gradient of planetary vorticity.

Ignaszewski, M. 1982. The vorticity balance of Gulf Stream meanders off North Carolina. Master's Thesis. Texas A&M Univ.

Imamura, E. ed. 1989. Summary of the physical oceanographic processes for the U.S. Atlantic and Southeastern Gulf of Mexico. Battelle Memorial Institute. Ventura. 199 pp.

Abstract. This background document is the result of a comprehensive literature search conducted for the study, "Summary of the Physical Oceanographic Processes for the U.S. Atlantic and Southern Gulf of Mexico". It will serve as a reference information source for generating the upcoming manuscript. Nearly 1200 documents were reviewed and summarized. This updated document contains over 270 new references, in addition to 70 from a previously issued addendum. Emphasis was placed on more recently available publications retrieved from an extensive literature search conducted at the Woods Hole Oceanographic Institution library.

Ingham, M.C. 1979. Marine environmental conditions off the Atlantic and Gulf Coasts of the US, January 1977-March 1978. Mar. Fish. Rev. 41(5-6):35-47.

Abstract. General description of the offshore environment is presented along with its implication to offshore fisheries in the regions. The predominant atmospheric events influencing the coastal marine environment in 1977 and early 1978 were two severe winters which yielded record or near-record low temperatures along most of the Atlantic and Gulf coasts. The impact of two successive severe winters on fish stocks on nearshore estuarine waters may have been very significant for some species. Reports have been received of high mortalities in both years of juvenile croaker in Chesapeake Bay and white shrimp in South Carolina's coastal waters.

Ionov, V.V., G.L. Weatherly and R. Harkema. 1986. On the temporal variability of the surface Gulf Stream and near-bottom flows. J. Geophys. Res. 91(C2):2661-2666.

Abstract. Long (3-4 years) time series of the surface Gulf Stream position and near-bottom flow south of Nova Scotia support earlier findings of a barotropic semimonthly periodicity in the region, a bimodal Gulf Stream path downstream of the New England Seamount Chain, and a seasonal shift in the Gulf Stream position. New results are (1) a marked reduction of the meridional shifts of the surface Gulf Stream when it is in its north position mode, (2) the semimonthly periodicity seeming to be related at times to the M_f tide (the most energetic long-period tide), and (3) an energetic, highly coherent (but out of phase) motion with a near-40-day period in the surface Gulf Stream position and near-bottom flow.

Iselin, C.O'D. 1939. The influence of vertical and lateral turbulence of the characteristics of the waters at mid-depth. Trans. Am. Geophys. Un. 20:414-417.

Abstract. Seminal paper that ascribes lateral transfer of characteristics to mixing.

Iselin, C.O'D. 1940. Preliminary report on long period variations in the transport of the Gulf Stream system. MIT/WHOI Phys. Oceanogr. Meteorol. Papers. 8(1):40.

Abstract. Identified variations in the Gulf Stream based on hydrographic measurements and flow characteristics.

Iselin, C.O'D. 1955. Coastal currents and the fisheries. Papers in Marine Biology and Oceanography, Deep-Sea Research. Supplement to 3:474-478.

Isemer, H.-J. and L. Hasse. 1985. The Bunker climate atlas of the North Atlantic Ocean, Vol. 1 Observations. Springer-Verlag.

Isemer, H.-J. and L. Hasse. 1987. The Bunker Climate Atlas of the North Atlantic Ocean, Vol. 2 - Air-sea interactions. Springer-Verlag. New York. 470 pp.

Isley, A.E., R.D. Pillsbury and E.P. Laine. 1990. The genesis and character of benthic turbid events, Northern Hatteras Abyssal Plain. Deep-Sea Research, Part A [Oceanographic Research Papers]. 37(7A):1099-1119.

Abstract. Benthic turbid events, with particle concentrations of up to 1.5 mg/l, occupy about 20% of a two-year record of near-bottom light attenuation made above the Northern Hatteras Abyssal Plain. They are most often associated with deep-sea mesoscale eddies, although rare events occur during periods when southward contour flow predominates. In a temporal sense, the presence of deep-sea mesoscale eddies corresponds strongly to periods when cold-core Gulf Stream rings propagate through surface waters of the study area. Additionally, over half of the benthic turbid events observed are initiated within a day of the passage of atmospheric storms with propagation speeds in excess of 800 km/day. (47 Refs.).

Jacobson, J.P. 1974. A socio-economic environmental baseline summary for the South Atlantic region between Cape Hatteras, North Carolina and Cape Canaveral, Florida. In Physical Oceanography. Vol. 1. Virginia Institute of Marine Science, Gloucester Pt.

Jaffe, B.E., R.W. Sternberg and A.H. Sallenger. 1984. The role of suspended sediment in shore-normal beach profile changes. Proceedings of the 19th International Coastal Engineering Conference. 1983-1996.

Abstract. Field measurements of suspended sediment-transport were made across a dissipative surf zone during a storm. A correlation between high suspended mass in the water column and periods of onshore flow caused a net onshore transport of suspended sediment even though the mean near-bottom flow was directed offshore. The observed onshore migration of a nearshore bar was predicted by gradients in the cross-shore suspended-sediment transport.

James, R.W. 1974. Dangerous waves along north wall of the Gulf Stream. Mar. Weather Log. 18(6):363-366.

Abstract. In spite of the increased use of weather satellites to locate and track storms over the ocean, ships still encounter heavy weather and, on occasion, founder. A partial explanation for these mishaps is that the ship is overwhelmed

by the violence of a storm, which at first appears no different than many other storms the master has successfully transitted with his ship. The reason for this is that under certain conditions, storms of the same size and isobaric configuration can differ considerably in their surface wind and seaway characteristics. An example of variability is found off the U.S. east coast where certain coastal storms are particularly changed by the Gulf Stream. The warm current acts in two ways: (a) affecting the winds through the creation of unstable conditions, and (b) modifying the waves by the interaction between wave and current velocities. These phenomena are particularly enhanced in the North Wall, a narrow band of extreme horizontal water temperature change marking the north edge of the Gulf Stream. The North Wall also indicates the region where strong, northeasterly currents will be encountered that reach a maximum value within the next 10 to 20 mi into the Gulf Stream.

Janowitz, G.S., L.J. Pietrafesa and R.W. Houghton. 1991. Alongshore Variations in Coastal Sea Level in the Middle Atlantic Bight. EOS, Trans. AGU. 72(51):91.

Abstract. A simple analytical model is used to determine alongshore variations in coastal sea level. The model which is barotropic, steady, and geostrophic, is developed in the viscous parameter regime where advection of relative vorticity can be neglected with respect to production of relative vorticity by the bottom Ekman layer induced vertical velocity; the latter is then balanced by the topographically induced vertical velocity. The effects of the alongshore wind stress on coastal sea level are discussed and it is found that an upwelling favorable wind stress causes a continual drop in coastal sea level downstream from an initial cross-shelf location; the effects of cross-shelf profile the initial location on the downstream variation in coastal sea level is also addressed. The model is then extended in a quasi-steady manner and is applied over the Mid Atlantic Bight from Woods Hole, Massachusetts to Lewes, Delaware. To assess more general applicability over the east coast of the United States, the model is also applied to the region from Cape Hatteras to Charleston. Reasonable agreement exists between observations and model predictions which suggests that a predictive capability has been established.

Jarvinen, B.R. and C.J. Neumann. 1978. Atlantic tropical cyclone tracks by 5, 10, 15, and 30-day periods. National Hurricane Center, Coral Gables, FL, Tech. Memo. :62.

Abstract. Provides hurricane tracks by 5 and 15-day intervals for selected hurricanes which occurred in the Atlantic region.

Jarvinen, B.R., C.J. Neumann and M.A.S. Davis. 1984. A Tropical Cyclone Data Tape for the North Atlantic Basin, 1886-1983: Contents, Limitations and Uses. NOAA Tech. Memo. NWS NHC 22:21.

JAYCOR, R.T.P., NC. 1979. Proceedings of the Continental Shelf Physical Oceanographic Model Evaluation Workshop Held at Research Triangle Park, North Carolina on April 25-26, 1979. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-79-29:187.

Abstract. The Bureau of Land Management contracted with Jaycor to perform an

assessment of the State-of-the-Art of physical oceanography models and their utility for application to the South Atlantic. A small group of experts reviewed each of the four topical areas assessed, i.e., surface, water column, sediment transport, and ocean structure interaction models. Proceedings from this workshop are included in this report.

Jeffries, H.P. and W.C. Johnson II. 1976. Petroleum, Temperature and Toxicants: Examples of Suspected Responses by Plankton and Benthos on the Continental Shelf. NOAA Tech. Rep. NOAA-77011708:17.

Abstract. Gross population changes carefully enumerated over time in natural communities of the New York Bight and nearby areas are examined. From such comparisons a basic appreciation of sensitivity within natural systems can be obtained. It is suggested that for open-coastal areas in the Mid-Atlantic Bight, the direct effect of energy-related activities on copepod populations, by far the major component in the zooplankton, is at present not a concern. Limited, short-term effects are seen only at point discharges. Lasting damage to the benthos, however, is another matter. Experience suggests that on the bottom persistent, small-scale environmental changes have cumulative effects that are enhanced, rather than dissipated as in the plankton, by ecosystem processes.

Jenkins, J.S. 1980. Effects of the Western Boundary Undercurrent on sediment transport and deposition in the Pamlico Canyon off Cape Hatteras. Master's Thesis. Texas A&M University.

Jenkins, W.J. and W.B. Clarke. 1976. The distribution of ^{3}He in the western Atlantic Ocean. Deep-Sea Res. 23:481-494.

Abstract. Over 250 samples of Atlantic seawater have been analyzed for the dissolved helium isotopes, and a distinctive pattern has emerged. Two components of excess ^{3}He are seen: a component due to *in situ* decay of nuclear-era tritium, and a primordial component evolved from the solid Earth. A prominent feature at about 3-km depth can be traced from 51°N along the western boundary to the equator. The source of this feature is most probably in the Gibbs fracture zone, where we suppose that primordial ^{3}He is released into westward-flowing bottom water. The South Atlantic profiles clearly show the effect of ^{3}He-rich Circumpolar Water, entrained by Antarctic Intermediate Water flowing north ward.

Jensen, R.E. 1983. Atlantic Coast Hindcast, Shallow-water significant wave information. Army Eng. WES Final Rep. WIS Report 9.

Abstract. Report presents wave data in six data products: geographical variation in wave climate, twenty-year percent occurrence tables, wave rose diagrams, mean and largest wave-height tables, return period tables and overall duration tables.

Jocobsen, J.P. 1974. A socio-economic environmental baseline summary for the South Atlantic region between Cape Hatteras, North Carolina and Cape Canaveral, Florida. pp. 247. In Physical Oceanography. Vol. 1. Virginia Institute of Marine Science, Gloucester Point.

Johns, E. 1984. Geostrophy and potential vorticity in the Gulf Stream northeast of Cape Hatteras, N.C. (North Carolina). Ph.D. Thesis. University of Rhode Island. 236 pp. (DAI 46/06B, p.1855; AAC8516675)

Abstract. During July 1982 a two-ship observational program produced a set of simultaneous, closely-spaced sections of density (using CTD) and absolute velocity (using PEGASUS) across the Gulf Stream northeast of Cape Hatteras near 73°W. These data were used in a detailed test of the geostrophic balance of the current. The result was that the Gulf Stream was in geostrophic balance everywhere but in the high velocity central core of the current, in the upper 500m, where the absolute velocity exceeded the geostrophic velocity by as much as 20 cm/sec, or 10%. Measurement error can account for only 10 to 12 cm/sec of this difference. Analysis of the horizontal momentum equation suggests that the time-dependent and nonlinear advective terms $\partial u/\partial t$, $u\partial u/\partial x$ and $v\partial u/\partial y$ could cause a 5% departure from geostrophic balance, and possibly explain the remaining 10 cm/sec difference. The density and velocity sections were also used to examine the potential vorticity (π) distribution across the Gulf Stream. The potential vorticity distribution was found to have four major zones. The surface waters, above 250m depth, had uniformly high values of π (greater than 1000 X 10^{-14}/cm/sec); the main thermocline was characterized by intermediate (100 to 400 X 10^{-14}) π values; the 18°C water was a pronounced relative minimum in (pi) between the surface waters and the main thermocline, with π values $\leq$ 50 X 10^{-14}; and the deep waters were uniformly low, with values of 5 to 25 X 10^{-14}/cm/sec. Finally, the cross-stream gradient of the potential vorticity, $\partial Q/\partial x$, was examined in order to determine whether certain necessary conditions for barotropic and/or baroclinic instability (Pedlosky, 1979) were satisfied. These conditions are, briefly, that $\partial Q/\partial x$ have regions of positive and negative sign in the horizontal for barotropic instability, and in the vertical for baroclinic instability. The observations made during this study show that the necessary conditions from quasi-geostrophic theory for both barotropic and baroclinic instability are satisfied by the Gulf Stream $\partial Q/\partial x$ distribution.

Johns, E.M. and D.R. Watts. 1982. Analysis of the potential vorticity distribution across the Gulf Stream. pp. 11. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982, AD-A128 789.

Abstract. Results from a potential vorticity analysis are presented for a section taken in July 1967 off Cape Hatteras which utilized transport floats in addition to hydrographic measurements.

Johns, E., H.T. Rossby and D.R. Watts. 1983. A test of geostrophy in the Gulf Stream. EOS, Trans. AGU. 64(52):1026.

Abstract. CTD data obtained northeast of Cape Hatteras are used to compute geostrophic velocity which compares well with absolute velocities taken with a profiler when inertial variability is removed.

Johns, E., D.R. Watts and H.T. Rossby. 1989. A test of geostrophy in the Gulf Stream. J. Geophys. Res. 94(C3):3211-3222.

Abstract. In July 1982 two detailed sections of density and absolute velocity

were taken across the Gulf Stream northeast of Cape Hatteras to conduct an accurate test of geostrophy in a strong current. The sections, which were taken about 4 days apart, were each completed within 48 hours, using one ship to make closely spaced (12 km) conductivity-temperature-depth measurements to 2000 m, and a second ship to simultaneously take Pegasus absolute velocity profiles to the ocean bottom. The Gulf Stream path and curvature were also surveyed. The dynamically inferred velocity profiles were made absolute by matching their velocities to the Pegasus profiles at 2000 m. (17 Refs.).

Johns, W.E. 1982. Observations on the vertical coherence of Gulf Stream meanders. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982. UNC-CH, Chapel Hill, NC.

Abstract. This paper examines the vertical coherence and structure of Gulf stream meanders in the region just downstream of Cape Hatteras where the meanders are known to exhibit rapid spatial growth.

Johns, W.E. 1984. Dynamics and structure of Gulf Stream meanders northeast of Cape Hatteras, N.C. (North Carolina). Ph.D. Thesis. University of Rhode Island. 261 pp. (DAI 46/06B, p.1856; AAC8516676)

Abstract. During 1979-1982 three arrays of inverted echo sounders (IES) and deep current meter moorings were deployed on the continental slope 100-200km northeast of Cape Hatteras, N.C. This array continuously monitored the path of the Gulf Stream and the deep currents under it. The mean currents 500-1000m off the bottom near the northern edge of the Stream were veered to the right of the mean surface path, indicating a nearly barotropic deep inflow to the Stream of 3-4 cm/s. Mean currents 500m and 1000m off the bottom 50km further offshore were northeastward, nearly collinear with the surface Stream path. The deep velocity fluctuations are characterized by a transition from transverse flow aligned with the local bathymetry for periods longer than 10-14 days, to fluctuations with a cross-stream orientation at shorter periods. The vertical structure, kinematics, and horizontal phase variations of the low-frequency motions are consistent with the properties of topographic-Rossby waves, while horizontal phase variations associated with higher-frequency motions (periods as short as 4 days) are consistent with the observed dispersion of near-surface meanders. For periods between 4 days and 1 month, cross-stream movements of the Gulf Stream temperature front in the upper ≈1500m are vertically coherent and nearly barotropic, based on correlations between the IES-measured Stream path and deep temperature fluctuations. Below ≈1500 m, the deep temperature fluctuations are coherent with near-surface path displacements near the northern edge of the Gulf Stream, but are much less coherent 30-50 km farther offshore. Within this frequency band, temperature fluctuations at the current meter sites lead cross-stream (positive onshore) velocity fluctuations by approximately 90°. Consideration of the non-diffusive fluctuating heat equation for deep layers suggests a 3-term balance between local rate of change, cross-stream horizontal advection, and vertical advection of temperature, with the first two being of like sign. Kinematically, this requires $|wT_z| > |vT_y|$, so that parcel trajectories in the cross-stream plane are inclined at angles steeper than the mean cross-stream slope of the isotherms. This description is consistent with the no-normal-flow boundary condition in this region, where the bottom slope is about a factor of two larger than the slope of

the isotherms.

Johns, W.E. 1988a. Near-surface current measurements in the Gulf Stream using an upward-looking acoustic Doppler current profiler. J. Atmos. Oceanic Technol. 5(5):602-613.

Abstract. During November 1986, a 6-day record was collected from a 150 kHz Acoustic Doppler Current Profiler (ADCP) mounted in the upward-looking mode on a subsurface mooring in the Gulf Stream near Cape Hatteras. The flotation unit used for the ADCP was a newly developed streamlined float, designed to minimize the effects of drag-induced tilt and high-frequency buoy motion on the range and precision of the Doppler measurements. Good velocity data were obtained to within 30 m of the surface from a mean depth of 375 m. A comparison was made of the near-field ADCP velocity data with a Conventional Aanderaa current meter moored 20 m below the ADCP. Also, a comparison was made with Pegasus velocity profiles taken within 1 n mi of the mooring site. (11 Refs.).

Johns, W.E. 1988b. One-dimensional baroclinically unstable waves on the observed Gulf Stream potential vorticity gradient near Cape Hatteras. Dyn. Atmos. Oceans. 11:323-350.

Johns, W. and D.R. Watts. 1983. Deep current observations in the Gulf Stream. EOS, Trans. AGU. 64(52):1026.

Abstract. During 1979-80 an array of inverted echo sounders (IES) and three deep current meter moorings were deployed on the continental slope 100-200km northeast of Cape Hatteras, N.C. This array continuously monitored the path of the Gulf Stream and the deep currents under it. The mean currents at two sites 1000m off the bottom near the northern edge of the Stream were eastward and southeastward, indicating a deep inflow to the Stream. Mean currents 500 and 1000m off the bottom 50km further offshore were northeastward, nearly collinear with the surface Stream path. Cross-stream movements of the Gulf Stream temperature front on time scales of 4 days to 1 month are coherent and nearly barotropic, based on correlations between the IES-measured Stream path and deep temperature fluctuations. Within this band, temperature fluctuations at the current meter sites lead cross-stream (positive onshore) velocity fluctuations by approximately 90°. Consideration of the nondiffusive fluctuating heat equation for deep layers suggests a 3-term balance between local rate of change, cross-stream horizontal advection, and vertical advection of temperature, with the first two being of like sign. Parcel trajectories in the cross-stream plane are inclined at angles steeper than the mean cross-stream slope of the isotherms. This description is consistent with the bottom boundary condition of "no-normal flow" in this region, where the bottom slope is about a factor of two larger than the slope of the isotherms.

Johns, W.E. and D.R. Watts. 1985. Gulf Stream Meanders: Observations on the Deep Currents. J. Geophys. Res. 90(C3):4819-4832.

Abstract. During 1979-1980, an array of inverted echo sounders (IES) and three deep current meter moorings were deployed on the continental slope 100-200 km northeast of Cape Hatteras, North Carolina. This array continuously monitored the path of the Gulf Stream and the deep currents under it. The mean currents

at two sites 1000 m off the bottom near the northern edge of the stream were veered to the right of the mean surface path, indicating a deep inflow to the stream. Mean currents 500 and 1000 m off the bottom 50 km farther offshore were northeastward, nearly collinear with the surface Gulf Stream path. The deep velocity fluctuations are characterized by a transition from transverse flow aligned with the local bathymetry for periods longer than about 12 days to fluctuations with a cross-stream orientation for shorter periods. For periods between 4 days and 1 month, cross-stream movements of the Gulf Stream temperature front are vertically coherent and nearly barotropic, based on correlations between the IES-measured stream path and deep temperature fluctuations. Temperature fluctuations at the current meter sites lead cross-stream (positive onshore) velocity fluctuations by approximately 90°. Consideration of the nondiffusive fluctuating heat equation for deep layers suggests a three-term balance between local rate of change, cross-stream horizontal advection, and vertical advection of temperature, with the first two being of like sign. Eddy energy conversion between the fluctuations and the mean field in deep layers is predominantly baroclinic, with e-folding growth time scales of approximately 10 days.

Johns, W.E. and D.R. Watts. 1986. Time Scales and Structure of Topographic Rossby Waves and Meanders in the Deep Gulf Stream. J. Mar. Res. 44(2):267-290.

Abstract. During July-November 1982, current and temperature records were collected from six current meters spanning the lower 2000 m of the water column on two moorings in the Gulf Stream northeast of Cape Hatteras, N.C. Frequency domain EOF analysis of the velocity cross-spectra reveals that there are two kinematically distinct wave processes present in the subinertial range, identifiable as topographic Rossby wave and meander-associated motions, which are energetically dominant at periods longer than and shorter than 14 days, respectively. Simultaneous thermocline depth measurements obtained using inverted echo sounders show that the low-frequency topographic Rossby wave motions are uncoupled with near-surface displacements of the Gulf Stream path, but that cross-stream velocity fluctuations in the 14-day and 5-day period bands are associated with vertically coherent meanders of the Gulf Stream temperature front.

Johnson, D.R., B.S. Hester and J.R. McConaugha. 1983. Studies of a wind mechanism influencing the recruitment of blue crabs in the Middle Atlantic Bight. Department of Oceanography, Old Dominion University. :52.

Johnson, T.C. 1989. Hydrography and sedimentation on the continental slope and rise off North and South Carolina. pp. 151-172. In R.Y. George and A.W. Hulbert, eds. North Carolina coastal oceanography symposium. University of North Carolina at Wilmington, Dept. of Oceanogr., Wilmington. (Report No. NURP 89-2)

Joyce, T.M. 1984. Velocity and hydrographic structure of a Gulf Stream warm-core ring. J. Phys. Oceanogr. 14(5):936-947.

Abstract. Investigation of the hydrographic and velocity structure of warm-core ring 81D. The ring pycnocline is depressed 500 m below that of the surrounding slope water and ring water mass characteristics are consonant with Sargasso Sea

water.

Joyce, T.M. and M.A. Kennelly. 1985. Upper-ocean velocity structure of Gulf Stream warm-core ring 82B. J. Geophys. Res. 90(C5):8839-8844.

Abstract. Acoustic-Doppler current profiling of warm-core ring (WCR) 82B revealed changes in the velocity structure over much of the ring's 7-month lifespan. As ring diameter decreased, peak speeds in the high-velocity region decreased from 0.8 m/s in April 1982 to 0.5 m/s in August 1982. Azimuthally averaged velocities revealed the core of WCR 82B to be in near solid-body rotation, with little measureable horizontal divergence at 100 m. In addition, potential vorticity was conserved in the ring core despite interactions with the Gulf Stream and large changes in ring size. Deviations from symmetry in WCR 82B were caused by superposition with the shelf-slope front, small cyclonic eddies, and upper-layer mean flow.

Joyce, T.M. and T.J. McDougall. 1992. Physical structure and temporal evolution of Gulf Stream warm-core ring 82B. Deep-Sea Res. 39:S19-S44.

Abstract. The hydrographic properties of warm-core ring 82B are shown from three cruises; April, June and August 1982. The velocity field for each cruise is formed from the gradient-current relationship, the observed hydrography, and the near surface flow as measured by a ship-mounted Acoustic Doppler Current Profiler. The data for each cruise were sorted into radial bins 15-km apart, and into vertical bins based on potential density. The changes in salinity on isopycnals from April to June 1982 were modelled as being due to radial advection, and both diapycnal and isopycnal mixing processes. The diffusivities in the pycnocline were found from a least-squares fit to the data. Most of the observed changes in salinity were explained with constant vertical diffusivity (0.53×10^{-4} m^2/s), while the required lateral diffusivity was only 26.5 m^2/s at ring center, decaying to zero at a radius of 40 km.

Joyce, T.M. and M.C. Stalcup. 1984. Upper ocean current jet and internal waves in a Gulf Stream warm core ring. J. Geophys. Res. 89(C2):1997-2003.

Abstract. On June 22, 1982, the R/V ENDEAVOR, while participating in a multi-ship study of a warm core ring 82B, encountered a strong front in the core of the ring. The vessel was headed on a radial section outward from ring center while a CTD was repeatedly raised and lowered between 10 and 300 m. Current profiles in the upper 100 m were obtained continuously with a Doppler acoustic profiling system. Above the shallow 45 m seasonal thermocline, a current jet of 4 km width was encountered having a central core of relatively light water and a maximum current of 1.1 m/s. This jet was both highly nonlinear and totally unexpected. A high frequency packet of directional internal waves was acoustically observed in the seasonal thermocline at the outer edge of the jet. Vertical velocities were large enough (6 cm/s) as to be directly observable in the Doppler returns. The waves were propagating from the northeast, parallel to the ship track, and orthogonal to the jet toward the center of the warm core ring. While a nonlinear, centrifugal term was required for the force balance of the jet, the high-frequency internal wave packet could be explained with linear, gravest-mode wave dynamics.

Joyce, T.M. and P.H. Wiebe. 1983. Warm core rings of the Gulf Stream. Oceanus. 26(2):34-44.

Abstract. Preliminary results of a comprehensive program which examined warm-core rings.

Joyce, T.M. and P.H. Wiebe. 1992. Warm-core rings, Interdisciplinary studies of Kuroshio and Gulf Stream Rings. Deep-Sea Res. 39(1A):418.

Abstract. This issue contains 13 papers dealing with the Kuroshio and Gulf Stream rings.

Joyce, T.M., C. Wunsch and S.D. Pierce. 1986. Synoptic Gulf Stream Velocity Profiles through Simultaneous Inversion of Hydrographic and Acoustic Doppler Data. J. Geophys. Res. 91(C6):7573-7585.

Abstract. Data from a shipborne acoustic profiling device have been combined with conductivity, temperature, depth/O_2 sections across the Gulf Stream to form estimates of the absolute flow fields. The procedure for the combination was a form of inverse method. The results suggest that at the time of the observations (June 1982) the net Gulf Stream transport off Hatteras was 107 ± 11 Sv and that across a section near 72.5°W it had increased to 125 ± 6 Sv (subject to further uncertainty from the definition of the stream). The transport of the deep western boundary current was 9 ± 3 Sv. These and other transport estimates are plausibly close to previous calculations, but we do not claim that they represent the temporal mean. For comparison purposes we have done an inversion using the hydrographic/O_2 data alone as in previously published results and obtained qualitative agreement with the combined inversion. Inversion of the acoustic measurements alone, when corrected for instrument biases, leaves unacceptably large mass transport residuals in the deep water. Our conclusion is that the inversion of the combined data sets produces results much improved over those from using either acoustic or hydrographic/chemical constraints in isolation. The procedures are close analogues to those which can be used with satellite altimeters and are a procedure for obtaining very accurate geoid slope measurements.

Joyce, T.M., K.A. Kelly, D.M. Schubert and M.J. Caruso. 1990. Shipboard and altimetric studies of rapid Gulf Stream variability between Cape Cod and Bermuda. Deep-Sea Res. Part A [Oceanographic Research Papers] 37(6A):897-910.

Abstract. The temporal variability of the Gulf Stream between Cape Cod and Bermuda was examined using shipboard ADCP measurements, satellite infra-red (AVHRR) and altimeter (GEOSAT) data for a period of about two weeks in April 1989. Dominant changes were a southward shift and rotation of the Gulf Stream due to a meander, a westward translation of a warm-core ring and an eastward translation of a cold-core ring. Terms in the along-track (nearly cross-stream) and cross-track momentum balances from the ADCP data showed that horizontal advection of horizontal momentum was the principal ageostrophic term, exceeding both measured temporal changes and estimated vertical velocity terms by about a factor of five at a depth of 100 m. (8 Refs.).

Joyce, T.M., J.K.B. Bishop and O.B. Brown. 1992. Observations of offshore shelf-water transport induced by a warm-core ring. Deep-Sea Res. 39:S97-S113.

Abstract. Gulf Stream warm-core rings often are observed to entrain water from the continental shelf and transport filaments of shelf water out over the continental slope. In June 1982 the R.V. ENDEAVOR made a transect through one such shelf-water "streamer" that was seen from satellite thermal imagery to the east of warm-core ring 82B. Acoustic doppler current profiles together with repeated CTD stations were made through the streamer. The CTD system was also equipped with a dissolved oxygen sensor and transmissometer. We were able to make an unprecedented section of velocity and water mass structure of the shelf-water filament. The offshore velocity structure observed was complicated with velocities ranging from 10 to 50 cm/s, temperatures, in a sub-surface temperature minimum, of less that 8°C, surface salinities less than 33‰, with high levels of suspended particulate matter and manganese, and with shelf-water properties as deep as 100 m in the center of the streamer.

Kantha, L.H., A.F. Blumberg, H.J. Herring and G.L. Mellor. 1981a. The physical oceanographic and sea surface flux climatology of the South Atlantic Bight. Dynalysis, Princeton, NJ, rep. to BLM (No. 70). 142 p.

Abstract. Atlas of the oceanographic and sea surface flux climatology is presented for the South Atlantic Bight. Provides distributions of temperature, salinity, geostrophic velocity, wind stress, heat, and mass fluxes at the sea surface.

Kantha, L.H., A.F. Blumberg and G.L. Mellor. 1981b. A diagnostic technique for deducing circulation as applied to the South Atlantic Bight. Dynalysis, Princeton, NJ, Rep. to BLM (No. 69). 124 pp.

Abstract. Provides description of the diagnostic technique for deducing circulation using density and bathymetric data.

Kantha, L.H., G.L. Mellor and A.F. Blumberg. 1982. A diagnostic calculation of the general circulation in the South Atlantic Bight. J. Phys. Oceanogr. 12(8):805-819.

Abstract. Results are presented stating that the characteristic-tracing method is a powerful tool for deducing information on circulation from density and bathymetric data.

Kantha, L.H., H.J. Herring and G.L. Mellor. 1986. South Atlantic Bight OCS circulation model. Dynalysis. Report No. 91:154.

Kao, T.W. 1980. The dynamics of oceanic fronts. Part I: The Gulf Stream. J. Phys. Oceanogr. 10(4):483-492.

Abstract. The establishment and maintenance of the mean hydrographic properties of large-scale density fronts in the upper ocean is considered. The dynamics is studied by posing an initial value problem starting with a near-surface discharge of buoyant water with a prescribed density deficit into an ambient stationary fluid of uniform density. The full time -dependent diffusion and Navier-Stokes

equations with constant eddy diffusion and viscosity coefficients and for a constant Coriolis parameter are used in this study.

Kao, T.W. 1981. The dynamics of oceanic fronts. Part II: shelf water structure due to fresh water discharge. J. Phys. Oceanogr. 11(9):1215-1223.

Abstract. In Part I of this series, a framework was introduced for the study of oceanic frontal dynamics. The dynamics was studied by posing an initial value problem, starting with a near-surface discharge of buoyant water with a prescribed density deficit into an ambient stationary fluid of uniform density. An essential aspect of the framework was the identification of the proper length scales: an inertial length scale L_o, a buoyancy length scale h_o and a diffusive length scale h_v.

Kao, T.W. 1987. The Gulf Stream and its frontal structure: A quantitative representation. J. Phys. Oceanogr. 17(1):123-133.

Abstract. Presents a model of the Gulf Stream cross-sectional density and current structure using the complete dynamical and mass-conservation equations. The model postulates a forcing, at the interior ocean boundary, by a cross-stream ageostrophic circulation with inflow of light water in the upper ocean and a return flow at greater depths. The model Gulf Stream is found to develop after initial geostrophic adjustment of several inertial periods. The model can be used to produce the entire cross-sectional structure of the Gulf Stream and its front from simple and limited observational inputs.

Kao, T.W. and R.E. Cheney. 1982. The Gulf Stream front: A comparison between SEASAT altimeter observations and theory. J. Geophys. Res. 87(C1):539-545.

Abstract. In a recent paper by Cheney and Marsh (1981), SEASAT altimeter data were used to derive quantitative information on sea surface height anomalies across the Gulf Stream. In another recent paper by Kao (1981), the dynamics of the Gulf Stream front was investigated, and a similarity solution was obtained. The model gives a universal shape of the sea surface height rise and the width of that anomaly across the Gulf Stream. In this paper we present a quantitative comparison between the model and six Gulf Stream altimeter profiles representing a broad range of conditions. The remarkable closeness of fit is mutually reinforcing to both the model and to the role of satellite altimetry in ocean dynamics. Comparisons of the data with the well-known theories of Stommel (1966) and Charney (1955) are also made, and implications of these comparisons are explored.

Kashgarian, M. and N. Tanaka. 1991. Antarctic Intermediate Water intrusion into South Atlantic Bight shelf waters. Cont. Shelf Res. 11(2):197-201.

Abstract. Surface seawater samples were collected from seven stations on the coastline bordering the South Atlantic Bight and the southern Mid-Atlantic Bight in March 1986 and analyzed for radiocarbon. Depletion in radiocarbon activity was observed in shelf water along the South Carolina coast at Myrtle Beach and Isle of Palms. If Sargasso Sea surface water with delta^{14}C = 168‰ and Antarctic Intermediate Water (AAIW) with delta^{14}C = -90‰ are two end members which supply water to this region, a contribution of about 20-25% AAIW is required to produce

the delta^{14}C values observed.

Kawai, H. 1992. A model for the structure of anticyclonic and cyclonic rings with uniform dynamical energy density. Deep-Sea Res. 39:S1-S18.

Abstract. This paper derives a model for interface depth and velocity profiles of anticyclonic and cyclonic rings under the assumption of uniform distribution of the sum of each density of kinetic and available potential energies. This assumption really means that the sum of each energy per unit area of a column of upper water of 1 1/2-layer rings in cyclogeostrophic and hydrostatic balances is proportional to the vertical thickness of the column.

Kawase, M. and J.L. Sarmiento. 1986. Circulation and nutrients in middepth Atlantic waters. J. Geophys. Res. 91(C8):9749-9770.

Abstract. Isopycnal analyses of distributions of salinity, oxygen, apparent oxygen utilization, nitrate, and silica in the depth range 800-3000 m in the North Tropical Atlantic Ocean are carried out using data from the Transient Tracers in the Oceans, METEOR cruise 56 leg 5, ATLANTIS II cruise 109 legs 1 and 3, and the GEOSECS Atlantic Study. The results are summarized in isopycnal distribution maps and property-property plots. The layer between 800 and 1500 m is oxygen poor and nutrient rich and is poorly ventilated. Below this is a better aerated layer with the deep western boundary current, part of which separates along the equator. Regeneration of nutrients and consumption of oxygen persist into the deep ocean in regions off the west coast of Africa. The Mediterranean Outflow Water apparently is causing significant cross-isopycnal mixing through salt fingering. The resultant cross-isopycnal velocity may be large enough to cause significant vorticity stretching.

Keller, G.H. and F.P. Shepard. 1978. Currents and sedimentary processes in submarine canyons off the Northeast US. pp. 15-31. In D.J. Stanley and G. Kelling, eds. Sedimentation in submarine canyons, fans, and trenches. Dowden, Hutchinson & Ross, Inc.

Abstract. Provides overview of currents in deep waters of the western North Atlantic and their influence on sediment transport in the region. Descriptive morphology of canyon systems in the region is also presented.

Keller, G.H., D. Lambert, G. Rowe and N. Staresinic. 1973. Bottom currents in the Hudson Canyon. Science. 180(4082):181-183.

Abstract. In-place measurements of the bottom currents in the Hudson Canyon reveal that the current regime is characterized by a pronounced reversal of flow up and down the canyon. Velocities are commonly of the order of 8 to 15 centimeters per second, reaching 27 centimenters per second on occasion in the upper and central portion of the canyon. Although a 2.5-day recording of currents showed a net transport upcanyon, a combination of 66 current measurements from the submersible ALVIN, the analysis of sediment texture and organic carbon, and the determination of the benthic fauna-nutrient relationship indicate that over the long term there is a net transport of fine material through the canyon to the outer continental rise.

Keller, W.C., F. Askari, G.O. Marmorino and J.A.C. Kaiser. 1991. Comparison of Airborne and Shipboard Scatterometer Data. EOS, Trans. AGU. Suppl to 72(17):149.

Abstract. During the 1990 Gulf Stream experiment, Ku-band scatterometer and PRT-5 radiometer measurements were made both from the NRL-P3 aircraft and the R/V CAPE HENLOPEN in the vicinity of the northern edge of the Gulf Stream. The PRT-5 measurements show an abrupt approximately 2°C surface temperature front. Visual observations showed whitecapping and roughness changes at the front. Across-front changes in radar backscatter of about 3 dB are found in both the airborne and shipboard scatterometer data. We will show the spatial variability of these signals and how they compare for similar radar look-directions.

Kelly, K.A. 1991. The meandering Gulf Stream as seen by the Geosat altimeter: surface transport, position, and velocity variance from 73 degrees to 46 degrees W. J. Geophys. Res. 96(C9):16721-16738.

Abstract. The surface geostrophic velocity field for the Gulf Stream region was analyzed for the position, structure and surface transport of the Gulf Stream for 2.5 years of the Geosat altimeter Exact Repeat Mission. Synthetic data using a Gaussian velocity profile were generated and fit to the sea surface residual heights to create a synthetic mean sea surface height field and profiles of absolute geostrophic currents. Most of cross-track velocity variance was due to the meandering of the Gulf Stream, rather than to rings or complicated velocity profiles, which suggested that the simple model parameters are an efficient description of the Gulf Stream fluctuations. Two different flow regimes were revealed for the Gulf Stream connected by a narrow transition region coincident with the New England Seamount Chain.

Kelly, K.A. and D.R. Watts. 1991. Comparison of Surface and Baroclinic Transport Fluctuations in the Gulf Stream at 68°W. EOS, Trans. AGU. 72(51):57.

Abstract. A recent analysis of sea surface height from the Geosat altimeter showed low-frequency fluctuations in the Gulf Stream path and surface transport (the height difference across the stream) which are correlated in the sense that more northerly paths correspond to larger surface transports.

Kennett, J.P. 1982. Marine Geology. Prentice-Hall, Inc. Englewood Cliffs. 813 pp.

Abstract. A single, modern, comprehensive text about the geology of the oceans. The text covers the broad spectrum of marine geology in a largely nonquantitative way: the rocks, sediments, geophysics, structure, microfossils, and stratigraphy and history of the ocean basins and their marigins.

Ketchum, B.H. and D.J. Keen. 1955. The accumulation of river water over the continental shelf between Cape Cod and Chesapeake Bay. Deep-Sea Res. Supplement to 3:346-357.

Ketchum, B.H., A.C. Redfield and J.C. Ayers. 1951. The oceanography of the New York Bight. Pap. Phys. Oceanogr. Meteorol. 12(1):46.

Ketchum, B.H. and N. Corwin. 1964. The persistence of "winter" water on the continental shelf south of Long Island, N.Y. Limnol. Oceanogr. 9:467-475.

Kim, H.-S. 1991. An observational streamfunction in the Gulf Stream. Master of Science Thesis. Univ. of Rhode Island Graduate School of Oceanography, Narragansett. 126 pp.

Kim, H.-S. and D.R. Watts. 1991. Observations of geostrophic vortices and ageostrophic motions in the Gulf Stream. EOS, Trans. AGU. 72(51):58.

Abstract. Geostrophic streamfunction fields, optimally mapped from daily IES (Inverted Echo Sounder) observations in the Gulf Stream for the year 1984-85, have been shown to accurately determine currents at the 400 m level.

Kim, H.S., K.L. Tracey and D.R. Watts. 1989. The SYNOP Pilot Experiment: Inverted Echo Sounder Data Report for November 1986 to March 1987. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 88-1:60.

Kim, S.C. 1990. Inner continental shelf benthic boundary layer dynamics and suspended sediment transport. Ph.D. Thesis. The College of William and Mary. 221 pp. (Wright, LD (adviser); DAI 51/04B, p.1717; AAC9025869)

Abstract. An experiment conducted over the shoreface at Duck, North Carolina in 1985 embraced both fair-weather low energy and storm-related high energy conditions. To differentiate the diffusion and advection processes of suspended sediments under the high energy conditions from those under the low energy conditions, numerical modeling and the analysis of field data are exercised. A simple two-layer eddy viscosity wave-current combined boundary layer model is developed. The modeled characteristics of the boundary layer are incorporated with a diffusion equation to give suspended sediment concentration profiles. A velocity scale related to factors other than turbulent diffusion is formulated, representing the diffusion under varying energy conditions. With increasing bed friction, the vertical diffusion of sediment is reduced due to stratification, thus reducing velocity. From the measured suspended sediment concentration profiles, the resuspension coefficient shows a tendency to decrease with increased flow intensity, suggesting the role of the armoring effect. The coefficient varies between 0.003 for high-energy conditions and 0.002 for low-energy conditions. The energetics approach to predicted sediment transport overestimates the role of wave transport for the low energy conditions. Cross-correlations between cross-shore velocity and sediment concentration show that the role of wave for the transport under low energy conditions is not substantial. The direction of transport under now energy conditions is governed by the mean current. Under high energy conditions, transport by waves is onshore but superseded by offshore transport by the mean current, resulting in net offshore transport. The energetics model based on the surfzone dynamics underestimates the transport rate by an order of magnitude compared to the depth integration of the average product of mean cross-shore velocity and mean concentration. This indicates that the calibration of the efficiency factors in an energetics model is essential.

Kirby-Smith, W.W. and J. Ustach. 1985. Effects of a Natural Disturbance on a Continental Shelf Live Bottom Community off North Carolina. U.S. Dept. Interior, MMS Rep. MMS-85-0055:22.

Abstract. In September 1984, Hurricane Diana with maximum winds of 132 mph was stalled off Cape Fear, North Carolina, for over 24 hours in the vicinity of a previously sampled live bottom study site on the mid-continental shelf. Research cruises were undertaken to assess the impact of the storm on the large epibenthic organisms (sponges, corals, mollusks, algae and fishes) found at this site. Damage observed was limited to dead mussels, some dead coral and necrotic spots on corals. These data suggest that these communities are well adapted to the severe sand scour and water currents caused by waves generated during the passage of major storms.

Kirshen, P.H. ed. 1979a. Summary and analysis of physical oceanographic and meteorological information on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. Vol. 2, Sections 1-5. U.S. Dept. of the Interior. Washington, D.C. 368 pp.

Abstract. This report represents the Synthesis and Analysis of the Physical Oceanographic and Meteorological Data on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral.

Kirshen, P.H. 1979b. Summary and analysis of physical oceanographic and meteorological information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral, Executive Summary. Vol. 1. U.S. Dept. of the Interior. Washington, D.C.

Kirshen, P.H. 1979c. Summary and analysis of physical oceanographic and meteorological information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral, Technical Appendices. Vol. 3, Sections 6,7 and 8. U.S. Dept. of the Interior. Washington, D.C. 355 pp.

Abstract. This report represents the Synthesis and Analysis of the Physical Oceanographic and Meteorological Data on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. Numerous information sources were searched to obtain an analysis of the Climatology, Wave Data, Hydrography, and the Circulation of the Continental Shelf Waters, which are crucial to platform construction, safety procedures and management decisions. Seasonal variances of air temperature, wind speed and wind direction, cloud cover, cloud ceilings, visibility, precipitation, storms, weather fronts, solar radiation and precipitation run-off are discussed and summarized. Several programs are currently in progress to better define the Physical Oceanography and Meteorology of the OCS Study Area. As these studies continue, noticeable improvements in both the statistics and the extremes in seasonal variations of this area will be forthcoming in a form suitable for management and design decisions in the OCS development of oil and gas.

Kirwan, A.D., Jr., G. McNally and J. Coehlo. 1976. Gulf Stream kinematics inferred from a satellite-tracked drifter. J. Phys. Oceanogr. 6:750-755.

Abstract. A drifter was deployed in the Gulf Stream and tracked for 5 months by

the Nimbus 6 satellite. From this experiment we have assessed the technical capability of the satellite fixing system for measuring ocean currents, the drifter trajectory as it relates to the Gulf Stream position as determined by other independent means, and the kinematics and accelerations following the Stream axis. It is shown that the trajectory agrees quite well with the other data on the location of the Gulf Stream. The velocities, accelerations and kinetic energies derived from the trajectory are compared with previous studies. A comparison is made of the kinetic energy of the Gulf Stream as inferred from the drifter with some recent calculations made from ship drift.

Klasik, J. 1972. Sedimentation under the influence of contour currents, on the middle continental rise, between the Hatteras Canyon System and the Blake Outer Ridge (Atlantic Ocean). M.S. Thesis. Duke Univ.

Abstract. Sedimentation rate was found to be dependent on deep water currents in the region. A relationship between flow and topography was also indicated.

Klavans, A.S. 1983. Tidal Hydrodynamics and Sediment Transport in Beaufort Inlet, North Carolina. NOAA Tech. Rep. NOAA-TR-NOS-100:130.

Abstract. This report is based on a water circulation survey conducted by the National Ocean Service in the Beaufort Inlet estuarine area from February through May 1976. The primary purpose of the survey was to acquire tide and current data supplemented by salinity, temperature and meteorologic data. Analysis of these data is expected to provide a detailed description of water movement and its influence on estuarine sediment transport. By furnishing information about water movement and sediment transport, it is anticipated that this report will assist navigation and coastal management in the Beaufort Inlet area.

Knauss, J.A. 1967. The transport of the Gulf Stream. Repts. Plenary Session, 2nd Int. Oceanogr. Congress, June 1966, UNESCO Special Pub., pp. 67-82.

Knebel, H.J. 1980. Processes controlling characteristics of a surficial sand sheet, U.S. Atlantic Outer Continental Shelf. Bull. Am. Assoc. Pet. Geol. 64(5):733.

Abstract. Identifies controlling processes of surficial sand sheets. Processes include both ancient (glacial, ancestral rivers, nearshore marine environments, and subaerial solution and erosion) and modern (tidal, wind stress, and wave-driven currents, internal waves, water mass movement, regional circulation patterns, sediment bioturbation, and biogenic components).

Knebel, H.J. 1981. Processes controlling the characteristic of the surficial sand sheet, U.S. Atlantic Outer Continental Shelf. Mar. Geol. 42:349-368.

Abstract. A review of recent data on the velocity of bottom currents, the frequency of bottom-sediment movement, the kinds and amounts of suspended sediments in near-bottom waters, and the acoustic and sedimentary features of subbottom strata indicates that the characteristics of the ubiquitous sand sheet on the Atlantic outer continental shelf of the United States have been controlled by a variety of past and present processes. Although these processes collectively have had a widespread effect on the characteristics of the sand

sheet, the relative importance of each process changes geographically. On Georges Bank, late Pleistocene glaciations along with modern tidal currents and the regional circulation pattern have played a dominant role. On the Middle Atlantic shelf, ancestral rivers, former near-shore processes, and modern wind- and wave-generated currents are important factors. On the South Atlantic shelf, the sediments reflect subaerial weathering, erosion or nondeposition over or near hardgrounds, and the production of biogenic carbonate. Other processes such as the movement of water masses, bioturbation, and bottom fishing probably have affected the sediments in all areas. A knowledge of the various factors affecting the sand sheet is fundamental to an understanding of its general geologic history and to the paleoenvironmental interpretation of ancient sand strata.

Knowles, C.E. 1981. Wind-Wave Climatology and Wind-Tides for Fort Raleigh Wave-Gauge Site, 1979. UNC Sea Grant Pub. UNC-SG-WP-81-8:46.

Abstract. The wave data presented and discussed in this report were recorded almost continuously from January 26 to December 31, 1979 by a pressure transducer mounted 30 cm above the bottom offshore immediately adjacent to the Fort Raleigh National Historic Site. The data were collected as part of a shoreline stabilization project. This technical summary report deals specifically with the monthly wave climatologies and wind tides at the Fort Raleigh site for 1979.

Knowles, C.E. and J.J. Singer. 1977. Exchange through a Barrier Island Inlet: Additional Evidence of Upwelling off the Northeast Coast of North Carolina. J. Phys. Oceanogr. 7(1):146-152.

Abstract. During the period 20 June-2 July 1973, hydrographic data were collected at Oregon Inlet, N.C. An examination of the water temperature time-history record at three stations in and near the inlet show 1) that in two periods with predominately southerly winds, the temperature fluctuated in the range from 13.7° to 27.5°C with an apparent tidal periodicity; 2) that for nearly 48 h between these two periods and with northeasterly winds, a nearly constant temperature of 22.0° to 22.5°C was maintained in spite of normal tidal fluctuations; and 3) this constant temperature period is bracketed by two 24 h transitional periods that are initiated almost coincidentally with wind directional changes. It appears that the sequence and relationship of these wind and water temperature data may be explained by and provide additional evidence and documentation of wind-induced upwelling along the northeastern North Carolina coast previously reported by Wells and Gray (1960), Carter, Prichard and Carpenter (1966) and Boicourt (1973). Indeed, an important conclusion that can be drawn from this sequence and relationship of data is that temperature, salinity and current velocity records in and near a barrier island inlet can furnish much information about the exchange and mixing processes on the adjacent continental shelf, especially when there are differences in temperature and salinity between the sound and shelf waters.

Knowles, C.E., J. Langfelder and R. McDonald. 1973. A preliminary study of storm-induced beach erosion for North Carolina. NCSU Center for Mar. Coastal and Studies Rep. 73-5:18.

Abstract. This report presents the results of a study to determine the expected

storm induced beach erosion which can provide preliminary information needed for coastal land management.

Ko, D.S. 1991. Data Assimilation of Satellite Altimetry into a Gulf Stream. EOS, Trans. AGU. 71(52):63.

Abstract. Continuous data assimilation of satellite altimetry into numerical ocean models can provide nowcast fields and initial conditions for a forecast. A scheme which relies on the correlations between subsurface temperature and salinity anomalies and surface elevation anomalies to assimilate altimetry data into a multi-level, primitive equation ocean model of the Gulf Stream, using an optimal interpolation method, has been presented by Mellor and Ezer (JGR, 1991). When testing the scheme using simulated GEOSAT altimetry data, significant nowcast skill has been demonstrated, reducing the area averaged rms error between the nowcast and the control ocean fields to 40 to 50 percent of the corresponding error of the unassimilated case.

Konrad, T.G. and S.J. Colucci. 1989. An examination of extreme cold air outbreaks over eastern North America. Mon. Wea. Rev. 117:2687-2700.

Abstract. The sequence of development and thermodynamic aspects of two strong cold air outbreaks over eastern North America during January 1977 are described. In the first outbreak, surface cyclogenesis occurs prior to the outbreak onset (local 850 mb temperature decreases). Regions of strong cold air advection and adiabatic warming are found immediately upstream of the cyclone over the cold air outbreak area. Since the two regions are nearly superimposed, the effect of advective cooling is partially opposed by adiabatic warming. In the second outbreak, surface cyclogenesis follows the outbreak onset. In this case, local and advective cooling is observed over a larger region as a cold air pool over central Canada is transported southeastward. Initially, adiabatic warming is weak or replaced by adiabatic cooling over eastern North America as cold air advection dominates the thermodynamic energy balance. As downstream cyclogenesis proceeds during the later stages of the outbreak, adiabatic warming intensifies over the cold air advection region, reducing the cooling effect. An inspection of 15 other strong cold air outbreaks in a ten-winter sample reveals a qualitatively similar relationship among the size of the advection region, timing of the surface cyclogenesis and areal averaged 850 mg temperatures. It is hypothesized that the intensity of cold air outbreaks over the eastern North America is proportional to the areal coverage of the cold air advection region and timing, relative to cold air advection onset, of surface cyclogenesis.

Kontoyiannis, H. 1988. The Role of the Pressure Field in the Dynamics and Energetics of the Gulf Stream at 73°W. Master of Science Thesis. Univ. of Rhode Island, Kingston. 95 pp.

Kourafalou, V., J.D. Wang and T.N. Lee. 1984. Circulation on the continental shelf of the southeastern United States. Part III: Modeling the winter wind-driven flow. J. Phys. Oceanogr. 14(6):1022-1031.

Abstract. Model used to study wind-driven flow on the South Atlantic Bight shelf during winter is in good agreement with observations for both constant and varying wind fields, though poor comparison exists at the shelf-break due to

strong influence of the Gulf Stream.

Kraus, N.C. and J.L. Dean. 1987. Longshore sediment transport rate distributions measured by trap. pp. 881-896. In N.C. Kraus, ed. Coastal Sediments '87. American Society of Civil Engineers, New York.

Abstract. Lateral and vertical distributions of the longshore sediment transport rate in the surf zone were measured in the DUCK85 field data collection project held in Duck, North Carolina. The transport rate was measured with portable traps that collect both bedload and suspended load. The longshore current at two locations in the surf zone and the wave height across the surf zone were measured during the sediment trapping. The vertical distribution of the longshore sediment flux exhibited three general properties: (1) exponential decrease with distance from the bed, (2) non-zero value above the mean water line, and (3) independence of shape on location in the surf zone. Lateral distributions of the flux occurred as four types: (1) unimodal with a probinent peak in the outer surf zone, (2) bimodal with prominent peaks in the swash zone and in the outer surf zone, (3) flat with no prominent peaks, and (4) broad peak in the inner surf zone. The total measured longshore sediment transport rate, Q, was well described by the empirical formula $Q = a (R - R_c)$, in which $R = V X_b H_b$ (V = mean longshore current speed; X_b = surf width; H_b = breaking wave height), a is an empirical coefficient, and R_c is a threshold quantity. In the experiments, the major portion of the sediment moved as suspended load.

Kupferman, S.L. and N. Garfield. 1977. Transport of low-salinity water at the slope water-Gulf Stream boundary. J. Geophys. Res. 82(24):3481-3486.

Abstract. Hydrographic and drogue measurements were used to estimate the transport of shelf water by the freshened water bands at the slope water-Gulf Stream boundary, north of Cape Hatteras. Surface and subsurface bands were observed. Total transport was found to be 40,000 m^3/s. The source of the water for the surface and subsurface bands is the water above and below the shelf thermocline north of Cape Hatteras. The bands carry a significant, perhaps major, fraction of the shelf water passing through the Middle Atlantic Bight.

Lai, C.-C.A. 1991. On the Development of a Climatology-Analogy Forecast Model for the Gulf Stream System. EOS, Trans. AGU. 72(51):58.

Abstract. Auer's (1987) climatological survey of the Gulf Stream system and associated rings sheds light on predicting the Gulf Stream path through a climatology-analogy approach, Based on meteorologists' experience in tropical cyclone forecast, climatological-persistent models can perform as well as dynamical models. This research is to create an economical, portable, fast, affordable, flexible forecast model which can be considered an alternative to the complicated and expensive dynamic models. The steps are 1) conducting a statistical analysis of the climatology record of Gulf Stream features, 2) designing a climatology-analogy forecast algorithm, 3) developing a prototype model, and 4) testing, verifying, and modifying the prototype into a forecast model. Eight years of digitized Gulf Stream paths are used in the statistical analysis of Gulf Stream features. Preliminary results will be discussed. The algorithm of the climatology-analogy forecast will be elaborated, too.

Lai, C.-C.A. 1992. Gulf Stream Climatology and the Development of an Analogy Forecast Model. EOS, Trans. AGU. 73(14):159.

Abstract. A project is underway to develop a portable and computationally economical Climatology-Analogy Forecast Model. The purposes are manifold: (1) to compare the dynamical model skills with the climatology-analogy model skill, (2) to provide a long-term forecast beyond the current capabilities of contemporary dynamical models, (3) to evaluate the sufficiency of ocean climatic data for analogy approach, and (4) to provide an alternative to the complicated and computationally-expensive dynamical models when they are not suitable because of the limitations in observation, facilities or other, say on-board ships. Eight years of digitized Gulf Stream paths derived from AVHRR images are being combined with Navy bogus maps. Results from statistical analysis of the paths represented in a "rotated longitude-latitude" coordinates will be discussed. Candidate analogy forecast algorithms will be elaborated.

Lai, D. 1987. Distribution and Movement of Cyclonic Gulf Stream Rings from Historical Data (1970-73). Master of Science Thesis. Univ. of Rhode Island, Kingston. 116 pp.

Lai, D. and P.L. Richardson. 1977. Distribution and movement of Gulf Stream rings. J. Phys. Oceanogr. 7:670-683.

Abstract. The distribution, number and movement of cyclonic Gulf Stream rings were estimated from an analysis of 50,000 temperature records obtained from the National Oceanographic Data Center and Fleet Numerical Weather Central. The data were taken from 1970 through September 1976 in the region bounded by 20-40°N and 50-80°W. Additional ring observations from other sources were also used. Twenty-five ring time series, together with 26 single ring observations were obtained; approximately 11 rings were found to exist at one time. Rings typically moved westward, turned southwest when close to the Gulf Stream and appeared to coalesce with the Stream near Florida. On the average, two rings per year moved down this path with a mean speed of 3 km/day and an estimated life span of 2-3 years. Although ring observations were concentrated in the northwestern Sargasso Sea, several were documented east of 60°W. In addition to cold core rings several warm eddies were found south of the Stream; they consisted of at least a 150 m deepening of the main thermocline. The movement of anticyclonic rings north of the Stream was also determined; approximately three exist at a single time and they move westward with a mean speed of 5 km/day.

Lagneia, E.P. and C.D. Hollister. 1977. The interaction between the Gulf Stream and the Western Boundary Undercurrent. EOS, Trans. AGU. 58(6):405.

Abstract. Describes the interaction of the Worthington Gyre and the Western Boundary Undercurrent near the Hudson Fan. They were found to be in proximity and sediment stratigraphy indicated the historical circulation patterns.

Lane, J.S. 1986. Offshore Environmental Studies Program: North Carolina Physical Oceanography Programs. U.S. Dept. Interior, MMS Rep. OCS/MMS-85/0108:17.

Abstract. The report is a brief summary of past and on-going field physical

oceanography studies funded by the Atlantic OCS Region in the vicinity of North Carolina. Completed studies are described by study title, measurement summary, and study cost. The information was presented on June 3, 1985, in Raleigh, N.C. at a meeting of a technical panel formed under the Memorandum of Understanding between the Department of the Interior and the State of North Carolina.

Langfelder, J., T. French, R. McDonald and R. Ledbetter. 1974. A historical review of some of North Carolina's coastal inlets. NCSU Center for Mar. Coastal and Studies Rep. 74-1:42.

Abstract. The purpose of this study is to review the historical record of most of North Carolina's inlets as indicated by aerial photographs dating back to 1938. A knowledge of the historical behavior of the inlets is useful when attempting to predict the future migrations of these same inlets.

Langfelder, J., Y. Sorrell, B. Smith, G. Janowitz, C.Y. Peng, M. Amein, C.Y. Lee, T.B. Curtin, S. Riggs, S. Bellis, M. Brinson, G. Davis, C. O'Rear, L. Pearce, C. Smallwood, M. Sobsey, D. Hyman, J. Maiolo and P. Tschetter. 1979. Ocean Outfall Wastewater Disposal Feasibility and Planning-Final Report. Department of Marine Science and Engineering, North Carolina State University. Raleigh. 430 pp.

Abstract. Major findings of the study were: 1) Construction and operation of a well designed and operated sewage treatment plant that utilizes an ocean outfall and secondary treatment should not adversely affect the water column on fishery resources. Some build up of effluent constituents may occur in the bottom sediments in the immediate vicinity of the diffuser and could result in bottom community changes. 2) Effluent discharge should have essentially no adverse affect on recreational swimming in the areas of the diffuser. Areas now closed to shellfishing in the estuaries could be reopened as a result of reduced pathogen loadings; these pathogens are presently coming from septic tanks and treatment plants that discharge into these waters. 3) Centralized sewer systems will increase land values, allow reduced lot size and stimulate growth. This will lead to change in the population composition and demands for expanded goods and services.

Lapenta, W.M. 1990. A numerical investigation of wintertime east coast cyclogenesis. Ph.D. Thesis. The Pennsylvania State University. 179 pp. (Advisor: Seaman, NL; DAI 51/06B, p.2941; AAC9032322)

Abstract. A nested version of the Penn State/NCAR mesoscale model with 35-km fine-mesh resolution is used to study wintertime cyclogenesis along the east coast of the United States. Evaluation of the numerical results indicates that the model successfully reproduced most principal synoptic and mesoscale features associated with this complex East Coast cyclogenesis case, including storm path and intensification, coastal front structure, cold-air damming, circulations induced by a polar jet streak, low-level jets, and precipitation. In particular, this study (1) provides an in-depth numerical examination of a case of East Coast cyclogenesis in which entrance region jet streak dynamics provides the dominant upper level support; (2) reveals the existence of two air streams fed by moist onshore flow from the marine boundary layer east of the coastal front (a southeasterly low-level jet and a rapidly rising "feeder" supporting an

anticyclonically curving unstable airstream); (3) explores the origin, history and significance of these moist airstreams to cyclogenesis (the southeasterly low-level jet supports inland precipitation, while the feeder contributes to coastal and offshore precipitation and to falling pressure along the coast); and (4) demonstrates that both airstreams are well developed during the early phase of cyclogenesis. A series of numerical experiments is designed to explore the impact of several physical processes on the evolution and interaction between atmospheric phenomena of differing scales, each of which contributed to the development of the storm. In particular, the physical processes studied include (1) the role of diabatic heating associated with convective and grid-scale precipitation, (2) modification of the marine planetary boundary layer by fluxes of heat and moisture over the Gulf Stream and (3) the role of a thermally direct transverse circulation about the entrance region of a strong polar jet streak. The numerical experiments indicate that the intensity of heavy precipitation and latent heat release along the coastal front has the greatest impact upon the development of this storm, in terms of timing, phase speed, and intensity.

Lasley, S.R., L.P. Atkinson, J.J. Singer and W.S. Chandler. 1979. Hydrographic observations in the Georgia Bight (April 1978). Georgia Marine Sci. Center Tech. Rep. 79-5:101.

Abstract. This report contains chemical and physical data obtained during Georgia Bight Cruise (10-23 April 1978) aboard the R/V COLUMBUS ISELIN. The investigation was part of a larger multi-institutional Department of Energy program to understand event scale, physical, chemical and biological processes of the South Atlantic Bight, the continental shelf region from Cape Hatteras to Cape Canaveral. The study reported here is concentrated in the Georgia Bight near Brunswick, Georgia. The objective was to collect physical and chemical data such that three-dimensional quasi-synoptic measurements of the interactions of shelf and gulf stream waters could be made.

Lawrence, M.B. 1977. Atlantic hurricane season of 1976. Mon. Weather Rev. 105(4):497-507.

Abstract. Summary of the 1976 hurricane season is presented along with detailed accounts of individual storms. Interesting aspects of the 1976 season include the absence of any named storms in either the Gulf of Mexico or Caribbean Sea. Two storms in the central north Atlantic recurved toward the east at unusually low latitudes. Hurricane Belle struck Long Island after weakening dramatically during the 24 h period prior to landfall.

Lawrence, M.B. and P.J. Hebert. 1979. Annual data and verification tabulation Atlantic tropical cyclones 1977. National Hurricane Center, Coral Gables, FL, Tech. Memo. Rep:53.

Abstract. Summary of hurricane season by the National Hurricane Center for 1977.

Lazier, J.R. 1991. Does the Gulf Stream Split East of Newfoundland Determine the Water Characteristics in the North Atlantic Current. EOS, Trans. AGU. 72(51):32.

Abstract. The North Atlantic Current transports Subpolar Water eastward across

the northern North Atlantic Ocean. This is a North Atlantic Central Water (NACW) without the warm-salty upper layer which characterizes the Subtropical or Eighteen Degree Water. The usual argument is that Subtropical Water flows north in the North Atlantic Current and becomes Subpolar Water via heat loss and the addition of fresh water. That these processes are unlikely is indicated by calculating of the conversion using published values of E-P, heat loss, freshwater runoff and drift rates. It is proposed instead that the Subpolar Water originates at the splitting of the Gulf Stream southeast of Newfoundland. The division of the water masses occurs because density surfaces rise across the Stream toward the surface of the Sargasso Sea pycnocline into the surface layer. The warmer-saltier versions of NACW are thus found on the right (south) of the Stream and the colder-fresher water, the Subpolar Water, goes with the current on the left, the North Atlantic Current. The warmer-saltier water continues in the right hand branch, the Azores Current.

Leaman, K.D., E. Johns and T. Rossby. 1989. The average distribution of volume transport and potential vorticity with temperature at three sections across the Gulf Stream. J. Phys. Oceanogr. 19(1):36-51.

Abstract. Average cross sections of downstream velocity and temperature, obtained using PEGASUS current profilers at three locations along the Gulf Stream, have been partitioned into 2.5°C temperature intervals to examine the distribution of transport increase versus temperature between the two southern sections (27° and 29°N) and off Cape Hatteras (73°W). Cross-stream distributions of layer transport, potential vorticity, and thickness are estimated. A simple model based on conservation of layer potential vorticity is proposed to describe the transport structure. (41 Refs.).

Lee, J.C. 1989. Circulation in the Vicinity of the Shelf/Slope Front in the Mid-Atlantic Bight. Ph.D. Thesis. North Carolina State University. 106 pp.

Abstract. Subtidal variability of the shelf circulation in the Mid-Atlantic Bight was studied using a set of meteorological, coastal sea level, current velocity, temperature, salinity, chlorophyll content and light attenuation data obtained principally from a fixed array of SEEP-I moorings deployed from 16 February to 11 April 1984. A simple theoretical model with linear bottom friction and oscillating wind stress was developed in order to explain the phase relations between wind forcing and shelf circulation. The mean alongshore current is in the downshelf direction. The vertical gradient of the alongshelf velocity (v_z) is relatively small at the inner stations and greater at the outer stations due to the stronger horizontal density gradient (ρ_x) in the vicinity of the shelf/slope front. In effect, the time series of v_z at the outer station and ρ_x show high visual correlation. The mean cross-shelf circulation consists of onshore motion occurring at 84 meters depth in 124 meters of water and ridging of the frontal interface as predicted by Ou (1984) was observed. At the foot of the front, the temperature fluctuation is highly correlated with net displacement of cross-shelf flow. Phase lags of the alongshelf current in response to the longshore component of wind stress are found to be between 45° and 90° in the band of synoptic scale forcing corresponding to about 24 hours. A frictional adjustment time scale of about 40 hours in 100 m is obtained empirically by the application of a linear bottom stress model to the observed phases.

Lee, T.N. 1975. Florida Current spin-off eddies. Deep-Sea Res. 22:753-765.

Abstract. Analysis of one year of near-surface current meter records, obtained from inside the Florida Current, demonstrate the occurrence of frequent cyclonic current reversals that are not wind or tide induced.

Lee, T.N. 1983. On Gulf Stream variability in the South Atlantic Bight. EOS, Trans. AGU. 64(52):1027.

Abstract. Preliminary results from a Gulf Stream meander experiment in the South Atlantic Bight are presented. Subsurface, taut-wire current meter moorings were deployed in three cross-stream arrays that spanned the Gulf Stream off Savannah, GA, Long Bay, NC, and Onslow Bay, NC, during the period from February to July 1983. Niskin Winged Current Meters were used on faired moorings to measure currents in the high speed core region of the flow. Initial results indicate strong offshore turning of the flow over the Charleston bump, a cyclonic gyre downstream of the bump off Long Bay, onshore/offshore shifts of the axis with one month periods, and downstream propagating meanders and cyclonic cold-core frontal eddies with weekly periods.

Lee, T.N. 1988. Fall transport experiment on the South Atlantic Bight, report, DE-FG05-85ER60355, Dep. of Energy, Washington, D.C.

Lee, T.N. and L.P. Atkinson. 1982. Gulf Stream frontal eddies along the southeast U.S. Outer Continental Shelf. pp. 37. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982, AD-A128 789.

Abstract. Low frequency current and temperature time series from the outer shelf between Cape Canaveral, Florida and Cape Romain, South Carolina are compared to shipboard hydrographic data, satellite VHRR, coastal and buoy winds and coastal sea level during period from February to June 1980.

Lee, T.N. and L.P. Atkinson. 1983. Low-frequency current and temperature variability from Gulf Stream frontal eddies and atmospheric forcing along the southeast U.S. Outer Continental Shelf. J. Geophys. Res. 88(C8):4541-4568.

Abstract. Low-frequency current and temperature time series from the outer shelf between Cape Canaveral, Florida, and Cape Romain, South Carolina, are compared with shipboard hydrographic data, satellite VHRR, coastal and buoy winds, and coastal sea level during the period from February to June 1980. Low-frequency current and temperature variability along the shelf break was primarily produced by cyclonic, cold core Gulf Stream frontal eddies. These disturbances traveled to the north at speeds of 50 to 70 cm/s with periods of 5 to 9 days throughout the experiment and produced cold cyclonic perturbations of the northward mean flow and temperature fields over an along-shelf coherence scale of 100 km. Frontal eddies appear to be an important mechanism in the observed eastward transport of northward momentum and heat along the shelf edge. They also appear to play a key role in the transfer of eddy kinetic and potential energy back to the mean flow, which suggests an upstream formation region and shear-induced dissipation. Upwelling velocities of about 10^{-2} cm/s in the cold core provide the major source of new nutrients to the outer shelf. Subtidal flow variability

at the 40-m isobath was a mixed response to Gulf Stream and wind forcing. Barotropic along-shelf current oscillations were coherent with the local winds and coastal sea level at periods of 3-4 and 10-12 days over along-shelf scales of 400 km with a small phase laps, suggesting a nearly simultaneous frictional equilibrium response to coherent wind-induced sea level slopes.

Lee, T. and P. Cornillon. 1991. Propagation and Growth of Gulf Stream Meanders. EOS, Trans. AGU. Suppl to 72(17):148.

Abstract. The path of the Gulf Stream has been subjectively digitized from two-day composite satellite images for the period 1982-1989. The portion of the path digitized extends from Cape Hatteras, North Carolina, the point at which the stream leaves the continental shelf, to 45°W, the limit of satellite infrared coverage available at the University of Rhode Island. The wavelength, amplitude, and phase speed of meanders of the stream's path were obtained objectively from this data set. Results of the analysis of these quantities confirm the previously observed decrease of phase speed with increasing wavelength and amplitude. Further analysis shows that meanders tend to be less dispersive as the amplitude increases, and that the dependence of phase speed on amplitude is larger for meanders of shorter wavelength than for the longer ones. The derived observational nonlinear dispersion diagram is in good qualitative agreement with the theoretical counterpart obtained by Pratt (1988). Individual meanders are characterized by near exponential growth in amplitude. Finally, the mean growth rates calculated for these meanders are consistent with results obtained from other observational studies.

Lee, T.N. and P.A. Mayer. 1977. Low-frequency current variability and spin-off eddies off Southeast Florida. J. Mar. Res. 35:193-220.

Abstract. Characterizes shingles as cyclonic vortices.

Lee, T.N. and L.J. Pietrafesa. 1987. Summer upwelling on the southeastern U.S. continental shelf of the U.S.A. during 1981: Circulation. Prog. Oceanogr. 19:267-312.

Lee, T.N., L.P. Atkinson and R. Legeckis. 1981. Observations of a Gulf Stream frontal eddy on the Georgia continental shelf, April 1977. Deep-Sea Res. 28(4):347-378.

Abstract. Describes the formation of a cold eddy due to upwelling between the continental shelf, and offshore displaced front. Satellite, hydrographic, and moored current meter data is utilized to demonstrate the effect of Gulf Stream frontal disturbances on low-frequency current and temperature variability, water exchange, and nutrient flux in the outer region of the Georgia shelf.

Lee, T.N., W.J. Ho, V. Kourafalou and J.D. Wang. 1984a. Circulation on the continental shelf of the southeastern United States. Part 1: Subtidal response to wind and Gulf Stream forcing during winter. J. Phys. Oceanogr. 14(6):1001-1012.

Abstract. Subtidal current and sea level response to wind and Gulf Stream forcing are investigated for the South Atlantic Bight shelf during winter conditions.

Low-frequency flow variability in the outer shelf results primarily from wavelike meanders and eddies in the Gulf Stream front that occur in a 2-day to 2-week period band. Current meter derived vertically integrated momentum balances indicated that these large amplitude flow events are in approximate geostrophic balance with baroclinic pressure gradients induced by northward propagating Gulf Stream disturbances. Low-frequency flow at midshelf is primarily a local Ekman response to wind forcing.

Lee, T.N., W.-J. Ho, V. Kaurafalou and J.D. Wang. 1984b. Circulation on the southeast U.S. continental shelf, II, Model development and application to tidal flow. J. Phys. Oceanogr. 14(6):1013-1021.

Lee, T.N., V. Kourafolou, J.D. Wang, W.J. Ho, J.O. Blanton, L.P. Atkinson and L.J. Pietrafesa. 1985. Shelf Circulation from Cape Canaveral to Cape Fear during Winter. pp. 33-62. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. American Geophysical Union, Washington, DC.

Abstract. Subtidal current and sea level response to wind and Gulf Stream forcing are investigated for the South Atlantic Bight shelf during winter conditions. Low-frequency flow variability in the outer shelf results primarily from wavelike meanders and eddies in the Gulf Stream front that occur in a 2-day to 2-week period band. Current meter derived vertically integrated momentum balances indicated that these large-amplitude flow events are in approximate geostrophic balance with baroclinic pressure gradients induced by northward propagating Gulf Stream disturbances. Low-frequency flow at midshelf is primarily a local Ekman response to wind forcing. Cross-shelf momentum balance for the total water column is between the alongshelf geostrophic current and the cross-shelf barotropic pressure gradient resulting from wind-induced sea level changes at the coast. This balance holds for both mean and fluctuating parts of the flow, with the alongshelf barotropic current lagging sea level by 6 to 12 hours and alongshelf wind by 12 to 24 hours. The alongshelf balance of momentum is between the Coriolis force, alongshelf pressure gradient and alongshelf wind stress for the mean flow, with additional contribution from the local alongshelf acceleration of the water column and alongshelf bottom stress for the fluctuating flow. Near the transition from midshelf to outershelf flow regimes, which occurs at about the 40-m isobath, there is a significant contribution to the mean and fluctuating alongshelf momentum from the divergence of cross-shelf transport of alongshelf momentum. An alongshelf slope of Gulf Stream origin of the order of -10^{-7} appears to make a significant contribution to the observed mean northward flow over the shelf. The inner shelf is characterized by a band of low-salinity water from river runoff, which is vertically stratified throughout the year and forms a surface front at the eastern edge of the band. The alongshelf component of the flow is highly correlated with local wind stress, and the vertical distribution of the current is influenced by an internal (baroclinic) pressure gradient deriving from the river runoff. Alongshelf currents tend to lag wind-forcing events by about 3 hours and lead coastal sea level changes by about 15 hours at periods of 3 to 5 days. Mean volume transports for the innershelf and midshelf regions combined are approximately 20×10^4 m^3 s^{-1} northward, which indicates a shelf residence time of 3 months. A vertically integrated two-dimensional model has been adapted for the study of the wind-driven flow on the South Atlantic Bight (SAB) shelf during the winter season. Wind data are used

as an input to the model, and current data are used to verify the model results. Initially, a constant wind field in time and space is applied over the whole domain; the predicted flow pattern shows good agreement with observations. Model results using observed spatially and temporally varying wind fields are also in good agreement with midshelf observations. At the shelf break the comparison is rather poor owing to the strong influence of the Gulf Stream in the outer shelf data, which was neglected in the model. Water particle trajectories resulting from wind forcing, tidal forcing, and the combined effect of an alongshelf slope seem to have a significant effect on the net displacement of water particles as well as on the alongshelf volume transport. comparison of momentum balances from model results and observations indicates that low-frequency current variability at midshelf during winter is primarily an Ekman response to local wind forcing.

Lee, T.N., E. Williams, J. Wang, R. Evans and L.P. Atkinson. 1989. Response of South Carolina Continental Shelf Waters to Wind and Gulf Stream Forcing During Winter of 1986. J. Geophys. Res. 94(C8):10715-10754.

Abstract. The South Carolina shelf water response to strong winter atmospheric forcing and Gulf Stream variations over the slope is discussed with the aid of a comprehensive set of atmospheric and oceanic observations made during project GALE (Genesis of Atlantic Lows Experiment). A mixed response is observed to wind and Gulf Stream forcing. Subtidal variability of inner and middle shelf waters is primarily a barotropic, forced response to coherent, synoptic scale, alongshore winds. This response is not trapped over the shelf, as has been found for other wide, non-equatorial shelves, but is also significant at the shelf edge, possibly because of the comparable widths of the shelf and slope. The outer shelf also shows a significant Gulf Stream influence. The Gulf Stream appears to have two preferred position modes, either onshore, with the stream flowing over the Charleston bump and along the shelf break, or offshore, when the stream can be located up to 100 km east of the shelf break; transition between the two states is rapid.

Lee, T.N., J.A. Yoder and L.P. Atkinson. 1991. Gulf Stream Frontal Eddy Influence on Productivity of the Southeast U.S. Continental Shelf. J. Geophys. Res. 96(C12):22191-22205.

Abstract. Weekly period meanders and eddies are persistent features of Gulf Stream frontal dynamics from Miami, Florida, to Cape Hatteras. Satellite imagery and moored current and temperature records reveal a spatial pattern of preferred regions for growth and decay of frontal disturbances. Growth regions occur off Miami, Cape Canaveral, and Cape Fear due to baroclinic instability, and decay occurs in the confines of the Straits of Florida between Miami and Palm Beach, between 30° and 32°N where the stream approaches the topographic feature known as the Charleston bump and between 33°N and Cape Hatteras. Eddy decay regions are associated with elongation of frontal features, offshore transport of momentum and heat, and onshore transport of nutrients. Onshore transport of new nitrogen from the nutrient-bearing strata beneath the Gulf Stream indicates that frontal eddies serve as a "nutrient pump" for the shelf. New nitrogen to the shelf due to Gulf Stream input could support new production of 7.4×10^{12} g C/yr or about 8 million tons carbon per year if all nitrate were utilized. Calculations indicate that approximately 70% of this potential new production is realized, yielding an annual new production for the outer shelf of 4.3×10^{12} g

C.

Leenknecht, D.A., J.A. Earickson and H.L. Butler. 1984. Numerical Simulation of Oregon Inlet Control Structures' Effects on Storm and Tide Elevations in Pamlico Sound. CERC Tech. Rep. CERC-TR-84-2:167.

Abstract. Three numerical hydrodynamic models with progressively finer grid resolutions, utilizing the finite difference code WIFM, were developed for the purpose of evaluating the influence of proposed structures under storm conditions and providing elevation and velocity data for concurrent numerical sediment transport studies at Oregon Inlet, North Carolina. The offshore model encompassed the entire Carolina coast over the continental shelf and was used to propagate storm effects from deep water to the finer resolution models. The nearshore model extended from Cape Henry to Cape Lookout, and provided finer detail along the Outer Banks, within Pamlico and Albermarle Sounds, and at Oregon Inlet. This model was used both tide and surge simulations and was the primary tool for establishing structural effects under storm conditions in the Oregon Inlet vicinity. It also was used to provide boundary conditions for the most detailed model of the study known as the shore process model. The shore process model encompassed less than 85 square miles centered about Oregon Inlet and provided high resolution at the inlet and in the surf zone. It provided more realistic circulation patterns of the inlet, the effects of jetties on inlet flow, and hydrodynamic data for concurrent numerical sediment transport studies.

Leetma, A. and A.F. Bunker. 1978. Updated charts of the mean annual wind stress, convergences in the Ekman Layers, and Sverdrup transports in the North Atlantic. J. Mar. Res. 36(2):311-322.

Abstract. Provides computation of mean and seasonal vertical velocities as a result of converging Ekman layers.

Legeckis, R.V. 1975. Applications of synchronous meteorological satellite data to the study of time dependent sea surface temperature changes along the boundary of the Gulf Stream. Geophys. Res. Lett. 2:435-438.

Abstract. Time series of images of the Gulf Stream off Florida show northward-propagating cyclonic eddies on the inshore edge of the current boundary.

Legeckis, R.V. 1979. Satellite observations of the influence of bottom topography on the seaward deflection of the Gulf Stream off Charleston, SC. J. Phys. Oceanogr. 9:483-497.

Abstract. Data provides evidence that onshore meanders are related to northward-traveling waves.

Legeckis, R.V. and J.M. Bane Jr. 1983. Comparison of the TIROS-N satellite and aircraft measurements of Gulf Stream surface temperatures. J. Geophys. Res. 88(C8):4611-4616.

Abstract. A comparison is made between multi-channel infrared (3.7 and 11 μm) temperatures measured by the TIROS-N satellite and aircraft single channel radiometer and AXBT measurements over the Gulf Stream between Cape Hatteras and

Savannah, Georgia, on November 27, 1979. After reducing the noise in the 3.7 μm TIROS-N data, a multi-channel method is used to estimate the sea surface temperatures. For a temperature band of 19 to 26°C, the estimated and AXBT measurements are in agreement within a standard error estimate of 0.5°C. A bias of 1.2°C was found between the aircraft radiometer and the AXBT measurements, and part of this bias is attributed to radiometer calibration errors.

Li, L. and M. Wimbush. 1985. Bottom temperatures related to Gulf Stream displacement off the southeast United States shelf. J. Atmos. Oceanic Technol. 2(1):90-94.

Abstract. Bottom temperature is found to be coherent with vertical displacement of the thermocline, suggesting that bottom temperature under the Gulf Stream front is a potentially useful indicator of Gulf Stream displacement.

Lillibridge, J.L., III, G. Hitchcock, T. Rossby, E. Lessard, M. Mork and L. Golmen. 1990. Entrainment and mixing of shelf/slope waters in the near-surface Gulf Stream. J. Geophys. Res. 95(C8):13065-13087, 13559-13560.

Abstract. In October 1985 a physical-biological study of the entrainment of shelf waters, and the formation of Gulf Stream shingles, was organized as a joint undertaking between the University of Rhode Island and the University of Bergen, Norway. The University of Bergen provided a towed conductivity-temperature-depth system known as 'SeaSoar,' which allowed them to obtain high-resolution vertical sections of temperature, salinity, oxygen, and fluorescence. The objective of this study was to construct a three-dimensional picture of the low-salinity Ford water intrusion, describe its relation to the surrounding waters, and follow its subsequent course and evolution as it was advected downstream. By repeatedly towing the SeaSoar across the low-salinity feature and north wall of the Gulf Stream, its change in shape and intensity was documented. (37 Refs.).

Lin, G. 1992. A Numerical Model of the Hydrodynamics of the Albemarle-Pamlico-Croatan Sounds System, North Carolina. Master of Science Thesis. North Carolina State University. 118 pp.

Abstract. A linear, barotropic, three-dimensional, time-dependent, constant eddy viscosity model is developed for the entire Albemarle-Pamlico-Croatan sounds system. The study first analyzes the scales of time, velocity, and water level fluctuation of the flow field in the system. Analytical solutions under steady state are obtained to gain physical insight into the water motions. The factors influencing the flow field, e.g., wind stress, river discharge, tidal effect, eddy viscosity, bottom friction, and Coriolis effect are examined in terms of their relative importance. The finite difference method is used to numerically solve the time-dependent governing equations. The numerical model incorporates a spatially and temporally varying atmospheric wind stress, a stress bottom condition, river discharges, and tidal exchanges as boundary conditions. The bottom topography is incorporated into the model by utilizing a σ-coordinate. The model is verified using the results of field measurements within the sounds system. Several case runs of the model show that the flow field in Pamlico Sound is dynamically coupled with that in Albemarle Sound via restricted flow through Croatan Sound. The sounds system fully responds to wind action in a period of about 6 hours for north/south direction and about 4 hours for east/west

direction. The water parcels throughout the water column in Croatan Sound flow in the direction of a constant north/south wind for the first 14 hours after wind onset. The circulation response reaches quasi-steady state condition for a constant wind forcing in a period of about 24 hours for the north/south wind and about 18 hours for the east/west wind.

Lindstrom, S.S. and D.R. Watts. 1991. Comparisons of vertical motion computed from three different data sources in the Gulf Stream northeast of Cape Hatteras. EOS, Trans. AGU. 72(51):58.

Abstract. Three independent methods of determining vertical motion, one based on observations, are compared in the SYNOP (Synoptic Ocean Prediction Experiment) domain near 38°N, 78°W. A Q-vector formulation of the quasi-geostrophic omega equation, using data from the Inverted Echo-sounder (IES)-mapped geostrophic streamfunction (Kim 1991), is solved to yield the quasi-geostrophic component of the vertical motion. This is compared to vertical motion inferred from the turning of the current with height (as measured by current meters) such that veering (backing) currents imply rising (sinking) motion. Both estimates are compared to the 'true' motion as depicted by isopycnal RAFOS floats. The favorable comparisons indicate that the vertical motion can in large part be related to quasi-geostrophic adjustments. The Q-vector and current meter estimates also agree with the conceptual model rising motion between trough and crest, and sinking motion between crest and trough (Bower and Rossby 1969).

Lippert, A. and M.G. Briscoe. 1990. Observations and EOF analysis of low-frequency variability in the western part of the Gulf Stream recirculation. J. Phys. Oceanogr. 20(5):646-656.

Abstract. This study of low-frequency oceanic variability is based on data collected during the Long Term Upper Ocean Study (LOTUS), which was a two year program of moored meteorological and oceanographic measurements. The mooring arrays were centered at 34°N, 70°W over the Hatteras Abyssal Plain. With a distance of about 300 km to the mean Gulf Stream axis and the continental slope, LOTUS was the most northern and western long-term mooring site in the Gulf Stream recirculation region to date. The vertical structure of the variability was examined by empirical orthogonal function analysis. (52 Refs.).

Lippmann, T.C. and R.A. Holman. 1989. Quantificatiion of sand bar morphology: a video technique based on wave dissipation. J. Geophys. Res. 94(C1):995-1011.

Abstract. A technique is presented to remotely measure the scales and morphology of natural sand bars based on the preferential dissipation of wind waves and swell over the crests of the bar. Photographic or video images are recorded and statistical uncertainties associated with incident wave height modulations removed by averaging (time exposures). Ground truth testing of the technique was carried out as part of the SUPERDUCK experiment in October 1986. The time exposures generally provided a good mapping of underlying morphology, allowing detection of the bar and determination of cross-shore and longshore length scales. However, during high waves, persistent surface foam obscures the relationship of image intensity to local dissipation (modeled theoretically by dissipation of a random wave field), and an enhancement technique of image differencing must be done to remove the bias. Errors in the estimate of bar

crest distance from the shoreline are generally less than 35%, but this value depends on the geometry of the particular bar. Logistic simplicity and quantitative capabilities make this technique very attractive.

Liu, M. 1991. The Upper Ocean Velocity Structure of Gulf Stream Meanders--An Application of the ADCP. Master of Science Thesis. Univ. of Rhode Island, Kingston. 101 pp.

Longuet-Higgins, M.S. 1952. On the statistical distribution of the heights of sea waves. J. Mar. Res. 11(3):245-266.

Abstract. The statistical distribution of wave-heights is derived theoretically on the assumptions (a) that the wave spectrum contains a single narrow band of frequencies, and (b) that the wave energy is being received from a large number of different sources whose phases are random. Theoretical relations are found between the root-mean-square wave-height, the mean height of the highest one-third (or highest one-tenth) waves and the most probable height of the largest wave in a given interval of time. There is close agreement with observation.

Longuet-Higgins, M.S. 1980. On the distribution of the heights of sea waves: Some effects of nonlinearity and finite band width. J. Geophys. Res. 85(C3):1519-1523.

Abstract. It is shown that some recent data on the crest-to-trough heights of sea waves are fitted just as well as by the one-parameter Rayleigh distribution as by the two-parameter Weibull distribution, provided that the rms amplitude $\underline{a}$ is taken as $0.925(2m_0)^{1/2}$, where m_0 is the lowest moment of the frequency spectrum. Reasons why the ratio $\underline{a}/(2m_0)^{1/2}$ should differ from unity are discussed. It is shown that the effect of finite wave steepness would be to increase the ratio by a factor $[1+\frac{1}{2}(ak)^2]$ approximately, contrary to observation. The effect of finite band width is estimated from a model assuming low background noise superposed linearly on a delta function spectrum. For narrow band widths one obtains the formula $\underline{a}^2/2m_0 = 1 - 0.734\upsilon^2$, where υ is the rms spread of the noise about the mean frequency. Values of υ^2 corresponding to Pierson-Moskowicz spectra give results in close agreement with observation.

Lorenson, K.R. 1980. Three-dimensional, Mesoscale Characteristics of the Gulf Stream Thermal Frontal Zone South of Cape Hatteras. Master of Science Thesis. University of North Carolina at Chapel Hill. 181 pp.

Abstract. A series of eight aircraft flights were conducted during February 1979 to obtain synoptic temperature measurements of the Gulf Stream frontal zone between Savannah, GA and Cape Hatteras, NC. Subsurface temperature profiles, provided by 422 airborne expendable bathythermographs (AXBT's), were used to describe the spatial and temporal fluctuations of the upper 400 meters of the thermal front. Two types of Gulf Stream meanders were observed as they propagated through the survey area. Large-amplitude meanders were skewed wave-like motions with lateral amplitudes of 60 km, wavelengths ranging from 150 to 215 km, and periods of about 5 days. Average phase speeds of 35 km/day were observed for the meanders as they propagated to the northeast. Smaller amplitudes, shorter wavelengths, and increased symmetry characterized the second type of meander. These small-amplitude meanders had phase speeds near 43 km/day

and periods of about 2 days. A comparison of the AXBT temperature data with moored instrument data gave similar estimates of phase speeds, periods, and wavelengths for both types of meanders. On 10 February, two large-amplitude meanders were present downstream of a strong seaward deflection of the Stream in the vicinity of Charleston, SC. The subsurface temperatures showed that the greatest deflection occurred at the surface and that the degree of deflection decreased with depth until the Stream's path was essentially parallel to the isobaths at 300 meters. By the later surveys, the meanders had propagated farther downstream and the degree of deflection lessened. This suggests a relationship between the deflection and the passage of meanders through the area. Along the inshore edge of the front, tongue-like extrusions, filaments, of Gulf Stream water extended to the southwest behind the meander crests. These filaments were shallow features, reaching to depths less than 100 meters. Their lengths were quite variable, ranging from 50 to 250 meters. They appeared to have been formed at the crests and to have elongated as the meanders moved downstream. A region of cool water separated the filaments from the Stream. The subsurface temperatures suggest that upwelling of deep Gulf Stream water was the source of these cooler waters.

Lorenson, K.R. and D.R. Watts. 1983. Variations in the Gulf Stream position northeast of Cape Hatteras. EOS, Trans. AGU. 64(52):1026.

Abstract. Gulf Stream path fluctuations were monitored by a moored array of inverted echo sounders (IES) centered 150 km northeast of Cape Hatteras. Earlier comparisons with shipboard surveys have shown that the position of the subsurface front may be determined within an error of 5-8 km by this method. Long term statistics on the northwall position are presented from this 36-month observational period (1979-1982). The mean subsurface position is 5 km offshore of the mean surface front. The Gulf Stream shifts up to 33 km shoreward and 60 km offshore of this mean; this results in a skewed frequency distribution with the most probable position 10 km shoreward of the mean. Displacement spectra are presented with emphasis on periodicities from 30 days to 1 year. In particular, seasonal averages show that the Stream is 14 km further south in the spring than in the late summer. This trend conforms to the traditional notion that the Stream shifts southward (or northward) when the wind-driven transport is supposed to be high (or low). However our data show large interannual variability in this pattern.

Lorenzzetti, J.A. 1985. On the modeling of the summer circulation in the South Atlantic Bight by a two-layer finite element model. Ph.D. Thesis. University of Miami. 217 pp. (DAI 47/02B, p.552; AAC8607983)

Abstract. The summer circulation in the South Atlantic Bight (SAB) was investigated using a two-layer finite element model. An impulsive wind experiment was done indicating that the frictional adjustment time on the shelf varies between 12 and 24 hours. The momentum balance study of this experiment indicated that for inner and mid-shelf regions a geostrophic balance dominates the dynamics for the cross-shelf direction. In the along-shore direction the coriolis acceleration of the cross-shore flow, the pressure gradient, the wind and the bottom stresses are all significant in the momentum balance. Both findings agree with results of data analysis of Lee and Pietrafesa (1985). The results of a real wind event experiment showed that modeled coastal sea level and currents compared

reasonably well to observed coastal sea level and current velocities observed at mid-shelf at the 30 and 40 m isobaths. Shelf break currents could not be modeled since their main forcing are the Gulf Stream mean and transient components, which are not accounted for by the model. The results of this experiment together with the momentum balance study referred to above and the data analysis indicate that the inner and mid-shelf response of the SAB during the summer of 1981 was in the form of wind forced continental shelf waves. The short adjustment time of the shelf compared to the time scale of the forcing results in a quasi-steady state dynamic balance, giving these waves properties similar to the 'arrested topographic waves' of Csanady (1978). The summer upwelling present north of Cape Canaveral and off Daytona was represented very well in the model results both for upwelling favorable winds and by forcing the model at the shelf break by a negative along-shelf slope of -1.6×10^{-7} as suggested by previous studies. These results indicate that the summer upwelling in that region is not produced by a single mechanism, but is the result of the joint effect of northward winds and onshore migrations of the Florida Current over the shelf. The implementation of sponge layers along the south and north open boundaries of the numerical domain was found to be very efficient in attenuating the wave reflections along these boundaries.

Louis, J.P. and P.C. Smith. 1982. The development of the barotropic radiation field of an eddy over a slope. J. Phys. Oceanogr. 12:56-73.

Abstract. Presents barotropic models for characterizing of the radiation field of an eddy over a sloping bottom.

Lozier, S.M. and S.C. Riser. 1990. Potential vorticity sources and sinks in a quasi-geostrophic ocean: beyond western boundary currents. J. Phys. Oceanogr. 20(10):1608-1627.

Abstract. Potential vorticity dynamics for a quasi-geostrophic eddy-resolving general circulation model (EGCM) are studied in order to determine the effects of mesoscale variability on the potential vorticity distribution of a wind-driven ocean. The study employs both Eulerian and Lagrangian analyses in the effort to describe the potential vorticity gain/loss cycle along the path of a particle. While the mean wind stress curl is the dominant potential vorticity source for the interior of the upper layer, a redistribution of eddy potential vorticity creates sources of potential vorticity for the multiple gyres in the lower layers. This redistribution is a result of the local generation of eddies via baroclinic instabilities. These eddies are advected by the western boundary current into the midlatitude jet where they are responsible for a cross-gyre potential vorticity exchange. (21 Refs.).

Lozovatskij, I.D., M.Y. Lilover and A.N. Porfir'eva. 1987. Small-scale spatial-temporal variations of hydrophysical fields in the Gulf Stream upper layer.; Melkomasshtabnaya prostranstvenno-vremennaya izmenchivost' gidrofizicheskikh polej° v verkhnem sloe okeana v rajone Gol'fstrima. Morsk. Gidrofiz. ZH No. 6:52-59.

Abstract. Analysis of upper 250m layer in the central part of the Gulf Stream revealed that the "internal" frontal zone is mainly of a thermocline origin with a clearly pronounced intrusive vertical structure, whereas the "external" zone

is purely baroclinic with a well-developed shear instability in the pycnocline.

Luternauer, J.L. and O.H. Pilkey. 1967. Phosphorite grains: Their application to the interpretation of North Carolina shelf sedimentation. Mar. Geol. 5:315-320.

Abstract. Study of phosphorite grains in North Carolina continental shelf, beach, sound, and river sediments reveal that: (1) the shelf is an important source of beach sediment, and (2) North Carolina shelf cuspate embayments are essentially independent entities, in terms of sediment content and transport.

Luther, M.E. 1980. Coastal-Trapped and Frontal-Trapped Waves in a Continuously Stratified Western Boundary Current. Master of Science Thesis. University of North Carolina at Chapel Hill. 77 pp.

Abstract. Research is presented on the effects of a realistic western boundary current on the alongshore propagation of sub-inertial waves trapped by a sloping bottom topography. A numerical model is developed incorporating realistic bottom topography and a current field which is in thermal wind balance with the density field; this models the Gulf Stream as it flows along the continental slope off North Carolina. The mean state velocity and density fields do not vary alongshore and are continuous in the horizontal as well as the vertical. The linearized, inviscid equations of motion for small amplitude disturbances yield a single governing equation for the perturbation pressure. This equation is solved using the marching method for elliptic problems of Roache (1978). The dispersion relations are obtained by searching for the resonance response of the system to an arbitrary uniform forcing term. Four discrete stable modes of Rossby-like waves are identified, all propagating in the upstream direction. A mode-coupling resonance is found between the first two modes. For small wavenumber, the first mode is trapped within the frontal zone on the cyclonic side of the mean current with a smaller barotropic component over the shelf. This "frontal trapping" is due to the quasi-geostrophic potential vorticity gradient in the mean current. For large wavenumber, the first mode becomes primarily a barotropic shelf wave. The second mode is a purely barotropic shelf wave for small wavenumbers, but becomes a frontal-trapped wave at large wavenumbers. For the higher wave modes, most of the energy is trapped near the surface in the frontal zone.

Luther, M.E. 1982a. Mixed instabilities in the Gulf Stream over the continental slope. Ph.D. Thesis. The University of North Carolina at Chapel Hill. 137 pp. (DAI 43/08B, p.2487; AAC8229400)

Abstract. A numerical model study is presented of the unstable normal modes of oscillation of a boundary current. The model background current approximates the Gulf Stream south of Cape Hatteras, North Carolina. Both vertical and horizontal shear in current velocity and a sloping bottom topography are included. The study seeks small amplitude, alongshore propagating perturbations with real frequency and complex alongshore wave number. A non-zero imaginary part of the wave number ensures that the wave amplitude either grows or decays in the alongshore direction. The first four eigenmodes are identified and their dispersion relations are investigated. Higher order modes are not resolved by the model. The dispersion surfaces (eigenvalues of frequency as a function of complex wave

number) appear to bifurcate with increasing wave number. Observations in the Gulf Stream south of Cape Hatteras have revealed a persistent wave-like meander pattern in the Stream with a period of 7-8 days, henceforth called the 8-day wave. This wave form propagates in the downstream direction with a phase speed of about 40 km/day and is uncorrelated with local wind forcing. An 8-day wave also appears as an eigenmode in the model, and the perturbation velocity and buoyancy fields are consistent with obstructions. The instability mechanism of the model wave is of the mixed barotropic-baroclinic type, with the majority (about 80%) of the perturbation energy derived from the potential energy of the background flow. The model 8-day wave consists of a side to side meandering of the core of the current with filament-like structures of warm water (positive perturbation buoyancy) trailing the shoreward-most excursion of the core of the current. These filaments are separated from the core of the current by a cold dome of upwelled water.

Luther, M.E. 1982b. Spatially unstable waves in the Gulf Stream over the Carolina continental slope. Proceedings of the Workshop on Gulf Stream Structure and Variability held at Research Triangle Park, North Carolina 1-2 April 1982. UNC-CH, Chapel Hill, NC.

Abstract. A numerical model is presented investigating the unstable normal modes of oscillation of a realistic boundary current.

Luther, M.E. and J.M. Bane Jr. 1980. Coastal-Trapped and Frontal-Trapped Waves in a Continuously Stratified Western Boundary Current - A Contribution to the Gulf Stream Meanders Experiment. UNC Tech. Rep. CMS-81-1:85.

Abstract. The effects of a realistic western boundary current on the alongshore propagation of sub-initial waves trapped by a sloping bottom topography are studied using a numerical model incorporating realistic bottom topography and a current field which is in thermal wind balance with the density field. This models the Gulf Stream as it flows along the continental slope off North Carolina. The mean state velocity and density fields do not vary alongshore and are continuous in the horizontal as well as the vertical. The linearized, inviscid equations of motion for small amplitude disturbances yield a single governing equation for the perturbation pressure. This equation is solved using a marching method for elliptical problems. The dispersion relations are obtained by searching for the resonance response of the system to an arbitrary uniform forcing term. Four discrete stable modes of Rossby-like waves are identified, all propagating in the upstream direction. A mode-coupling resonance is found between the first two modes. For small wavenumber, the first mode is trapped within the frontal zone on the cyclonic side of the mean current with a smaller barotropic component over the shelf. This 'frontal trapping' is due to the quasi-geostrophic potential vorticity gradient in the mean current. For larger wavenumber, the first mode becomes primarily a barotropic shelf wave. The second mode is a purely barotropic shelf wave for small wavenumbers, but becomes a frontal-trapped wave at large wavenumbers. For the higher wave modes, most of the energy is trapped near the surface in the frontal zone.

Luther, M.E. and J.M. Bane Jr. 1985. Mixed instabilities in the Gulf Stream over the continental slope. J. Phys. Oceanogr. 15(1):3-23.

Abstract. A numerical model study is presented of the unstable normal modes of oscillation of a boundary current is presented. The model background current approximates the Gulf Stream south of Cape Hatteras, North Carolina. Both vertical and horizontal shear in current velocity and a sloping bottom topography are included. The study seeks small amplitude, alongshore propagating perturbations with real frequency and complex alongshore wavenumber. A nonzero imaginary part of the wavenumber ensures that the wave amplitude either grows or decays in the alongshore direction. the first four eigenmodes are identified and their dispersion relations are investigated. Higher order modes are not resolved by the model. The dispersion surfaces (eigenvalues of frequency as a function of complex wavenumber) appear to bifurcate with increasing values of real wave number. Observations in the Gulf Stream south of Cape Hatteras have revealed a persistent wave-like meander pattern in the Stream with a period of 7-8 days. This wave form propagates in the downstream direction with a phase speed of about 40 km/day and is uncorrelated with local wind forcing. An 8-day wave also appears as an eigenmode in the model, and the perturbation velocity and buoyancy fields are consistent with observations. The instability mechanism of the model wave is of the mixed barotropic-baroclinic type, with the majority (about 80%) of the perturbation energy derived from the potential energy of the background flow. The model 8-day wave consists of a side-to-side meandering of the core of the current with filament-like structures of warm water (positive perturbation buoyancy) trailing the shoreward-most excursion of the core of the current. These filaments are separated from the core of the current by a cold dome of upwelled water.

Luyten, J.R. 1977. Scales of motion in the deep Gulf Stream and across the deep continental rise. J. Mar. Res. 35(1):49-74.

Abstract. Describes large-scale long-period variability associated with the flow field near the Gulf Stream extension region.

Lybanon, M. 1991. A Rule-Based System Accurately Forecasts Isolated Gulf Stream Ring Motion. EOS, Trans. AGU. 72(51):58.

Abstract. While models show skill in predicting the Gulf Stream's path, they do not exhibit comparable skill in predicting the motion of associated warm- and cold-core rings (WCR's and CCR's). However, an expert system under development at the Naval Oceanographic and Atmospheric Research Laboratory can forecast isolated (i.e., not interacting with the Gulf Stream) WCR and CCR motion accurately based on several error measures for up to 14 days. Tests on a data set that includes both isolated and interacting rings also yield good results.

Lybanon, M., E.J. Molinelli, G. Muncill and K. Pepe. 1991. Neural network labeling of the Gulf Stream. Proceedings of the SPIE--The International Society for Optical Engineering. 1469(pt.1, vol.2):637-647.

Abstract. An expert analyst can study an infrared image of sea surface temperature (SST) in the western North Atlantic offshore of Cape Hatteras and define a Gulf Stream north wall where the surface is not cloud covered, but human

analyses are time consuming, tedious, qualitative, and subjective. Numerical depictions range from a latitude-longitude grid to a complex vector form to a complex empirical orthogonal function (CEOF) or normal mode sum, in which ten modes 'explain' most of the variability. The CEOFs can be used to interpolate to give reasonable Gulf Stream position analyses from spotty observations provided by an analyst. The next step was to use neural network technology to get CEOF coefficients directly from SST imagery. A two-layer perception network trained by the back-propagation algorithm was used for this study. The authors trained a neural network to output the first three coefficients using the Gulf Stream vectors as inputs. They then simulated image-type input by mapping the vectors onto a 40 km grid; the CEOF coefficients were highly correlated to the correct ones for the training set, but less so for the test set. The authors upgraded the hardware and software to reduce the training time, and also increased the input grid resolution and the number of output modes. Doubling the resolution while confining input to the Gulf Stream's historical envelope gave a 100% resolution increase with a 64% increase in input nodes. The paper gives details of the results, conclusions, and recommendations. This work shows that neural networks can yield coefficients which can produce realistic Gulf Streams, accurate enough to use with edge labeling and optimal interpolation schemes.

Lyne, V.D., B. Butman and W.D. Grant. 1990a. Sediment movement along the U. S. continental shelf-I. Estimates of bottom stress using the Grant-Madsen-Glenn model and near-bottom wave and current measurements. Cont. Shelf Res. 10(5):397-428.

Abstract. Bottom stress is calculated for several long-term time-series observations, made on the U.S. east coast continental shelf during winter, using the wave-current interaction and moveable bed menthods of Grant and Madsen (1979, Journal of Geophysical Research, 84, 1797-1808: 1982, Journal of Geophysical Research, 87, 469-482). The wave and current measurements were obtained by means of a bottom tripod system which measured current using a Savonius rotor and vane and waves by means of a pressure sensor. The variables were burst sampled about 10% of the time. Wave energy was reasonably resolved, although alaised by wave groupiness, and wave period was accurate to 1-2 s during large storms. Errors in current speed and direction depend on the speed of the mean current relative to the wave current. In general, errors in bottom stress caused by uncertainties in measured current speed and wave shacteristics were 10-20%.

Lyne, V.D., B. Butman and W.D. Grant. 1990b. Sediment movement along the U.S. continental shelf-II. Modelling suspended sediment concentration and transport rate during storms. Cont. Shelf Res. 10(5):429-460.

Abstract. Long-term near-bottom wave and current observations and a one-dimensional sediment during winter storms at 60-80 m water depth along the southern flank of Georges Bank and in the Mid-Atlantic Bight. Calculations are presented for five stations, separated by more than 600 km alongshelf, that have different bottom sediment texture, bedforms and current conditions.

Machemehl, J.L. and T.C. Gopalakrishnan. 1977. Comparison of Numerical Simulation Flow Models for Coastal Inlets. UNC Sea Grant Pub. UNC-SG-112:8.

Abstract. The finite difference scheme and the characteristic theory have been

used in the development of numerical models for unsteady flow in coastal inlets. A numerical simulation model for the computation of flow in inlets with junctions has been developed. This model uses the Galerkin Technique with a finite element analysis. The vertically integrated equations of momentum and mass conservation are used with the appropriate boundary and initial conditions. The finite element model is used to investigate the flow in Masonboro Inlet, North Carolina.

MacIntyre, I.G. and J.D. Milliman. 1970. Physiographic features on the outer shelf and upper slope, Atlantic continental margin, southeastern United States. Bull. Geol. Soc. Am. 81:2577-2598.

Abstract. Delineation of four physiographic features through detailed topographic and lithographic examination of the shelf-break areas between Cape Hatteras, NC, and Fort Lauderdale, FL. Both erosional and constructional processes appear to have formed physiographic features near the shelf break along the southeastern United States, as indicated by extensive echo-sounder profiles.

Maciolek, J., J.F. Grassle, B. Hecker, P.D. Boehm, B. Brown, B. Dade, W.G. Steinhauer, E. Baptiste, R.E. Ruff and R. Petrecca. 1987. Study of Biological Processes on the U.S. Mid-Atlantic Slope and Rise. Executive Summary Prepared for the U.S. Department of the Interior, Minerals Management Service under Contract No. 14-12-0001-30064.

Magaard, L., P. Muller and R. Pujalet. 1983. Role of Eddies in the General Ocean Circulation: Proceedings of 'Aha Huliko'a Hawaiian Winter Workshop Held at Manoa on January 5-7, 1983. Hawaii Institute of Geophysics. :357.

Abstract. Waves and Circulation Driven by Oscillatory Winds in an Idealized Ocean Basin; Recent Work and Thoughts on Eddy-Mean Flow Interaction; Estimation and Prediction of Oceanic Eddy Fields; Oceanic Mesoscale Variability and General Circulation from Satellite Altimetry: A Status Report; Eddy-Mean Flow Interaction Diagnostics; Simulation of Midlatitude Variability; Evidence for the Direct Atmospheric Forcing of Mid-Ocean Eddies; Ventilated and Unventilated Models of the Wind-Driven Circulation; Hamilton's Principle as the Basis for Ocean Circulation Models; On the Driving of Ocean Currents by Rossby Waves; Observational Evidence for an Eddy-Driven Deep Circulation; On the Mean Dynamical Balances of the Gulf Stream Recirculation Zone; The Impact of Gulf Stream Rings upon the Slope Water; Studies of the Velocity Structure of the Gulf Stream East of Cape Hatteras; The Eddy Field of the Central North Atlantic; Annual and Interannual Variability in the Kuroshio Current System; Eddy Heat Flux in the North Pacific.

Main, J. and G.I. Sangster. 1981. A study of sand clouds produced by trawl boards and their possible effect on fish capture. Scottish Fisheries Research Report. No. 20., Department of Agriculture and Fisheries for Scotland, Aberdeen:19.

Abstract. Experiments were carried out during the summers of 1978 and 1979 on fishing grounds off Lossiemouth, Scotland, on four types of trawl board with twin 27.5 m and twin 55 m bridles.

Mairs, R.L. 1970. Oceanographic interpretation of Apollo photographs. Photogrametric Engineering. 36:1045-1058.

Maksimenko, N.A. 1990. Comparative analysis of Lagrangian statistical characteristics for synoptic-scale currents in hydrophysical study areas. Oceanol. 30(1):5-9.

Abstract. Comparison of the results of a Lagrangian statistical analysis of synoptic-scale currents in three ocean study areas leads to the conclusion that large-scale horizontal mixing processes in the open ocean have a turbulent character. The empirical correlation obtained between the turbulent diffusion coefficient and the synoptic-scale eddy kinetic energy reflects the role of the nonstationary character and the nonlinearity of these eddies in mixing processes. (10 Refs.).

Malanotte-Rizzoli, P. and R.E. Young. 1991. Assimilation of Oceanographic Datasets into a Primitive Equation Model of the Gulf Stream System. EOS, Trans. AGU. 72(51):57.

Abstract. A Semi-Spectral Primitive Equation Model has been adapted to the Gulf Stream system using the real coastline configuration and realistic bathymetry. The domain of the model has been tailored to be suitable for assimilation of data from the three mooring arrays of the SYNOP (Synoptic Ocean Prediction) Experiment, i.e. the Inlet Array at Cape Hatteras, the Central Array at about 70°W and the Eastern Array at 55°W.

Manheim, F.T., R.H. Meade and G.C. Bond. 1970. Suspended Matter in Surface Waters of the Atlantic Continental Margin from Cape Cod to the Florida Keys. Science. 167:371-376.

Abstract. Appreciable amounts of suspended matter (> 1.0 milligram per liter) in surface waters are restricted to within a few kilometers of the Atlantic coast. Particles that escape estuaries or are discharged by rivers into the shelf region tend to travel longshoreward rather than seaward. Suspended matter farther offshore, chiefly amorphous organic particles, totals 0.1 milligram per liter or less. Soot, fly ash, processed cellulose, and other pollutants are widespread.

Manning, J. 1987. Temperature and Velocity Structure of the Gulf Stream Northeast of Cape Hatteras, North Carolina: The Variability and Physical Implications. Master of Science Thesis. Univ. of Rhode Island, Kingston. 141 pp.

Manning, J. 1991. Middle Atlantic Bight salinity: interannual variability. Cont. Shelf Res. 11(2):123-137.

Abstract. Twenty-eight hydrographic surveys of the Middle Atlantic Bight (MAB) were conducted during 1977-1987 as part of the National Marine Fisheries Service's Marine Resources, Monitoring, Assessment, and Prediction program. The average temperature and salinity for Shelf Water (<34 psu) in the MAB were determined for each survey. While temperature followed a well-defined seasonal cycle, the Shelf Water salinity exhibited large interannual variations. A stepwise multiple linear regression model is used to show that variations in river discharge and in precipitation can explain 70% of the year-to-year changes

in the Shelf Water salinity.

Manning, J.P. and D.R. Watts. 1989. Temperature and velocity structure of the Gulf Stream northeast of Cape Hatteras: modes of variability. J. Geophys. Res. 94(C4):4879-4890.

Abstract. Expendable bathythermograph sections and Pegasus velocity sections taken approximately normal to the Gulf Stream northeast of Cape Hatteras were used to examine the variability of the current's structure. The temperature variability is heavily weighted by seasonal warming; hence the following results exclude temperatures from the upper 200 m. The first mode (48% of the variance) is due to a deepening of the thermocline relative to the mean on the offshore side of the Gulf Stream and a shoaling on the inshore edge, associated with a change of geostrophic velocity and baroclinic transport. The amplitudes of this 'transport mode' indicate a slight downstream increase in baroclinic transport and a seasonal modulation. The Pegasus velocity sections were combined with corresponding temperature sections to compute their joint empirical modes. The dominant combined mode has a thermocline structure change as in the transport mode that is coupled with an increase in alongstream velocity and an inflow from both sides toward the center. (31 Refs.).

Marcus, S.O., Jr. 1973. Environmental conditions within specified geographical regions. Offshore east and west coasts of the United States and in the Gulf of Mexico. National Oceanic and Atmospheric Administration Environmental Data Service, National Data Buoy Center. Report No. COM-73-11775:735.

Abstract. This atlas-type report is a comprehensive, but dated, summary of environmental conditions (many parameters) for continental U.S. coasts. Included are seasonal wave statistics based on ship observations and observations at U.S. Coast Guard east coast light ships. Information includes results from an obsolete 1959 North Atlantic Ocean wave hindcast.

Martin, W.W. 1981. Oceanic frontal stability: a numerical model. Ph.D. Thesis. University of Delaware. 145 pp. (DAI 42/11B, p.4341; AAC8210111)

Abstract. A stable, convergent numerical model has been developed to study the evolution of mesoscale meanders of oceanic fronts. A finite difference model was used with the frontal zone divided into two regions, a dissipative zone near the surface expression of the front, and an inviscid region where the frontal interface was deeper. Tests using this model focused on some of the parameters which affect the stability characteristics of these meanders. The parameters studied were: wavelength/Rossby radius ratio, amplitude/wavelength ratio, and cross stream Froude number. Tests were run using oceanographic conditions representative of two regions, the Gulf Stream downstream of Cape Hatteras, and the Sargasso Sea at 30°N. The model was shown to be sensitive to the wavelength/Rossby radius ratio. For the Sargasso Sea conditions a 30 km disturbance was more stable with respect to amplitude growth than a 100 km disturbance. Both the magnitude and sign of the cross stream Froude number affected the meander stability, with a negative Froude number (downward entrainment near the surface front) showing the greatest amplitude growth. The model results were very sensitive to the meander amplitude. Amplitude growth rates obtained from this model for small amplitude meanders were similar to

results from several small amplitude analytic models. The growth rates from large amplitude tests were much lower, and closely matched observational results. This model also showed a tendency toward growing inertial period oscillations near the boundary between the dissipative and inviscid regions. These oscillations were controlled here by interfacial friction. A more accurate representation of the dissipative region may be necessary to properly dissipate the inertial period energy.

Mason, C., W.A. Birkemeier and P.A. Howd. 1987. Overview of DUCK85 nearshore processes experiment. pp. 818-833. In N.C. Kraus, ed. Coastal Sediments '87. American Society of Civil Engineers, New York.

Abstract. During September and October, 1985, DUCK85, a major nearshore processes experiment was conducted at the U.S. Army Engineer Waterways Experiment Station Coastal Engineering Research Center's (CERC'S) Field Research Facility (FRF) in Duck, NC. Investigators from CERC joined with others from universities and government agencies to collect, analyze, and interpret data on waves, currents, winds, and sediment movement. An overview of the experiment objectives, a description of the studies conducted, and a summary of their accomplishments, is provided.

Mason, C., A.H. Sallenger, R.A. Holman and W.A. Birkemeier. 1984. DUCK82 - a Coastal Storm Processes Experiment. pp. 1913-1927. In Proceedings of the 19th Coastal Engineering Conference. American Society of Civil Engineers,

Abstract. The DUCK82 nearshore processes field experiment which took place at the Coastal Engineering Research Center's Field Research Facility (FRF) during October, 1982, is described.

Mason, C., W.E. Grogg and E.W. Bichner. 1985. Oceanographic and Meteorological Conditions during a Ship Mooring Force Study. CERC Misc. Paper. CERC-MP-85-6:38.

Abstract. The objectives of this experiment were to determine mooring loads on cables mooring a ship in the open and to collect data on the environmental forces (waves, currents, and wind) producing these loads. Waves and current data collected about 3 km from shore at Duck, North Carolina, are summarized. Six-hourly wave heights, periods, and spectra; 15-min average values of current speed and direction; and wind speed and direction are presented for the period between 1900 hours 14 November 1983 and 1430 hours 17 November 1983. The response of the coastal wave and current fields to passage of a local wind system is illustrated.

Masse, A.K. 1990. Withdrawal of shelf water into an estuary: A barotropic model. J. Geophys. Res. 95(C9):16085-16096.

Abstract. Coupled circulation between an estuary and the adjacent shelf is a new area of study. At low frequencies estuarine gravitational circulation requires landward flow of lower layer shelf water to balance the seaward flow of brackish estuarine water over the shelf. Here a clearer description of the low frequency physical coupling between the estuary and shelf waters is developed through the use of a steady, linear, barotropic model. Complex bottom topography for the shelf is treated. The shelf adjacent to Delaware Bay, located on the east coast

of the United States, is used as an example. The results show that the landward flow field driven only by withdrawal of flow through the estuary's entrance is independent of the flow field otherwise present over the shelf. In the northern hemisphere this landward flow passes along the coast to the right of the estuary entrance, when viewed facing offshore, before it enters the estuary. Model results are supported by near bottom current observations collected on the shelf adjacent to the mouth of Delaware Bay.

Massina, S. and N. Pinardi. 1991. Merging of barotropic symmetric vortices. A case study for Gulf Stream rings. Nuovo Cimento C. 14C(ser. 1, no. 6):539-553.

Abstract. Numerical experiments were made to study the merging dynamics of axisymmetric barotropic ringlike vortices using a quasi-geostrophic model in a beta-plane. The initial conditions and the physical parameters that cause the merging or that affect the merging rates of ringlike structures are explored. The initial vortices have a 'realistic' shape, i.e., they are taken to simulate closely the horizontal structure of Gulf Stream rings. In the first set of experiments the initial conditions are varied. The results agree with the classical solution in that there is a critical initial separation distance d between the two vortices: for bigger merging distances the process cannot occur. The initial distance affects the merging rates and it determines the development of the lateral arms and the behavior of the 'near-field' vortices. The latter form near the elongated arms of the merging vortices; sometimes the arms of the merged vortex become unstable and get detached from the central merged vorticity region to form dipolar structures with 'near-field' vortices.

Mathews, T.D. and O. Pashuk. 1986. Summer and winter hydrography of the U.S. South Atlantic Bight (1973-1979). J. Coast. Res. 2(3):311-336.

Abstract. Temperature and salinity data from cruises during 1973-1979 are used to describe areas of upwelling and Gulf Stream intrusions in the South Atlantic Bight.

Mattie, M.G., D.E. Lichy and R.C. Beal. 1980. Seasat Detection of Waves, Currents and Inlet Discharge. J. Remote Sens. 1(4):377-398.

Abstract. A new era of remote sensing for coastal and oceanographic monitoring was born on 26 June 1978 with the launch of Seasat. Duck-X was a 2 month experiment conducted during August to October 1978 off the east coast of the U.S.A. for the validation of the Seasat synthetic aperture radar (SAR). During this field experiment, various oceanographic phenomena were monitored. Ground truth observations of these phenomena have been correlated with Seasat SAR imagery. The ground truth sensors included airborne photographic and radar imagery, meteorological satellite imagery, land based radars, and conventional wave gauges. This paper focuses on ocean surface waves, ocean currents and coastal inlet discharge.

Maul, G.A. 1972. Observation of the Gulf Stream surface front structure by ship, aircraft, and satellite. Remote Sens. Environ. 2(2):109-116.

Abstract. Demonstration of the usefulness of data synthesis from a wide range of

measurement techniques in the especially difficult case of interpreting the complex flow associated with the Gulf Stream system.

Maul, G.A. 1975. An evaluation of the use of the earth resources technology satellite for observing ocean current boundaries in the Gulf Stream system. NOAA, NWS Tech. Rep. ERL 335 AOML-18:125.

Maul, G.A. 1976. Variability in the Gulf Stream System. Gulfstream. 11(10):2-7.

Abstract. Interprets data for the entire Gulf Stream System: the Gulf Loop Current, the Florida Current and the Gulf Stream from Cape Hatteras to the Grand Banks. Provides insight as to the degree of non-uniformity and complexity of the System.

Maul, G.A. and N.J. Bravo. 1989. Fate of satellite-tracked buoys and drift cards off the southeastern Atlantic coast of the United States. Florida Sci. 52:154-170.

Maul, G.A. and H.R. Gordon. 1975. On the use of the Earth Resources Technology Satellite (LANDSAT-1) in optical oceanography. Remote Sens. Environ. 4:95-128.

Abstract. Observations of the Gulf Stream system in the Gulf of Mexico were obtained in synchronization with LANDSAT-1 passes. Images show that the current system can be observed in both color anomalies associated with sea state effects along the cyclonic boundary even in absence of a surface thermal signature.

Maul, G.A. and D.E. Hansen. 1972. An observation of Gulf Stream front structure by ship, aircraft, and satellite. Remote Sens. Environ. 2:109-116.

Maul, G.A. and K. Hanson. 1991. Interannual coherence between North Atlantic atmospheric surface pressure and composite southern USA sea level. Geophys. Res. Lett. 18(4):653-656.

Abstract. Annual mean sea levels along the southern United States have been examined for interannual variability. Fifteen sea level stations from Cape Hatteras to the Rio Grande that best covered the three lunar nodal cycles from 1931-87 were selected for analysis. The composite time series of the 15 residuals was compared with time series of surface air pressure over the North Atlantic Ocean during the period 1947-87. The best correlation is a negative relationship between composite sea level and wintertime air pressure north of 45 degrees N, and a positive relationship from 20°-45°N. (17 Refs.).

Maul, G.A., P.W. DeWitt, A. Yanaway and S.R. Baig. 1978. Geostationary satellite observations of Gulf Stream meanders: Infrared measurements and time series analysis. J. Geophys. Res. 83(C12):6123-6135.

Abstract. Data and multiyear time series analysis of meanders in the Gulf of Mexico, off the coast of North Carolina, and off New England. Includes a summary of meanders between the Yucatan Strait and the Grand Banks.

Maul, G.A., D.A. Mayer and M. Bushnell. 1990. Statistical relationships between local sea level and weather with Florida-Bahamas cable and Pegasus measurements of Florida Current volume transport. J. Geophys. Res. 95(C3):3287-3296.

Abstract. Straits of Florida sea level is studied as a measure of Florida Current volume transport because sea level provides an independent time series both (1) for detecting changes in the calibration of the Florida-Bahamas submarine cable which has the operating since 1982, and (2) as a measure of the strength of the Gulf Stream system dating to the 1930s when cable measurements were not available. Accordingly, tide gauge records from Haulover Beach (Miami) and Lake Worth, Florida, and from Cat Cay and Settlement Point, The Bahamas, together with Miami weather and cable voltage, are correlated with each other and with discrete volume transport estimated from all Pegasus moorings data taken during the intensive 1982-4 Subtropical Atlantic Climate Studies observations. (34 Refs.).

May, S.K. 1983. Regional wave climate and shorezone response (North Carolina). Ph.D. Thesis. University of Virginia. 114 pp. (DAI 44/12B, p.3701; AAC8406059)

Abstract. The U.S. Army Corps of Engineers, as part of the Wave Information Study, developed a 3-phase wave model with inner shelf wave statistics (Phase III) calculated every 3 hrs over a 20 yr period (1956-1975) at an along-the-coast interval of 10 naut mi. Phase III data were used to define the regional wave climate along the North Carolina coast. A matrix of 8 shorezone attributes, including storm frequency, water level, and sediment characteristics, 10 bathymetry measurements defining the inner shelf profile, and 4 measures of shorezone morphologic change was constructed with a 1 minute sampling interval. Power spectrum analysis and principal components analysis were used to determine modes of variation within the data sets. The wave climate along the mid-Atlantic coast has periodic temporal organization. Fourteen month, annual, 6-month, 4-month, and synodic (29.5 day) cycles are present. These periodicities correspond to cycles in extratropical cyclone frequency and intensification, and shifts in mean cyclone tracks relative to the shoreline. Three statistically independent components of the wave climate are defined: overall wave energy, swell, and sea/swell (high seas with low swells). Swell waves provide 55% to 60% of the wave energy to the nearshore zone. Four modes of inner shelf profile variation exist along the North Carolina coast. Volumetric differences are associated with wave approach angles. Regional distributions of steep inner shelf profiles are correlated with along-the-coast variations in the 20 yr wave climate, particularly wave period. Wave climate is not correlated with shorezone response measures (rate of change and overwash distance) in most of the data set (60% to 75%). In those components where an association is described, low amplitude, short period waves are correlated with high erosion and large overwash distances.

Mayer, D.A., D.V. Hansen and D.A. Ortman. 1979. Long-term current and temperature observations on the Middle Atlantic Shelf. J. Geophys. Res. 84(C4):1776-1792.

Abstract. Nearly 2200 days of current and temperature data were collected at a midshelf location in the Middle Atlantic Bight between June 1974 and March 1977. These data were examined for the average conditions and seasonal cycles of water circulation and temperature and some statistical properties of their variation

at higher frequency. The average flow is found to be toward the south-southwest at about 5 cm/s near the surface, diminishing to about 1 cm/s near the bottom. The occurrence of energetic wind-driven transient current events which can exceed a 2-month duration makes it impossible to determine a clear seasonal pattern in the sequence of monthly mean flows. There is, however, a clear seasonal pattern in the distribution of higher-frequency fluctuations. Storm wind-induced transient currents of 3- to 10-day duration appear prominently in winter records. Inertial currents appear selectively in the summer, that is, in parts of the water column well insulated from the bottom by a strong thermocline. For low-frequency motions (periods from 3 to 10 days) in both summer and winter records the preferred directions of motion throughout the water column appear to be consistent with equilibrium (mean) Ekman veering arguments. The water column response was found also to be most sensitive to the component of wind stress parallel to the bathymetry. The temperature follows a well-known seasonal cycle of heating and stratification. During the unstratified seasons, very little high-frequency temperature variation is observed, but during summer, thermal oscillations due to daily heating and inertial and semidaily tidal frequencies (3/3, 4/3, and 6/3 cpd) and a 5/3-cpd oscillation appear prominently.

Mayer, D.A., G.C. Han and D.V. Hansen. 1982. Circulation in the Hudson Shelf Valley: MESA physical oceanographic studies in New York Bight, 1. J. Geophys. Res. 87(C12):9563-9578.

Abstract. Over 900 days of current velocity data were obtained at mainly two locations in the inner and outer Hudson Shelf Valley (HSV). the large cross-axis depth gradients in the HSV, together with the strong winter cyclones and the baroclinic density distribution over the shelf, are primarily responsible for the major circulation features observed in the valley.

McBride, R.A., T.F. Moslow and A. Figueiredo. 1986. Origin and occurrence of shoreface-attached sand ridges, North Atlantic Shelf, U.S.A.,Society of Economic Paleontologists, annual midyear meeting, Raleigh, NC, Sept. 26-28, 1986.

McCann, M.P. 1984. Physical Processes Influencing Temperature and Salinity on the North Carolina Cape Shoals. Master of Science Thesis. North Carolina State University. 138 pp.

Abstract. Cross-spectral analysis and a heat budget are used to relate atmospheric and river runoff data with seven years of daily surface temperature and salinity on the North Carolina continental shelf. Salinity on Diamond Shoals is highly correlated with alongshore wind stress implying wind driven advection of the front between Virginia Coastal Water and Carolina Coastal Water. In the presence of strong horizontal and vertical temperature gradients, temperature at Diamond Shoals quickly responds to cross-shelf winds. At Frying Pan Shoals, the plume of the Cape Fear River is detected when winds blow seaward. Atmospheric fluxes primarily control the cycle of heating and cooling at Frying Pan Shoals, but advection of heat buffers the water temperature in the winter and summer.

McCann, M.P., L.J. Pietrafesa, G.S. Janowitz and T.B. Curtin. 1984. Physical Processes Influencing Temperature and Salinity on the North Carolina Cape Shoals. Department of Energy. DOE/EV/00902-T1:149.

Abstract. Cross-spectral analysis and a heat budget are used to relate atmospheric and river runoff data with seven years of daily surface temperature and salinity on the North Carolina continental shelf. Salinity on Diamond Shoals is highly correlated with alongshore wind stress implying wind driven advection of the front between Virginia Coastal Water and Carolina Coastal Water. In the presence of strong horizontal and vertical temperature gradients, temperature at Diamond Shoals quickly responds to cross-shelf winds. At Frying Pan Shoals, the plume of the Cape Fear River is detected when winds blow seaward. Atmospheric fluxes primarily control the cycle of heating and cooling at Frying Pan Shoals, but advection of heat buffers the water temperature in the winter and summer.

McCartney, M.S. 1991. The System of Deep Western Boundary Currents and Recirculations in the Atlantic Ocean. EOS, Trans. AGU. 72(51):31.

Abstract. The net meridional overturning mode of circulation in the Atlantic has been estimated by many methods and generally quantified at about 15 Sv. As the collection of estimates of the DWBC contributions to the cold limb of the meridional circulation grows, it has become apparent that the DWBC transport more often than not is significantly larger than 15 Sv. Early examples include the reinforcement of the westward DWBC flow south of Newfoundland and Nova Scotia by a cyclonic recirculation of NADW north of the Gulf Stream, the boost of the DWBC at mid-latitudes by confluence of AABW into its southward transport. More recently, measurements show large NADW transport in the DWBC off Abaco and the Antilles, and off the eastern side of Greenland. Compensating interior flows are required to achieve the net 15 Sv, and these are observed in the interior shear distributions at a number of locations, sometimes basin filling, sometimes more compact.

McCartney, M.S. and L.D. Talley. 1982. The Subpolar Mode Water of the North Atlantic Ocean. J. Phys. Oceanogr. 12:1169-1188.

McCave, I.N. and B.E. Tucholke. 1986. Deep current-controlled sedimentation in the Western North Atlantic. WHOI Tech. Rep. WHOI-CONTRIB-5970:20.

Abstract. Discusses contribution of the Gulf Stream and associated eddies to the variability of current velocity at depths and to erosion and redistribution of sediments. "Sediment drifts" probably contain a detailed record of the fluctuations in bottom-current activity of the North Atlantic.

McClain, C.R. and L.P. Atkinson. 1985. A note on the Charleston Gyre. J. Geophys. Res. 90(C6):11857-11861.

McCormack, R.S. 1990. Explosive Cyclogensis: A Case Study of the Veterans' Day Storm of 11-12 November 1987. U.S. Naval Academy. Final Report USNA-TSPR-169:80.

Abstract. An important breeding ground for explosive cyclone development is off the east coast of the United States, near Cape Hatteras. An important factor in

cyclone development is the enormous energy requirement needed for explosive deepening of these systems. The presence of the warm Gulf Stream current in the western Atlantic provides a significant portion of this energy. This energy source, coupled with strong upper and lower level forcing, provides the mechanisms responsible for rapid intensification of these significant weather-producing storms.

McCreery, C.J. and E.P. Laine. 1986. Acoustic Structure and Echo Character of Surficial Sediments of the Northern Hatteras Abyssal Plain. Department of Energy. SAND-85-7232:120.

Abstract. A study has been made of the high frequency acoustic response of abyssal plain depositional facies. Piston cores have been obtained at six stations and deep hydrophone recordings at three stations on the northern Hatteras Abyssal Plain. 3.5 kHz seismic profiles indicate acoustically transparent lobes of surficial sediment which thicken towards the Hatteras Transverse Canyon and Sohm Gap/Wilmington Fan. Physical property data from piston cores indicate a higher percentage of coarse sediment in the areas of transparent acoustic response. Many of the characteristics normally used in mapping of conventional 3.5 kHz profiler acoustic response varied only slightly in the study area. Regions of diffuse 3.5 kHz surface echoes, similar to prolonged echoes attributed to high percent sand beds, have been identified in the study area. High trace to trace variation in deep hydrophone/pinger recordings in these areas suggests that the diffuse echo returns are due to unresolved microtopography and are not necessarily associated with a sandy seafloor.

McGillivary, P.A. 1988. Biogeochemical cycling and zooplankton community structure at Gulf Stream fronts off the southeastern United States. Ph.D. Thesis. University of Georgia. 801 pp. (DAI 49/11B, p.4639; AAC8823823)

Abstract. Biogeochemical cycling in Gulf Stream and outer continental shelf waters off the southeastern U.S. was considered in terms of trace metal inputs at oceanic fronts via aeolian deposition, and vertical particulate removal fluxes, which varied in relation to zooplankton dynamics, and due to effects of the strong 1982-83 El Niño-Southern Oscillation (ENSO) event. The 1982-83 ENSO event caused: (1) warm winter shelf waters due to reduced southerly winter storm penetration; (2) delayed spring shelf warming due to increased winds; and, (3) fewer Gulf Stream rings formed, hence Gulf Stream recirculation over the Blake Plateau was dominated by reentry of older rings moving west along the Subtropical Convergence Zone. Using insects as indicators, highest aeolian particulate concentrations were over the shelf-Stream front, but insect behavior interfered with deposition estimates. Proton-Induced X-ray Emission (PIXE) analysis showed thaliacean feces accounted for significant removal of iron, copper and zinc associated with $SrSO_4$, presumably from acantharians, which showed high concentrations of these metals. Sparse eastern Gulf Stream epipelagic salp populations (10-30/1000m^3) were dominated by Thalia cicar. Dense western Gulf Stream salp populations (100-3000+/100m^3) were dominated by Thalia democratica, Cyclosalpa floridana, and Weelia cylindrica, the latter reaching highest densities. Salp population regulation via parasitism of solitaries differed among species: 25% of Cyclosalpa, 10% of Thalia, and 0% of Weelia. Proportions of fecund Thalia (40%) were density independent, but these had high parasitism rates (33%) and host:parasitoid (Sapphirina) ratios (1:3-4), likewise density

independent. Sapphirina nigromaculata, gemma and opalina dominated the six Sapphirina species taken. Hyperparasitic neutering of the latter was by ellobiopsid protozoans appeared incidental to salp dynamics. Summarizing, the 1982-83 ENSO reduced early summer shelf water temperatures that favored Thalia over Weelia, and increased spring resuspension, probably delayed annual summer surface water particulate depletion. Salps could filter surrounding shelf waters within weeks based on literature filtration rates, but detritivore and coprophage densities (1-20/100m^3) were also sufficient to influence particle fluxes, except when excluded by salp densities >2000/100m^3. Salp and acantharian co-occurrence appears important in outer shelf trace metal fluxes.

McGregor, B.A. 1983. Submarine canyon and slope processes on the U. S. Atlantic continental margin. U.S. Geol. Surv. Open-File Rep. OF 83-0735:34.

McKee, T.R. and B.J. Presley. 1975. Microstructure of ferromanganese micronodules from the northwest Atlantic Ocean. EOS, Trans. AGU. 56(6):458-459.

Abstract. Micronodules for this study were obtained by sieving the >62μm fraction from several red clay cored from the abyssal plain and hills region of the Northwest Atlantic (S.K.A. aboard R/V CONRAD cruise R-16). The coarse fraction was mainly micronodules (dia≤1mm) with negligible quartz and biogenic material. They were examined by light and scanning electron microscopy (JEOL JSM-U3 with an EDAX energy dispersive spectrometer). The micronodule morphologies are similar to larger nodules, ranging from near-spherical lumps to botryoidal clusters. The surface textures vary from rough to smooth and appear to be related to pore water Mn concentration. Rock fragments are the most common nuclei in the study area. A number of micronodules were fractured, exposing central voids, hollow layers, or both. Thus suggesting dissolution of occluded material (possibly carbonate material such as forams). The fractured micronodules commonly show layers of two types. One type exhibits a compact, homogeneous structure containing larger amounts of detrital material (shown by EDAX, variations in SiK_α/MnK_α peak ratios of >3 vs <0.7). The lesser amount of detrital material in the compact units may be due to deposition of new ferromanganese material in interior voids. Dehydration cracks appearing in some micronodules are most frequent in the compact units. Microtextures found in these micronodules are similar to those commonly associated with growth surfaces in larger nodules, however the commonly observed crystalline boxwork texture has not been found.

McKinney, T.F., W.L. Stubblefield and D.J.P. Swift. 1974. Large-scale current lineations on the central New Jersey shelf: Investigations by side scan sonar. Mar. Geol. 17:79-102.

Abstract. Two morphological orders of ridge and trough topography can be recognized on a terraced segment (at 37 m) of the central New Jersey shelf: (1) a first-order system with ridges to 14 m high, 2-6 km apart, in a Z-shaped pattern trending to the NNE, and (2) a second order system with ridges 2-5 m high, 0.5-1.5 km apart and trends to the NE.

McLeish, W. and D.B. Ross. 1985. Wave refraction in an ocean front. J. Geophys. Res. 90(C6):11929-11938.

Abstract. Side-looking airborne radar near Cape Hatteras, N.C. recorded images

of ocean waves, wind streaks, and intermediate water bodies within the Gulf Stream front.

McLellan, H.J. 1957. On the distinctness and origin of the slopewater off the Scotian Shelf and its easterly flow south of the Grand Banks. J. Fish. Res. Bd. Can. 14(2):213-239.

Abstract. The Slope Water south of Nova Scotia lies as a distinct water mass between Coastal Water and the Gulf Stream. A characteristic temperature-salinity correlation exists. Although the T-S curve lies close to that for Central Atlantic Water, if a reasonable system of mixing is assumed, the composition is shown to be Atlantic Water diluted by the addition of approximately 20% of Coastal Water. The rate of production of Slope Water is estimated to be of the order of 2 X 10^7 m^3/sec and the observed eastward flow carries this mixing product from the area of formation. A secondary current in the Gulf Stream system is thus generated by means other than simple bifurcation of the main stream. Such a current has been consistently observed.

Meade, R.H. 1972. Chapter 11 Sources and Sinks of Suspended Matter on Continental Shelves. pp. 249-262. In D.J.P. Swift, D.B. Duane and O.H. Pilkey, eds. Shelf Sediment Transport: Process and Patterns. Dowden, Hutchinson and Ross, Inc., Stroudsburg.

Abstract. While river sediments are the principal sources of suspended matter on many continental shelves, their importance on the Atlantic Continental Shelf of the United States is less than that of biogenic detritus produced by shelf organisms and of material resuspended from the shelf bottom. The major sites of accumulation of suspended matter from Atlantic shelf are in the large estuaries and coastal marshlands rather than on the shelf itself or in the deep sea. Sources other than river sediments and sinks other than the sea floor should be given ample consideration in assessing the dispersal of suspended sediments on the other continental margins of the world.

Meade, R.H., P.L. Sachs, F.T. Manheim, J.C. Hathaway and D.W. Spencer. 1975. Sources of Suspended Matter in Waters of the Middle Atlantic Bight. J. Sed. Petrol. 45(1):171-188.

Abstract. Suspended matter collected in the Middle Atlantic Bight (the coastal segment of the United States between Cape Cod and Cape Hatteras) in September 1969 was predominantly organic: an average of 80% combustible organic matter in surface waters and 40% near bottom. Total suspended concentrations decreased between the inner shelf and the shelf break by an order of magnitude in both near-surface and near-bottom waters. The noncombustible (ash) fraction of the suspended matter decreased over the same distance by one order of magnitude in the near-bottom waters and two orders of magnitude in near-surface waters. Recently contributed river sediment is not a significant constituent of the suspended matter in the waters of the shelf, particularly the outer shelf. Most of the inorganic material in suspension represents bottom sediments (at least some of which are relict) whose suspended concentrations are increased noticeably by storms.

Mei, C.C. and P.L.-F. Liu. 1977. Effects of Topograhy on the Cirulation in and Near the Surf Zone--Linear Theory. Estuar. Coastal Mar. Sci. 5(1):25-37.

Abstract. Rhythmic variations in depth along the shoreline causes variations in the radiation stress components and in the mean sea level in the surf zone. In particular, the effect of ray deflection due to refraction affects the component S_{xy} only, where x is in the offshore and y in the alongshore directions respectively, and tends to oppose the influences of other components. A linearized theory for the mean current is given for normal incidence and small depth perturbation. Lateral turbulence is ignored. The positions of the rip currents are shown to depend on the surf zone width and the on-off shore variation of depth.

Meindl, E.A. 1991. Calculation of Gulf Stream Velocities Using Moored Buoy Data and AVHRR Imagery. EOS, Trans. AGU. 72(51):70.

Abstract. Sea surface temperature measured by a buoy moored east of Chesapeake Bay indicated that the western edge of the Gulf Stream was moving repeatedly underneath and away from the buoy. This buoy was equipped to measure directional waves. Comparisons of the wave data were made between the times the buoy was in and outside of the current. An attempt was made to calculate relative velocities between the Gulf Stream and quiescent waters landward of the Stream by examining changes in direction of wave energy propagation at different frequencies, in conjunction with high resolution NOAA-11 AVHRR imagery. The buoy-measured wave energy directions were unimodal and energy levels were sufficiently high, good internal consistency for velocity values were obtained.

Mellberg, L.E., A.R. Robinson and G. Botseas. 1991. Azimuthal variation of low-frequency acoustic propagation through asymmetric Gulf Stream eddies. Journal of the Acoustical Society of America. 89(5):2157-2167.

Abstract. A numerical modeling study of the azimuthal variation of 25-Hz acoustic propagation through radially asymmetric Gulf Stream eddies is presented. Both a cold-core (cyclonic) and a warm-core (anticyclonic) eddy, which are quasi-elliptical in shape, are investigated. Sources located both inside and outside the eddies are considered with transmission out to 240 km. The source is at a depth of 150 m where there are substantial environmental variations due to eddies. Receivers are at depths of 100, 150, and 300 m. The dimensions of the first four convergence zones (CZ) are utilized as indicators of the azimuthal variation of propagation. Propagation conditions assumed an absorbing bottom and no azimuthal coupling of energy. Sensitivity to change in azimuth is dependent upon the orientation of the eddy relative to the direction of transmission. It is increased for transmission paths parallel to the major axis relative to those parallel to the minor axis. For propagation parallel to the major axis, a 15 degrees change in azimuth can result in a change of as much as 13 km in width and 15 km in range for the third CZ. An irregularity in the shape of a quasi-elliptical eddy is shown to effect an appreciable difference in transmission. A 30° shift in the direction of propagation to the right side of the major axis of a cold-core eddy produced a 20% change in the width of the third CZ, while a 30 degrees shift to the left side of the axis gave a 64% change in the width. Sensitivity can depend upon the direction of propagation along a major axis for a source located within the eddy. Propagation in one direction can produce a

sensitivity for a 20° change in azimuth of more than double the shift in range to the third CZ, as the opposite (180°) direction yielded over a 75 degrees change in azimuth. (40 Refs.).

Mellor, G.L. and T. Ezer. 1991. A Gulf Stream model and an altimetry assimilation scheme. J. Geophys. Res. 95(C5):8779-8795.

Abstract. A continuous data assimilation scheme and a multilayer, primitive equation, numerical model are described. The model is an eddy-resolving, coastal ocean model that has been extended to include the Gulf Stream region. It has complete thermohaline dynamics, a bottom-following, sigma, vertical coordinate system, and a coastal-following, curvilinear orthogonal, horizontal coordinate system. Calculated model fields are used to provide a model climatology and correlations between subsurface temperature and salinity anomalies and surface elevation anomalies. An optimal interpolation method, the surface to subsurface correlations, and estimated model and data errors are the basis of the assimilation technique. (33 Refs.).

Menard, Y. 1983. Observation of eddy fields in the northwest Atlantic and northwest Pacific by SEASAT altimeter data. J. Geophys. Res. 88(C3):1853-1866.

Abstract. Sea level variability, related to the eddy field activity, can be calculated from repeating tracks of altimetric data, such as the SEASAT 3-day repeat data (September 13 to October 10, 1978). If we consider the eddy field in geostrophic balance, the geostrophic relation gives the surface eddy velocities. Also, an estimation of the eddy kinetic energy can be deduced under the assumption of quasi-isotropy of the velocity variability. This approach is used in the northwest Atlantic and northwest Pacific through the processing of SEASAT data. High variability of sea surface topography (up to 20 cm) and high eddy kinetic energy (800-1600 cm^2/s^2) are detected in the vicinity of the Gulf Stream and the Kuroshio. Power spectra of the observed sea level fluctuations give wavelengths ranging from 100 to 900 km for time scales between 3 and 25 days. Maps of sea surface topography variability and eddy kinetic energy are presented and discussed.

Meyers, S.D. 1991. Conditions for Cross-Frontal Mixing in a Meandering Jet With Application to the Gulf Stream. EOS, Trans. AGU. 72(51):58.

Abstract. Previous work has shown the center of a two-dimensional meandering jet to be a mixing barrier, acting as an impermeable wall to horizontal transport, and breaking only for large time-dependent perturbations. Mixing across the center of such a jet is shown to occur above a critical meander amplitude that depends upon the meander phase speed and maximum jet velocity.

Mied, R.P. and G.J. Lindemann. 1983. Simulations of streamers in warm core Gulf Stream rings. EOS, Trans. AGU. 64(52):1083.

Abstract. Recent satellite and hydrographic observations of warm core rings frequently show that tendrils (called streamers) of shelf front or Gulf Stream water have been entrained around the perimeter of the ring. In this work, we use a two-layer, primitive-equation model on a beta plane to simulate the formation

of these streamers which occur when an anticyclonic ring is in proximity to a shoreward stream meander. An upper ocean eddy with an azimuthal velocity profile $v(r)=-Ur/L \exp(-r^2/2L^2)$ with U=100 cm/s and L=60km is placed to the north of another ring to simulate this configuration. By placing a tracer in the upper layer of the northern ring and allowing it to diffuse and be advected into the northern ring, a streamer is formed around the northern ring which persists well after the two rings have separated. Nine different experiments were performed in which the horizontal kinematic viscosity (A_H) and tracer diffusivity (B_H) were each allowed to vary over two orders of magnitude ($2.5X10^5$ - $2.5X10^7 cm^2/s$). These different values caused the physical appearance of the tracer to change greatly. Some streamers appeared very unrealistic, but others were similar to those in satellite pictures. In particular, when A_H and B_H are each of order 10^6 cm^2/s, the streamers formed are the most realistic appearing ones. And, lastly, it is surprising that when A_H and B_H are each varied over such a large interval, only about 10% of the total available tracer gets into the northern eddy by day 25 when $A_H=B_H=2.5X10^5 cm^2/s$. This fraction increases to about 30% for the same time interval when $A_H=B_H=2.5X10^7 cm^2/s$.

Mied, R.P. and G.R. Valenzuela. 1992. Overview of the 1990 Gulf Stream Sensing Experiments. EOS, Trans. AGU. Suppl to 72(17):148.

Abstract. Two Gulf Stream experiments are reviewed. These were conducted during the July 17-21, 1990 and October 2-5, 1990 time periods, and made use of extensive remote sensing and *in-situ* observations involving a number of laboratories. Four specific tasks were addressed in each of the experiments. They are: (1) Properties of Kelvin wakes across fronts, (2) The displacement of the radar cross section signature of a front from its actual hydrodynamic location, (3) Wave/current interactions in curved current regions, and (4) The temperature, salinity and velocity within slick features on the shelf front.

Miller, H.C. 1980. Instrumentation at CERC's Field Research Facility, Duck, North Carolina. CERC Misc. Rep. CERC-MR-80-8:42.

Abstract. This report describes the oceanographic and meteorological instrumentation used for the collection of environmental data at the Coastal Engineering Research Center's Field Research Facility at Duck, North Carolina. The necessary information for proper interpretation of the instrument data is also presented. An appendix contains installation summaries for each instrument described in the report.

Miller, H.C. 1982. CERC (Coastal Engineering Research Center) Field Research Facility Environmental Data Summary, 1977-79. CERC Misc. Rep. CERC-MR-82-16:145.

Abstract. The U.S. Army Coastal Engineering Research Center's (CERC) Field Research Facility (FRF), located on 176 acres at Duck, North Carolina, consists of a 561-meter-long research pier and an accompanying office building. The FRF site is near the middle of Currituck Spit along a 100-kilometer unbroken stretch of shoreline that extends south from Rudee Inlet in Virginia to Oregon Inlet in North Carolina. It is bordered by the Atlantic Ocean to the east and the Currituck Sound and mainland to the west. The facility is designed to (1) provide a rigid platform for measuring waves, currents, water levels, and bottom

elevations, especially during severe storms; (2) provide CERC with the field experience and data to complement laboratory studies and the evaluation of numerical models; (3) provide a manned field facility for testing new instrumentation; and (4) serve as a permanent field base of operations for physical and biological studies of the site and adjacent region. This report, the first in a series of annual reports, summarizes the results of the first two complete years (1978 and 1979) of basic measurements; available data for 1977 are also included. The report is organized such that descriptions of the instrumentation (Sec. III) and data collection and analysis procedures (Sec. IV) precede reporting of the data (Sec. V). Section VI describes the procedure for obtaining additional data. Although this is intended as a stand-alone document, references should be consulted for details of some procedures and instrumentation.

Miller, H.C. and R.E. Jensen. 1990. Comparison of Atlantic Coast Wave Information Study Hindcasts with Field Research Facility Gage Measurements. Army Eng. WES Final Rep. Tech. Report CERC-90-17.

Abstract. Comparisons of hindcasts made with the Wave Information Study (WIS) numerical wave model with wave measurements at the Coastal Engineering Research Center's Field Research Facility (FRF) are described.

Miller, H.C., W.E. Grogg Jr., M.W. Leffler, C.R. Townsend and S.C. Wheeler. 1986a. Annual Data Summary for 1984 CERC (Coastal Engineering Research Center) Field Research Facility. CERC Tech. Rep. CERC-TR-86-11:223.

Abstract. This report provides basic data and summaries for the measurements made during the 1984 at the US Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center's Field Research Facility in Duck, N.C. The report includes comparisons of the present year's data to prior years and cumulative statistics from 1980 to the present. Summarized in this report are meteorological and oceanographic data, monthly bathymetric survey results, samples of quarterly aerial photography, and descriptions and hourly data for 14 storms that occurred during the year. Wave conditions were slightly lower than average with the fewest storms since 1980. The year was highlighted by the close passage of hurricanes Isidore in September and Josephine in October.

Miller, H.C., W.E. Grogg Jr., M.W. Leffler, C.R. Townsend III and S.C. Wheeler. 1986b. Annual Data Summary for 1983 CERC (Coastal Engineering Research Center) Field Research Facility. CERC Tech. Rep. CERC-TR-86-9:241.

Abstract. This report provides basic data and summaries for the measurements made during 1983 at the US Army Engineer Waterways Experiment Station Coastal Engineering Research Center's Field Research Facility in Duck, N.C. The report includes comparisons of the present years' data to prior years, and cumulative statistics from 1980 to the present. Summarized in this report are meteorological and oceanographic data, monthly bathymetric survey results, samples of quarterly aerial photography, and descriptions and hourly data for the storms that occurred during the year. Wave conditions were the highest since measurements began at the FRF. The year was highlighted by 24 storms that included the close passage of Tropical Storm Dean in September.

Miller, H.C., M.W. Leffler, W.E. Grogg Jr., S.C. Wheeler and C.R. Toensend III. 1986c. Annual Data Summary for 1982 CERC (Coastal Engineering Research Center) Field Research Facility. CERC Tech. Rep. CERC-TR-86-5:262.

Abstract. This report provides basic data and summaries for the measurements made during 1982 at the US Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) in Duck, North Carolina. The report includes comparisons of the present year's data to those of prior years and cumulative statistics from 1980 to the present. Summarized in this report are meteorological and oceanographic data, monthly bathymetric survey results, samples of quarterly aerial photography, and descriptions and hourly data for 16 storms that occurred during the year. The report is the fourth in a series of annual summaries of data collected at the FRF; the first, which summarized data collected during 1977-79, was published as CERC Miscellaneous Paper 82-16; the second, which summarized data collected during 1980, was published as CERC Technical Report 84-1; and the third, which summarized data collected during 1981, was published as CERC Technical Report 85-3. These reports are available from the WES Technical Report Distribution Section, Vicksburg, Mississippi.

Miller, H.C., A. Militello, M.W. Leffler, W.E. Grogg and M.M. Dominguez. 1987a. Annual Data Summary and Climatological Evaluation CERC (Coastal Engineering Research Center) Field Research Facility, 1985. Volume 1. Main Text and Appendixes A and B. CERC Tech. Rep. CERC-TR-87-13-Vol-1:93.

Abstract. This report provides basic data and summaries for the measurements made during 1985 at the US Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center's (CERC's) Field Research Facility(FRF) in Duck, N.C. The report includes comparisons of the present year's data to those of previous years and cumulative statistics from 1980 to the present. Summarized in this report are meteorological and oceanographic data, monthly bathymetric survey results, samples of quarterly aerial photography, and descriptions and hourly data for 13 storms that occurred during the year. The year was highlighted by the close passage of tropical storms Ana in July and Henri in September and Hurricanes Claudette in August and Gloria in September. Waves over 6m were measured, at a location 6km from shore, during Hurricane Gloria. This report is seventh in a series of annual summaries of data collected at the FRF.

Miller, H.C., A. Militello, M.W. Leffler, W.E. Grogg and M.M. Dominguez. 1987b. Annual Data Summary and Climatological Evaluation, CERC (Coastal Engineering Research Center) Field Research Facility, 1985. Volume 2. Appendix C. CERC Tech. Rep. CERC-TR-87-13-Vol-2:128.

Abstract. Wave data summaries for 1985 and climatological summaries for 1980 through 1985 are presented in this appendix. An explanation of the summary formats is followed by the data for Gages 625, 630, 640, and 645. Wave data are summarized in the following forms: Gage Histories; Time-Histories; Annual, Seasonal, and Monthly Maxima, Mean, and Standard Deviations of Wave Height and Peak Period; Distributions of Wave Height Versus Peak Period; Cumulative Distributions of Wave Height; Peak Spectral Wave Period Distributions of Wave Height; Persistence of Wave Heights; Wave Roses; Spectra.

Miller, H.C., A. Militello, M.W. Leffler, W.E. Grogg and B.L. Scarborough. 1988. Annual Data Summary for 1986 CERC (Coastal Engineering Research Center) Field Research Facility. Volume 2. Appendix B. CERC Tech. Rep. CERC-TR-88-8-Vol-2:82.

Abstract. Wave data summaries for 1986 and summaries for all years from 1980 through 1986 are presented in this appendix. An explanation of the summary formats is followed by the data for Gages 625, 630, 640, and 645. Wave data are: (1) Gage Histories; (2) Daily H_{mo} and T_p; (3) Distributions of Wave Height Versus Peak Period; (4) Cumulative Distributions of Wave Height; (5) Peak Spectral Wave Period Distributions; (6) Persistence of Wave Heights; (7) Spectra.

Miller, J.L. 1991. Dynamics of Gulf Stream Meanders and Frontal Eddies in the South Atlantic Bight. EOS, Trans. AGU. 72(51):63.

Abstract. Circulation of the outer continental shelf and slope waters adjacent to the southeastern United States is largely controlled by Gulf Stream meanders and associated frontal eddies which propagate northward along the shelf break. Such events appear to be a ubiquitous feature of western boundary currents and are found in other regimes as well. Since they have been most extensively observed in this region, the South Atlantic Bight (SAB), we concentrate on the Gulf Stream case herein. An analytical representation of a mean Gulf Stream density cross-section has been developed which, when combined with a corresponding geostrophic velocity section, reproduces the known patterns of potential vorticity.

Miller, M.C., I.N. McCave and P.D. Komar. 1977. Threshold of sediment motion under unidirectional currents. Sedimentology. 24:507-527.

Milliman, J.D., O.H. Pilkey and D.A. Ross. 1972. Sediments of the Continental Margin off the Eastern United States. Geol. Soc. Am. Bulletin, 83:1315-1334.

Abstract. The character and distribution of surficial sediments on the continental shelf and slope between northern Maine and southern Florida have been defined on the basis of more than 6,000 bottom samples. Most shelf sediments were deposited in shallow water (probably littoral depths) during the last lower stand of sea level. Modern sediments are accumulating only in estuaries, in certain nearshore areas on the continental slope.

Minerals Management Service, V., VA. Atlantic OCS Region. 1984. Draft Environmental Impact Statement: Proposed 1985 Outer Continental Shelf Oil and Gas Lease Sale No. 90 Offshore the South Atlantic States. U.S. Dept. Interior, MMS Rep. OCS/MMS-84-0007:640.

Abstract. The proposed action is the offering of 7245 blocks (40.8 million acres; 16.5 million hectares) located from 12 to 210 statute miles offshore North Carolina, South Carolina, Georgia, and Florida for leasing in accordance with the Outer Continental Shelf Lands Act, as amended. The average water depths of the blocks range from 30 to 3900 m (98 to 12,796 feet). Sale No. 90 will be held in March 1985. Alternatives considered include a delay of the salt, canceling the sale (no action), and four deferral options. The deferral options include one to protect coastal and nearshore resources, one relating to blocks in the clearance

zone for the NASA Kennedy Space Center and Eastern Space and Missile Center, one to protect the calico scallop and royal red shrimp fishing grounds, and one to protect the nominated Oculina National Marine Sanctuary. All blocks studied pose some degree of risk to the environment. Mitigating measures, which may reduce the risk, have been identified. 379 references, 22 figures, 46 tables.

Mizenko, D. and J.L. Chamberlin. 1979. Gulf Stream anticyclonic eddies (warm-core rings) off the northeastern United States in 1977. ICES Annals of Biology. 34:39-44.

Moody, J.A. and B. Butman. 1980. Semidiurnal bottom pressure and tidal currents on Georges Bank and in the Mid-Atlantic Bight. U.S. Geol. Surv. Open-File Rep. 80-1137:22.

Abstract. Report of data from long-term moorings at depth focusing on barotropic component.

Moody, J.A. and B. Butman. 1982. Semidiurnal bottom pressure and tidal currents on Georges Bank and in the Mid-Atlantic Bight. pp. 2.1-2.16. In J.M. Robb, ed. Environment geologic studies in the Mid-Atlantic outer continental shelf area-results of 1978-1979 field seasons. final report to the U.S. Bureau of Land Management,

Moody, J.A., B. Butman, R.C. Beardsley, W.W. Brown, P. Daifuku, J.D. Irish, D.A. Mayer, J.O. Mofjeld, B. Petri, S. Ramp, P. Smith and W.R. Wright. 1984. Atlas of tidal elevation and current observation on the northeast American continental shelf and slope. U.S. Geol. Surv. Bulletin 1611.

Morgan, C.W. 1977. Average monthly wind stress along coastal regions of the United States and Western Canada. Ocean. Unit Tech. Paper 77-1.

Abstract. Average monthly values for wind stress are provided for Gulf of Mexico and Atlantic regions. These wind stress values can be used as boundary conditions for numerical circulation models but only on coarse-grids.

Morgan, C.W. and J.M. Bishop. 1977. An example of Gulf Stream eddy-induced water exchange in the Mid-Atlantic Bight. J. Phys. Oceanogr. 7:472-479.

Abstract. Temperature and salinity data collected by USCG EVERGREEN in August 1974 provide an interesting example of eddy-induced horizontal water exchange across the continental slope of the mid-Atlantic bight. A tongue of shelf water (MSW), defined by a salinity of <34 parts per thousand, extending seaward of the 100-fathom curve behind the eddy contained a measured volume of shelf water. The volume transport of MSW through this tongue was estimated. Assuming a typical eddy residence time of 3 months in the mid-Atlantic bight and an eddy frequency of 3 per year, the annual offshore transport of MSW across the 100-fathom curve due to eddies is also estimated. This line of reasoning suggests that eddies may be responsible for an important portion of the mixing of shelf water with the slope water region in the mid-Atlantic bight.

Morris, W.D. 1977. Coastal Wave Measurements During Passage of Tropical Storm Amy. NASA. NASA-TM-74060:38.

Abstract. Aerial photographic and laser profilometer data of waves generated by tropical storm Amy are presented. The data mission consisted primarily of two legs, one in the direction of the wind waves, and the second along the direction of swell propagation, using Jennette's Pier at Nags Head, North Carolina, as a focal point. At flight time, Amy's center was 512 nmi from shore and had maximum winds of 60 knots. The storm's history is presented, along with a satellite photograph, showing the extent of the storm on the day of the flight. Flight ground tracks are presented along with sample aerial photographs of the wave conditions showing approximate wavelength and direction. Sample wave energy spectra are presented both from the laser profilometer onboard the aircraft, and from the Corps of Engineers Research Center (CERC) shore gauge at Nags Head, North Carolina.

Morris, W.D., C.E. Grosch and L.R. Poole. 1982. Wave Spectra of a Shoaling Wave Field: A Comparison of Experimental and Simulated Results. NASA Tech. Memo. NASA-TM-83211:33.

Abstract. Wave profile measurements made from an aircraft crossing the North Carolina continental shelf after passage of Tropical Storm Amy in 1975 are used to compute a series of wave energy spectra for comparison with simulated spectra. Results indicate that the observed wave field experiences refraction and shoaling effects causing statistically significant changes in the spectral density levels. A modeling technique is used to simulate the spectral density levels. Total energy levels of the simulated spectra are within 20 percent of those of the observed wave field. The results represent a successful attempt to theoretically simulate, at oceanic scales, the decay of a wave field which contains significant wave energies from deepwater through shoaling conditions.

Morrison, J.M. and S. Raman. 1991. Oceanographic and Meteorological Measurements Collected as Sea Truth for the July 1990 Gulf Stream Experiment. EOS, Trans. AGU. Suppl to 72(17):148.

Abstract. A cruise was made to the region at the mouth of the Chesapeake Bay and to the edge of the Gulf Stream during the period 17-21 July 1990 to provide sea truth data for aircraft borne active radar remote sensing instruments.

Morrison, J.M., L.J. Pietrafesa, G.S. Janowitz, M.P. McCann, J. Churchill and R.W. Houghton. 1991. Water Mass Linkages Between the Middle and South Atlantic Bights. EOS, Trans. AGU. 72(51):87.

Abstract. Time and frequency domain analysis are used to relate coastal meteorological data with seven years of daily surface temperature and salinity collected on the North Carolina cape shoals and Chesapeake Bay. Salinity on Diamond Shoals, the Cape Hatteras extension, is highly correlated with alongshore wind stress implying wind driven advection of the front between Virginia Coastal Water and Carolina Coastal Water across the shoal axis. The data collected at the shoals suggest that more than 50% of the time there is significant leakage of MAB water into the SAB around Cape Hatteras, contrary to the notion that VCW is entirely entrained into the Gulf Stream. In fact VCW can appear as far south

as Frying Pan Shoals, covering the entire North Carolina Capes inner to mid shelf. By assuming that this transport occurred approximately 50% of the year, the net transport of MAB water around Cape Hatteras into the SAB is minimally .45 to 0.6 X 10^5 m^3/s or approximately 17.5% to 23% of the 0.26 X 10^6 m^3/s estimated mean transport of shelf water over the MAB computed by Beardsley et al. (1976). Temperature and salinity time series also indicate that water masses directly over Diamond Shoals quickly respond to cross-shelf winds. Cross-shelf wind stress is significantly correlated with surface temperature at Diamond Shoals at periods less than 14 days. Changes in temperature can be brought about by wind driven cross-shelf circulation and by wind induced upwelling. AVHRR imagery taken during spring 1988 confirm these concepts.

Morse, W.W., M.P. Fahay and W.G. Smith. 1987. MARMAP Surveys of the Continental Shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1977-1984). Atlas No. 2. Annual Distribution Patterns of Fish Larvae. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Technical Memo. NOAA-TM-NMFS-F/NEC-47:228.

Abstract. This report is the second in a series of atlases containing data on the phytoplankton, zooplankton, ichthyoplankton, hydrography, nutrients, or productivity of the Northeast Continental Shelf ecosystem. The sampling was conducted as part of the Marine Resources Monitoring, Assessment and Prediction (MARMAP) Program of the Northeast Fisheries Center.

Moses, T., G.N. Kiladis, H.F. Diaz and R.G. Barry. 1987. Characteristics and frequency of reversals in mean sea level pressure in the North Atlantic sector and their relationship to long-term temperature trends. J. Climatol. 7(1):13-30.

Abstract. Discusses relationship between reversals in mean sea level pressure and temperature trends, which relate well to trends in the strength of the zonal wind and the frequency of blocking in the north-east Atlantic area.

Mountain, D.G. 1991. The volume of Shelf Water in the Middle Atlantic Bight: seasonal and interannual variability, 1977-1987. Cont. Shelf Res. 11(3):251-267.

Abstract. The volume of Shelf Water (salinity<34 psu) is determined for three regions in the Middle Atlantic Bight (MAB) and for Georges Bank from a combination of hydrographic data and shelf/slope front positions derived from satellite imagery. The hydrographic data were obtained on 49 surveys of the shelf between 1977 and 1987. In each region the shelf water volume exhibits a significant annual cycle with a range of 50-80% of the mean volume. The annual volume cycle appears to be advected southwestward from Georges Bank through the MAB with the mean circulation. Large interannual changes in volume are observed which have a range comparable to the mean volume of Shelf Water in the MAB. Both the seasonal and interannual changes in volume appear to be related to changes in the inflow to the Gulf of Maine through Northeast Channel and from the Scotian Shelf.

Mountain, D.G. and T.J. Holzwarth. 1989. Surface and Bottom Temperature Distribution for the Northeast Continental Shelf. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA-TM-NMFS-F/NEC-73:39.

Abstract. Horizontal distributions of expected or mean surface and bottom temperatures on the Northeast Continental Shelf from Cape Hatteras to the Gulf of Maine are presented for the beginning and middle of each month. Data used to generate these distributions are from the period 1977-87. The distributions, therefore, represent an 11-year mean annual temperature cycle. Horizontal distributions of the interannual variability in temperature within the 11-year period are also presented.

Moustafa, M.S.J. 1988. Swash induced zonation of a foreshore; sediment size distribution. Master's Thesis. College of William and Mary. 139 pp.

Mullin, J.V. 1991. North Carolina Physical Oceanography Panel Report. U.S. Dept. Interior, MMS Rep. OCS/MMS-91/0011:51.

Abstract. The report is the result of a panel review consisting of three physical oceanographers chosen by the Secretary of the Interior, the Governor of North Carolina and one chosen jointly by the Secretary and the Governor of North Carolina. The panel evaluated the Mobil report entitled, 'Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina.' In addition, the panel was charged to provide recommendations on the need for additional physical oceanographic field measurements between the mouth of the Chesapeake Bay and Cape Hatteras, North Carolina.

Nardin, B. 1971. Suspended sediments in continental shelf water of Cape Hatteras, North Carolina. Master's Thesis. University of Illinois, Chicago.

Nash, R.D.M., J.J. Magnuson, T.K. Stanton and C.S. Clay. 1989. Distribution of peaks of 70 kHz acoustic scattering in relation to depth and temperature during day and night at the edge of the Gulf Stream-EchoFront 83. Deep-Sea Research, Part A [Oceanographic Research Papers]. 36(4A):587-596.

Abstract. The depth and temperature distribution of acoustical scattering peaks in the near-surface frontal zone of the Gulf Stream was examined with a 70 kHz downward-looking sonar to 130 m. A peak was defined as a layer with relatively more scattering than layers just above or below it. Data were collected during the day and night in July 1983, approximately 115 km ENE of Cape Hatteras in a front with sharp thermal gradients above 130 m, and in the Gulf Stream with rather homogeneous temperatures above 130 m. 'Peaks' in the front occurred more frequently both day and night above 60 m and at temperatures warmer than 15°C; in the Gulf Stream peaks occurred more frequently only above 20 m and at temperatures warmer than 24.5°C and then only during the day. The distribution of peaks was more homogeneous with depth and temperature in the Gulf Stream than in the front. (36 Refs.).

National Aeronautics and Space Administration. 1974. Wave climate model of the Mid-Atlantic shelf and shoreline (Virginian Sea). NASA Report SP-348:146.

Abstract. Discusses a modified wave refraction analytical model developed for the Mid-Atlantic region.

National Aeronautics and Space Administration. 1976. Wave refraction diagrams for the Baltimore Canyon Region of the Mid-Atlantic continental shelf computed by using three bottom topography approximation techniques. Rep. No. NASA-TM-X-3423; L-11004, 156 pp.

Abstract. Use of computed water depth estimates to specify surface gravity wave ray paths.

National Science Foundation. 1977. Oceanographic study of warm core Gulf Stream rings and the northwest Atlantic slope water region. A prospectus for multidisciplinary research. Rep. NSF/IDOE-78/62:126.

Abstract. Prospectus for research needs based on observations of a ring which traversed the North Atlantic region.

Naval Weather Service Command, W., D.C. 1970. Summary of Synoptic Meteorological Observations: North American Coastal Marine Areas. Volume 3. Area 8 - Norfolk, Area 9 - Cape Hatteras, Area 10 - Charleston. Naval Weather Service Command. :482.

Abstract. The report is part of a series of compilations which is regional in scope. It consists of climatological and air-sea interface data in tabular form for specified water areas adjoining Norfolk, Cape Hatteras, and Charleston.

Nelson, D.M., J.J. McCarthy, T.M. Joyce and H.W. Ducklow. 1989. Enhanced near-surface nutrient availability and new production resulting from the frictional decay of a Gulf Stream warm-core ring. Deep-Sea Research, Part A [Oceanographic Research Papers]. 36(5A):705-714.

Abstract. Warm-core eddies in at least three different current systems have been observed to evolve for a few weeks' time from local minima to local maxima in phytoplankton biomass and primary productivity. The authors report a possible explanation of this phenomenon, based on events observed in Gulf Stream warm-core ring 82-B. During the time when a phytoplankton biomass maximum was present in this ring, nutrient concentration gradients beneath a nutrient-depleted surface layer were consistently both greater in magnitude and closer to the sea surface in the interior of the ring than in the surrounding Slope Water. In addition, surface-layer densities were greater inside than outside the ring, resulting in much smaller density differences between the surface and the nitracline. The cumulative result of these two factors was that, compared to the surrounding Slope Water, less than one fifth as much wind energy would have been needed near the center of the ring to mix the water column from the nitracline to the surface. The altered nutrient and density profiles within the ring were consistent with physical and biological models of eddy dynamics, which predict that the frictional decay of the rotational flow field should result in shoaling of the main thermocline, and thus upwelling, in the interior of a warm-core eddy.

(30 Refs.).

Neu, H.J.A. 1976. Wave climate of the North Atlantic-1970. Bedford Institute of Oceanogr. Dartmouth, Nova Scotia. Rep. Ser. Bio. (BI-R-76-10).

Abstract. Wave climatology summary.

Neumann, C.J. and G.W. Cry. 1978. A revised Atlantic tropical cyclone climatology. Mar. Weather Log. 22(4):231-236.

Abstract. Records of tropical cyclones occurring 1871-1977.

Neumann, C.J. et al. 1981. Tropical cyclones of the North Atlantic Ocean, 1871-1980. National Climatic Center: 174.

Abstract. Tabulation of storm occurrences indicating that 85 percent of the tropical cyclones occur in August, September, and October.

Neumann, C.J. and M.J. Pryslak. 1981. Frequency and motion of Atlantic tropical cyclones. National Climatic Center:57.

Abstract. Summarizes the frequency of occurrence and paths of severe storms.

Neumann, C.J., G.W. Cry, E.L. Caso and B.R. Jarvinen. 1978. Tropical cyclones of the North Atlantic Ocean, 1871-1977. National Climatic Center: 176.

Neumann, C.J., G.W. Cry, E.L. Caso and B.R. Jarvinen. 1981. Tropical cyclones of the North Atlantic Ocean, 1871-1980. NOAA/NCDC/NHC. Asheville. 174 pp.

Abstract. Tabulation of storm occurrences indicating that 85 percent of the tropical cyclones occur in August, September, and October.

Newton, C.W. 1978. Fronts and wave disturbances in Gulf Stream and atmospheric jet stream. J. Geophys. Res. 83(C9):4697-4706.

Abstract. Similarities in their basic features, including spatial variations of frontal structure along the current, suggest that Gulf Stream meanders are dynamically analogous to atmospheric jet stream waves, with descending motions upstream and ascending motions downstream from a wave trough. In a symmetrical wave with uniform speed along the current it is shown that confluence, together with the distribution of vertical motions, accounts for the greater baroclinity in the frontal zone at troughs than at crests, a necessary feature of such a wave. Gross features of the three-dimensional motions are discussed for an eddy in the process of cutting off to form a Gulf Stream Ring. Prior to its detachment from the slope water mass, deduced sinking motions exceed, by 2 orders of magnitude, the vertical motions in ring eddies that have become isolated. The large downward volume flux during the formative stage is associated with the asymmetrical structure (more water pouring into a cold tongue on its west side than leaves it on its east side) and with the vertical distribution of volume transport (greater inflow than can be accommodated by horizontal expansion in the upper layers). The inflation time for a Gulf Stream ring is about a month, much shorter than the decay time.

Newton, J.G., O.H. Pilkey and J.O. Blanton. 1971. An Oceanographic Atlas of the Carolina Continental Margin. N.C. Dept. Cons. Develop. 57 pp.

Nichols, C.R. 1991. Hydrodynamics of Oregon Inlet; Possible Mechanisms for Larval Fish Recruitment into the Pamlico Sound. Master of Science Thesis. North Carolina State University. 253 pp.

Abstract. Certain commercially significant fish species such as Atlantic spot, flounder, croaker and menhaden spawn in the continental shelf waters of North Carolina during late fall to early winter. Following spawning, the eggs and resultant larvae are transported shoreward. As the larvae are advected, they metamorphose into juveniles and those that successfully negotiate the continental shelf may subsequently migrate into the estuaries to primary nurseries to grow until the reach maturity. Hydrological data collected during this study indicates that larvae enter the northern part of the Pamlico Sound, a bar-built estuary, through Oregon Inlet via flood periods associated with enhanced inlet jetting. The hydrodynamics which exist between Pamlico Sound and the coastal ocean are such that the timing of larval arrival to the inlets and subsequent transport into the sound are in synchronization with winds from the north. The resulting ocean-to-estuary pressure gradient force, from the offshore passage of late winter weather systems, drives a rapid current through Oregon Inlet. The responses of Oregon Inlet currents to atmospheric forcing are analyzed using time series analysis techniques to determine if larvae, acting as passive water particles, are transported through estuary inlets during favorable wind-enhanced jetting. First, exaggerated ebb and flood events are identified using data sets from Oregon Inlet and Davis Channels. Second, flood prisms are estimated to determine the volume of water available for larval transport through Oregon Inlet. Finally, the relationships between the atmospheric wind field and the inlet's water properties are evaluated for coherent relationships. Synoptic wind events in the vicinity of Oregon Inlet affect ocean and sound sea level as well as temperature and salinity. Multiple coherence analysis suggests that the flood events which are paramount to fish migration are attributed to local winds.

Niiler, P.P. 1975. Variability in western boundary currents. pp. 216-235. In Numerical Models of Ocean Circulation. National Academy of Sciences, Washington, D.C.

Abstract. Review of numerical models available at that time and their ability to accurately capture the stochastic fluctuations associated with western boundary currents.

Niiler, P.P. and W.S. Richardson. 1973. Seasonal variability of the Florida Current. J. Mar. Res. 31(1):144-167.

Abstract. Data from 90 transects off Miami (1960s) used to determine seasonal variability of directly measured transport and horizontal currents in Florida Strait. Estimates seasonal variability to account for 45% of total variability in total transport.

Noble, M.A. 1984. Shelf circulation studies on the northeastern United States continental shelf. Ph.D. Thesis. University of Rhode Island. 156 pp. (DAI 45/03B, p.811; AAC8414890)

Abstract. Between May 1975 and March 1979, several sets of instrumented arrays were deployed on the northeastern United States Continental Shelf to investigate subtidal shelf circulation patterns. Two longshelf arrays, which consisted of current meters, subsurface pressure sensors and cameras to photograph the seabed, were deployed in the winters of 1976 and 1978 from the Middle Atlantic Bight (MAB) to the southern flank of Georges Bank (a distance spanning 615 km). On the southern flank of Georges Bank, current meters were deployed for several years at a single site. Subtidal currents are found to be strongly correlated along the shelf (minimum coherence amplitudes of 0.6). The longshelf current consists predominantly of wind-forced motions and freely propagating events. Subtidal currents in the MAB are much stronger than on Georges Bank. The MAB/Georges Bank energy ratio for wind-forced currents is 20 and is 3 for freely propagating events. The several years of current observations on the southern flank of Georges Bank show that wind-current coupling is primarily between longshelf wind and longshelf current, consistent with observations from the shorter term longshelf array. However, the coupling varies on a seasonal cycle and changes with forcing frequency. The strongest wind-current coupling occurs in winter and the coupling is highest for periods between 100 and 300 hours (for periods from 60 to 1,344 hours). The longshelf current is linearly related to wind stress and responds approximately symmetrically to wind forcing.

Noble, M. and B. Butman. 1978. Wind induced low-frequency bottom pressure fluctuations along the East Coast of the United States. EOS, Trans. AGU. 58(6):403.

Abstract. Computed wind induced low-frequency bottom pressure variability from tide and atmospheric pressure gauges located from Cape Hatteras to Halifax. Results show coherence at low frequencies and large spatial separations.

Noble, M. and B. Butman. 1979. Low-frequency wind-induced sea level oscillations along the east coast of North America. J. Geophys. Res. 84(C6):3227-3236.

Abstract. Atmospherically adjusted coastal sea level observations (ASL) and wind measurements at stations along the east coast of North America from Cape Hatteras, North Carolina, to Eddy Point, Nova Scotia, for a 6-month winter period were used to study the spatial structure of ASL and wind stress on the continental shelf and to determine the low-frequency response of ASL to wind forcing. In the Middle Atlantic Bight (MAB), sea level response was 17 cm for a 1 dyn/cm^2 longshore wind and symmetric in the longshore wind stress directions. If coastal winds were representative of winds over the shelf, the observations imply that the wind-driven longshelf geostrophic currents were larger for unit wind stress in the MAB than in the Georges Bank-Scotian Shelf region. A low-frequency longshelf ASL slope was observed in the MAB that was incoherent with longshelf wind stress.

Noble, M.A., B. Butman and E. Williams. 1983. On the long shelf structure and dynamics of subtidal currents on the eastern U.S. Continental Shelf. J. Phys. Oceanogr. 13:2125-2147.

Abstract. Documents that 75-90% of long-shore current energy is due to wind and self-propagating events.

Nof, D. 1983. On the migration of isolated eddies with application to Gulf Stream rings. J. Mar. Res. 41(3):399-425.

Abstract. Model is proposed to describe the beta-induced drift of isolated nonlinear eddies such as those found in the Gulf Stream. Significant differences between the behavior of cyclonic and anticyclonic eddies are found.

Nof, D. 1988. The propagation of 'streamers' along the periphery of warm-core rings. Deep-Sea Research, Part A [Oceanographic Research Papers]. 35(9A):1483-1498.

Abstract. The collision between the Gulf Stream and warm-core rings usually involves narrow bands (approximately 5 km) of Gulf Stream water that envelop the colliding rings. Such bands ('streamers') propagate along the ring's edge in a clockwise manner; they sometimes lead to the recapture of the rings by the Gulf Stream. A nonlinear layered model is used to examine the streamers' propagation rate. The streamers are viewed as an intrusion of light Gulf Stream water along a curved surface that contains the slightly heavier ring water. Their propagation rate is determined by (i) transforming the governing equations to a coordinate system that rotates steadily with the intrusion's nose, (ii) using the fact that the fluid must stagnate at the intrusion's nose, and (iii) considering the integrated torque of the intrusion. Analytical solutions are constructed by using a perturbation scheme in mu, the ratio of the streamer's width to the ring's radius. Surprisingly, it is found that, no matter what the radius of the ring is, the propagation rate is always one half of the particle speed along the upstream front of the Gulf Stream. (20 Refs.).

North Carolina Department of Environmental, Health and Natural Resources. 1991. North Carolina Inventory of Environmental Data Sets. The State Center for Health and Environmental Statistics. Raleigh. 133 pp.

Abstract. The inventory contains descriptive information about state government environmental data sets that are routinely compiled and are potentially significant to research pertaining to North Carolina's environment. The Inventory is useful for locating environmental statistics and for contacting those who have firsthand knowledge of the data.

North Carolina Marine Science Council. 1972. North Carolina's Coastal Resources--A Preliminary Planning Report for Marine And Coastal Resources Development in North Carolina. North Carolina Marine Science Council. Raleigh. 218 pp.

Abstract. This document is a preliminary planning report for marine and coastal resource development in North Carolina, and contains recommendations for certain key legislative and administrative actions and research programs needed in the State. This report was prepared by the North Carolina Marine Science Council in

consultation with the recently created North Carolina State-Federal Planning Committee for Marine Resources. An earlier report, "North Carolina and the Sea," was prepared by the Marine Science Council in 1970. The next phase, to be built on these first efforts, will include the development of a comprehensive plan with specific guidelines, details and priorities, for its implementation. It is anticipated that such a plan will be periodically revised and updated as required.

North Carolina Marine Science Council and North Carolina Department of Administration. 1981. Coastal Study, Final Report to the 1981 North Carolina General Assembly, 83 pp.

Abstract. Shoreline erosion along North Carolina.

Notario, J.J., R.P. LaBelle and A.D. Lucas. 1985. An oil-spill risk analysis for the Mid-Atlantic (proposed sale no. 111) outer continental shelf lease area. U.S. Dept. of Interior, Minerals Management Service, Branch of Environmental Modeling. OCS Rep. MMS 86-001:108.

Nurser, A.J.G. and R.G. Williams. 1990. Cooling Parsons' model of the separated Gulf Stream. J. Phys. Oceanogr. 20(12):1974-1979.

Abstract. The effect of cooling on the separated boundary current predicted by the model of Parsons (1969) is studied. The separating current is found to strengthen and to move southwards and eastwards. The model is also robust to limited heating, in which case the separating current weakens and moves northwards. (8 Refs.).

Ochadlick, A.R., Jr. 1991. SAR Segments of the Life Cycle of Dark Slick-Like Features During Gulf Stream 1990. EOS, Trans. AGU. Suppl to 72(17):148.

Abstract. Perhaps more than any form of imagery, the sunglint photographs taken by Scully-Power during a Shuttle flight show a rich complex structure and a ubiquitous nature for dynamical patterns on the ocean surface. SAR imagery allows us to sample the structure of small segments of the patterns seen by Scully-Power. In SAR imagery, the segments of the patterns appear as dark slick-like features in the form of spirals, filaments and broad dark regions.

O'Connor, W.P. 1991. User's Manual for the Princeton Numerical Ocean Model. Institute for Naval Oceanography Special Project. INO-SP-5:73.

Abstract. This is a user's guide for the numerical ocean model developed at Princeton University and presently in use at the Institute for Naval Oceanography. The basic model has been applied successfully to study such diverse regions as Chesapeake Bay (Blumberg 1977), the South Atlantic Bight (Blumberg and Mellor 1983), the Mid Atlantic Bight (Blumberg and Kantha 1985), the Gulf of Mexico (Blumberg and Mellor 1985), New York Harbor (Oey et al 1985a,b,c), Delaware Bay (Galperin and Mellor 1990a,b), and the western Atlantic including Gulf Stream (Mellor and Ezer 1991). It can model regions from the size of bays and estuaries to basin scale North Atlantic domains. A good discussion of modeling bays and coastal oceans is given by Blumberg and Oey (1985).

Oey, L.Y. 1986. The formation and maintenance of density fronts on the U.S. southeastern continental shelf during winter. J. Phys. Oceanogr. 16(6):1121-1135.

Abstract. A cross-shelf and depth, time-dependent numerical model suggests that three or more winter storms are required to establish fronts on the midshelf. Otherwise, the front is situated just inshore of the shelf-break front.

Oey, L.-Y. 1988. A model of Gulf Stream frontal instabilities, meanders and eddies along the continental slope. J. Phys. Oceanogr. 18(2):211-229.

Abstract. For a simplified model of the Gulf Stream front along a vertical-walled continental slope of constant-depth ocean basin, the dynamics governing frontal instabilities, meanders, and eddies depend primarily on (i) L_o/R_o, the ratio of the cross-stream distance of the stream axis from the slope, L_o, to the Rossby radius of deformation, R_o, and (ii) h_o/H, the ratio of the depth h_o of the upper layer of light water to ocean basin depth H. A nonlinear, time-dependent three-dimensional model is used to study this interdependency. Two different types of meander solutions are found, depending on the value of the (nondimensionalized) initial available potential energy per unit alongfront length and per unit "Rossby area," HR_o, $ABE=(L_o/R_o)(h_o/H)/2$. For small APE, the meanders and their associated cyclones are slope-bounded as they propagate downstream. This solution has characteristics similar to observed Gulf Stream meanders south of a topographic feature at 31.5°N (the so-called "Charleston Bump") on the southeastern continental margin. For large APE, the meander displays branching surface currents upstream of its associated cyclone. One branch is deflected seaward while the other, weaker, branch hugs close to the slope. The two branches envelop the cyclone as they propagate downstream in unison. This solution has features similar to observed Gulf Stream meanders north of the Charleston Bump.

Oey, L.-Y., L.P. Atkinson and J.O. Blanton. 1987. Shoreward intrusion of upper Gulf Stream water onto the U.S. southeastern continental shelf. J. Phys. Oceanogr. 17(12):2318-2333.

Abstract. In winter, cooling of the South Atlantic Bight continental shelf water results in higher density in the middle shelf region relative to the shelf-break region where the western flank of the Gulf Stream flows. Shoreward, estuarine-like intrusion of the upper Gulf Stream water in the presence of such a positive onshore density gradient is then possible through advective processes triggered either by the meander of the Stream or onshore Ekman transports by southward wind stresses. Repeated cross-shelf hydrographic transects were conducted from 10 January through 30 January 1986 to more closely study this intrusion process. These observations show many features predicted by a previous numerical model study. A semi-empirical model is proposed here wherein the state of stratification of water on the outer continental shelf region just inshore of the shelf break is used as an indicator of the intrusion process. Model analysis suggests correlating the observed time rate of change of potential energy of the water column with wind-induced cross-shelf Ekman transport. The correlation fit is good for at least half of the dataset, suggesting that wind-induced intrusion was significant during the observations. The analysis also suggests that it is possible to distinguish intrusion processes which are wind induced from those

which are induced by Gulf Stream meanders.

Oka, E. 1989. Nonlinear solutions to a 2-layer quasi-geostrophic model of the Gulf Stream. Ph.D. Thesis. Old Dominion University. 129 pp. (GROSCH, CE (adviser); DAI 51/03B, p.1174; AAC9019332)

Abstract. The Gulf Stream shows a large meander off Cape Hatteras. This is driven by an energy conversion process known as baroclinic instability and observations suggest that nonlinearity is an important part in this process. In order to understand the fundamental role of nonlinearity in baroclinic instability, an inviscid 2-layer quasi-geostrophic model is studied. The linear solution is obtained by methods of normal mode and Fourier-Laplace transforms. It is found that the set corresponding to the continuous spectrum is null and the set corresponding to the discrete spectrum is complete. The nonlinear solution is expanded in terms of the complete set of the eigenfunctions in the north-south direction and a Fourier series in the east-west direction. Using a certain form of orthogonality of the eigenfunctions, a 6-dimensional dynamical system which solves for the amplitudes of the components is derived. A solution to this system is obtained for certain initial conditions using the Runge-Kutta method. In particular, it is found that stability of any solution of this system, such as a fixed point, can be determined by transforming the system into a set of Hamiltonian equations. A computed meander represents either an eastward or a westward propagating wave with an amplitude vacillation. Effects of severe truncation appear to be significant in some cases. Judging from the solution of the dynamical system, the computed meander is found to be quasi-periodic and sensitive to initial conditions.

Olson, D.B. 1986. Lateral exchange within Gulf Stream warm-core ring surface layers. pp. 20-24. In P.H. Wiebe and T.J. McDougall, eds. Workshop on Warm-Core Rings, Tokyo, 1985.

Abstract. The radial exchange of near-surface properties in Gulf Stream anticyclonic warm-core rings is studied with the use of hydrographic and satellite data in conjunction with some simple models.

Olson, D.B., O.B. Brown and S.R. Emmerson. 1982. Gulf Stream Frontal Statistics from Florida Straits to Cape Hatteras Derived from Satellite and Historical Data. pp. 278-301. In J.M. Bane Jr., ed. Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982. The Office of Naval Research, (NTIS Accession Number: AD-P001 055/3)

Abstract. A five year record (1976-1980) of weekly Gulf Stream paths digitized from the U.S. Navy Ocean Frontal Analysis is analyzed to define a mean Gulf Stream path and weekly space-time series of fluctuations about the mean between the Florida Straits and Cape Hatteras. This satellite derived Gulf Stream frontal mean locus is used as a natural coordinate system in which NODC historical expendable bathythermograph (XBT) data is averaged to determine the mean cross stream thermal structure. The results show that the 15 deg C isotherm crosses the 200 m level at the mean location of the satellite derived front, that is, the cold wall of the stream as derived from IR imagery is in good agreement with a classical definition of the stream path. The Gulf Stream path is discussed in

relationship to the bottom topography. Frontal location time series at various locations along the Gulf Stream are analyzed to generate occupation statistics and spectra for stream position. A steady increase in the variance of stream position occurs from Cape Canaveral to the Charleston Bump. This trend is followed by a sharp increase in variance just downstream of the bump and then a gradual decay from approximately 33 deg N to Cape Hatteras. A similar distribution of variance is found in the depth of the 15 deg C isotherm. An annual signal is seen in the path data all along the U.S. east coast.

Olson, D.B., O.B. Brown and S.R. Emmerson. 1983. Gulf Stream frontal statistics from Florida Straits to Cape Hatteras derived from satellite and historical data. J. Geophys. Res. 88(C8):4569-4577.

Abstract. A 5 year record (1976-1980) of weekly Gulf Stream paths digitized from the U.S. Navy Ocean Frontal Analysis is analyzed to define a mean Gulf Stream path and weekly space-time series of fluctuations about the mean between the Florida Straits and Cape Hatteras. This satellite-derived Gulf Stream frontal mean locus is used as a natural coordinate system in which NODC historical expendable bathythermograph (XBT) data is averaged to determine the mean cross stream thermal structure. The results show that the satellite-derived front; that is, the cold wall of the stream as derived from IR imagery is in good agreement with a classical definition of the stream path. The Gulf Stream path is discussed in relationship to the bottom topography. Frontal location time series at various locations along the Gulf Stream are analyzed to generate occupation statistics and spectra for stream position. A steady increase in the variance of stream position occurs from Cape Canaveral to the Charleston Bump. This trend is followed by a sharp increase in variance just downstream of the bump and then a gradual decay from approximately 33°N to Cape Hatteras. A similar distribution of variance is found in the depth of the 15°C isotherm. An annual signal is seen in the path data all along the U.S. east coast. The stream front north of Charleston (about 32°N) exhibits the strongest annual variation with the surface front being further offshore in the late winter and early spring. This annual signal is not obvious at the thermocline level (15°C). It is consistent, however, with observed shifts in the isotherm patterns in the upper 100 m.

Olson, D.B., R.W. Schmitt, M. Kennelly and T.M. Joyce. 1985. Two-layer diagnostic model of the long-term physical evolution of warm-core ring 82B. J. Geophys. Res. 90(C5):8813-8822.

Abstract. A two-layer model of ring 82B's structure is used to compute gradient current, kinetic energy, available potential energy, and potential vorticity in the ring, and changes in these quantities as the ring evolves are discussed.

Oltman-Shay, J., P.A. Howd and W.A. Birkemeier. 1989. Shear instabilities of the mean longshore current 2. Field Observations. J. Geophys. Res. 94(C12):18031-18042.

Abstract. A new type of alongshore progressive wave with periods and alongshore wavelengths of the order of 10^2 seconds and meters, respectively, has been observed in the surf zone. These periods fall into the lower end of the much studied infragravity frequency band previously shown to contain surface gravity

edge and leaky waves. However, their short wavelengths (more than an order of magnitude smaller than the mode 0 edge wave) distinguish these new waves from surface gravity waves. In addition, they are only observed in the presence of mean longshore current and they change celerity (O(1 m/s)) and direction with the mean current. Alongshore wavenumber-frequency spectra clearly identify these waves, distinct from edge and leaky waves, by their approximately linear dispersion line at wavenumbers greater than the mode 0 edge wave dispersion curve. Their rms horizontal velocities can exceed 30 cm/s. These waves are shown to be consistent with a model [Bowen and Holman, this issue] of vorticity waves generated by the shear instability of the mean longshore current.

Onishi, Y., L.F. Hibler and C.R. Sherwood. 1987. Review of Hydrodynamic and Transport Models and Data Collected Near the Mid-Atlantic Low-Level Radioactive Waste Disposal Sites. Battelle Pacific Northwest Labs. PNL-6331:105.

Abstract. The objectives of this study were to (1) briefly review and evaluate available simulation models that may be used to predict the distribution of low-level radioactive waste (LLW) from the 2800-m and 3800-m Low Level Radioactive Disposal Sites in the Mid-Atlantic Continental Slope and Rise on a regional (a few hundred kilometers square) scale, (2) identify pertinent physical, biological, and geological oceanographic data in or near those LLW disposal sites, and (3) determine minimum data requirements for regional modeling. With suitable model modifications such as turbulence closure, enhanced sediment transport, radionuclide transport, and/or curvilinear coordinate system setup, the FLESCOT model, the FLOWER model, and Blumberg's model would be appropriate candidates for regional radionuclide modeling to predict the transport and dispersion of LLW disposed in the 2800-m and 3800-m sites. Although the RMA10 model does not incorporate a turbulence closure scheme, this model, with some modifications, is also an appropriate candidate for regional radionuclide modeling. FLESCOT is currently the only one that solves distributions of flow, turbulence, salinity, water temperature, sediments, dissolved contaminants, and sediment-sorbed contaminants. Thus, the FLESCOT model is recommended to be applied to the 2800-m and 3800-m sites to predict the transport and accumulation of LLW on a regional scale.

Orlanski, I. and M.D. Cox. 1973. Baroclinic instability in ocean currents. Geophys. Astrophys. Fluid Dyn. 4(4):297-332.

Abstract. Unstable waves in a western boundary current are investigated in a full three-dimensional, numerical model. A numerical integration is carried out which traces the evolution of a growing wave on an initially uniform current with vertical shear. As indicated in earlier analytic studies based on simpler 2-layer models (Orlanski, 1969) the current is baroclinically unstable for the observed parameter range of the Gulf Stream. Large meanders of the jet in the western boundary current are noticeable within 10 days. Finite amplitude effects, which can be investigated by the numerical model, reduce the growth rate of the disturbance by nearly an order of magnitude compared to linear theory. Comparison with observations indicate that the meanders of the Florida Current between Miami and Hatteras are probably baroclinically unstable waves.

Osgood, K.E. 1986. Vertical Velocities, Structure and Dynamics of Gulf Stream Meanders in the South Atlantic Bight. Master of Science Thesis. University of North Carolina at Chapel Hill. 67 pp.

Abstract. A triangle array of current meter moorings was deployed within the cyclonic flank of the Gulf Stream in the South Atlantic Bight from September, 1981 to April, 1982. Using the velocity and temperature data and the nondiffusive heat equation, a time series of vertical velocity was derived. A mean vertical velocity of -.016 cm/sec and standard deviation of .108 cm/sec were obtained from the time series. To better understand the subsurface structure of Gulf Stream meanders, the time series of horizontal and vertical velocities and temperature were examined at times when events were passing through the array. Using the horizontal and vertical velocity time series, cross and along stream momentum balances were calculated. The dominant balance in the cross stream equation was found to be geostrophic, whereas in the along stream equation it was found that the Coriolis term and the acceleration terms were of equal importance. In addition, the time series of the momentum equation terms were examined in order to illustrate the dynamics of Gulf Stream meanders.

Osgood, K.E., J.M. Bane Jr. and W.K. Dewar. 1987. Vertical velocities and dynamical balances in Gulf Stream meanders. J. Geophys. Res. 92(C12):13029-13040.

Abstract. A triangular array of current meter moorings was deployed within the cyclonic flank of the Gulf Stream in the South Atlantic Bight from September 1981 to April 1982. Using velocity and temperature data and the nondiffusive heat equation, a time series of vertical velocity was derived. A mean vertical velocity of -0.013 cm/s and standard deviation of 0.078 cm/s were obtained. To better understand the subsurface structure of Gulf Stream meanders, the time series of horizontal and vertical velocities and temperature were examined at times when events were passing through the array. The flow along the trailing edge of a Gulf Stream meander and within the leading portion of a cold core frontal eddy was found to have an upward component (positive w), while that within the trailing portion of the frontal eddy and along the leading edge of a meander had a downward component (negative w). Using the horizontal and vertical velocity time series, cross-stream and along stream momentum balances were calculated. The downstream flow was found to be in geostrophic balance. In contrast, the Coriolis and nonlinear terms were found to contribute equally to the determination of the cross-stream flow.

Ou, H.W., R.C. Beardsley, D. Mayer, W.C. Boicourt and B. Butman. 1981. An analysis of subtidal current fluctuation in the Middle Atlantic Bight. J. Phys. Oceanogr. 11(10):1383-1392.

Abstract. Spectral analysis of subtidal current fluctuations provides evidence for both locally wind-forced response and free waves that propagate downshelf which are not correlated with the local wind.

Ou, H.W. and R. Houghton. 1982. A model of the summer progression of the cold-pool temperature in the Middle Atlantic Bight. J. Phys. Oceanogr. 12(10):1030-1036.

Abstract. A simple model incorporating spatially non-uniform heating, advection and initial temperature field to explain summer progression of the cold-pool temperature in the Middle Atlantic Bight agrees with all the gross features observed in the thermal field.

Owens, W.B. 1991. A statistical description of the mean circulation and eddy variability in the northwestern Atlantic using SOFAR floats. Prog. Oceanogr. 28:257-303.

Abstract. Velocity data obtained from trajectories of SOFAR floats launched as part of several experiments carried out in the Northwest Atlantic during the last two decades are used to give a statistical description of the mean Gulf Stream and its recirculation. The distribution of eddy variability in the region is also presented. A mean Gulf Stream which bifurcates between 55° and 45°W to feed the North Atlantic Current and a southern recirculation can be clearly identified. A weak interior Sverdrup flow is also suggested. The spatial distribution of eddy variability is consistent with previous descriptions, showing a maximum near the Gulf Stream.

Pacheco, A.L. 1988. Characterization of the Middle Atlantic Water Management Unit of the Northeast Regional Action Plan. NOAA Tech. Memo. NOAA-TM-NMFS-F/NEC-56:328.

Abstract. Physical oceanography of the Middle Atlantic Bight; Surficial morphology and sediments of the continental shelf of the Middle Atlantic Bight; Middle Atlantic Bight nutrient availability; Phytoplankton abundance and community size composition in the Middle Atlantic Bight; Zooplankton of the northeast shelf ecosystem with a focus on waters of southern New England and the Mid-Atlantic Bight; Benthic macrofauna of the Middle Atlantic continental shelf; Shellfish; Seasonal distribution, abundance and diversity patterns of fish eggs and larvae in the Middle Atlantic Bight; Fish and fisheries of the Middle Atlantic Bight; Cetaceans, sea turtle, and pinnipeds of the Mid-Atlantic water management unit; Contaminant input, fate and biological effects.

Parker, C.E. 1972. Some direct observations of currents in the Gulf Stream. Deep-Sea Res. 19:879-893.

Abstract. This paper presents a description of currents in the upper layers of the Gulf Stream in an area between 53°W and 73°W and their relationship to the thermal structure within the system. The experiments were done during 1968 and 1969 and demonstrated for the first time that it was possible to trace Gulf Stream currents with drogues for paths greater than 1000 kilometers and that these drogues would maintain their same relative position within the Stream as indicated by the temperature field. It is also shown that the swiftest currents are associated with the left-hand portion of the Stream near the location of the 15°C isotherm at a depth of 200 m and that, in the area studied, both the currents and the cross-stream thermal gradients were reduced by about 50% along the track from west to east. A description of the current and thermal conditions

in two anticyclonic loops is also given.

Parr, A.E. 1933. A geographic-ecological analysis of the seasonal changes in temperature conditions in shallow water along the Atlantic coast of the United States. Bulletin of the Bingham Oceanographic Collection. 4:1-90.

Pashinski, D.J. and G.A. Maul. 1973. Use of ocean temperature while coasting between the Straits of Florida and Cape Hatteras. Mar. Weather Log. 17(1):1-3.

Abstract. Throughout history seafarers have had a need for familiarity with ocean currents. Beyond exploration, a knowledge of the currents is vital to the safe and expedient transport of the mariner's cargo. An early official recognition of the importance of knowing the currents came in 1769 when Benjamin Franklin commissioned the printing of the first char, with the location of the Gulf Stream, to assist the mail packets sailing between England and the Americas.

Pedlosky, J. 1991. The Link between Western Boundary Currents and Equatorial Undercurrents. J. Phys. Oceanogr. 21(10):1553-1558.

Abstract. A constant potential vorticity model is used to investigate the relation between the properties of an equatorward-directed western boundary current and the formation of the Equatorial Undercurrent (EUC) in the western equatorial oceans. It is shown that the value of the Bernoulli function at the equator, undetermined in earlier purely inertial EUC models, is fixed by the bifurcation latitude of the western boundary current that feeds the EUC. This is an additional example of the nonlocal forcing of the EUC by the subtropical gyre. The constant potential vorticity model yields reasonable values for the initial EUC core velocities for a bifurcation latitude on the order of 6° from the equator.

Pelegrí, J.L. and G.T. Csanady. 1991a. Diapycnal Mixing in the Gulf Stream. EOS, Trans. AGU. 72(51):91.

Abstract. We use isopycnal coordinates to analyze the distribution of the Jacobian (dz/drho), total vorticity and potential vorticity for a hydrographic section across the Gulf Stream, off the Mid Atlantic Bight. The distributions show the existence of regions of low Jacobian values in the core of the Gulf Stream ($26.65 < \sigma_\theta < 27.1$), which are responsible for concurrent large values of the potential vorticity. These regions correspond to small Richardson numbers ($Ri<0.25$), caused by high vertical shear in the along-stream velocity.

Pelegri, J.L. and G.T. Csanady. 1991b. Nutrient transport and mixing in the Gulf Stream. J. Geophys. Res. 96(C2):2577-2583.

Abstract. Brewer and Dyrssen (1987) obtained first-order estimates for the nitrate and phosphate transport across the Florida Straits and suggested that the Gulf Stream is a principal source of nutrients for the North Atlantic. The present authors trace this transport further and show that it increases greatly as the stream flows along the continental margin of North America. In addition to estimating total nutrient transport, they also examine the questions of how the transport of water mass and nutrients is distributed over the different

isopycnal layers, what the downstream increase of the transport implies for the circulation of the nutrient-bearing stratum in the ocean interior, and what the changing profile of nutrient transport reveals about processes within the boundary current itself. Specifically, they examine what support there is in the data for the concept of 'western boundary upwelling' (Csanady, 1989). (17 Refs.).

Pertle, W.E. 1987. Synoptic investigation of maritime cyclogenesis during GALE. Master's Thesis. Naval Postgrad. School. 104 pp.

Abstract. Operationally available data and some preliminary Genesis of Atlantic Lows Experiment (GALE) data were used to describe key synoptic and subsynoptic features important to the coastal and ocean cyclogenesis such as mesoscale structure.

Pettigrew, N.R. 1981. The dynamics and kinematics of the coastal boundary layer off Long Island. Ph.D. Dissertation. Massachusetts Institute of Technology/Woods Hole Oceanographic Institution. 262 pp. (WHOI Technical Report No. WHOI-81-14).

Paffenhöffer, G.-A. 1985. The Abundance and Distribution of Zooplankton on the Southeastern Shelf of the United States. pp. 104-117. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. Episodic upwelling of nutrient-rich subsurface water from the Gulf Stream leads, through phytoplankton production, to high zooplankton abundances on the middle and outer southeastern continental shelf (South Atlantic Bight). The most abundant zooplankton taxa in relatively young intrusions are those which reproduce asexually (e.g., doliolids and cladocerans) and small copepods with high rates of egg production. Both groups respond rapidly to increased food supply. Large copepods, with longer generation times, become abundant only after stranded intrusions "age." Zooplankton concentrations in upwelled waters can approach those in quasi-continuously upwelling environments such as off Peru, the Ivory Coast, and Oregon. High concentrations of small zooplankton temporarily support fish larvas, which occur at high average densities (5 to 10 larvae m^{-3}). It is suggested that (1) the episodic nature of upwellings results in discontinuous supplies of food for zooplankton and (2) water displacement, due to winds and motions of the Gulf Stream on the outer shelf, and the predatory behavior of many adult copepods and fish cause high losses of fish larvae. Large stocks of adult fish are not encountered on the southeastern shelf.

Philander, G. 1980. An inviscid model for the Gulf Stream. Ocean Modelling. 30:unpublished manuscript.

Pickart, R.S. 1990. Shallow and Deep components of the North Atlantic Deep Western Boundary Current. Deep-Sea Res. Submitted.

Pickart, R.S. 1991. Investigating how the Deep Western Boundary Current Crosses the Gulf Stream. EOS, Trans. AGU. 72(51):32.

Abstract. A set of recently collected hydrographic sections is analyzed to

determine the manner in which the Deep Western Boundary Current (DWBC) crosses the Gulf Stream. The hydrographic survey consisted of five sections spanning the crossover region, and included measurements of oxygen, chlorofluorocarbons and silicate. Absolute geostrophic velocities are computed by matching the vertically integrated transport between station pairs to *in-situ* transport float measurements. The resulting velocity sections are then cross-stream averaged along density surfaces to remove smaller scale variations; this effectively reduces the deep topographic Rossby wave signal and clearly reveals the DWBC.

Pickart, R.S. 1992. Space-time variability of the deep western boundary current oxygen core. J. Phys. Oceanogr. 22(9):1047-1061.

Abstract. Twelve historical CTD/oxygen sections between the Grand Banks and Cape Hatteras, occupied over the time period 1981-85, are analyzed to investigate the variability of the Deep Western Boundary Current (DWBC) property core. The sections are transformed into a coordinate system of bottom depth versus height above the bottom, then interpolated onto a regular grid in order to facilitate an inter-sectional comparison. The average sections show a high-oxygen core near 3200-m depth, θ = 2.2°C, which corresponds to a region of upward sloping isotherms against the boundary, inshore of the deep Gulf Stream. As the DWBC progresses toward Cape Hatteras it shoals significantly and becomes less dense as a result of mixing with surrounding fluid along its path. There is, however, much scatter about this general alongstream trend and large density fluctuations are correlated with changes in bottom depth and cross-sectional area of the DWBC core. This variability is most likely the downstream response to changes in the overflow source waters of the DWBC. Some of the DWBC appears to recirculate with the deep Gulf Stream near Cape Hatteras (where the two currents cross each other), forming a weaker offshore oxygen core.

Pickart, R.S. and D.R. Watts. 1990a. Deep Western Boundary Current variability at Cape Hatteras. J. Mar. Res. 48(4):765-791.

Abstract. Data from an array of inverted echo sounders and bottom current meters off Cape Hatteras, where the Gulf Stream and Deep Western Boundary Current (DWBC) cross each other, are analyzed to investigate the deep components of flow. While the mean flow is to the southwest with the DWBC, the observed temporal variability is dominated by energetic 40 day topographic Rossby waves. By optimally weighing the individual deep current meter measurements, the deep flow is averaged across the wavelength of the 40 day wave, thereby reducing the wave signal and revealing variations of the spatially averaged DWBC. The DWBC fluctuations are found to be oriented more along the isobaths than the wave motions (which have an essential cross-isobath component). Lateral path displacements of the upper layer Gulf Stream, as measured by the inverted echo sounders, are correlated with deep velocity and temperature fluctuations at specific sites, which can be understood in terms of deep Gulf Stream influence. Cross-slope flow of the spatially averaged DWBC is found to vary with changes in angle of the Gulf Stream path in a manner consistent with simple dynamics.

Pickart, R.S. and D.R. Watts. 1990b. Using the inverted echo sounder to measure vertical profiles of Gulf Stream temperature and geostrophic velocity. J. Atmos. Oceanic Technol. 7(1):146-156.

Abstract. The methodology for converting the travel time measurement of the inverted echo sounder (IES) into an amplitude of the first baroclinic dynamical mode, A_1, is presented. For a Gulf Stream IES record the so-generated $A_1(t)$ time series is used to compute a vertical profile of first mode temperature versus time by perturbing a basic state temperature profile. The basic state is constructed by averaging together historical CTD data collected near the IES site. Similarly the first mode amplitudes are used to perturb a basic state dynamic height profile, and, using neighboring IESs, a profile of alongstream geostrophic velocity is obtained at the same location. (18 Refs.).

Pickart, R.S., X. Qian and D.R. Watts. 1991. SYNOP Inlet Experiment, Bottom Current Meter Data Report for October 1987 to August 1990 Mooring Period. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 91-1:38.

Pickart, R.S., T.K. McKee and W.M. Smethie Jr. 1992. Hydrographic Data from ENDEAVOR 214: A Study of the Gulf Stream--Deep Western Boundary Current Crossover. WHOI Tech. Rep. Draft.

Pierce, S.D. 1986. Gulf Stream velocity structure through combined inversion of hydrographic and acoustic doppler data. Master's Thesis. Woods Hole Oceanogr. Inst. 69 pp. (WHOI Report No.:WHOI-86-41)

Abstract. Near-surface velocities from an acoustic doppler instrument are used in conjunction with CTD/O_2 data to produce estimates of the absolute flow field off of Cape Hatteras.

Pierson, W.J. 1982. The Spectral Ocean Wave Model (SOWM), a northern hemisphere computer model for specifying and forecasting ocean wave spectra. Report DTNSRDC-82/011. David W. Taylor Naval Ship Research and Development Center, Bethesda, MD.

Abstract. Scientific documentation is provided for the Spectral Ocean Wave Model (SOWM) which became operational at the U.S. Navy Fleet Numerical Oceanography Center in 1974. Model concepts and theory are described and the equations and computer program structure are provided. Wave sampling variability effects and their implications for wave modeling are discussed. Limited evaluations of the model with measured data are included and an assessment of the model's use for development of wave climatologies is made. The SOWM model had been used for a twenty year hindcast that provides deep water wave climatological information pertaining to the Cape Hatteras region.

Pietrafesa, L.J. 1981. Continental shelf processes affecting the oceanography of the South Atlantic Bight, progress report. U.S. Dept. of Energy. Washington, D.C. 765 pp.

Pietrafesa, L.J. 1983a. Shelfbreak circulation, fronts and physical oceanography: East and west coast perspectives. pp. 233-250. In D.J. Stanley and G.J. Moore, eds. The Shelfbreak: Critical Interface on Continental Margins, Spec. Publ. 33. Society of Economic Paleontologists and Mineralogists, Tulsa.

Abstract. A survey of fundamental physical oceanographic processes that may affect sediment distribution along shelfbreak regions is presented, emphasizing the Atlantic and Pacific coasts of the USA. The processes encompass the entire spectrum of known motions and are thus generic to all shelfbreak interfacial zones. These shelfbreak strips couple the bounded coastal oceans to the open seas, but there is no systemic pattern to this coupling. In the South Atlantic Bight, the Gulf Stream acts like a vibrating, permeable wall which can variously entrain shelf waters, flood the shelf with North Atlantic Central Water and violently mix shelf waters by towing whirling vortices through the outer shelf. Middle Atlantic Bight, New York Bight and Gulf of Maine shelfbreak processes contain many of the dynamic elements of their southeastern counterpart, but the relative importances of various random surface and offshore driving forces change.

Pietrafesa, L.J. 1983b. Survey of a Gulf Stream frontal filament. Geophys. Res. Lett. 10(3):203-206.

Abstract. An assortment of data is used to map and characterize a Gulf Stream filament. During 21-25 April 1980, a filament was captured as it moved through an array of moored current meters on the northeast Florida continental shelf. Current and temperature time series along with satellite VHRR and aircraft ART are used to reconstruct the event. The event is found to consist of an anticyclonically rotating, warm tongue inshore of a cold dome. The rotational scheme of the current in the warm tongue is opposite to previous hypotheses. Upwelling occurs in both the cold dome region and below the warm tongue.

Pietrafesa, L.J. and R. D'Amato. 1977. Continental Shelf Processes Affecting the Oceanography of the South Atlantic Bight. Progress Report. Department of Energy. :47.

Abstract. Results are reported from studies on the physical and dynamical processes controlling and affecting the distribution of phytoplankton nutrients on the continental shelf in the South Atlantic Bight off the coast of North Carolina, South Carolina, Georgia, and Florida. The initial objectives were to determine the short term, i.e., 2 to 10 days and longer term flux of nutrients onto the continental shelf. This is clearly related to the more general problem of combined physical and biogenic control of phytoplankton nutrients.

Pietrafesa, L.J. and G.S. Janowitz. 1979. A note on the identification of a Gulf Stream spin-off eddy from Eulerian data. Geophys. Res. Lett. 6:549-552.

Abstract. The variability of currents and hydrography along the outer continental shelf of the South Atlantic Bight is occasionally dominated by Gulf Stream frontal spin-off eddies. These eddy events have been recognized as an important mechanism for water mass, nutrient and larvae exchange on the outer shelf. Recent efforts to characterize the dynamics of these events from moored recording current meter data have considered a detection scheme based on a Lagrangian

viewpoint, i.e., that the eddy events are cold core with the velocity vector at a fixed point rotating counterclockwise with time in the horizontal plane. However, as we show in this paper, the horizontal velocity vector at a fixed point can rotate either clockwise or counterclockwise depending on whether the mooring is located to the right or to the left of the center of the eddy as it is advected past the mooring and is independent of sense of rotation of the eddy as viewed by an observer moving with it. Further, depending on the shelf hydrographic season, the eddy event could either warm or cool the shelf locally. Therefore, conventional eddy detection schemes using moored instrument data are lacking in perspective.

Pietrafesa, L.J. and G.S. Janowitz. 1980a. Dynamics of Carolina Capes and Implications for Sediment Transport.

Abstract. Observations from arrays of moored current, temperature and pressure recording instruments, coastal sea level and meteorological stations, shipboard hydrography and satellite imagery are used to describe the circulatory dynamics of the continental margin between Charleston, S.C., and Cape Hatteras, N.C. The semidiurnal tide, inertial oscillations and sea breeze related motions are discussed.

Pietrafesa, L.J. and G.S. Janowitz. 1980b. On the dynamics of the Gulf Stream front in the Carolina Capes. pp. 184-197. In Proceedings of the Second International Symposium on Stratified Flows. Tapin Publishing Co., Trondheim.

Abstract. Concludes that Gulf Stream meanders are vertically coherent, skewed, wave-like motions that propagate northeastward, have wave lengths from 90 to 260 km, and have periods of three to eight days.

Pietrafesa, L.J. and G.S. Janowitz. 1985. Physical Oceanographic Processes Affecting Larval Transport around and Through North Carolina Inlets. Department of Energy. DOE/ER/60376-12B:46.

Abstract. Atlantic Spot, Flounder, Croaker and Menhaden all spawn in shelf waters of North Carolina during late fall to early winter. The juveniles use estuaries such as Pamlico Sound and the Cape Fear River as nurseries during their first winter and spring. Previous studies of recruitment into the estuaries through barrier island inlets or estuarine mouths assume that the pre and post metamorphosed larvae enter the estuaries at the bottom of the water column and move upstream thereafter. The mechanisms were presumed tidal. The Pamlico Sound has several inlets, Oregon, Hatteras and Ocracoke, through which larvae can enter not only during flood stages of the tide but also in the presence of favorable oceanic to estuary sea level pressure gradients. The Cape Fear River has a strong semi-diurnal tidal flow both flood and ebb and also responds vigorously to one-sided divergences and convergences at its mouth. Flow, looking out of the mouth, is in at the left and out on the right. The conclusions are that, in addition to flooding tides, non-local forcing at the estuary mouths can effect transport of larval fish through the estuary mouths, throughout the entire water column.

Pietrafesa, L.J. and G.S. Janowitz. 1988. Physical Oceanographic Processes Affecting Larval Transport around and through North Carolina Inlets. pp. 34-50. In M.P. Weinstein, ed. Larval Fish and Shellfish Transport through Inlets--American Fisheries Society Symposium 3. American Fisheries Society, Bethesda.

Abstract. Atlantic croaker Micropogonias undulatus, flounders Paralichthys spp., spot Leiostomus xanthurus, and Atlantic menhaden Brevoortia tyrannus all spawn in the continental shelf waters of North Carolina during late fall to early winter. The juveniles use the bays and tributaries adjoining estuaries such as Pamlico Sound and the Cape Fear River as nurseries during their first winter and spring. In previous studies of recruitment into the estuaries through barrier island inlets or estuarine mouths, it was assumed that both larvae and juveniles entered the estuaries at the bottom of the water column and moved upstream thereafter. The mechanisms were presumed to be tidal. Larvae can enter Pamlico Sound through Oregon, Hatteras, and Ocracoke inlets not only during flood stages of the tide but also in the presence of favorable ocean-to-estuary sea-level pressure gradients. The Cape Fear River has strong semidiurnal flood and ebb tidal flows and also responds vigorously to one-sided divergences and convergences of the adjacent coastal ocean. Facing seaward, flow at the river mouth is in at the left and out on the right. We conclude that, in addition to flooding tides, nonlocal forcing at the estuary mouths can effect transport of larval fish through the estuary mouths, throughout the entire water column.

Pietrafesa, L.J. and R.H. Weisberg. 1979. Summary and analysis of physical oceanographic and meteorological information on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. Environ. Res. Tech., Concord, MA. 3(6) Doc. P-2904:369-548.

Abstract. Summarizes meteorological data for the South Atlantic Bight.

Pietrafesa, L.J., J.O. Blanton and L.P. Atkinson. 1978. Evidence for deflection of the Gulf Stream at the Charleston Rise. Gulfstream. 4(9):3,6-7.

Abstract. Documents hydrographic data, nutrient data, and remotely-sensed imagery of sea surface topography to support the deflection theory.

Pietrafesa, L.J., R. D'Amato, C. Gabriel and R.J. Sawyer Jr. 1978a. Continental Margin Atmospheric Climatology and Sea Level 1974-75. UNC Sea Grant Pub. UNC/SG-78/09:217.

Abstract. Atmospheric wind and pressure have been examined and correlated with coastal sea level changes at various coastal stations along the South Atlantic Bight. The atmospheric climate overlying the South Atlantic Bight is determined by both polar and tropical marine air masses, resulting in a 'temperature rainy' climate with mild winters, long hot summers, and adequate moisture in all seasons. Wintertime extratropical cyclones can affect the coastal oceanic circulation in a number of direct and indirect ways. Two years of hourly heights, recorded to the nearest 2-3 centimeters, were analyzed at each sea level station. Three hourly observations of atmospheric pressure and wind speed direction were obtained from the Savannah and Wilmington airports and Charleston and Cape Hatteras coastal stations. Alongshore winds tend to dominate both in magnitude

and duration relative to the cross-shelf components. Wind stress reversals, noted at all of the meteorological stations, occurred on time scales of several days to several weeks, which is the typical period of forcing within the atmospheric stress continuum.

Pietrafesa, L.J., R. D'Amato, C. Gabriel and R.J. Sawyer Jr. 1978b. Continental margin atmospheric climatology and sea level. Center for Marine and Coastal Studies Tech. Rep. 78-4, 189 pp.

Abstract. Investigation of the role of atmospheric forcing on coastal sea level height along the Atlantic coast.

Pietrafesa, L.J., R. D'Amato, C. Gabriel and R.J. Sawyer Jr. 1978c. Continental Margin Atmospheric Climatology and Sea Level (Historical Setting 1974--1975). Department of Energy. :300.

Abstract. From the many continental shelf dynamics studies which have been made in the past decade, it has become increasingly apparent that a detailed analysis of continental margin waters can only be accomplished with an appreciation of the coastal meteorology. Fortunately, coastal meteorological and, in addition, coastal sea level data have been archived and thus provide coastal oceanographers with inexpensive, priceless and complimentary data sets. Past coastal sea level studies have demonstrated that these data contain not only tidal data but also sub-inertial frequency information which measurably details shelf response to atmospheric forcing. Additionally, a particular region, such as the South Atlantic Bight, can be characterized by the statistics of the temporal spectra of both data sets as well by the alongshore coherences which may exist between stations. In this study, atmospheric wind and pressure have been examined and correlated with coastal sea level changes at various coastal stations along the South Atlantic Bight. (ERA citation 03:045436).

Pietrafesa, L.J., J.O. Blanton, J.D. Wang, V. Kourafalou, T.N. Lee and K.A. Bush. 1985a. The Tidal Regime in the South Atlantic Bight. pp. 63-76. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. Tidal currents, particularly at the M_2 frequency, dominate South Atlantic Bight inner shelf and midshelf dynamics, with M_2 tides accounting for almost 80% of the total kinetic energy there. Maximum energy occurs offshore of Savannah, where the shelf is widest. Outer shelf dynamics are less influenced by tides and more dependent on Gulf Stream interaction. There appear to be some seasonal differences in the tidal currents. A simple vertically integrated two-dimensional tidal model was used to reproduce tidal characteristics in the midshelf region during well-mixed winter conditions.

Pietrafesa, L.J., G.S. Janowitz, J.M. Miller, E.B. Noble and S.W. Ross. 1985b. Abiotic Factors Influencing the Spatial and Temporal Variability of Juvenile Fish in Pamlico Sound, North Carolina. Department of Energy. DOE/ER/60376-11B:26.

Abstract. A 3-D, time dependent model of the circulation in Pamlico Sound, NC,

is used to relate the direction and magnitude of winds to the number of juvenile fish sampled at specified estuarine nursery locations. NC marine sport fishes are known to be spawned in NC continental waters, and then make transit to an through barrier island inlets, into Pamlico Sound. The juveniles then move 40-70 kilometers across the Sound to the nurseries. It is hypothesized that wind driven, pressure gradient induced and topographically steered currents, all abiotic factors, provide the transport mechanisms, during the recruitment period February-April, necessary for the transect. Moreover, the inherent variability in the atmospherically derived physical factors and the influence of topographic irregularities such as a large shoal which laterally bisects the Sound and bifurcates the bottom currents are seen as sources of the temporal and spatial variation observed in the distribution of juvenile fish, while the influence of biological processes is viewed as providing fine-tuned structuring.

Pietrafesa, L.J., G.S. Janowitz and P.A. Wittman. 1985c. Physical Oceanographic Processes in the Carolina Capes. pp. 23-32. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. Oceanographic processes in the Carolina Capes region of the South Atlantic Bight are influenced by the cuspate shore line and prominent shoals that extend to the shelf break. Meteorological, hydrographic, and moored current data indicate that synoptic scale wind and Gulf Stream events are the primary driving forces in the region. Topographically enhanced upwelling may be important at the shelf break.

Pietrafesa, L.J., G.S. Janowitz, S.-Y. Chao, R.H. Weisberg and F. Askari. 1986. Physical Oceanography of Pamlico Sound. UNC Sea Grant Pub. UNC/SG/WP-86/5:139.

Abstract. The report is Part I of a two-part report on the physical oceanography of Pamlico Sound and the peripheral nursery regions. Part I provides an overview of the present knowledge based on field and modeling studies of the sound proper, conducted principally at North Carolina State University (NCSU). The sound field program at NCSU was conducted during 1978 and 1979. The modeling effort was also conducted at NCSU during 1979 and 1980. While the sound study was under way, an NCSU continental shelf program was also in place in the Carolina Capes coastal waters. This allowed for a coherent, coupled study. The studies have provided new insights into how fish are recruited from the Gulf Stream to the coast through barrier island inlets and across the sound to the nurseries.

Pietrafesa, L.J., G.S. Janowitz, K.S. Brown, F. Askari and C. Gabriel. 1988. Invasion of the Red Tide in North Carolina Coastal Waters. UNC Sea Grant Pub. UNC/SG/WP-88/1:40.

Abstract. The red tide outbreak of 1987 was disastrous to the North Carolina shellfish industry. Although this appears to have been a singular event in remembered history, it is entirely possible that it happened previously to some lesser degree and moreover that it could happen again. The possibility of a future outbreak of the red tide in North Carolina coastal waters hinges on the sequential occurrence of a set of specific biological, meteorological and

physical oceanographic conditions. Since red tide outbreaks are a common occurrence on the west Florida shelf then the assumption is that conditions there are a contributory factor. The occurrence of a high pressure system over the northern Gulf of Mexico coupled with a dinoflagellate outbreaks on the south Florida Gulf coast appear to be essential to red tide outbreak on the N.C. coasts.

Pietrafesa, L.J., J.M. Morrison, M.P. McCann, J. Churchill and R.W. Houghton. 1992. Water Mass Linkages Between the Middle and South Atlantic Bights. Cont. Shelf Res.

Abstract. Time and frequency domain analysis are used to relate coastal meteorological data with seven years of daily surface temperature and salinity collected on the North Carolina cape shoals and Chesapeake Bay. Salinity on Diamond Shoals, the Cape Hatteras extension, is highly correlated with alongshore wind stress implying wind driven advection of the front between Virginia Coastal Water and Carolina Coastal Water across the shoal axis. The data collected at the shoals suggest that more than 50% of the time there is significant leakage of MAB water into the SAB around Cape Hatteras, contrary to the notion that VCW is entirely entrained into the Gulf Stream. In fact VCW can appear as far south as Frying Pan Shoals, covering the entire North Carolina Capes inner to mid shelf. Temperature and salinity time series also indicate that water masses directly over Diamond Shoals quickly respond to cross-shelf winds. Cross-shelf wind stress is significantly correlated with surface temperature at Diamond Shoals at periods less than 14 days. Changes in temperature can be brought about by wind driven cross-shelf circulation and by wind induced upwelling. AVHRR imagery taken during the SEEP II, spring 1988 experiment confirm these concepts.

Pietrafesa, L.P. 1989. The Gulf Stream and Wind Events on the Carolina Capes Shelf. pp. 89-129. In R.Y. George and A.W. Hulbert, eds. NOAA-NURP Rep. 89-2. National Undersea Research Program.

Abstract. The subdiurnal frequency motions and thermohaline distributions on the Carolina Capes continental shelf are controlled by navifacial momentum and buoyancy flux exchanges and offshore Gulf Stream frontal events. Atmospheric forcing dominates current fluctuations and thermohaline variability in inner to midshelf waters in which Gulf Stream frontal meanders and filaments become increasingly more important from middle to outer continental shelf waters. Gulf Stream frontal events are created as a result of the interaction of the Gulf Stream and the Charleston Bump, a topographic feature at 32°N, 79°W, and propagate north into North Carolina waters. The alongshore component of the wind provides the principal forcing of inner to mid-shelf waters. Wind effects are manifested directly and mechanically via Ekman dynamics, but also occur indirectly through the setup of coastal pressure gradients. The mid to inner shelf current field consists of a wind driven surface component and slope currents which extend throughout the water column and are geostrophically coupled to both surface and mass field slopes. The bottom boundary layer consists of geostrophic and bottom stress induced current components.

Pilkey, O.H. and M.E. Field. 1972. Chapter 21 Onshore Transport of Continental Shelf Sediment: Atlantic Southeastern United States. pp. 429-446. In D.J.P. Swift, D.B. Duane and O.H. Pilkey, eds. Shelf Sediment Transport: Process and Patterns. Dowden, Hutchinson and Ross, Inc., Stroudsburg.

Abstract. Several lines of evidence indicate beach and estuarine sands from the southeastern United States Atlantic coast are derived in part from the adjacent continental shelf. Abundance anomalies of phosphorite grains, total gold content, ooids, and various heavy mineral (in particular, epidote, staurolite, and garnet) on the shelf show a close correspondence to abundance anomalies in adjacent shoreline and near-shore environments. Carbonate content and textural parameters of beach and shelf deposits show a correlation between the two environments on a regional scale. Close correlation of shelf- and shore-sediment parameters may reflect ultimate derivation of sediment from similar sources or similar environments of deposition during Pleistocene sea-level fluctuations other than from onshore transportation. However, it can be shown that oolitic grains in central Florida beach sands and phorphorite grains on North Carolina beaches originate exclusively from continental shelf sources lying appreciable distances (up to 20 km) offshore, thus demonstrating onshore transportation in these cases. Furthermore, presence of easily abraded, shelf-derived oolite grains in quartz beach sands is evidence of onshore transportation occurring at present. Some of the inferred movement of sediment may have occurred actually by the simple process of landward migration of the surf wedge or shoreface during the last rise in sea level rather than by present-day processes. Possible mechanisms of present-day movement include asymmetry of shoaling waves, and tidal and storm-induced currents. This close correlation between beach- and shelf-sediment characteristics may provide an excellent basis for low-cost mineral reconnaissance on the continental shelf by preliminary beach sampling. Delineation of economic mineral deposits along the coast may facilitate location of similar deposits in adjacent offshore regions and reduce the necessity for costly regional shelf reconnaissance.

Pochapsky, T.E. and F.D. Malone. 1972. A Vertical Profile of Deep Horizontal Current Near Cape Lookout, North Carolina. J. Mar. Res. 30(2):163-167.

Abstract. The acoustic transit times for a float to sink to a bottom-anchored triangular array of disposable transponders are used to construct a horizontal current profile in the anticyclonic shear region of the Gulf Stream, southeast of Cape Lookout, North Carolina. The main features of the currents and temperatures, including the depth of the layer of no motion, are similar to those obtained by Swallow and Worthington (1961) 13 years earlier from a hydrographic section near this location. Fluctuations in the change of current with depth are small.

Popenoe, P., E.L. Coward and K.V. Cashman. 1982. A regional assessment of potential environmental hazards to and limitations on petroleum development of the southeastern United States Atlantic continental shelf slope, and rise offshore North Carolina. U.S. Geol. Surv. Open-File Rep. 82-136:67.

Abstract. Describes the seafloor along the Florida-Hatteras shelf as potentially hazardous for petroleum development due to extremely hard and rugged bottom. Describes the relief along the shelf break as varying from 0.5 m to 15 m in

height.

Price, J.F. and H.T. Rossby. 1982. Observations of a barotropic planetary wave in the western North Atlantic. J. Mar. Res. 40(Suppl.):543-558.

Abstract. SOFAR float observations from 1300 m depth are used to describe a major feature of the large-scale, subthermocline velocity field observed in the western North Atlantic that had many of the characteristics of a barotropic planetary wave.

Priddy, L.J. and R. Carraway. 1978. Inlet hazard areas, the final report and recommendations to the coastal resources commission, the North Carolina Department of Natural Resources and Community Development, 51 pp.

Abstract. The Division will develop and apply a Commission approved method for the identification and delineation of hazard areas adjacent to existing inlets for use by the Commission in designating Inlet Lands AEC's in the vicinity of inlets.

Qian, W. and C.-C.A. Lai. 1991. Applications of Anomaly Correlation and Pattern Correlation to the Verification of Gulf Stream Forecast. EOS, Trans. AGU. 72(44):260.

Abstract. The seven evaluation measures for Gulf Stream forecast proposed by Lai (1991) provide not only the choices of measures but also the possibility of wider application. This research concentrates on the applications of two measures - anomaly correlation and pattern correlation - because of their interesting difference. Harvard open ocean primitive equation model output of temperature fields are verified against the "best available" operation analysis of temperature fields provided by Navy's OTIS package. Levitus' (1982) climatology fields are used in computing anomaly correlation. The results show the dependency of the correlations on the resolution of the analysis field and the domain of concern. The correlations are also computed for 1-dimensional feature, e.g., the Gulf Stream axis. The results are compared with those of 2-dimensional fields.

Qian, X., K. Tracey, E. Fields and D.R. Watts. 1990. The SYNOP Experiment: Inverted Echo Sounder Data Report for October 1987 to May 1988. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 90-3:157.

Raman, S. 1991. Mesoscale Atmospheric Convergences Over the Gulf Stream and Their Implications on Remote Sensing of Sea Surface Roughness. EOS, Trans. AGU. Suppl to 72(17):148.

Abstract. The geography along the southeast coast of the United States is unique in that during winters the cold continent is bounded by the relatively warmer shelf/slope water which is again bounded by the consistently warmer Gulf Stream waters. The slightly cooler Sargasso sea region borders the Gulf Stream in the east. Each of these underlying surfaces caused a different response in the marine boundary layer growth and its structure due to changes in the stability parameters and surface roughness. Low level convergence and acceleration of wind occur changing the structure of the marine boundary layer. This leads to the

common occurrence of a low level jet in response to the boundary layer baroclinicity. Mesoscale circulations in this region also produce Gulf Stream cloud and rainbands. Winter, Summer and Fall observations of the wind structure over the Gulf Stream will be presented and their implications on changes in surface roughness observed by microwave remote sensing discussed.

Raman, S. and A.J. Riordan. 1988. The Genesis of Atlantic Lows Experiment: The Planetary-Boundary-Layer Subprogram of GALE. Bulletin of the American Meteorological Society. 69(2):161-172.

Abstract. The Genesis of Atlantic Lows Experiment (GALE), focused an intensive data-gathering effort along the mid-Atlantic coast of the United States from 15 January through 15 March 1986. Here, the general objectives and experimental layout are described with special emphasis on the planetary-boundary-layer)PBL) component of GALE.

Ramp, S.R. 1989. Moored observations of current and temperature on the shelf and upper slope near ring 82B. J. Geophys. Res. 94(C12):18071-18087.

Abstract. An array of current meters deployed along the continental shelf and upper slope from April 15 to July 1, 1982, as part of the Warm Core Rings Experiment. The array consisted of four mooring sites long the 325-m isobath making the 'X' with another line of moorings extending from the 60-m to the 900-m isobath. The purpose of the array was to examine the current and temperature variability induced at the shelf break and upper slope by the formation and passing of ring 82B. The velocity records consisted of 2- to 10-day fluctuations embedded on a long-period signal with a period ranging from 15 to 26 days, increasing offshore. The temperature records contained three time scales: The 2- to 10-day scale, longer (about 1-2 months) scales due to mopvements of the shelf-slope front induced by the ring, and an increasing trend due to seasonal warming. The 2- to 10-day fluctuations of velocity and temperature appear to be visually correlated with small (sub-ring) scale undulations along the shelf-slope front as seen in the advanced very high resolution radiometer (AVHRR) sea surface temperature imagery on an event by event basis.

Rao, P.K., A.E. Strong and R. Koffler. 1971. Gulf Stream meanders and eddies as seen in satellite infrared imagery. J. Phys. Oceanogr. 1(3):237-239.

Abstract. Examination of use of satellite imagery data to characterize dominant oceanic flow and features. With the launching of several earth-orbiting satellites carrying infrared (IR) radiometers, it has now become possible to detect structure in sea surface temperature distributions under relatively clear sky conditions. This brief report shows two informative examples of surface temperature distributions over the western Atlantic which were detected by means of data from the scanning radiometer on the Improved TIROS Operational Satellite-1 (ITOS-1).

Redfield, A.C. 1958. The influence of the continental shelf on the tides of the Atlantic coast of the United States. J. Mar. Res. 17:432-448.

Abstract. Concludes that shelf topography is a major factor in local tidal variations.

Regal, R. and C. Wunsch. 1972. M_2 tidal currents in the Western North Atlantic. Deep-Sea Res. 20(5):493-502.

Abstract. A number of current meter records collected by the Woods Hole Oceanographic Institution have been examined to determine the structure of M_2 tides in the western North Atlantic. Though the signal to noise ratio is low, a simple picture emerges when sufficiently many records are averaged. At a site north of the Gulf Stream, the tidal current is baroclinic, and concentrated near the surface. The result is consistent with generation of internal tides along the continental slope just to the north. At positions south of the Gulf Stream, the records are too few to conclude more than that the tidal velocities are consistent with high mode internal waves.

Research Inst of the Gulf of Maine. 1976. Summary of Environmental Information on the Continental Slope Canadian/United States Border to Cape Hatteras, N.C. U.S. Dept. Interior, BLM Rep. No. BLM/NYOCS-01A:353.

Abstract. The results of an environmental survey of the Mid-Atlantic and North Atlantic Regions of the Outer Continental Slope are described. This region is the area extending from Cape Hatteras, N.C. to the U.S./Canada border and from the 200 to 2000 meter depth contour; however, many topic areas include information from the continental shelf break to the Gulf Stream. The continental slope is a complex feature representing the transition between two principal levels of the earth's surface, the low density rocks of the continent and the high density rocks of the ocean floor. In the northwest Atlantic, the slope width averages 100 km (62 mi). This relatively narrow band of ocean is a region of change. The geologic structure is a transitional one. The physical and chemical characteristics of the water are highly variable, reflecting the mixing between several major water masses; the coastal waters, Gulf Stream, Labrador Current and western boundary undercurrent. The flora and fauna of the study region are highly diverse.

Resio, D.T. and B.P. Hayden. 1975. Recent secular variations in Mid-Atlantic winter extratropical storm climate. J. Appl. Meteorol. 14(7):1223-1234.

Abstract. Presents areal distributions and interannual climatology of extratropical cyclones.

Reverdin, G. and W.M. Smethie Jr. 1991. Modelling Spatial and Temporal CFC Distributions in the DWBC. EOS, Trans. AGU. 72(51):32.

Abstract. The uniform boundary current model for the north Atlantic DWBC developed by Pickart et at. (1989) has been fit to CFC data collected between 1983 and 1990 in the western north Atlantic. The CFC source function for the model includes CFC input from Denmark Strait Overflow Water (DSOW) and Gibbs Fracture Zone Water (GFZW). Analysis of the potential temperature and salinity characteristics of the deep core of the DWBC (defined by the deep subsurface maximum of CFCs) suggests that the deep core is composed of about two-thirds GFZW and one-third DSOW. However, 80% or more of the CFC signal in the deep core of the DWBC comes from DSOW which appears to form in the Iceland Sea by convection during winter and to flow through Denmark Strait within a year after formation. The model fit the CFC data at several locations along the western boundary

between 32° and 45°N and at several different times.

Rhines, P.B. 1970. Edge, bottom, and Rossby waves in a rotating stratified fluid. Geophys. Fluid Dyn. 1:273-302.

Richardson, P.L. 1970. Transport and Velocity of the Gulf Stream at Cape Hatteras. Master of Science Thesis. Univ. of Rhode Island, Kingston. 106 pp.

Richardson, P.L. 1974. Current measurements under the Gulf Stream near Cape Hatteras, North Carolina. Univ. R.I., Grad. School Oceanogr. Tech. Rep. Ref. 74-3:141.

Abstract. Data report on Gulf Stream current velocity observations. Measurements were made in the Gulf Stream and Western Boundary Undercurrent in order to determine how the two currents cross each other near Cape Hatteras, North Carolina.

Richardson, P. 1976. Gulf Stream rings. Oceanus. 19(3):65-68.

Abstract. Provides general description of distribution, movement, and decay of several Gulf Stream rings.

Richardson, P.L. 1977. On the crossover between the Gulf Stream and the Western Boundary Undercurrent. Deep-Sea Res. 24:139-159.

Abstract. Utilizes current meter data to describe the crossover of the Gulf Stream and Western Boundary Undercurrent (WBUC) near Cape Hatteras, noting the WBUC flows southwest under the Gulf Stream parallel to bottom contours.

Richardson, P.L. 1980. Gulf Stream ring trajectories. J. Phys. Oceanogr. 10(1):90-104.

Abstract. During the period 1976-78, the movement of 14 Gulf Stream rings, including two anticyclonic and 12 cyclonic rings, was measured with satellite-tracked free-drifting buoys. The buoys in the cyclonic rings showed a tendency to move out toward the high-velocity region of the ring and to remain there circling the center. One buoy stayed in a ring as long as 8 months and completed 86 loops. Periods of rotation ranged from less than 2 days up to 10 days. The movement of the rings was complicated and appears to be related to the Gulf Stream and strong topographic features such as the New England Seamounts.

Richardson, P.L. 1983. Gulf Stream rings. Chapter 3. pp. 19-45. In A. Robinson, ed. Eddies in marine science. Springer-Verlag, New York.

Abstract. Documents the absorption of a specific cold core ring into the Gulf Stream, which may result in some of the strongest currents found on the offshore edge of the Gulf Stream.

Richardson, P.L. and J.A. Knauss. 1970. Transport and velocity of the Gulf Stream at Cape Hatteras. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 31(Ref. 70-1):110.

Abstract. Estimate of absolute velocity and volume transport based on specified level of no motion.

Richardson, P.L. and J.A. Knauss. 1971. Gulf Stream and Western Boundary Undercurrent observations at Cape Hatteras. Deep-Sea Res. 18:1089-1109.

Abstract. During July 1967 three volume transport measurements of the Gulf Stream were made off Cape Hatteras, North Carolina. The measurements were made using 'transport floats', free falling instruments which measure the vertically averaged horizontal velocity and depth. The transport values were 58, 67 and 64 X $10^6 m^3/sec$; the average transport was 63 X $10^6 m^3/sec$. The edge of the Gulf Stream for these determinations was defined as the point at which the transport per unit width of the Stream vanished. The transport refers to values normal to a baseline bearing 135°. The velocity measurements indicated that the Gulf Stream extends to the bottom underneath the offshore of the high speed surface layer. A deep southward flow was found on both sides of the deep northward flow. A single hydrographic section was also made across the Gulf Stream. Absolute velocities of the geostrophic currents were determined by forcing the geostrophic transport to agree with the direct transport measurements. An analysis of the temperature-salinity and dissolved oxygen distributions failed to reveal discontinuities between the deep north and south flows. These properties can be related to water properties in the slope water region and Labrador Basin and thus indicate that the southward flowing water is the Western Boundary Undercurrent.

Richardson, P.L. and J.A. Knauss. 1972. Observations of a cyclonic eddy southeast of Cape Hatteras. EOS, Trans. AGU. 53(4):393.

Abstract. A cyclonic Gulf Stream eddy or Gulf Stream ring is presently being tracked southeast of Cape Hatteras, North Carolina. In May 1971, the eddy was near 32°45' N, 73°30'W. It was characterized by a) surface temperatures of 19°C, three degrees cooler than normally found in this location and time b) a cold core which was a maximum of 8°C cooler than temperatures outside the eddy and which extended to at least 3,000 m, and c) a surface cyclonic circulation of approximately 1 knot. The shape of the eddy was elliptical with the size of the 15°C isotherm at 500 m approximately 65 by 110 miles. The major axis was at 030°T. The size based on rising isotherms may be as large as 150 to 175 miles. In October 1971, the eddy moved to 31°00' N, 75°10' W and was located over the Blake Bahama Outer Ridge. The surface temperature was similar to temperatures in adjacent areas of the Sargasso Sea. The surface velocity, the temperatures below 150 m and the size were approximately the same as in May. The shape was circular. These plus confirming measurements from March 1971 through January 1972, suggest that the eddy moved southwest at about one mile per day.

Richardson, P.L., R.E. Cheney and L.A. Mantini. 1977. Tracking a Gulf Stream ring with a free drifting surface buoy. J. Phys. Oceanogr. 7(4):580-590.

Abstract. A newly developed buoy which is free drifting and tracked by satellite was successfully used to measure the movement of a Gulf Stream ring. The buoy,

launched in a young ring at 36°15'N, 58°00'W, looped around its center with a period of 54 h, radius of 25 km and speed of 75 cm/s. For two months the ring moved rapidly and consistently to the northeast with an average speed of 9 cm/s. An airborne XBT survey and satellite infrared radiometry measurements provided evidence that the ring coalesced with the Gulf Stream near 53°W. This study presents the most convincing evidence yet that a ring can coalesce with the Gulf Stream. When this result is combined with the results of other studies, there is a suggestion that rings may coalesce with the Gulf Stream more frequently than previously believed.

Richardson, P.L., R.E. Cheney and L.V. Worthington. 1978. A census of Gulf Stream rings, spring 1975. J. Geophys. Res. 83(C12):6136-6144.

Abstract. During 1975 several shipboard expendable bathythermograph surveys plus satellite infrared imagery provided a nearly synoptic view of the distribution and number of Gulf Stream rings in the western North Atlantic. Twelve rings were identified; none were cyclonic (cold core) rings and three were anticyclonic (warm core) rings. This is the largest number of rings ever observed during a short period of time (4 months). Evidence suggests that the mean movement of these rings was southwestward.

Richardson, W.S., W.J. Schmitz Jr. and P.P. Niiler. 1969. The velocity structure of the Florida Current from the Straits of Florida to Cape Fear. Deep-Sea Res. 16:225-231.

Abstract. Provides descriptive data of transport fluctuations, volume transport, and velocity structure to describe vertical configuration of velocity section.

Richmond, B.M. and A.H. Sallenger Jr. 1984. Cross-shore transport of bimodal sands. Proceedings of the 19th International Coastal Engineering Conference. :1997-2008.

Abstract. Foreshore sediment level and sediment size were monitored as part of an extensive nearshore processes experiment - DUCK 82. Changes in foreshore testure were compared with computed values of onshore transported material based on current measurements from the surf zone and sediment transport theory (Bagnold, 1963, 1966). Preliminary results indicate reasonable agreement between predicted size of sediment transported onshore and beach texture changes. It is also demonstrated that coarse sediment may move onshore while finer material may simultaneously move offshore.

Riggs, S.R. and M.P. O'Connor. 1975. Geological Bibliography of North Carolina's Coastal Plain, Coastal Zone, and Continental Shelf. UNC Sea Grant Pub. UNC-SG-75-13:141.

Abstract. One of the major objectives in the State Program for Marine Science in North Carolina is the accumulation and dissemination of basic marine science information to the general public, academic and scientific communities, and to the governmental agencies involved in various aspects of coastal zone management. It is hoped this bibliography which deals with the basic geologic materials and processes of this dynamic coastal zone will help meet this objective and will allow man to more readily live with and use this exciting portion of our

environment in harmony with the natural system.

Roberts, M.H., Jr. 1974. A Socio-Economic Environmental Baseline Summary for the South Atlantic Region between Cape Hatteras, North Carolina and Cape Canaveral, Florida. Volume III. Chemical and Biological Oceanography. U.S. Dept. Interior, BLM Rep. No. BLM/YM/ES-74/7:808.

Abstract. This report provides an overview of marine chemistry, including biologically active material, suspended solids, organic pollutants, and heavy metals, and marine biology, including phytoplankton communities and productivity, zooplankton communities, benthic communities, marine fisheries, marine mammals, coastal zone birds, and coastal vegetation for the coastal and oceanic areas of the southeastern United States. The report summarizes significant regional literature, 1974 and previous.

Robinson, A.R. 1987. Predicting Open Ocean Currents, Fronts, and Eddies. pp. 89-112. In J.C.J. Nihoul and B.M. Jamart, eds. Three Dimensional Ocean Models of Marine and Estuarine Dynamics. Elsevier Science Publishers, B.V., Amsterdam.

Robinson, A.R., N.E. Huang, C.D. Leitao and C.G. Parra. 1983. A study of the variability of ocean currents in the northwestern Atlantic using satellite altimetry. J. Phys. Oceanogr. 13(4):565-585.

Abstract. New technique utilizing all points along the satellite tracks is applied to data from GEOS-3 during 1975-1978 for a region which includes part of the Gulf Stream. Results include spatial distribution of geostrophic eddy kinetic energy and examples of a synoptic map of the eddy field and are generally in good agreement with *in situ* observations.

Robinson, A.R., J.R. Luyten and F.C. Fuglister. 1974. Transient Gulf Stream Meandering. Part I: An Observational Experiment. J. Phys. Oceanogr. 4(2):237-255.

Abstract. The results from an observational experiment on the mesoscale space-time variability of the Gulf Stream are reported. Various techniques, including aerial surveys, ship trackings of the 15°C isotherm at 200 m, drogues and moored current meters were used and are compared, to give estimates of the variability of the motion over a wide range of scales. A two-week time series of daily tracks of the Stream near 70°W are used to interpolate instantaneous paths over 2° of longitude. These paths provide the first detailed information on the small-scale variability of the path indicator of the Gulf Stream northeast of Cape Hatteras. Similarly, the long time series of triweekly aerial surveys provides a detailed picture of the evolution of a large-scale meander.

Rodolfo, K.S., B.A. Buss and O.H. Pilkey. 1971. Suspended Sediment Increase Due to Hurricane Gerda in Continental Shelf Waters Off Cape Lookout, North Carolina. J. Sed. Petrol. 41(4):1121-1125.

Abstract. Suspended sediment concentrations and average grain sizes in surface and near-bottom inshore waters off Cape Lookout, North Carolina increased significantly following the passage of Hurricane Gerda in September, 1969. This

effect was dissipated within a week after the hurricane. Transport of inner shelf sediment to the outer Carolina shelf may be accomplished mainly by such storms.

Roelvink, J.A. and J.F. Stive. 1989. Bar-generating cross-shore flow mechanisms on a beach. J. Geophys. Res. 94(C4):4785-4800.

Abstract. Random waves normally incident on a dissipative beach induce a variety of cross-shore flow, such as asymmetric oscillatory flow, wave grouping-induced long-wave flow, breaking-induced turbulent flow, and momentum decay-induced undertow. These flows are identified, analyzed and hindcasted in a set of laboratory experiments with the aim of revealing the role of each of the flow mechanisms in the two-dimensional case of bar generation on a beach.

Rogers, S.G. and M.J. Van Den Avyle. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic) - Atlantic Menhaden. U.S. Fish and Wildlife Service, Division of Biological Services. FWS/OBS-82/11.11:30.

Abstract. Species profiles are literature summaries of the taxonomy, range, life history, environmental requirements, and significance of coastal aquatic species. They are prepared to assist in environmental impact assessment. The Atlantic menhaden, Brevoortia tyrannus, contributes 25% to 40% of the landings of the largest commercial fishery (by weight) in the United States. Landings for 1979-81 averaged about 400,000 mt (440,920 t) and $38 million annually. All ages are important prey for many fishes and birds; the species is a seasonally important and migratory component of estuarine and shelf fish assemblages. In the South Atlantic, major spawning occurs from December through February near Cape Hatteras, North Carolina, in shelf waters that are 100-200 m (328-655 ft) deep. Atlantic menhaden occur in a broad range of temperatures and salinities. Larvae move toward low-salinity areas upon entering estuaries, and prejuveniles are dependent on low-salinity marsh habitats and river shoals for nurseries.

Rooney, D.M., G.S. Janowitz and L.J. Pietrafesa. 1978. A simple model of deflection of the Gulf Stream by the Charleston Rise. Gulfstream. 4(11):3-7.

Abstract. Describes model based on earlier ocean station data and satellite imagery proposing that the deflection observed around the Charleston Bump is caused by bottom topography.

Rosati, J.D., K.J. Gingerich and N.C. Kraus. 1990. SUPERDUCK surf zone sand transport experiment. CERC Tech. Rep. CERC-90-10:51.

Ross, D.B. 1976. A simplified model for forecasting hurricane generated waves (abs.). Bull. Am. Meteorol. Soc. :113.

Abstract. Describes an aircraft experiment during Pacific Hurricane Ava and applies resulting model to measurements obtained in a subsequent aircraft flight into Atlantic Hurricane Eloise.

Ross, D.B. and V.J. Cardone. 1978. A comparison of parametric and spectral hurricane wave prediction products. pp. 647-665. In A. Favre and K. Hasselmann, eds. Turbulent Fluxes through the Sea Surface, Wave Dynamics, and Prediction. Plenum Press, New York.

Abstract. Discussion of models of hurricane generated waves.

Rossby, T. 1983. Studies of the velocity structure of the Gulf Stream east of Cape Hatteras. pp. 265-274. In Proceedings of Aha Huliko'a Hawaiian Winter Workshop Held at Manoa on January 5-7, 1983.

Abstract. Preview of study in which seventeen bimonthly sections of velocity and temperature will be obtained between September 1980 and May 1983.

Rossby, T. and D. Halkin. 1982. Pegasus program east of Cape Hatteras. pp. 789. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982, AD-A128.

Abstract. (See above Rossby 1983). Defines objectives of two-year program to determine total mass transport, variations in mass and heat transport, mean and eddy kinetic energies, and what coupling, if any, exists between the baroclinic and barotropic components of motion.

Rossby, T. and D. Halkin. 1983. The distribution of kinetic energy in the Gulf Stream. EOS, Trans. AGU. 64(52):1027.

Abstract. In a three year program that ended in May 1983 seventeen bimonthly transects across the Gulf Stream were obtained 200km east of Cape Hatteras. Using the depth of the 15°C isotherm (Z_{15}) as a simple index of cross-stream position, the vertically averaged kinetic energy increases from approximately 100 ergs/gm north of the stream to values between 1500 and 2500 ergs/gm for $250m<Z_{15}<550m$ and drops to less than 300 ergs/gm to the south. We have found that the total kinetic energy at any point can be accounted for with the barotropic mode plus the two lowest order linear, flat bottom baroclinic modes computed from the local density field. Typically, 95% of the total kinetic energy in the Gulf Stream is harbored in the barotropic and first baroclinic modes. Their ratio (m_1/m_o) decreases from about 1.5 to 1.0 from north to south across the Stream. Mode 2 is weak (but generally positive, i.e. surface velocity to the NE) for $Z_{15}<250m$ whereas it is strong (about 30-100 ergs/gm) and consistently negative in the region of strong anticyclonic shear. This appears to be due to the reverse geostrophic shear near the surface on the Sargasso Sea side of the warm surface jet. Residual kinetic energies (after modes 0-5 have been removed are the order of 10-50 ergs/gm with the largest values occurring in the center of the Stream.

Rossby, T., A.S. Bower and P.T. Shaw. 1985. Particle pathways in the Gulf Stream. Bull. Am. Meteorol. Soc. 66(9):1106-1110.

Abstract. An experiment is under way to study the kinematics, dynamics, and path evolution of the Gulf Stream front between Cape Hatteras and 60°W. The Rafos float, which can track the true motion of water parcels along density surfaces which slope steeply across the Gulf Stream, has recently been developed for this

study. These instruments are launched in the center of the Gulf Stream every 5-15 days for a 30-day mission. Each float provides a trajectory and a continuous record of temperature and pressure along the trajectory. Our results so far show that: a) cross-stream motion has a significant vertical component (ranging to some 0.1 cm/s) compared to vertical velocities in midocean; b) floats systematically shoal (upwell) as they approach cyclonic meanders; c) more than half of the floats launched so far remained trapped in the Gulf Stream for distances on the order of 1000 km; d) when floats do escape from the stream, it is more likely they will do so to the south; and e) both internal processes, such as the rapid growth of meanders, and external features, such as nearby rings or eddies, can expel or extract floats from the stream. These observations are also being used in numerical simulations of the Gulf Stream to develop predictive skills for the path of the current.

Rossby, T., J. Fontaine and J. Hummon. 1991. Measuring mean velocities with POGO. J. Atmos. Oceanic Technol. 8(5):713-717.

Abstract. POGO is a simple technique for measuring water transport between the surface and some preselected depth. Equipped with a 12-kHz pinger for tracking and range measurement, a xenon flasher for nighttime relocation, and a VHF beacon for daytime recovery, it has been used over 200 times in the Gulf Stream to measure volume transport and to provide a reference velocity (transport) for geostrophic calculations from pairs of hydrographic stations. This note gives a brief technical description of POGO and how it is used. Loran C was used for navigation in this study, but with the advent of the Global Positioning System (GPS), POGO can be used worldwide. (6 Refs.).

Rowe, G.T. 1971. Observations on bottom currents and epibenthic populations in Hatteras Submarine Canyon. Deep-Sea Res. 18:569-581.

Abstract. Bottom currents and populations of large epifauna were surveyed using bottom photography in the Pamlico axis of the Hatteras Submarine Canyon system. Most species known to be numerically dominant along the continental slope north and south of the canyon were absent or found in reduced densities, whereas other species were found only near or in the canyon and can be considered canyon 'indicator' species. The implication in previous studies (Rowe and Menzies, 1969; Sanders and Hessler, 1969) that narrow faunal zonation is continuous along the margins of ocean basins must be modified to acknowledge the exceptional zonations found in canyons. The photographs and current meter data indicated that the bottom current was to the southwest along the lower continental rise, but turned to the west and northwest, or up the canyon, at lesser depths. Indurated sedimentary outcrops common the canyon were probably result of intermittent slumping and turbidity current flows.

Ruzecki, E.P. 1974. A socio-economic environmental baseline summary for the South Atlantic region between Cape Hatteras, North Carolina and Cape Canaveral, Florida. pp. 211. In Climatology. Vol. 2. Virginia Institute of Marine Science, Gloucester Point.

Ruzecki, E.P. 1979. On the water masses of Norfolk Canyon. Ph.D. Thesis. Univ. of Virginia. 316 pp.

Abstract. Water mass characteristics analyzed in a limited region.

Sager, R.A. and W.C. Seabergh. 1977. Physical Model Simulation of the Hydraulics of Masonboro Inlet, North Carolina. U.S. Engineer Waterways Experiment Station Technical Report. WES-GITI-15:258.

Abstract. This report is part of the General Investigation of Tidal Inlets 'Inlet Hydraulics Study.' The study involves the investigation of the tide- and wave-generated flow regime and water-level fluctuations in the vicinity of coastal inlets. Masonboro Inlet was selected as an inlet to be used in determining the usefulness and reliability of physical and mathematical models in predicting hydraulic characteristics of inlet/bay systems. This report presents results obtained from the physical model study. The Masonboro Inlet fixed-bed model, constructed to scales of 1:300 horizontally and 1:60 vertically, reproduced an area extending to the -45 ft contour in the Atlantic Ocean and to the nodal points in each interior channel. The wetlands were accurately reproduced near the inlet; but those areas farther bayward, being relatively flat, were reproduced schematically and artificially bent into the research flume to provide storage for the tidal prism. The model was equipped with appurtenances necessary for accurate reproduction and measurement of tides, tidal currents, waves, and other significant prototype phenomena. Model verification tests assured that the model hydraulic regimen was in satisfactory agreement with that of the prototype. Five velocity ranges with three stations at each range were verified in the model (readings were taken at three depths at each station); and seven tidal elevation gages in the ocean and bay were also verified.

Sakamoto-Arnold, C.M., A.K. Hanson, D.L. Huizenga and D.R. Kester. 1987. Spatial and Temporal Variability of Cadmium in Gulf Stream Warm-Core Rings and Associated Waters. J. Mar. Res. 45:201-230.

Abstract. Seawater samples were collected and analyzed for cadmium during four cruises studying Gulf Stream warm-core rings and associated waters. Warm-core ring (WCR) 82-B was sampled in April (approximately two months after formation), in June (after seasonal stratification), and in August (during its interaction with the Gulf Stream). The Sept-Oct cruise studied closure and separation of a meander that formed ring 82-H. The depth of the cadmium maximum varied with the depth of the main thermocline; the maximum occurred at a potential temperature of 7.8 ±0.5°C and σ_θ 27.4 ±0.05 in the Slope Water, Gulf Stream, and Sargasso Sea stations. As the upper 100 m of the ring progressed from vertically well-mixed in April to seasonally stratified in June, the mole-ratios of cadmium/nutrient removal in the mixed layer were similar to the calculated slopes of the linear regressions of cadmium with phosphate, nitrate and silicate calculated from spatial distributions. Lateral mixing processes near the boundaries of WCR 82-B markedly influenced the vertical cadmium distribution via intrusions of Shelf/slope water containing elevated levels of cadmium. Comparison of ASV-labile and total dissolvable cadmium from the august WCR 82-B station indicated essentially 100% ASV-labile cadmium in the waters within and below the main thermocline but none-detachable (<0.010 nmol/kg) ASV-labile cadmium in the waters above the thermocline.

Sallenger, A.H., Jr. 1984. Undercurrents and nearshore erosion during storms. pp. 73-80. In S.H. Clarke, ed. U. S. Geological Survey highlights in marine research. U.S. Geological Survey Circular.

Sallenger, A.H., Jr. 1987. Mean cross-shore flows in a high-energy surf zone. EOS, Trans. AGU. 68(44):1307.

Abstract. During the DUCK82 field experiment at the Corps of Engineers' Field Research Facility in North Carolina, measurements of cross-shore flow were obtained across the surf zone under a variety of wave conditions. The measurements were made with a vertical array of three electromagnetic current meters mounted on the USGS sled. Using a double-drum winch and a triangular line arrangement, the sled was pulled onshore and offshore along a shore-normal transect. With relatively low-energy incident waves, mean cross-shore currents were weak. However, as offshore significant wave height increased to greater than 2 m, mean cross-shore currents in the surf zone became strong. Maximum mean flows of 0.5 m/s were directed offshore and occurred in the trough of the bar. The mean circulation was in the vertical plane with offshore flows at depth and onshore flows high in the water column above the level of wave troughs. During the period of near-bottom offshore flows, a bar became better developed and migrated offshore. The vertical distributions of mean flows will be compared to theory.

Sallenger, A.H. and R.A. Holman. 1984. On predicting infragravity energy in the surf zone. Proceedings of the 19th International Coastal Engineering Conference. :1940-1951.

Abstract. Flow data were obtained in the surf zone across a barred profile during a storm. RMS cross-shore velocities due to waves in the infragravity band (wave periods greater than 20 s) had maxima in excess of 0.5 m/s over the bar crest. For comparison to measured spectra, synthetic spectra of cross-shore flow were computed using measured nearshore profiles. The synthetic spectra were calculated assuming a white runup spectrum of mode-4 edge waves of unit amplitude, although the results would be essentially the same for standing waves or any edge-wave mode above 2. The structure, in the infragravity band, of these synthetic spectra corresponded reasonably well with the structure of the measured spectra. Total variances of measured cross-shore flow within the infragravity band were nondimensionalized by dividing by total infragravity variances of synthetic spectra. These nondimensional variances were independent of distance offshore and increased with the square of the breaker height. Thus, cross-shore flow due to infragravity waves can be estimated with knowledge of the nearshore profile and incident wave conditions.

Sallenger, A.H., Jr. and R.A. Holman. 1985. Wave energy saturation of a natural beach of variable slope. J. Geophys. Res. 90(C6):11939-11944.

Abstract. Time series of flow were measured across the inner surf zone during a storm. These data were used to quantify the dependence of wave height (transformed from measured flow) and velocity on local slope and depth. Similar to previous studies, as incident waves broke and propagated into the surf zone, wave energy became saturated, and wave height was strongly dependent on depth. However, the ratio of rms wave height to local depth (γ_{rms}) was found not to be

constant but to vary between 0.29 and 0.55; γ_{rms} increased with local slope and was independent of deepwater wave steepness. Thus the surf zone similarity parameter (the ratio of slope to the square root of steepness) did not adequately parameterize γ_{rms}.

Sallenger, A.H., Jr., R.A. Holman and W.A. Birkemeier. 1985. Storm-induced response of a nearshore-bar system. Mar. Geol. 64:237-257.

Abstract. A nearshore-bar system was surveyed periodically through a storm and the following recovery period. The data showed a very rapid response of morphology to changing wave conditions and allowed various models on bar formation to be tested. Under low-energy condidions prior to the storm a small bar was surveyed 13 m offshore. Both the high reflectivity of the beach and the cross-shore distance to the bar are consistent with a model of sediment convergence at the node or antinode of a standing wave of incident period. Such a small-scale bar may be a common feature on beaches with steep foreshores and more gentle offshore slopes. With the increase in wave height during the storm, the bar became better developed and intigrated offshore at rates up to 2.2 m/h. The bar maintained its form in that the ratio of trough depth to crest depth (h_t/h_c) remained roughly constant. The bar was in no way related to processes which would cause the convergence of sediment in the breaker zone; through most of the storm the bar-crest distance off shore was typically only 10% of the surf-zone width. Analysis of the bar distance offshore in terms of a standing wave motion showed that the causative wave period must have been much longer than that of incident waves, probably on the order of a minute. Surf-zone wave data showed significant energy in the infragravity band at these periods although no definite link has been made. After the height of the storm, the bar had a crescentic morphology. The development of this morphology occurred very rapidly with parts of the bar migrating onshore at rates up to 1.2 m/h. In contrast to the storm, during the recovery period h_t/h_c varied by nearly a factor of three. Analysis of the offshore and longshore length scales showed the bar to be similar to one which would be generated by a standing mode 1 edge wave of period on the order of one minute.

Samelson, R.M. 1992. Fluid Exchange across a Meandering Jet. J. Phys. Oceanogr. 22(4):431-440.

Abstract. The motion of fluid parcels in a two-dimensional kinematic model of a meandering jet is investigated using Melnikov's method. The study is motivated by a recent analysis of float trajectories in the Gulf Stream. The results indicate that the efficiency of cross-jet exchange induced by fluctuating meander amplitudes depends strongly on the frequency of the fluctuations. For high frequencies (>0.04 cpd), exchange between the core of the jet and regions of "trapped" fluid moving with the meander is preferred, while for low frequencies (<0.04 cpd), exchange between the "trapped" fluid and the slow-moving fluid surrounding the jet is preferred. Propagating waves superimposed on the meandering jet can efficiently cause exchange between regimes when their phase speeds roughly match the basic flow velocities along the regime boundaries. Numerical results suggest that exchange across the center of the jet is less efficient than exchange between adjacent regimes so that the meandering jet will tend to stir fluid along each of its sides but preserve gradients across the jet core.

Sanders, F. 1983. Unexpected cyclogenesis in the western North Atlantic Ocean, June 1981. Bull. Am. Meteorol. Soc. 64(9):1038-1049.

Abstract. Account of cyclogenesis of Tropical Storm "Bret" illustrating limits of operational models in particular situations.

Sanford, T.B. 1984. Circulation and Internal Waves in a Cold Gulf Stream Waves. Washington University, Applied Physics Laboratory. :22.

Abstract. Under this program an existing salt-bridge GEK was refurbished and used extensively in the Florida Current and Gulf Stream. The purposes of these measurements were to measure the ambient electric field in the ocean and to determine from a moving vessel the voltage differences across the Current and Stream. The experiment was conducted as part of a joint ONR-NOAA sponsored cruise on the USNS Lynch. The GEK is a device to measure the voltage between two points at or near the sea surface at separations of about 16 m. The velocity component of the ocean normal to the ship's heading was determined by tracking several LORAN-C stations using a precise receiver, Internav LC404, in a range-range mode. The accuracy of the LORAN system developed for this work is estimated to be about 1 cm/s over 5 minute intervals. The vessel's gyrocompass was used to determine heading. The plan for the Lynch cruise was to conduct several joint axcp and Pegasus stations, traverse the Florida Current on reciprocal courses several times, conduct an experiment to measure depth-averaged vorticity in the Current and survey a cold core ring inn the Sargasso Sea. The goals of the measurements were to test the wave-mean flow interaction theory of Kunze (1984) and to describe the baroclinic and barotropic structure of a cold-core ring from underway measurements. Using the techniques described above it was possible to discover and map the feature in terms of temperature and velocity. The velocity information is notable and the innovation of this particular research and cruise.

Saunders, P.M. 1977. Wind stress on the ocean over the eastern continental shelf of North America. J. Phys. Oceanogr. 7(4):555-566.

Abstract. Employing one million ship reports gathered in the years 1941-72 seasonal averages of the wind stress and its standard deviation have been computed for the shelf region of the eastern North American continent (out to a depth of 200 m). An offshore increase in stress is widespread and dominates the mid-Atlantic Bight; in winter the stress there increases from 0.5 to 1.0 dyn/cm^2 in going 200 km offshore. In the Gulf of Maine and especially in the Gulf of St. Lawrence local maxima occur; the tail of the Grand Banks 500 km from shore shows a minimum. Probably much of this variation is associated with the intensity (and frequency) of cyclonic activity rather than directly with changes in friction at the underlying surface. Some oceanographic consequences are commented on but the computations are principally intended as a data source for further research.

Savidge, D.K., J.O. Blanton, T.N. Lee and R.H. Evans. 1992. Influence of an Offshore Shift in the Gulf Stream on Waters of the South Carolina Continental Shelf. J. Phys. Oceanogr. In Press.

Scanlon, K.M. 1984. The continental slope off New England: a long-range sidescan-sonar perspective. Geo-Marine Letters. 4:1-4.

Abstract. The first continuous overview of a large segment of the continental slope and rise off the northeastern United States has been obtained using the GLORIA II long-rang sidescan-sonar system. Extensive dissection by canyon and gully systems and evidence of possible large-scale sediment sliding are seen on the slope. The style and degree of incision, as well as the numbers and locations of canyons, have been found to differ sigificantly from previously published maps. It is suggested that the slope is a significant source of the sediment that has been deposited on the rise, and that some abrupt changes in the courses of canyons may be the result of local structural control.

Schaff, T.R. 1991. Spatial Heterogeneity of Continental Slope Benthos off the Carolinas. Master of Science Thesis. North Carolina State University. 131 pp.

Abstract. Spatial heterogeneity in macrofaunal and microbial communities was examined at three continental slope sited (160 km apart) off of Charleston, SC, Cape Lookout, NC and Cape Hatteras, NC, all at 850 m water depth, on large (100-km) and small (10cm-100m) scales. Significant variation was found on 100-km scales, among sites, in both microbial and macrofaunal community structure. One site (off Cape Hatteras) was found to have macrofaunal abundances (>55,000/M^2) higher than any previously recorded from this depth. From these investigations I conclude that the Carolina slope fauna at 850 m is fairly homogeneous on small (10-100m scales), but that significant variation in faunal abundance and composition occurs on 100-200km scales. This heterogeneity is probably related to variable influence from the Gulf Stream, vary angle of the slope floor, and influence from other currents and oceanographic processes (e.g., upwelling) that occur off Cape Hatteras.

Schink, D., J. McCarthy, T.M. Joyce, G.R. Flierl, P.H. Wiebe and D.R. Kester. 1982. Multidisciplinary program to study warm core rings. EOS, Trans. AGU. 63(44):834-835.

Abstract. A major research program is underway to study warm core rings off the East Coast of the United States. The program involves more than 25 principal investigators and 13 different institutions. The program started with is first field operation in September-October 1981. This was a three-ship exercise involving the ENDEAVOR from the University of Rhode Island, the KNORR into the ring circulation. Satellite infrared images permit us to see rings form, to follow their movements and their interactions with Gulf Stream and with slope water, and to see them coalesce with Gulf Stream. Warm core rings are the dominant form of oceanographic variability in the slope water off the East Coast of the United States.

Schmitz, W.J., Jr. 1976. Eddy kinetic energy in the deep western North Atlantic. J. Geophys. Res. 81(27):4981-4982.

Abstract. Long-term moored current meter data are used to demonstrate the existence of 2 orders of magnitude of variation for the kinetic energy per unit mass associated with low-frequency fluctuations in the western North Atlantic Ocean at depths near 4000 m. The maximum is observed to be located near the Gulf

Stream and the minimum outside of a recently hypothesized deep mean gyre.

Schmitz, W.J., Jr. and J.R. Luyten. 1991. Spectral time scales for mid-latitude eddies. J. Mar. Res. 49(1):75-107.

Abstract. A few hundred current meter records of roughly one to two years' duration are now available from diverse locations in the world's oceans, primarily the North Atlantic. The shape of the spectrum for low-frequency ocean current fluctuations is shown to have a geographical distribution related to the general circulation. In the offshore segment of the Gulf Stream and Kuroshio Extension systems along with their recirculations, and near the Agulhas Current as well, normalized frequency distributions of eddy kinetic energy tend to be comparatively depth-independent and peaked at the mesoscale. However, in the immediate vicinity of current axes or fronts, spectral shapes may become "red" in the thermocline, as a result of low-frequency meandering of a baroclinic jet across mooring sites. Normalized frequency distributions of eddy kinetic energy from some areas distant from strong currents but perhaps near weaker upper-ocean fronts tend to be baroclinic and not peaked at the mesoscale in the thermocline, rather they are "red" there, although peaked at the mesoscale at abyssal depths. There are also low energy regions where spectral shapes tend to be red and comparatively independent of depth. In some areas, frequency distributions are relatively energetic or peaked at periods of order days, normally at depth near bottom relief.

Schnitker, D. 1973. Abyssal benthonic Foraminifera as indicators of present and past deep sea circulation in North Atlantic ocean. Bull. Am. Assoc. Pet. Geol. 57(4):803.

Abstract. Establishes correlation between foraminifera and deep water circulation and states that analyses indicate shifting of faunal boundaries since the last Ice Age.

Schubel, J.R. and A. Okubo. 1972. Chapter 15 Comments on the Dispersal of Suspended Sediment Across the Continental Shelves. pp. 333-346. In D.J.P. Swift, D.B. Duane and O.H. Pilkey, eds. Shelf Sediment Transport: Process and Patterns. Dowden, Hutchinson and Ross, Inc., Stroudsburg.

Abstract. Since most of the fine-grained inorganic deep-sea sediment is derived from the continents, it must have crossed the continental shelves to reach the ocean basins. Most of it crossed the shelves in suspension, but the routes and rates of transport are obscure. The bulk of the sediment now being discharged by rivers is trapped in the estuaries, but nearly all of the fraction that escapes apparently crosses the shelf. A simple steady-state, two-dimensional mathematical model applied to a section off the mouth of Chesapeake Bay supports the idea of bypassing of the shelf by fine-grained terrigenous sediment, and suggests that much of the fine-grained sediment that escapes the estuaries may be accumulating on the continental slope and rise. The results from the model also suggest that the cross-shelf flux of sediment associated with the mean (residual) flow can account for most of the mass of sediment that is estimated from erosion rates to reach the ocean basins.

Schultz, J.R. 1987. Structure and Propagation of Topography Rossby Waves Northeast of Cape Hatteras. Master of Science Thesis. Univ. of North Carolina, Chapel Hill. 63 pp.

Abstract. Along the continental rise off the east coast of the United States topographic Rossby waves are observed to propagate with 'the shallow water on the right'. A one year time series of velocity and temperature measurements were collected from the anticyclonic side of the Gulf Stream and surrounding Sargasso Sea waters in the region 150 kilometers northeast of Cape Hatteras, North Carolina. These records have shown that the period of the dominant energetic fluctuations in the deep waters below the Stream was near 32 days.

Schultz, K.L. and T. Rossby. 1988. Cross- and downstream variability of static stability in the Gulf Stream. J. Phys. Oceanogr. 18(12):1933-1937.

Abstract. The spatial distribution of static stability in the Gulf Stream was studied using cross- and downstream XBT sections taken between Cape Hatteras and 70°W. The cross-stream sections revealed large variations in static stability, even over small spatial scales (≈10 km). In the downstream direction, following isopycnal Swallow floats, changes occur more gradually and are clearly correlated with the curvature of the float trajectory. With curvature effects removed, the residual downstream or Lagrangian variance is just 15% of that in the cross-stream direction. The variability of the cross-stream sections which sample different water parcels, compared to that of the downstream sections which follow a single parcel, suggests that the balance of the constituent terms of potential vorticity varies from one fluid parcel to another, reflecting their different origins. (5 Refs.).

Schumacher, J.D. 1974. A study of near-bottom currents in North Carolina shelf waters. Ph.D. Thesis. The University of North Carolina at Chapel Hill. 144 pp. (DAI 35/06B, p.2918; AAC7426935)

Abstract. Circulation within the North Carolina shelf waters was investigated between June 1972 and April 1973 to determine the relative importance of natural driving mechanisms. The study emphasized seabed drifter data, although some current meter measurements were used, and information on wind velocity, river discharge, Gulf Stream position and momentum transfer was incorporated. Seabed drifter trajectories revealed a tendency for onshore components of near-bottom drift in Raleigh Bay and in the North Carolina shelf waters north of Cape Hatteras. In spite of this onshore tendency these trajectories displayed considerable month to month directional variation. It is concluded that salt balance is dominant in generating onshore components, and that momentum transfer from the Gulf Stream is mainly responsible for the consistent residual drift toward the northeast. The observed complexities are attributed to variability in the local wind field and in Gulf Stream position. The overall near-bottom circulation picture developed during this study is reinforced by phosphorite distribution, the carbonate fraction, and sediment budgets within the North Carolina shelf-beach region.

Schwartz, F.J. and A.F. Chestnut. 1973. Hydrographic Atlas of North Carolina--Estuarine and sound waters, 1972. UNC Sea Grant Pub. UNC-SG-73-12:132.

Abstract. An atlas of figures, tables, and short text presents water temperature and salinity data for all North Carolina estuarine and sound coastal waters from Virginia to South Carolina except Currituck Sound. Monthly surface and bottom isohalines and isotherms are illustrated in 42 figures. The tables list actual raw determinations for these parameters.

Schwing, F.B., B. Kjerfve and J.E. Sneed. 1983. Nearshore coastal currents on the South Carolina continental shelf. J. Geophys. Res. 88(C8):4719-4729.

Abstract. Simultaneous current, sea level and atmospheric pressure data from the South Carolina nearshore shelf during the summer are analyzed and compared.

Science Applications, Inc. 1980a. South Atlantic OCS Physical Oceanography. Volume I. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-80-1:17.

Abstract. This final progress report represents the results of the first year of a four year physical oceanographic and meteorological data collection effort on the Outer Continental Shelf (OCS) from Cape Hatteras, North Carolina to Cape Canaveral, Florida, during the period of September 1977 through November 1978. The report is to be used to provide an understanding of the currents, circulation and mixing processes in the Georgia Embayment/South Atlantic Bight (SAB) to assess the effects of OCS oil and gas activities on the biological environment, as well as on recreational and commercial fishing. This program will eventually lead to analytical and numerical estimation (modeling) of the SAB physical oceanography.

Science Applications, Inc. 1980b. South Atlantic OCS Physical Oceanography. Volume II. U.S. Dept. Interior, BLM Rep. No. BLM-YM-ES-80-2:348.

Abstract. This final progress report represents the results of the first year of a four year physical oceanographic and meteorological data collection effort on the Outer Continental Shelf (OCS) from Cape Hatteras, North Carolina to Cape Canaveral, Florida, during the period of September 1977 through November 1978. The report is to be used to provide an understanding of the currents, circulation and mixing processes in the Georgia Embayment/South Atlantic Bight (SAB) to assess the effects of OCS oil and gas activities on the biological environment, as well as on recreational and commercial fishing.

Science Applications, Inc. 1980c. South Atlantic OCS Physical Oceanography. Volume III. U.S. Dept. Interior, BLM Rep. No. BLM-YM/ES-80-3:638.

Abstract. This final progress report represents the results of the first year of a four year physical oceanographic and meteorological data collection effort on the Outer Continental Shelf (OCS) from Cape Hatteras, North Carolina to Cape Canaveral, Florida, during the period of September 1977 through November 1978. The report is to be used to provide an understanding of the currents, circulation and mixing processes in the Georgia Embayment/South Atlantic Bight (SAB) to assess the effects of OCS oil and gas activities on the biological environment, as well as on recreational and commercial fishing.

Science Applications, Inc. 1981. South Atlantic OCS Physical Oceanography, Year II. Volume I: Executive Summary. U.S. Dept. Interior, BLM Rep. No. BLM-YL-ES-81-01:18.

Abstract. This final report presents a summary of field activities and analyses of physical oceanographic and meteorological data collected on the Outer Continental Shelf (OCS) from Cape Fear, North Carolina to Cape Canaveral, Florida during the period of November 1978 through February 1980. One aspect of this program is the physical oceanography study, which is designed to provide both a description and understanding of circulation and mixing in the South Atlantic Bight (SAB), as well as an understanding of the nature and relative importance of the responsible forcing mechanisms.

Science Applications, Inc., Raleigh, NC. 1982a. Characterization of currents over Chevron tract 510 off Cape Hatteras, North Carolina, Final Report. Chevron Service Order and Agreement. No. 509328:150.

Abstract. Science Applications, Inc. (SAI) was hired late October 1981 to characterize the physical oceanographic conditions prevailing at several lease tracts off North Carolina, and in particular the current speeds and variability likely to be found over Block 510 (Manteo Group), chosen as the potential site for initial exploratory drilling. A review of existing current meter data and relevant literature pertaining to the area of interest was completed. A field program was initiated. This final report discusses the program activities and presents all data and findings generated in the course of the study.

Science Applications, Inc., Raleigh, NC. 1982b. South Atlantic OCS Physical Oceanography, Year III. Volume II: Technical Report. U.S. Dept. Interior, BLM Rep. No. BLM/YL/ES-82/03:541.

Abstract. Analyses of data completed during year 3 of the 5-year South Atlantic Physical Oceanography Study are presented. Topics of technical discussions include: Gulf Stream variability, wind and tide data, wind predictor studies, Blake Plateau hydrography results, North Carolina continental margin hydrography and subsurface currents and circulation in the South Atlantic Bight and 'Charleston Bump' region.

Science Applications, Inc., Raleigh, NC. 1982c. South Atlantic OCS Physical Oceanography, Year III. Volume III: Data Products, Part I. U.S. Dept. Interior, BLM Rep. No. BLM/YL/ES-82/04:257.

Abstract. The report is a compilation of data products associated with the Year III, South Atlantic Physical Oceanography Study. These data are organized to provide a concise reference for more in-depth presentations associated with material presented in the Technical Report, Volume 2, of this three-volume report. Part 1 includes data from the Blake Plateau hydrographic cruise (Sept., 1980), North Carolina Shelf hydrographic cruise (Sept., 1980), South Atlantic Bight subsurface current measurements (April, 1980).

Science Applications, Inc., Raleigh, NC. 1983a. South Atlantic OCS (Outer Continental Shelf) Physical Oceanography (Year Four). Volume III. Data Products. U.S. Dept. Interior, MMS Rep. MMS/AT/ES-83/03:200.

Abstract. Results of the 4th year efforts of a 5-year program to study the physical oceanography of the South Atlantic Outer Continental Shelf are presented in 3 volumes. Volume III is a compilation of 4th year field data not specifically utilized in Volume II reports and is primarily concerned with hydrographic data collected off North Carolina.

Science Applications, Inc., Raleigh, NC. 1983b. South Atlantic OCS (Outer Continental Shelf) Physical Oceanography (Year Four). Volume II. Technical Report. U.S. Dept. Interior, MMS Rep. MMS/AT/ES-83/02:323.

Abstract. Results of the 4th year efforts of a 5-year program to study the physical oceanography of the South Atlantic Outer Continental Shelf are presented in 3 volumes. Volume II is a detailed technical report presenting studies on the variability and range of Gulf Stream western boundary positions, effects of local wind stress on across-shelf transport and general circulation patterns, seasonal means and variance of hydrographic and current data, and a detailed analysis of forcing mechanisms and resulting circulation in the Georgia Embayment.

Science Applications, Inc., Raleigh, NC. 1983c. South Atlantic OCS (Outer Continental Shelf) Physical Oceanography (Year Four). Volume I. Executive Summary. U.S. Dept. Interior, MMS Rep. MMS/AT/ES-83/01:16.

Abstract. Results of the 4th year efforts of a 5-year program to study the physical oceanography of the South Atlantic Outer Continental Shelf are presented in 3 volumes. Volume I is an executive summary, presenting a brief summary of the study.

Science Applications International Corporation. 1987. Study of Physical Process on the U.S. Mid-Atlantic Slope and Rise. Final Report, Volume II Technical. Minerals Management Service, OCS Study MMS 87-0024, Atlantic OCS Region, Vienna, VA.

Science Applications International Corporation/Battelle. 1988. Draft Report on Current Meter Measurements at the 106-Mile Site in Support of Municipal Waste Disposal. Submitted to the U.S. Environmental Protection Agency under Contract No. 68-03-3319. Work Assignment 46. 75p.

Science Applications International Corporation. 1990. Characterization of Curents at Manteo Block 467 off Cape Hatteras, NC -- Final Report. SAIC. Raleigh. 152 pp.

Abstract. This report has been prepared to document the results of investigations of the Gulf Stream dominated current regime of Cape Hatteras, North Carolina, at a site where Mobil Oil Corporation and its partners plan to drill an exploratory well for natural gas. The proposed drilling site is approximately 39 nautical miles east-northeast of Cape Hatteras in about 1000 meters (3100 feet) of water. Subsurface current measurements taken at or near the planned Manteo Block 467 exploratory well and more than six years of high resolution satellite infrared

imagery of the region have been analyzed and the results compared with those published in the scientific literature. Results of the analysis suggest that close to the maximum currents likely to occur at the site (about five knots near the surface) have been measured in detail during the 1989 Mobil program and that similar high currents were seen at the site in the 1985-1986 MASAR current meter data and in the 1981-1982 Cghevron data. Satellite imagery has been used to provide data on the long term (about monthly) Gulf Stream front configurations, which appear to be associated with the high speed current regimes. Based on this evaluation of six year of (monthly) Gulf Stream front statistics, high speed surrents can be expected about 56% of the time and weak currents about 15% of the time.

Science Applications International Corporation. 1991. Characterization of Currents at Manteo Block 467 off Cape Hatteras, NC -- Addendum-Shelf Currents. SAIC. Raleigh. 96 pp.

Abstract. This addendum documents an additional year (October 1989 through September 1990) of imagery and ADCP data at the site and almost six months (April - October 1990) of current meter data on the continental shelf along with meteorological and sea level data for the same six months. These data show episodes when shelf water (Virginia Coastal Water) is moved off the shelf along the bottom near the site, as well as south along the coast, and the strong interaction in January 1990 between a cold core ring and the Gulf Stream. This interaction resulted in the deepest penetration of high speed currents (about 0.8 knots at 450 m) observed at the site. The net motion observed on the continental shelf appeared to be southward and offshore. Shelf circulations were correlated with the Gulf Stream. The conclusions in the CSR about the amount of time the site is influenced by the Gulf Stream remain valid and are shown to be conservative.

Scott, J.T. and G.T. Csanady. 1976. Nearshore currents off Long Island. J. Geophys. Res. 81(30):5401-5409.

Abstract. Currents were observed for a 25-day period in September 1975 at 11 km south of Long Island, where the water is 32 m deep, at three levels by using electromagnetic current meters. Tidal currents were found to be moderately strong, of the order of 20 cm/s. Nontidal flow is caused by wind stress, horizontal density contrasts due to fresh water influx, and a longshore surface level gradient sloping down south-westward. The time-averaged flow has simple characteristics, adequately described by classical Ekman models in frictional equilbrium. By suitable changes in the averaging period, quantitative estimates of a bottom friction coefficient and a longshore pressure gradient are deduced from boundary layer theory for roughness elements of about 70-cm height. The longshore pressure gradient deduced from the behavior of currents agrees with the evidence of geodetic leveling.

Seagergh, W.C. 1988. Observations on Inlet Flow Patterns Derived from Numerical and Physical Modeling Studies. pp. 16-25. In Larval Fish and Shellfish Transport through Inlets--American Fisheries Society Symposium 3. (Series ed.: M.P. Weinstein.) American Fisheries Society, Bethesda.

Abstract. Due to its responsibility to provide navigable entrance channels

through coastal inlets, the U.S. Army Corps of Engineers has conducted numerous site-specific model studies of tidal inlets and has performed generalized research on tidal inlets. This paper presents some insights about flow patterns at tidal inlets, and the factors that influence those patterns, that have arisen from the model studies.

SEASUN Power Systems. 1988. Wave energy resource and technology assessment for coastal North Carolina, Prepared for N.C. Alternative Energy Corporation and Virginia Power, Final Report, 224 pp.

Abstract. Possible use of waves to produce electricity.

Seay, C.M. 1981. Characteristics of the Gulf Stream Sea Surface Temperature Field Between Savannah, Georgia and Cape Hatteras, North Carolina. Master of Science Thesis. University of North Carolina at Chapel Hill. 115 pp.

Abstract. Sea surface temperatures in the Gulf Stream frontal zone between Savannah, Georgia, and Cape Hatteras, North Carolina, were measured with an airborne precision radiation thermometer (PRT) during eight daily flights in February, 1979. The PRT data revealed the presence of two large-amplitude meanders as they progressed northeastward through the study area. The meanders were characterized by peak-to peak lateral amplitudes of 50-80 km, wavelengths of about 200 km, and phase speeds near 35 km per day. Sea surface temperatures (SST's) compared well with simultaneously measured subsurface temperatures, with near-surface (1 m level) temperatures being consistently warmer than surface values by about 1°C. The subsurface temperature data, measured with AXBT's, showed that the two meanders had vertically coherent spatial structure to at least 400 m. Associated warm filaments, however, extended from the surface to only about 50 m depth. Current records from meters moored over the 400 m isobath show peaks in temperature and downstream velocity at the time one of the SST meander patterns passed over the mooring site. It is concluded that large-amplitude meander patterns apparent in the SST field are reliable indicators of subsurface meandering of the Stream during typical winter-time conditions off the continental shelf between Savannah and Cape Hatteras.

Seay, C.M. 1982. Synoptic measurements of sea surface temperature in the Gulf Stream frontal zone between Savannah, Georgia and Cape Hatteras, North Carolina. pp. 789. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982, AD-A128.

Abstract. Presents results of study which indicate that large-amplitude, wave-like meander patterns observed in the SST field between Savannah and Cape Hatteras are reliable indicators of subsurface meandering of the Gulf Stream during typical wintertime conditions.

Seay, C.M. and J.M. Bane Jr. 1981. On the usefulness of remotely sensed sea surface temperature patterns as indicators of subsurface meanders in the Gulf Stream. EOS, Trans. AGU. 62(17):302.

Abstract. Sea surface temperatures in the Gulf Stream frontal zone between Savannah, Georgia, and Cape Hatteras, North Carolina, were measured with an

airborne precision radiation thermometer (PRT) during eight daily flights in February 1979. The PRT data revealed the presence of two large-amplitude meanders as they progressed northeastward through the study area. The meanders were characterized by peak-to-peak lateral amplitudes of about 80 km, wavelengths of about 200 km, and phase speeds near 35 km per day. Sea surface temperatures (SST's) compared well with simultaneously measured subsurface temperatures, with the near-surface (1 m level) temperatures being consistently warmer than surface values by about 1°C. The subsurface temperature data, measured with AXBT's, show that the two meanders had vertically coherent spatial structure to at least 400 m. Associated warm filaments, however, extend from the surface to only about 50 m. Current records from meters moored over the 400 m isobath show that peaks in temperature and downstream velocity occurred each time a SST meander pattern passed over the mooring site. It is concluded that large-amplitude meander patterns apparent in the SST field are reliable indicators of subsurface meandering of the Stream.

Seelig, W.N. and J.P. Ahrens. 1980. Estimating Nearshore Conditions for Irregular Waves. CERC Tech. Paper. CERC-TP-80-3:48.

Abstract. Methods for estimating nearshore irregular wave conditions for the case of continuously shallowing bottom contours, given the bottom slope and offshore wave characteristics, are presented. The methods are based on the work of Goda, Takayama, and Suzuki. A sensitivity analysis is performed to show the influence of various input parameters on predicted nearshore significant wave height. The methods are applied to the nearshore region at the CERC Field Research Facility at Duck, North Carolina, and results are compared to observed nearshore wave height changes measured at the facility. Design curves are included.

Seelig, W.N., J.P. Ahrens and W.G. Grosskopf. 1983. Elevation and Duration of Wave Crests. CERC Misc. Rep. CERC-MR-83-1:75.

Abstract. The stream-function wave theory of Dean (1974) is used together with monochromatic and irregular laboratory wave data to develop methods for estimating the elevation and duration of wave crests. The resulting prediction techniques are applied to a wide range of wave conditions measured at CERC's Field Research Facility in Duck, North Carolina, and are shown to give reliable and often conservative estimates of crest elevation. The techniques presented in this report can be used for both nonbreaking and breaking wave conditions.

SethuRaman, S., A.J. Riordan, T.R. Holt, M. Stunder and J. Hinman. 1986. Observations of the marine boundary layer thermal structure over the Gulf Stream during a cold air outbreak. Journal of Climate and Applied Meteorology. 25(1):14-21.

Abstract. Thermal structure of the marine boundary layer (MBL) was studied during a five-day cruise over the coastal Atlantic Ocean off North Carolina. Three different synoptic conditions were present: ahead of a low moving along the coast, in the area of a frontal zone and during a cold air outbreak. The marine boundary layer height was deeper (approximately 1500 m) and more sharply defined during the cold air outbreak than when the flow was southwesterly with a long fetch over water; the height was only about 1000 m for the latter case. Latent heat fluxes were significantly larger than sensible heat, but during the cold air

outbreak, sensible heat fluxes increased appreciably.

Shaw, P.-T. 1982. The dynamics of mean circulation on the continental shelf. Ph.D. Thesis. WHOI/MIT Joint Program. 226 pp. (WHOI Tech. Rep. 82-1)

Abstract. Description of forces dominating the regional dynamics of the general circulation.

Shaw, P.-T. 1992. Effects of Bottom Topography on the Propagation of Gulf Stream Rings. EOS, Trans. AGU. 73(14):167.

Abstract. The evolution of warm-core Gulf Stream rings in a continuously stratified, beta-plane ocean with bottom depths varying in the north-south direction is investigated numerically. Rings are generated by a slow temperature forcing in the upper ocean over 6 inertial days, and their movement is then examined. In the first month of formation, rings move slowly toward the southwest, in a direction consistent with that of an eddy in a reduced gravity model. However, propagation is different from the initial translation after the first month. Rings accelerate toward the southwest over a bottom with depth increasing northward. When the bottom depth is constant or increases southward, rings propagate rapidly toward the southeast. Thus, rings south of New England may be steered toward the Gulf Stream and subsequently absorbed by the Gulf Stream. Tracer concentration in the rings shows that mixing reaches a much greater depth than that of temperature forcing. The result suggests that Gulf Stream rings may induce significant mixing along their paths of propagation.

Shaw, P.-T. and S. Divakar. 1991. Generation of topographic waves over the continental margin. J. Phys. Oceanogr. 21(7):1032-1042.

Abstract. Numerical experiments were carried out to simulate the generation of topographic waves by a Gulf Stream ring over the continental margin in a stratified ocean on an f-plane. The study was aimed at understanding the combined effect of density advection and bottom topography on the flow field. The momentum equation is linear, and nonlinearity is introduced in the density equation. The mechanism of wave generation was investigated by turning on and off the nonlinear density advection and by changing the strength of the ring and bottom topography.

Shaw, P.-T. and C.Y. Peng. 1987. A numerical study of the propagation of topographic Rossby waves. J. Phys. Oceanogr. 17:358-366.

Shaw, P.-T. and H.T. Rossby. 1984. Towards a Lagrangian description of the Gulf Stream. J. Phys. Oceanogr. 14(3):528-540.

Abstract. Downstream velocity relative to the axis of the Gulf Stream is examined through the use of data from SOFAR floats. The speed calculated from the position of the floats along constant pressure surfaces is expressed in terms of a transformed cross-stream coordinate given by temperature, which is telemetered from the floats. The result is a distribution of downstream velocity unaffected by meanders from Cape Hatteras to 46°W. The speed at 700 m is about 75 cm/s west of 57°W and decreases sharply to 40 cm/s to the east.

Sheres, D., G.R. Valenzuela, M. Kobrick, R. Goldstein and B. Holt. 1991. SAR looks at Gulf Stream/Loop Current Fronts. EOS, Trans. AGU. Suppl to 72(17):148.

Abstract. Linear brightness features with length scales of tens of kilometers and narrow width appear in many ocean SAR images. They must reflect processes that are coherent over such length scales. James (1973) described the dramatic change in sea state as cold winds from a "Nor'easter" hit the Gulf Stream northern edge; this due to waves steepening and boundary layer instability that increases the sea state significantly over a narrow front. A linear brightness feature in SAR imagery of the front is thus likely to occur. Such linear features can be expected, both along and perpendicular to an ocean current, due to the interaction of linear currents with surface gravity waves as described recently by Trulsen et al.(1990). The interaction of surface waves with undulating fronts (such as eddies), as described by many investigators in the last 20 years (Liu et al., 1989 and Sheres and Kenyon, 1990 for example), are likely to exhibit complex signatures in SAR imagery. Indeed SAR imagery around eddies show unique brightness signatures that have not been properly explained yet. We will discuss a number of results obtained during recent experiments over the Gulf Stream edge and its precursor, the Loop Current. The SAR images were obtained from the JPL/NASA DC-8 aircraft in preparation for the future SIR-C mission. Seasat SAR (1978) images taken over the Loop Current during the Summer, a period when AVHRR imagery is not available due to overcast conditions and uniform sea surface temperatures, will be shown for comparison.

Shi, N.C. and L.H. Larsen. 1984. Reverse sediment transport induced by amplitude-modulated waves. Mar. Geol. 54:181-200.

Abstract. Amplitude-modulated waves can induce bedload and suspended-load transports of sediment in the reverse direction of the wave propagation. The reverse transport rate is mainly controlled by the magnitude of the bottom orbital velocity. The mechanism is most effective in transporting silts and fine sands offshore, but not clays. The sorting characteristic may be amplified when non-uniform size sediments are present in the sea bar. The mechanism provides a feasible explanation for two shelf sedimentation patterns difficult to understand using conventional seaward sediment-transport models.

Shuchman, R.A., E.S. Kasischke, A. Klooster and P.L. Jackson. 1979. SEASAT SAR Coastal Ocean Wave Analysis. A Wave Refraction and Diffraction Study. NOAA, NESS Rep. ERIM-138600-2-F:117.

Abstract. Analysis techniques used to exploit Seasat synthetic aperture radar (SAR) data are discussed and the Seasat SAR's capability to image gravity waves in coastal waters is evaluated. Synthetic aperture radar analysis techniques investigated were the effects of gravity wave motion on Seasat SAR focusing, geometric rectification of SAR data, use of optical Fourier transforms to obtain dominant wavelength and direction information from SAR data, and the use of digital techniques to exploit SAR data. These digital techniques included fast Fourier transforms and maximum entropy spectral analysis. To evaluate the Seasat SAR's capability to image gravity waves in coastal waters, two SAR passes were examined: Revolution 762 near Cape Wrath, Scotland, and Revolution 974 near Cape Hatteras, North Carolina. On the Rev. 974 imagery, refraction of gravity waves

in coastal waters was clearly evident, and a wave refraction model was used to predict water depths using inputs from the Seasat SAR data.

Sibunka, J.D. and M.J. Silverman. 1984. MARMAP Surveys of the Continental Shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1977-1983). Atlas No. 1. Summary of Operations. NOAA Tech. Memo. NOAA-TM-NMFS-F/NEC-33:318.

Abstract. This atlas is the first in a planned set of publications dealing with a time series of mesoscale plankton surveys and attendant information from a comprehensive fishery ecosystem study known as MARMAP (Sherman 1980; Sherman et al. 1983). It summarizes sampling methods, station activities and geographic coverage to provide a single point of reference for those interested in knowing how, when and where MARMAP surveys were conducted off northeastern United States during the 7-year period between 1977 and 1983, a period when federally-funded fishery research turned from single species studies towards holistic ecosystems studies in response to provisions in the Fisheries Conservation and Management Act of 1976.

Sibunka, J.D. and M.J. Silverman. 1989. MARMAP (Marine Resource Monitoring, Assessment, and Prediction) Surveys of the Continental Shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1984-87). Atlas No. 3. Summary of Operations. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA-TM-NMFS-F/NEC-68:206.

Abstract. The atlas is the third in a series dealing with mesoscale plankton surveys and attendant information from a comprehensive fishery ecosystem study known as the MARMAP program. It summarizes sampling methods, station activities, and geographic coverage for MARMAP surveys conducted off the northeastern United States from 1984 through 1987, the final four years of an 11-year multidisciplinary survey program that began in 1977. The MARMAP data base of the Northeast Fisheries Center (NEFC) contains station information obtained from two types of cruises: (1) those with supportive biological, chemical, and physical oceanographic data collection; and 920 resource surveys in which the principal objective was to assess the distribution and abundance of fish and mollusk populations.

Simpson, R.H. and P.J. Hebert. 1973. Atlantic hurricane season of 1972. Mon. Weather Rev. 101(4):323-333.

Abstract. Overview of a relatively inactive hurricane season but one in which record hurricane damage was sustained. Observations of small hybrid cyclones are also included.

Singer, J.J. 1975. Hydrology and Circulation Patterns in the Vicinity of Oregon Inlet and Roanoke Island, North Carolina. Master of Science Thesis. North Carolina State University. 171 pp.

Abstract. The hydrology and circulation data compiled in the study encompassed three major areas of interest. These included flow in Roanoke and Croatan Sounds, the influences of wind on ebb and flood at Oregon Inlet, and thermographic data collected at Oregon Inlet. The flow of bottom waters in

Croatan Sound and in mid-Roanoke Sound was observed to be essentially a direct response to the prevailing winds, except where the winds had prevailed for in excess of 24 to 36 hours causing pileup and subsequent flow reversal. In north Roanoke Sound, the flow of bottom waters south during northerly winds was observed to be essentially non-existent. In south Roanoke Sound, the flow was observed to be influenced by both the winds and flood tides at the inlet. In conjunction with this interaction in south Roanoke sound, a mechanism was proposed for the northerly penetration of high salinity waters northward through Roanoke Sound towards Albemarle Sound. It is thought that a similar mechanism may be applicable to Croatan Sound. Both extended ebbs (missed floods) and extended floods (missed ebbs) were recorded at Oregon Inlet. The initiation of these events was observed to be not nearly so dependent on long durations of high wind speeds as previously thought. In fact, rapid wind reversals (within 24 to 36 hours) were noted as apparently enhancing the likelihood of such events. Thermographic records collected at three near bottom stations in or near Oregon Inlet revealed unexpected results. These suggest a rather unique documentation of oceanic upwelling off the North Carolina coast.

Singer, J.J., L.P. Atkinson, J.O. Blanton and J.A. Yoder. 1983. Cape Romain and the Charleston Bump: historical and recent hydrographic observations. J. Geophys. Res. 88(C8):4685-4697.

Abstract. Documents locations of doming isotherms and corresponding relationships between seasonal velocity fields and offshore deflections.

Singer, J.J. and C.E. Knowles. 1975. Hydrology and Circulation Patterns in the Vicinity of Oregon Inlet and Roanoke Island, North Carolina. UNC Sea Grant Program. UNC-SG-75-15:171.

Abstract. The hydrology and circulation data compiled in the study encompassed three major areas of interest. These included flow in Roanoke and Croatan Sounds, the influences of wind on ebb and flood at Oregon Inlet, and thermographic data collected at Oregon Inlet. The flow of bottom waters in Croatan Sound and in mid-Roanoke Sound was observed to be essentially a direct response to the prevailing winds, except where the winds had prevailed for in excess of 24 to 36 hours causing pileup and subsequent flow reversal. In north Roanoke Sound, the flow of bottom waters south during northerly winds was observed to be essentially non-existent. In south Roanoke Sound, the flow was observed to be influenced by both the winds and flood tides at the inlet. In conjunction with this interaction in south Roanoke Sound, a mechanism was proposed for the northerly penetration of high salinity waters northward through Roanoke Sound towards Albemarle Sound. It is thought that a similar mechanism may be applicable to Croatan Sound. Both extended ebbs (missed floods) and extended floods (missed ebbs) were recorded at Oregon Inlet. The initiation of these events was observed to be not nearly so dependent on long durations of high wind speeds as previously thought. In fact, rapid wind reversals (within 24 to 36 hours) were noted as apparently enhancing the likelihood of such events. Thermographic records collected at three near bottom stations in or near Oregon Inlet revealed unexpected results. These suggest a rather unique documentation of oceanic upwelling off the North Carolina coast.

Smedstad, O.M. and D.N. Fox. 1991. Assimilation of Altimeter Data in a 2-Layer Primitive Equation Model of the Gulf Stream. EOS, Trans. AGU. 72(51):79.

Abstract. A 2-layer finite depth, primitive equation model of the Gulf Stream region has been used to study the effect of updating the model with altimeter data as observations. In this study a simulated 17-day repeat orbit corresponding to GEOSAT was used. Satellite observations give only information about the sea surface elevation. Previous studies have shown that it is important to transfer the surface information to the lower layer as fast as possible in order for the model to have a realistic evolution. A statistical inference technique is therefore used to update the lower layer pressure field. In addition the velocity fields in both layer are updated using a geostrophic correction calculated from the change in the pressure fields. The updating scheme spreads the information to the neighboring gridpoints along the satellite track. The region of influence can be varied. Experiments performed show that a region of approximately 100km give a smooth model field evolution. Results obtained using identical twin data as observations, show that the rms error between the model solution and the "observations" is reduced by 65% after about 3 weeks of assimilation. These results are compared to experiments where a regularized field of sea level observations every 6 days were assimilated. The effect of errors in the observations will be discussed.

Smethie, W.M., Jr. 1991. CFC Evidence for Spreading of NADW from the DWBC to the Interior Between 32°N and 45°N in the Atlantic Ocean. EOS, Trans. AGU. 72(51):32.

Abstract. CFC measurements made along the western margin of the North Atlantic Ocean during the past decade clearly show newly formed NADW being transported equatorward in the DWBC and spreading into the interior. South of the Grand Banks, there are two subsurface CFC maxima in the DWBC, an upper maximum with θ about 4.5°C and a deep maximum with θ about 2.1°C. The upper maximum is thought to form by winter time convection in the southern Labrador Sea; the deep maximum is a mixture of Denmark Strait Overflow Water and Gibbs Fracture Zone Water.

Smith, J.D. 1977. Modelling of sediment transport on continental shelves. pp. 539-577. In E.D. Goldberg, I.N. McCave, J.J. O'Brien and J.H. Steele, eds. The Sea. Vol. 6. Wiley-Interscience, New York.

Abstract. At this time, it is useful to take stock of what is known and what must transport processes in the marine environment. This is done herein by presenting the components of a continental shelf sediment transport model in which both theoretical and empirical expressions are used to provide estimates of the essential quantities.

Smith, J.D. and S.R. McLean. 1977. Spatially averaged flow over a wavy surface. J. Geophys. Res. 82(12):1735-1746.

Abstract. An understanding of the mechanics of nonuniform flow is important in a variety of ecological and geophysical fluid mechanical problems. Moreover, the ability to predict local boundary shear stress on an uneven bed is essential in erosion and sediment transport problems. In order to elucidate the important fluid mechanical phenomena active over natural quasi-two-dimensional bed forms

a series of detailed flow measurements were made above 60- to 100-m-long 1- to 3-m-high dunes in the Columbia River. In this paper, velocity profiles obtained by averaging these flow data along lines of constant distance above the riverbed are examined, and it is shown that they can be constructed from well-known uniform flow results used in conjunction with a hypothesis about the structure of internal boundary layers. This approach permits skin friction as well as total boundary shear stress, averaged over one wavelength of the bed form, to be determined from spatially averaged velocity profiles and, conversely, provides a mechanism whereby zero-order velocity profiles can be constructed for two-dimensional nonuniform channel flows. Corrections for changes in the bottom roughness parameter caused by bed load transport and for flow stratification induced by suspended load transport are derived and applied in order to make the results consistent with the measured spatially averaged shear stress field.

Sommeria, J., S.D. Meyers and H.L. Swinney. 1989. Laboratory model of a planetary eastward jet. Nature. 337(6202):58-61.

Abstract. The concentration of eastward planetary currents into strong wavy jets is a major feature of the atmospheric general circulation (for example, the jet stream) and of oceanic currents (for example, the Gulf Stream east of Cape Hatteras). These strongly nonlinear jets are, however, not well understood. The authors describe experiments in which they have produced similar jets in a rotating annulus with mechanical forcing: the Coriolis force acting on fluid pumped radially inward from a ring of sources to a ring of sinks results in a strong eastward jet. For a wide range of parameters the jet has a robust wavy shape. The wave velocity and wavelength of these Rossby waves are accounted for by simple scaling arguments. Experiments with dye injected into the fluid show that the jets act as a barrier to tracer transport, much as the southern polar night jet may act as a barrier to the transport of ozone from lower latitudes into the polar region. The observations are insensitive to the details of the arrangement of the sinks and sources. (29 Refs.).

Sonu, C.J. 1972. Bimodal Composition and Cyclic Characteristics of Beach Sediment in Continuously Changing Profiles. J. Sed. Petrol. 42(4):852-857.

Abstract. In the paper simultaneous samplings of both sediment and beach profiles in a continuously changing ocean beach are reported. Acquisition of these data was coordinated with observations of wind, wave, tide, longshore current, and swash. The site was located at Nags Head, North Carolina, where a long, smooth coastline is exposed directly to the Atlantic Ocean on the east.

Sorrell, F.Y. 1978. Submarine Wastewater Outfall Near Field Flow Dynamics and Mixing. UNC Sea Grant Pub. UNC/SG/WP-78/4:43.

Abstract. A model is developed for the flow dynamics and mixing in the near-field of a multiple port outfall diffuser. The model employs the equations for gross conservation of mass, momentum and buoyancy of the fluid in the discharge jet or plume. These equations are obtained by assuming flow similarity and then integrating over the cross-sectional area of the plume. Two distinct interactions of the discharge jets or plumes are included in the model. These are the interaction of the individual round jets from the diffuser ports and the merging of the plume from either side of the diffuser, over the top of the diffuser. The

resulting equations are closed by the 'entrainment assumption' and solved numerically.

Sorrell, F.Y., R.R. Johnson, C.D. Wyman, P.S. Cribbins, J.J. Singer and M.C. Miller. 1982. Oil and gas pipelines in coastal North Carolina: Impacts and Routing Considerations. North Carolina Coastal Energy Impact Program. Raleigh. 266 pp. (CEIP Report No. 33)

Soulsby, R.L. 1983. The Bottom Boundary Layer of Shelf Seas. pp. 189-262. In B. Johns, ed. Physical Oceanography of Shelf Seas. Vol. 35, Chapter 5. Elsevier Oceanography Series, New York.

Spencer, A., E. D'Asaro and L. Armi. 1981. The Benthic Boundary Layer Experiment on the Hatteras Abyssal Plain: Current and Temperature Observations. Data Report, 1977. Volume XXV. WHOI Tech. Rep. WHOI-81-12:53.

Abstract. The near bottom density and velocity fields above the Hatteras abyssal plain were observed with a current/temperature measuring array and a towed-yo-yoing profiler. This report describes the array data and includes details of calibration and data quality. Sources of direction error were diagnosed from vane and compass performance and bearing direction.

Spiesberger, J.L. 1989. Remote sensing of western boundary currents using acoustic tomography. Journal of the Acoustical Society of America. 86(1):346-351.

Abstract. The utility of continuous long-range acoustic transmissions between fixed sources and receivers to measure the deflection and speed of a western boundary current front along the transmission paths is discussed in a theoretical context. A signal-processing technique, which utilizes both the amplitude and the phase of the acoustic arrivals, is used to estimate the change in acoustic travel time with more accuracy than is possible by using only the amplitudes of the arrivals. When the transmission path crosses the front only once, and when the rotations of the front are confined to orientations that are within about 60 deg of the normal direction to the transmission path, the deflection of the front can be measured with an accuracy of about 2 km over periods of a few days and its propagation speed can be measured with an accuracy of about 8 cm/s. Errors are imposed by the changes in acoustic travel time that arise from the influence of the random fluctuations of internal waves. The errors of the tomographic estimates of the deflection and speed of the front are small compared with observed deflections and speeds that are of order 10 km/day and 1 m/s, respectively. The spatial (temporal) resolution of the tomographic estimate of the frontal deflection and speed along the transmission path is the same as (is better than) that obtained by satellites. (10 Refs.).

Spindel, R.C. and P.F. Worcester. 1991. Ocean acoustic tomography programs: a decade of development. Acoustic Bulletin. 16(6):5-10.

Abstract. The concept of time-of-flight acoustic tomography was formulated just over ten years ago. It was proposed as a method to observe important yet poorly understood components of the general circulation of the ocean, the so-called meso and gyre scales, which are extremely difficult to monitor with conventional

oceanographic instruments because of their large spatial extent and slow time scales of variation. The mesoscale is dominated by ubiquitous, eddylike features of roughly 100 km size with time scales of 100 days, the ocean analogue of storm systems in the atmosphere. It also includes frontal systems associated with the mixing of strong currents like the Gulf Stream. It has been estimated that 90% of the ocean's kinetic energy is in mesoscale variability, which is superimposed on larger scale flow. Gyre scale phenomena are roughly 1000 km in extent, change on even slower time scales, and as their name implies, include rotating circulation patterns like the gyres in the Sargasso Sea or Gulf of Alaska.

Stanley, D.J. and C.M. Wear. 1976. Sediment transfer across the shelf break off the Mid-Atlantic states. Geol. Soc. Am. Abstr. Programs. 8(2):275.

Abstract. Briefly outlines a study of the Mid-Atlantic margin which demonstrates that the shelf break surface serves only as a temporary resting place for sediments before they are ultimately transferred to deeper water.

Stanley, D.J. and C.M. Wear. 1978. The "mud-line": An erosional-depositional boundary on the upper continental slope. Mar. Geol. 28:M19-M29.

Abstract. A survey of surficial sediments on the outer shelf, shelf break and upper slope between Norfolk and Wilmington canyons provides useful information on outer margin sedimentation off the Mid-Atlantic States. An outer shelf facies (to depths of about 130 m), a transitional facies (on the uppermost slope between the shelf break and 250-300 m), and a slope facies (deeper than 250-300 m) are recognized on the basis of textural and compositional attributes. The "mud-line", the lower limit of the transitional facies, is the depth of substantially increased mud content and the level on the upper slope where deposition prevails. Below this depth there is a decrease in frequency in currents exceeding the threshold velocities needed to erode fine sediment. The "mud-line" is primarily related to seasonally variable water mass flow patterns and suspended sediment concentrations at and below the shelf break; this line identifies a long-term separation of erosion versus deposition and thus serves as a major energy-level boundary on the upper continental slope.

Stanley, D.J., H. Sheng, D.N. Lanbert, P.A. Rona, D.W. McGrail and J.S. Jenkyns. 1981. Current-influenced depositional provinces, continental margin off Cape Hatteras, identified by petrologic method. Mar. Geol. 40:215-235.

Abstract. Analyses of DSRV "Alvin" core samples on the Cape Hatteras margin indicate major textural and compositional changes at depths of about 1000 and well below 2500 m. The distribution patterns of petrologic parameters correlate well with water mass flow and suspended-sediment plumes measured on this margin by other workers. Our study also shows: (a) vigorous erosion and sediment transport at depths of less than 400 m results from the NE-trending Gulf Stream flow; (b) deposition, largely planktonic-rich sediment released from the Gulf Stream, on the upper- to mid-slope, to depths of about 800-1200 m; (c) winnowing, resuspension and deposition induced by periodically intensified slope currents on the mid-slope to uppermost rise, between about 1000 and 2500 m; and (d) prevailing deposition on the upper rise proper (below 2500 m), from transport by the SW-trending Western Boundary Undercurrent. Sediments moved by bottom currents have altered the composition and distribution patterns of material

transported downslope by offshelf spillover; this mixing of gravity-emplaced and bottom-current-transported sediment obscures depositional boundaries. Moreover, reworking of the seafloor by benthic organisms alters physical properties and changes erodability of surficial sediments by bottom currents. Measurement of current flow above the seafloor and direct observation of the bottom are insufficient to delineate surficial sediment boundaries. Detailed petrologic analyses are needed to recognize the long-term signature of processes and define depositional provinces.

Stefansson, U. and L.P. Atkinson. 1971. Nutrient-density relationships in the western North Atlantic between Cape Lookout and Bermuda. Limnol. Oceanogr. 16(1):51-59.

Abstract. Presents results and applications of nutrient-density relationship studies that lend insight into flow patterns in the region.

Stefánsson, U., L.P. Atkinson and D.F. Bumpus. 1971. Hydrographic properties and circulation of the North Carolina Shelf and Slope water. Deep-Sea Res. 18:383-420.

Abstract. Processes affecting the renewal of the North Carolina Shelf Waters are discussed on the basis of temperature, salinity, dissolved oxygen, nutrients, runoff and wind data collected during 1965-1967. These consist of horizontal advection near the coast from the north, meanders of the Gulf Stream, subsurface intrusion, cascading and runoff. The wind-driven Virginia Water transport past Cape Hatteras may markedly reduce the temperature and salinity, and accelerate the freshwater exchange. The runoff from the watershed north of Cape Hatteras, when driven south by northerly winds, especially during the peak period in the early spring, has a much greater influence on the circulation in Raleigh and Onslow Bays than does that from the adjacent rivers south of Cape Hatteras. Meanders in the Gulf Stream may renew the shelf waters with warm, saline water. Intrusion of subsurface Caribbean Water on to the outer part of the shelf takes place most frequently during the late summer following a period of southerly winds. It is postulated that during the cold part of the year when the surface layers are only partly stratified, such an intrusion may lead to upwelling near the shelf break. Cascading from the shelf down the slope may occur during the cold season following periods of low air temperature. Intrusion of subsurface water replenishes nutrients in the area, while cascading reduces the available supply of nutrients.

Sternberg, R.W. 1968. Friction factors in tidal channels with differing bed roughness. Mar. Geol. 6:243-260.

Stetson, H.C. 1938. The sediments of the continental shelf off the eastern coast of the United States. Massachusetts Institute of Technology Papers of Physics, Oceanography and Meteorology. 5:5-48.

Stevenson, J.D. 1990. Historical Account of Tropical Cyclones That Have Impacted North Carolina Since 1586. NOAA Tech. Memo. NOAA-TM-NWS-ER-83:75.

Abstract. The report is a compilation of the tropical cyclones for which historical information could be found that have struck North Carolina, had any

effect on the state, or passed close enough offshore to have been a serious threat to the coastal area. The decision as to whether some early storms met these criteria was made rather subjectively, since information as to both path and effects was incomplete and highly variable. Where available, information on maximum (or near maximum) wind speed experienced in connection with the storm is given. Prior to about 1870, actual measurements were not made, so only descriptive statements as could be gleaned from news accounts are given. In the days of the U.S. Signal Corps, and even the Weather Bureau until about 1940, the highest wind given for a storm was usually the 'maximum velocity', which was an average over a 5-minute period. In recent years, the highest sustained wind used by the National Weather Service is an average over 1-minute period. The descriptions of the early storms may reflect their severity, but are also dependent on the amount of material which could be located. Obviously, there were many storms in the 17th, 18th and 19th centuries of which no records could be found.

Stirewalt, G.L. and R.L. Ingram. 1974. Aerial photographic study of shoreline erosion and deposition, Pamlico Sound, North Carolina. UNC Sea Grant Pub. UNC SG 74 09:66.

Abstract. Recent changes in the shoreline morphology of Pamlico Sound, North Carolina, were determined by examining aerial photographs of varying dates between 1938 and 1971 at 16 sites.

Stommel, H. and A.B. Arons. 1960. On the abyssal circulation of the world ocean--II. An idealized model of the circulation pattern and amplitude in oceanic basins. Deep-Sea Res. 6:217-233.

Strout, G. 1988. Variation in Shelf Slope Front position in 1987 from Georges Bank to Cape Hatteras. North Atlantic Fisheries Organization. SCR Doc., 88-08:8.

Stubblefield, W.L., J.W. Lavelle, D.J.P. Swift and T.F. McKinney. 1975. Sediment response to the present hydraulic regime on the central New Jersey shelf. J. Sed. Petrol. 45(1):337-358.

Abstract. Petrographic data, from vibracores and grab samples collected on the Central New Jersey Shelf, suggest a substrate still actively responding to the hydraulic regime. Radiocarbon dates of shell material from the ridge and swale topography indicates aggradation of the ridge's crest during the last 500 years and exposure of earlier Holocene material in the deeper troughs of the area. The samples from both the cores and the surficial samples were investigated for heavy mineral percentages and grain size analysis in addition to radiocarbon dating. The concentration of heavy minerals into disseminated bands, as observed in the vibracores, is compatible with sediment transport by sand ripples on the ridge's flanks. The grain size variation was subjectively analyzed by applying a Q-mode factor analysis which produced three distinct groupings of the grain size distribution. Each grouping is found to characterize a particular part of the ridge topography. Fine sand and moderate sorting occurs on the flanks, medium to fine sand and moderate sorting occurs on the crests whereas two populations are found in the troughs; coarse, poorly sorted sands and very fine, well sorted sands. This textural variation supports a hypothesis of up-flank rheologic and

suspensive transport of medium and fine sand during intense storms and subsequent down-flank winnowing of fine sand during less intense meteorological events. The radiocarbon dates indicate that size fractionation and heavy mineral concentrations are subsequent to isolation from a beach environment.

Stumpf, H.G. 1974. A satellite derived experimental Gulf Stream analysis. Mar. Weather Log. 18(3):149-152.

Abstract. Early use of satellite imagery data to augment pre-existing data concerning Gulf Stream location and structure. Under relatively cloud-free conditions, the Very High Resolution Radiometer (VHRR) aboard NOAA-2, which has a spatial resolution of 1 km at nadir, provides detailed thermal information about the underlying surfaces.

Stumpf, H.G. and P.K. Rao. 1975. Evolution of Gulf Stream eddies as seen in satellite infrared imagery. J. Phys. Oceanogr. 5:388-393.

Abstract. Presentation of NOAA-2 satellite data detailing the evolution of a Gulf Stream eddy from spin-off to meander stage.

Sturges, W. 1974. Sea level slope along continental boundaries. J. Geophys. Res. 79:825-830.

Sutton, C.H., V. Goldsmith and A.H. Sallenger. 1976. Detailed Bathymetry of Selected Areas of the Inner Continental Shelf of the Virginian Sea: Southeastern Virginia, Virginia Beach and Wachapreague, Virginia. Virginia Institute of Marine Science Special Report. SRAMSOE No. 69:10.

Abstract. Fuel shortages have initiated an intensive study of the adjacent continental shelf area for possible future sites of offshore drilling rigs, power plants and port facilities. Among the basic oceanographic information required in all such studies is detailed depth information. To help meet these needs we have prepared these detailed bathymetric maps containing significantly more information than has previously been compiled and made available from this region of the Atlantic shelf.

Sverdrup, H.U., M.W. Johnson and R.H. Fleming. 1942. The Oceans: Their Physics, Chemistry, and General Biology. Prentice-Hall. Englewood Clifts. 1087 pp.

Sweet, W., R. Fett, J. Kerling and P. LaViolette. 1981. Air-sea interaction effects in the lower troposphere across the north wall of the Gulf Stream. Mon. Weather Rev. 109(5):1042-1052.

Abstract. Significant atmospheric and oceanographic differences have often been observed in the regions lying on either side of the north wall of the Gulf Stream. Satellite visible-range sensors have revealed changes in reflectivity across the Gulf Stream believed to be due to changes in sea state that are related to these atmospheric and oceanic differences. In addition, lines of low-level cloud, paralleling the edge of the Gulf Stream, have been observed to persist in satellite imagery for several days at a time. Anomalous radar propagation also has been noted to occur in these same regions. In an attempt to document the interrelation of these phenomena, the lower atmosphere over the

north wall of the Gulf Stream was studied on two separate occasions. Sea state photography and measurements of sea surface temperature, air temperature, dew-point temperature and atmospheric pressure were made by an instrumented RP-3A aircraft flying at various altitudes from the Gulf Stream, across the north wall, and onto the Slope Water side. The data collected show significant low level atmospheric and sea state changes on crossing the north wall boundary. These changes appeared to be caused by differences in atmospheric turbulence created by variations int he air-sea temperature differential on each side of the north wall boundary.

Swift, D.J.P., J.W. Kofoed, F.P. Saulsbury and P. Sears. 1972. Holocene evolution of the shelf surface, central and southern Atlantic shelf of North America. pp. 499-573. In D.J.P. Swift, D.B. Duane and O.H. Pilkey, eds. Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Ross, Stroudsburg.

Swift, D.J.P., D.B. Duane and T.F. McKinney. 1973. Ridge and swale topography of the Middle Atlantic Bight, North America: Secular response to the Holocene hydraulic regime. Mar. Geol. 15:227-247.

Abstract. The ridge and swale topography of the Middle Atlantic Bight was originally interpreted as a relict strand plain whose ridges reflect stillstands of the returning Holocene sea. However, close examination indicates that the ridges appear to be instead longitudinal bed forms, responses to a regime of intermittent, south-tending storm currents. Ridges may be initiated on the shore face and detached as the coast retreats to form fields of isolated ridges, or they may be molded into the shelf-transverse sand massifs that mark the retreat paths of littoral-drift depositional centers at estuary mouths and off cuspate forelands. The ridge and swale topography is thus a stable end configuration toward which a variety of near-shore constructional topographies have converged during the Holocene transgression. Morphologic evidence for readjustment of ridge topography to the deepening shelf flow field during the Holocene transgression is discernable. However, the extent to which the offshore topography continues to respond to hydraulic regime is unclear. The role of helical flow structure in the storm flow field remains to be documented. Resolution of these problems will require more detailed information of hydraulic process and substrate response on storm-dominated shelves.

Swift, D.J.P., A.W. Niederoda, C.E. Vincent and T.S. Hopkins. 1985. Barrier island evolution, middle Atlantic shelf, U.S.A. Part I: Shoreface dynamics. Mar. Geol. 63:331-361.

Abstract. In Part I of this paper, near-bottom fluid velocity and sediment concentration measurements from the shoreface of a middle Atlantic barrier (Long Island coast) are analyzed to provide insight into the dynamics of erosional shoreface retreat.

Szabados, M.W. 1982. Intercomparisons of the offshore wave measurements during ARSLOE. Marine Technology Society and IEEE Oceans Conference Proceedings. 876-881.

Abstract. Intercomparisons of wave measurements by several techniques during the Atlantic Remote Sensing Land Ocean Experiment (ARSLOE) during October and

November, 1980, are described. Measurements were made by four types of nondirectional and directional wave buoys, a meteorological buoy, and aircraft radar remote sensing techniques.

Szydlik, S.J. 1980. Sedimentary processes on the continental slope around Cape Hatteras. Master's Thesis. University of South Florida, St. Petersburg.

Takahashi, K. and P.L. Blackwelder. 1992. The spatial distribution of silicoflagellates in the region of the Gulf Stream warm-core ring 82B: application to water mass tracer studies. Deep-Sea Res. 39:S327-S346.

Abstract. To delineate potential water mass affinities, we investigated silicoflagellates from the region of Gulf Stream warm-core ring (WCR) 82B in the northwestern Atlantic. Silicoflagellates from 202 samples from N-S and E-W transects across WCR 82B during late April were analyzed. Shelf to Sargasso Sea transects, one completed in early May and the other in June 1982 were also examined. Eight to 11 vertical profiles to 200 m comprised each of the transects. Six taxa of silicoflagellates were found in the samples studied and a total of more than 8000 specimens were encountered. Distribution of the silicoflagellate taxa suggests that WCR 82B April had a higher affinity with the Gulf Stream than the Sargasso Sea.

Tanaka, N., M.C. Monaghan and K.K. Turekian. 1990. Delta14C balance for the Gulf of Maine, Long Island Sound and the northern Middle Atlantic Bight: Evidence for the extent of Antarctic Intermediate Water contribution. J. Mar. Res. 48(1):75-87.

Abstract. The radiocarbon signatures of the western Sargasso Sea and the atmosphere as a function of time over the past 200 years are known. These can be combined with seawater dissolved inorganic carbon (DIC) radiocarbon data from the Gulf of Maine and the northern Middle Atlantic Bight (MAB), including Long Island Sound (LIS), for 1983 and pre-1955 shell analyses for radiocarbon, to set the amount of Antarctic Intermediate Water (AAIW) required to balance the ^{14}C budget in the northern MAB. Approximately 40% of the water entering the Middle Atlantic Bight from the north must be AAIW, the other 60% being Sargasso Sea water. Contemporary water from LIS, a part of northern MAB, can be explained as a mixture of Sargasso Sea water and Gulf of Maine water but at times in the past more low-^{14}C water (AAIW) was added to this mixture as recorded in shells from LIS. This implies variations in upwelling rates over time in the region of the Middle Atlantic Bight.

Tarbell, S., M. Chaffee, A. Williams and R. Payne. 1980. The WHOI moored array project 1963-1978: Data directory and bibliography. WHOI Tech. Rep. 79-88:173.

Abstract. Important index and description of an extensive set of meteorologic and current meter observations that pertain to the primary flow regime in the northwestern Atlantic. One of the longest continuous time series of current measurements available to date.

Taylor, Q.H. and J.A. Stephens. 1980. Latitudinal displacements of the Gulf Stream (1966-1977) and their relation to changes in temperature and zooplankton abundance in the NE Atlantic. Oceanol. Acta. 3(2):145-149.

Abstract. It is shown that the north wall of the Gulf Stream was displaced southward during 1966 to 1971 and returned northward after 1973. While there was no clear relation with any of several relevant wind and pressure indices, there were similar trends in sea-surface temperature, salinity and abundance of zooplankton in the NE Atlantic. The displacements of the Gulf Stream are therefore part of a large-scale change encompassing most of the North Atlantic. These changes are either separate manifestations of variations in the global atmospheric circulation, or the changes in the NE Atlantic are the indirect result of variations in the Gulf Stream.

Tenore, K.R. 1985. Seasonal Changes in Soft Bottom Macroinfauna of the U.S. South Atlantic Bight. pp. 130-140. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. The macroinfauna of soft bottom sediments of the U.S. South Atlantic Bight has high species diversity but low densities because of unstable sediments, wide temperature fluctuation, and low nutrient inputs. The fauna is homogenous, with no persistent latitudinal gradients. Communities may be delimitated into inner coastal and outer shelf zones. The inner community is quite distinct and persists throughout the year: the spatial scales of communities of the central and outer zones charge seasonally with influx of newly settled species. The outermost slope stations were distinct and did not cluster with each other. In the autumn the central and outer shelf were divided into northern and southern zones, because of a high number of transient species in the northern area. Thus there are few persistent or resident dominants, and species composition changes seasonally, perhaps in great part moderated by current regimes.

Tester, P. 1988. Red Tide Alga Extends its Range 800 Mile Northward. American Institute of Fisheries Research Biologists. 17(2).

Abstract. On 2 November 1987, Ptychodiscus brevis was identified from water samples taken from Emerald Isle, Carteret County, NC. This is the first occurrence of Ptychodiscus brevis north of Jacksonville, FL and extends its range approximately 800 miles northward. The warm, high-salinity water of the Gulf Stream provides appropriate conditions for the survival and transport northward of Ptychodiscus brevis.

Tester, P.A., R.P. Stumpf and P.K. Fowler. 1988. Red tide, the first occurrence in North Carolina waters: an overview. pp. 808-811. In Proceedings of the Oceans '88 Conference. Baltimore.

Abstract. On 2 November 1987, the toxic "red tide" dinoflagellate, Ptychodiscus brevis, was identified from nearshore waters of North Carolina. This massive and persistent red tide was a major bio-geographic event and extended the range of P. brevis by 800-900 km. Before the end of this bloom some 3.5 months later, there were 48 cases of neurotoxic shellfish poisoning reported in humans and over 1,480 km^2 of shell fish harvesting waters were closed. This affected

approximately 50% of the waters normally used for commercial harvest of oysters and 95-98% of those areas used for commercial harvest of clams. The economic loss to the coastal community was conservatively estimated at $25 million.

Tester, P.A., P.K. Fowler and J.T. Turner. 1989. Gulf Stream Transport of the Toxic Red Tide Dinoflagellate Ptychodiscus brevis from Florida to North Carolina. pp. 349-358. In E.M. Cosper, V.M. Bricelj and E.J. Carpenter, eds. Coastal and Estuarine Studies, 35. Novel Phytoplankton Blooms. Causes and impacts of recurrent brown tides and other unusual blooms. Springer Verlag.

Abstract. Cells from a red tide bloom off the Florida coast were probably transported to the North Carolina shelf by the Gulf Stream. Approximately 29-39 days after the Florida bloom there was a strong shoreward intrusion of the Gulf Stream onto the continental shelf of North Carolina. Satellite imagery of sea surface temperatures and thermal frontal analyses of the position of the Gulf Stream showed a warm filament of the Gulf Stream moving onto the continental shelf in Raleigh Bay on 19 October 1987. This Gulf Stream filament moved shoreward and by 22 October was within 7 km of the shore, east of Cape Lookout, where it remained intact for at least 17 days. Between 22 and 30 October the surface, inshore waters of both Onslow and Raleigh Bays, warmed from 21°C to 22-24°C. No unusually high nutrient levels or pollution events preceded this red tide.

Tester, P.A., R.P. Stumpf, F.M. Vukovich, P.K. Fowler and J.T. Turner. 1991. An expatriate red tide bloom: Transport, distribution, and persistence. Limnol. Oceanogr. 36(5):1053-1061.

Abstract. In November 1987, the toxic dinoflagellate Gymnodinium breve bloomed in North Carolina nearshore waters. This occurrence was the first record of G. breve north of Florida, a range extension of >800 km. We propose the (Gulf of Mexico) Loop Current-Florida Current-Gulf Stream system as the transport mechanism for G. breve cells from a late summer bloom off the southwest coast of Florida (Charlotte Harbor-Sarasota). The estimated transit time for cells around the peninsula and northward to the continental shelf off North Carolina is 22-52 d. About 30 d after the Charlotte Harbor-Sarasota bloom, satellite images of sea-surface temperature substantiated the shoreward movement of a filament of Gulf Stream water onto the narrow continental shelf between Cape Hatteras and Cape Lookout. This filament, the likely source of G. breve cells, remained in nearshore waters and was identifiable in satellite images for >19 d. Once the bloom was inshore, both windspeed and direction were important in determining its distribution.

The Ring Group. 1981. Gulf Stream cold-core rings: Their physics, chemistry, and biology. Science. 212:1091-1100.

Abstract. Cyclonic Gulf Stream rings are energetic eddies in the warm Sargasso Sea consisting of Gulf Stream water surrounding a core of cold Slope Water. Initially a ring core has the characteristics of the Slope Water; it is rich in plants, animals, and nutrients. As a ring decays the Slope Water properties of its core are gradually replaced by those of the Sargasso Sea, where standing crops of plants, animals, and nutrients generally are low. Although the decay rate suggests a rather long lifetime (2 to 4 years), the usual death of a ring

comes when it rejoins the Gulf Stream after 6 to 12 months.

Thompson, B.J. 1972. Thermal structure of the western Gulf Stream region, April and Oct. 1967. Internatl. Council Explor. Sea, Denmark, Rapports et Proces-Verbaux des Reunions, 162:251-263.

Abstract. Temperature sections across the Gulf Stream.

Thompson, D.R. and R.F. Gasparovic. 1986. Intensity modulation in SAR images of internal waves. Nature. 320(6060):345-347.

Abstract. Data from the SAR Signature Experiment conducted in 1984 in the New York Bight is used to test theories that predict that the intensity modulations observed in SAR images of internal waves are produced by variations in the small-scale surface roughness.

Thompson, E.F. and D.L. Harris. 1972. A wave climatology for U.S. coastal waters. pp. 13. In Fourth Offshore Technology Conference. Reprint of No. 1-72 ed. Vol. 2. U.S. Army, Corps of Engineers. Coastal Engineering Research Center, Houston, TX.

Abstract. Wave height probability distributions are provided for seven Coastal Engineering Research Center coastal wave gages located at: Buzzards Bay (MA), Atlantic City (NJ), Virginia Beach (VA), Nags Head (NC), Lake Worth (FL), Palm Beach (FL), and Daytona Beach (FL). Data were acquired from 1948 to 1972 and range in length from a few months to many years. Wave height distributions from ship wave observations from 1963 to 1968 are also provided.

Thompson, E.F. 1977. Wave climate at selected locations along U.S. coasts. U.S. Army Corps of Engr., CERC. Technical Report No. 77-1:364.

Abstract. Wave statistics are provided for eighteen locations along the U.S. east coast including Chesapeake Bay Bridge-Tunnel, Virginia Beach (VA), Cape Henry (VA), Nags Head (NC), Frying Pan Shoals (NC), Wrightsville Beach (NC), and Holden Beach (NC). Statistics include significant wave height and period monthly means and standard deviations, significant wave height and period monthly means and standard deviations, significant wave height and period time histories, and seasonal and annual significant wave height cumulative probability distributions. Most data on which statistics are based pre-date 1970.

Thompson, E.F. 1980. Energy spectra in shallow U.S. coastal waters. U.S. Army Corps of Engineers Coastal Engineering Research Center Report CERC-TP-80-2.

Abstract. Characteristics of shallow water wave spectra were developed at five U.S. east coast locations including Virginia Beach (VA) and Nags Head (NC). Data collected during 1968 and 1969 were used to determine maximum spectra, and mean spectra categorized by wave height, wave period, and water depth.

Thompson, E.F. 1981. A Model for the Distribution Function for Significant Wave Height. CERC CETA Rep. CERC-CETA-81-3:17.

Abstract. A model based on a three-parameter Weibull distribution function is

given for the long-term distribution of significant wave height. The model, formulated in dimensionless terms, is believed to provide a more general representation than the corresponding models given in the Shore Protection Model (SPM). A procedure for using available data from a site to estimate model parameters is described. The procedure extends the use of available data and leads to a model which more closely follows the data than the procedures in the SQM. The procedure is applied to shallow-water gage data from Nags Head, North Carolina. Example problems are given to illustrate the use of the model at the Nags Head site.

Thompson, J.D. and H.E. Hurlburt. 1985. Numerical modeling and assimilation of altimeter data in the Gulf Stream system: recent results. Unpublished manuscript.

Abstract. The dynamics of various portions of the Gulf Stream system, including the Loop Current in the Gulf of Mexico, were studied via numerical integrations, comparisons with field data, and simplified analytical models. Many observed features of Loop Current are simulated and explained including its northward penetration, westward bending, meandering, and generation of warm-core rings.

Thompson, J.D. and W.J. Schmitz Jr. 1989. A limited-area model of the Gulf Stream: design, initial experiments, and model-data intercomparison. J. Phys. Oceanogr. 19(6):791-814.

Abstract. A primitive-equation, n-layer, eddy-resolving circulation model has been applied to the Gulf Stream System from Cape Hatteras to east of the Grand Banks (78°-45°W, 30°-48°N). Within the limitations of the model, realistic coastlines, bottom topography, and forcing functions have been used. A two-layer version of the model was driven by observed mean climatological wind forcing and mass transport prescribed at inflow. Outflow was determined by a radiation boundary condition and an integral constraint on the mass field in each layer. Specification of a Deep Western Boundary Current was included in some model runs. Six numerical experiments, from a series of over fifty integrated to statistical equilibrium, were selected for detailed description and intercomparison with observations. (54 Refs.).

Thompson, R. 1977. Observations of Rossby waves near Site D. Prog. Oceanogr. 7:1-28.

Abstract. Companion paper to Thompson (1976) and Thompson and Luyten (1976) where current meter data from Site D conclusively relate lowfrequency motion to Rossby wave dynamics.

Tournadre, J. 1990. Sampling of oceanic rings by satellite radar altimeter. J. Geophys. Res. 95(C1):693-697.

Abstract. In the present paper, the probability for a mesoscale oceanic rings to be seen by a perfect satellite altimeter is investigated. First, the motion of a ring center is determined using a stochastic differential equation. The problem of radar altimeter sampling is then investigated, first in the one-dimensional case, then for two dimensions. The probability of a ring to be seen by a satellite is then computed and is shown to depend on the satellite period and

fundamental interval, the mean and standard deviation of the ring speed, and the distance between the ring center and the nearest track when the ring appears. The maximum of this probability and the time at which the maximum arises give an estimate of the satellite ability to sense the rings. The observation of Gulf Stream (GS) warm and cold core rings (WCR/CCR) by the Topex-Poseidon and Geosat altimeters are then presented as examples. (6 Refs.).

Tracey, K.L. and D.R. Watts. 1986a. Gulf Stream Dynamics Experiment. Inverted Echo Sounder Data Report for the April 1983 to June 1984 Deployment Period. Univ. R.I., Grad. School Oceanogr. Tech. Rep. URI/GSO-TR-86-4:237.

Abstract. The Gulf Stream Dynamics Experiment was conducted in the region just northeast of Cape Hatteras from September 1983 to May 1985 to study the propagation and growth characteristics of Gulf Stream meanders. Data collected as part of the field experiment included inverted echo sounders, current meter moorings, and AXBT survey flights. This report documents the inverted echo sounder data collected from September 1983 to June 1984, as well as additional measurements made from April to September 1983. Time series plots of the half-hourly travel time and low-pass filtered thermocline depth measurements are presented for twenty-two instruments. Bottom pressure and temperature, measured at seven of the sites, are also plotted. Basic statistics are given for all the data records shown. Maps of the thermocline depth field in a 240 km by 460 km region are presented at daily intervals.

Tracey, K.L. and D.R. Watts. 1986b. On Gulf Stream Meander Characteristics Near Cape Hatteras. J. Geophys. Res. 91(C6):7587-7602.

Abstract. From 1979 to 1982, Gulf Stream path fluctuations within 375 km downstream of Cape Hatteras, North Carolina, have been monitored by inverted echo sounders. Histograms of the north wall locations along four cross-stream sections change shape and increase in range dramatically downstream through the study area: Near Cape Hatteras, the histogram is peaked with the Gulf Stream found over half of the time within a narrow 10-km range. The distrubutions become progressively more symmetric and the ranges widen downstream such that in the eastern portion of the study area the Gulf Stream can be found with equal probability throughout its 145-km excursion range. From the 36-month-long time series near 73°W there is evidence of a seasonal cycle of Gulf Stream positions; northerly locations occur in the summer/fall, when transports are lower, and southerly locations occur in the winter/spring, when transports are higher. An observational dispersion relationship is presented for meander propagation and growth: Downstream propagation rates increase smoothly from about 14 km/d for meanders with periods and wavelengths (33 days, 460 km) to over 45 km/d for the (4 days, 180 km) meanders. Meander amplitudes show rapid growth rates in two separate bands, near (4-5 days, 180-230 km) and (10-33 days, 300-500 km).

Tracey, K.L. and D.R. Watts. 1991. The SYNOP Experiment, Thermocline Depth Maps for the Inlet Array, October 1987 to August 1990. Univ. R.I., Grad. School Oceanogr. Tech. Rep. 91-6:137.

Tracey, K.L., M. Cronin and D.R. Watts. 1985. Gulf Stream Dynamics Experiment. Inverted echo sounder data report for the June 1984 to May 1985 deployment period. Rhode Island Univ. Grad. School of Oceanogr. Summary Report No.: URI-GSO-TR-85-3. 185.pp.

Abstract. Report documents basic statistics for all data records including bottom pressure and temperature, maps of the thermocline depth field and time series plots of the half-hourly travel time and low-pass filtered thermocline depth measurements.

Treguier, A.M. 1992. Kinetic Energy Analysis of an Eddy Resolving, Primitive Equation Model of the North Atlantic. J. Geophys. Res. 97(C1):687-701.

Abstract. As part of the World Ocean Circulation Experiment community modelling effort, a realistic primitive equation model of the North Atlantic Ocean has been implemented with a resolution high enough to allow the generation of eddies. In the present paper, the kinetic energy of the model ocean circulation is analyzed. The eddy kinetic energy distribution in the model shows a good agreement with data in the western Atlantic but a deficit in the eastern Atlantic, especially at periods of about 100 days. Kinetic energy balances are computed to allow comparison between the primitive equation model and previous quasi-geostrophic eddy resolving models. Essential instability mechanisms are present in both cases, but they are not efficient enough in the primitive equation model, which is too viscous and lacks the inertial character of quasi-geostrophic solutions. Our study therefore emphasizes the need for even higher resolution models.

Tseng, Y.-C. 1985. Wave-current and wave-topographic interactions using seasat synthetic aperture radar observations and analytical ocean models (seasat sar, wave-current interaction, remote sensing, wave motion, wave-topographic interaction). Ph.D. Thesis. The University Of Michigan. 205 pp. (DAI 46/04B, p.1101; AAC8512527)

Abstract. This dissertation investigates the capability of SEASAT synthetic aperture radar (SAR) to detect wave-current and wave-topographic interactions in the Gulf Stream area by analyzing the refracted wave directions obtained from different methods. Four study methods have been employed: the optical Fourier transform (OFT), the fast Fourier transform (FFT), the kinematical, and the dynamical methods. The first two methods were applied to analyze the SAR data for estimating the dominant wave directions. The last two methods were applied to calculate the refracted wave directions for comparison with those measured by the OFT and FFT analyses. General theories of wave-current and wave-topographic interactions were formulated by assuming the ocean waves to be linear and steady-state. The SAR data from Rev. 0974 on September 3, 1978 over the Gulf Stream off Cape Hatteras, N.C. were utilized. Some 49 study positions located within this study area were chosen for this investigation. Results showed that the refracted wave directions obtained from the analyses of SAR data, from both the OFT and FFT methods, were in reasonable agreement with those obtained from kinematical and dynamical methods, with arithmetical means ranging from -0.2° to 6.9°. The bending tendency of the surface gravity wave rays constructed from the four methods was also in agreement. Intensities of SAR wave spectra at dominant wavelengths were highly correlated both with average waveheights and with squares of average waveheights, with the correlation coefficients of 0.79 and 0.80,

respectively. The FFT technique does offer surface wave dynamic information in great detail and the SAR wave spectra do provide high quantitative potential for the detailed observation of surface gravity waves.

Tsuchiya, M. 1989. Circulation of the Antarctic Intermediate Water in the North Atlantic Ocean. J. Mar. Res. 47(4):747-755.

Abstract. The Antarctic Intermediate Water in the North Atlantic Ocean is characterized by high concentrations of silica, and this characteristic is used to trace its circulation. An isopycnal map of silica reveals high-silica water extending on the west and north sides of the Mediterranean outflow water from the Straits of Florida as far northeast as 60°N just south of Iceland. The extent of this high-silica Antarctic Intermediate Water is in remarkably good agreement with the path of the Gulf Stream-North Atlantic Current indicated by the geostrophic-flow field at this level.

Tucholke, B.E. 1980. Acoustic Environment of the Hatteras and Nares Abyssal Plains, Western North Atlantic Ocean, Determined from Velocities and Physical Properties of Sediment Cores. J. Acoust. Soc. Amer. 68(5):1376-1390.

Twichell, D.C. and D.G. Roberts. 1982. Morphology, distribution and development of submarine canyons on the United States Atlantic continental slope between Hudson and Baltimore Canyons. Geology. 10:408-412.

Abstract. The distribution and morphology of submarine canyons off the eastern United States between Hudson and Baltimore Canyons have been mapped by long-range sidescan sonar. In this area canyons are numerous, and their spacing correlates with overall slope gradient; they are absent where the gradient is less than 3°, are 2 to 10 km apart where the gradient is 3° to 5°, and are 1.5 to 4 km apart where the gradient exceeds 6°. Canyons range from straight to sinuous; those having sinuous axes indent the edge of the continental shelf and appear to be older than those that head on the upper slope and have straighter axes. A difference in canyon age would suggest that canyons are initiated on the continental slope and only with greater age erode headward to indent the shelf. Shallow gullies on the middle and upper slope parts of the canyon walls suggest that submarine erosion has been a major process in a recent phase of canyon development.

U.S. Army Corps of Engineers, Wilmington District. 1980. Oregon Inlet Larval Transport Sensitivity Study. Wilmington. 89 pp.

Abstract. The Corps of Engineers developed a plan that includes dual jetties with a sand bypassing system and deepening the ocean bar channel to 20 feet. During the course of project planning, concern for the possible effects of the jetties on larval transport developed. Movement of larval organisms through Oregon Inlet into the estuary may be affected due to the length of the proposed jetties. Since much of the fishery within Pamlico and Albemarle Sounds is based on reinforcement organisms spawned in ocean waters, a thorough evaluation of the existing larval distribution, abundance and transport patterns is required to provide a basis for monitoring postconstruction performance and to allow for an assessment of the likelihood and degree of impact on larval organism migration. To aid in the evaluation, the existing physical model of Oregon Inlet at the U.S. Army Engineer

Waterways Experiment Station (WES), Vicksburg, Mississippi, was used in performing a sensitivity study that would allow observation of changes to assess the probable impacts of the jetties on larval organisms.

U.S. Department of Agriculture and Soil Conservation Service. 1975. Shoreline erosion inventory-North Carolina.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1971. Atlantic hurricane frequencies along the United States coastline. NOAA Tech. Memo. NWS SR-58:15.

Abstract. Statistical summary of the frequency of landfall occurrence for Atlantic hurricanes.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1975a. Expendable bathythermograph observations from the NMFS/MARAD Ship of Opportunity Program. NOAA Tech. Rep. NMFS Spec. Sci. Rep. Fish. NOAA-TR-NMFS-SSRF-692, -700, -709, -727:.

Abstract. Presents and discusses temperature and salinity data from the Ship of Opportunity Program (Years 2,3,4 and 5), including descriptive analysis of the Yucatan, Loop, and Florida Currents, the Gulf Stream System, and the Middle Atlantic Bight cold cell.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1975b. Quasi-realtime oceanographic experiment using NOAA satellite data and ship data. NOAA Final Rep. 3-35402:65.

Abstract. Provides comparison of sea surface data obtained from satellite and ships in the Gulf Stream.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1975c. Some climatological characteristics of hurricanes and tropical storms, Gulf and East Coasts of the U.S., 1975. NOAA, NWS Tech. Rep. 15:87.

Abstract. Historical summary of hurricanes and storms occurring in the Gulf of Mexico and the Atlantic Coast for 1975. General characteristics, such as duration, path, severity, wind speeds, origin, and direction are provided for each occurrence.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1976. Sea surface conditions in the western North Atlantic in 1976. NOAA Tech. Rep. NMFS Circ. 427:43-50.

Abstract. Provides sea surface characteristics in the North Atlantic region occurring in 1976. Data obtained from National Marine Fisheries Service cruises.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1977. Tidal Current Tables 1978. Atlantic Coast of North America. NOAA 77072801. 220pp.

Abstract. Data tabulation.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1978. Tidal current tables 1979. Atlantic Coast of North America. NOAA 78080702. 224pp.

Abstract. Data tabulation.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979a. Anticyclonic Gulf Stream eddies off the northeastern United States during 1976. NOAA Tech. Rep. NMFS Circ. 427:259-280.

Abstract. Characterization of the frequency of occurrence and distribution of warm-core rings.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979b. Atmospheric circulation in 1976. NOAA Tech. Rep. NMFS Circ. 427:11-18.

Abstract. Described summary data of large-scale weather patterns over the Atlantic.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979c. Bottom-water temperature trends in the Middle Atlantic Bight during spring and autumn, 1964-76. NOAA Tech. Rep. NMFS SSRF-739:13.

Abstract. Discusses factors affecting bottom water temperatures, the relationship between observed temperatures variations and temperature fluctuations in other areas of the northwestern Atlantic, and effects of temperature changes on the distribution of several commercially important fish species.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979d. Meteorological criteria for standard project hurricane and probable maximum hurricane windfields, Gulf and East Coasts of the United States. NOAA, NWS Tech. Rep. NOAA-TR-NWS-23:347.

Abstract. Description of standard hurricane windfield estimates.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979e. North Atlantic tropical cyclones, 1978. National Climatic Center, NOAA Climatological Data, National Summary, 29(13):8.

Abstract. Part of a summary of hurricane season by the National Hurricane Center.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979f. Temperature structure on the continental shelf and slope south of New England during 1976. NOAA Tech. Rep. NMFS Circ. 427:315-335.

Abstract. Summarizes temperature data for the Middle Atlantic region collected in 1976. Based primarily on expendable bathythermograph data. General temperature distributions for the region are provided.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979g. Variations in the position of the shelf water front off the Atlantic coast between Georges Bank and Cape Romain in 1976. NOAA Tech. Rep. NMFS Circ. 427:301-314.

Abstract. Presents data on tracking the position of a major front off the Atlantic coast.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1979h. Wind-driven transport, Atlantic coast and Gulf of Mexico. NOAA Tech. Rep. NMFS Circ. 427:175-208.

Abstract. Surface waters were found to respond to the surface wind stress by flowing in a direction 45° to the right of the stress direction. The net water transport is 90° to the right of the surface stress direction.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1983a. Environmental description of Norfolk Submarine Canyon - draft final report. Prepared for Sanctuary Programs Div. Office of Coastal and Ocean Resource Management, NOAA, Washington, D.C., under contract No. NA-82-AAA-03887.

Abstract. Environmental review of Norfolk Submarine Canyon. Descriptions are provided for biological communities in the canyons as well as the suspected current and hydrographic structure.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1983b. Gulf Stream system landward surface edge statistics. National Environmental Satellite, Data and Information Service Technical Memo. No. NOAA/TM/NWS/NMC-67; NOAA-83101201.

Abstract. Presents statistical evaluation of the mean position, standard deviation and maximum northward and southward positions of the Gulf Stream System landward surface edge.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1984. A tropical cyclone data tape for the North Atlantic Basin, 1886-1983: contents, limitations, and uses. NOAA Tech. Memo. NWS NHC 22.

Abstract. Describes the National Hurricane Center's computer file which contains dates, tracks, wind speeds, and central pressure values of all tropical cyclones between 1886 and 1983. Discusses data organization, format, limitations and several uses for the data files.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1990. Climatic summaries for NDBC buoys and stations. National Weather Service, National Data Buoy Center. Update 1:454.

Abstract. Seasonal and annual statistical summaries, as well as information about measured extremes, are provided for all National Data Buoy Center (NDBC) buoys and coastal stations with at least approximately three years of data. Results at approximately thirteen locations may be applicable to the Cape Hatteras

region. Descriptions of NDBC's measurement system accuracies, types of buoys, measurement techniques, and data processing techniques are provided.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 1991. NDBC data availability summary, latest version, updated annually by NDBC. NOAA National Data Buoy Center, Stennis Space Center, MS.

Abstract. This summary, which is updated annually, is a quick reference to determine the types of data available, and when the data acquisition systems were operating. It summarizes data that have been collected by the National Data Buoy Center (NDBC) since the early 1970's. It can be used before requesting archived NDBC data from the National Climatic Data Center (NCDC) or the National Oceanographic Data Center (NODC).

U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Weather Service. 1990. Climatic summaries for NDBC buoys and stations. National Weather Service, National Data Buoy Center. Update 1:454.

Abstract. Seasonal and annual statistical summaries, as well as information about measured extremes, are provided for all National Data Buoy Center (NDBC) buoys and coastal stations with at least approximately three years of data. Results at approximately thirteen locations may be applicable to the Cape Hatteras region. Descriptions of NDBC's measurement system accuracies, types of buoys, measurement techniques, and data processing techniques are provided.

U.S. Department of Commerce and National Oceanographic Data Center. 1978. NODC inventory of XBT data along transects in U.S. Atlantic and Gulf coastal waters from NMSF/MARAD ship of opportunity program for 1976. 24pp.

Abstract. Data catalogue.

U.S. Department of Commerce and National Ocean Survey. 1973. Surface water temperature and density: Atlantic coast, North and South America. NOS Publ. 31-1.

Abstract. General distributions of surface temperature and salinity are provided for the Western Hemisphere.

U.S. Department of Commerce and National Ocean Survey. 1979. Tidal current tables 1980: Atlantic Coast of North America: 234.

Abstract. Data tabulation.

U.S. Department of Commerce and National Ocean Survey. 1980. Tidal current tables 1981: Atlantic Coast of North America. 236pp.

Abstract. Data tabulation.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Ocean Service. 1989. United States Coast Pilot, Atlantic Coast: Cape Henry to Key West. 26th ed. National Ocean Service. Washington, D.C.

U.S. Department of Defense and Army Corps of Engineers. 1984. Summary of archived Atlantic coast wave information study. Pressure, wind, and water level data. Army Engineer Waterways Experiment Station Report, 1984.

Abstract. Summary of seven data sets produced and archived by the Wave Information Study (WIS) for the Atlantic coast.

U.S. Department of Defense and Department of the Navy. 1970. Summary of synoptic meteorological observations (SSMO) for North American coastal marine areas.

U.S. Department of Defense and Department of the Navy. 1973. Gulf Stream eddies in the western North Atlantic. Naval Oceanogr. Off. Rep. NOO-TN-6150-16-73:48.

Abstract. Discusses the evolution, life history, and decay of cyclonic eddies in the western North Atlantic.

U.S. Department of Defense and Department of the Navy. 1974. U.S. Navy marine climatic atlas of the world. North Atlantic Ocean (Revised 1974). GPO, Wash., D.C. Naval Weather Service Command, Naval Weather Service Detachment. Volume I:371.

Abstract. Demonstrates that there is very little continental climatic influence at the Georges Bank and Baltimore Canyon regions.

U.S. Department of Defense and Department of the Navy. 1976a. Climatic study of the near coastal zone: east coast of the United States. Naval Weather Service Command, Naval Weather Service Detachment. National Climatic Center:137.

Abstract. This atlas provides climatological information based on ship observations for the U.S. east coast. Information is similar to that in Standard Synoptic Meteorological Observations (SSMO's), but covers smaller individual geographic regions and is presented with graphics that are not in SSMO's.

U.S. Department of Defense and Department of the Navy. 1976b. Computer based wave refraction analysis for the Air Combat Maneuvering Range (ACMR) construction project. Ocean engineering and Construction Project Office, Chesapeake Division. Naval Facilities Engineering Command, Washington, D.C. Report. FPO-1-77:42.

Abstract. Numerical wave refraction analyses were performed for design of offshore platforms to serve as components of the U.S. Navy East Coast Air Combat Maneuvering Range. Analyses were made for twenty-seven sets of wave conditions at three sites in water depths of 80-100 ft (24-30 m) off Kitty Hawk, NC.

U.S. Department of Defense and Department of the Navy. 1978. Surface currents, west central North Atlantic Ocean including East Coast of the United States. U.S. Naval Oceanographic Office, Bay St. Louis (MS). Final report (NOO-SP-1400-NA-6):24.

Abstract. Summary report describing surface currents occurring primarily in the Northern Hemisphere. Dominant features of the western North Atlantic are also

described.

U.S. Department of Defense and Department of the Navy. 1981. Marine climatic atlas of the world: IX. World-wide means and standard deviations. Naval Air Systems Command, Washington, D.C. Report. NAVAIR-50-1C-65-VOL-9:355.

U.S. Department of Defense and Department of the Navy. 1983. U.S. Navy hindcast spectral ocean wave model climatic atlas: North Atlantic ocean. Naval Air Systems Command Report No.: NAVAIR-50-1C-538.

Abstract. Introduces a new, numerically derived, historical data set in the form of a wind and wave climatology intended to provide a more accurate representation of the overall North Atlantic wave climate than is available from other sources.

U.S. Department of Defense and Department of the Navy. 1987a. Final technical report of Naval Research control number N00014-77-C-0354. Univ. of North Carolina Report No.: CMS-87-2.

Abstract. Ten-year project supporting research on the physical oceanography of the Gulf Stream, including structure and energetics of Rossby Waves and Gulf Stream meanders.

U.S. Department of Defense and Department of the Navy. 1987b. Regional characteristics for interpreting inverted echo sounder (IES) observations. Naval Ocean Research and Development Activity Report, June 87, 8 pp.

Abstract. Dynamic height, isotherm and isopycnal depths have been calculated using CTD data from the Norwegian Current, the Sargasso Sea and the eastern Gulf Stream. Quasi random scatter about regression curves is found to be primarily the result of variability in the seasonal thermocline, where present.

U.S. Department of Defense and Department of the Navy. 1989. Regional climatic study of the United States Atlantic coast and associated waters.

U.S. Department of Defense and Department of the Navy. 1992. Marine climatic atlas of the world.

Abstract. CD-ROM based data base.

U.S. Department of Defense and United States Air Force. 1985. Case study of a mid-Atlantic coastal front. Air Force Institute of Technology Report, 1985.

Abstract. A unique case of mid-Atlantic coastal frontogenesis on December 21-22, 1983 is examined to determine the evolution of the three dimensional structure of this mesoscale phenomena.

U.S. Department of Energy. 1984. Physical processes influencing temperature and salinity on the North Carolina Cape Shoals. Prepared by North Carolina St. Univ., Raleigh, Report No.: DOE/EV/00902-T1.

Abstract. Cross-spectral analysis and a heat budget are used to relate atmospheric and river runoff data with seven years of daily surface temperature

and salinity on the North Carolina continental shelf.

U.S. Department of Energy. 1985. Measurement of Gulf Stream and wind induced shelf circulation in the South Atlantic Bight. Final Report, June 1, 1982-May 31, 1985. Prepared by Univ. of Miami, Report No.: DOE/EV/05163-T1.

Abstract. Report discusses a study to determine the relative importance of the forces driving shelf circulation and exchange in the South Atlantic Bight and to measure the shelf water response over variable time and space scales.

U.S. Department of Energy. 1986. Dynamic variability of the Gulf Stream front in the Carolina Capes. Prepared by North Carolina St. Univ., Raleigh, Report No.: DOE/ER/60376-T3.

Abstract. Theoretical investigation of the stability of a two-layer Gulf Stream model based on the hypothesis that the dynamic variability of the time-dependent baroclinic jet may be due to subinertial frequency disturbances propagating along the coast and acting as a time-dependent perturbation to the geostrophic jet.

U.S. Department of Energy. 1987. Nearshore transport processes affecting the dilution and fate of energy-related contaminants: Progress reports, January 1981 - December 1987. Prepared by Skidaway Inst. of Oceanogr., GA, Report Nos.: DOE/ER/60351-T1, -T2, -T3, -T4 and -2.

Abstract. Cited are five progress reports concerning one of several components in the DOE regional program of Coastal Oceanography in the southeastern U.S., or the South Atlantic Bight (SAB). In conjunction with SPREX and FLEX (FaLl EXperiment), research is focused on understanding the role of coastal fronts and associated circulation processed in transporting material on the continental shelf of the SAB.

U.S. Department of Energy. 1988. Continental shelf processes affecting the oceanography of the South Atlantic Bight: Progress reports. Prepared by Old Dominion Univ., VA, Report Nos.: DOE/ER/60348-1. -5 and -7.

Abstract. Three progress reports concerning the part of the interdisciplinary DOE-sponsored South Atlantic Bight Program which involves hydrographic and nutrient characteristics. Results of the FLEX field study are presented.

U.S. Department of Interior and Bureau of Land Management. 1974a. Scientific presentations. Presented by Bumpus, et al., at BLM Conference on Marine Environmental Implications of the Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast, College Park, MD, 74(372):93.

Abstract. General overview of the physical oceanography of the Middle Atlantic region. Purpose of the conference was to assess the existing information base for the purpose of identifying research needs for informed oil and gas decision making.

U.S. Department of Interior and Bureau of Land Management. 1974b. A socio-economic environmental baseline summary for the South Atlantic Region between Cape Hatteras, NC and Cape Canaveral, FL, Vol. I., Physical Oceanography. Final Rep. to BLM. 264 pp.

Abstract. Literature review sponsored by the Bureau of Land Management. Excellent overview of the physical oceanography of the South Atlantic Bight is provided.

U.S. Department of Interior and Bureau of Land Management. 1974c. A socio-economic environmental baseline summary for the South Atlantic region between Cape Hatteras, North Carolina and Cape Canaveral, Florida. Vol. II, Climatology. Bureau of Land Management. Washington, D.C. 211 pp.

Abstract. This report provides an overview of the general climatology, winds, air temperature, precipitation, relative humidity, visibility at sea, and occurrence of fog and severe weather events of the coastal and oceanic environments of the southeastern United States. The report summarizes significant regional literature, 1974 and previous.

U.S. Department of Interior and Bureau of Land Management. 1976. Summary of environmental information on the continental slope Canadian/United States border to Cape Hatteras, NC. TRIGOM (The Research Institute of the Gulf of Maine).

Abstract. Literature review report covering the continental slope from the Bay of Fundy to Cape Hatteras. Specifies background data sources for preparation of Environmental Impact Statements and planning of environmental studies pertinent to potential leasing areas. Includes a separate chapter on physical oceanography.

U.S. Department of Interior and Bureau of Land Management. 1977. Summarization and interpretation of historical oceanographic and meteorologic information for the Mid-Atlantic region. Final Rept. to BLM. AA550-1A6-12:295.

Abstract. Early summary of existing available data and studies for the Mid Atlantic OCS region.

U.S. Department of Interior and Bureau of Land Management. 1982. Summary of environmental geologic studies in the Mid-Atlantic Outer Continental Shelf area -- Results of 1978-1979 field seasons. Report submitted to BLM under Memoranda of Understanding AA551-MU8-21 and AA551-MU9-4.

Abstract. Summary of geologic field data from the Mid-Atlantic OCS.

U.S. Department of Interior and Bureau of Land Management. 1983. Second, third and fourth interim reports for the Canyon and Slope Processes Study. Prepared by Hunkins, et al. for the BLM under contract AA851-CTO-59 (1981, 1982 and 1983).

Abstract. Cited are three progress reports summarizing interim activities for the Middle Atlantic Canyon and Slope Processes Study in the Baltimore Canyon region. Results are preliminary but indicate mean current flows downward through the axis of Baltimore Canyon. Data also indicate presence of sediment transport downward

and upwelling and mixing at depth intervals along the adjacent slope and within Baltimore Canyon.

U.S. Department of Interior and Minerals Management Service. 1983. Blake Plateau: Near bottom current/temperature measurements on 36°N. Report No.: MMS/AT/ES-83/05.

Abstract. Included are a characterization of the mean flow and variability of the Western Boundary Under Current and patterns of change observed resulting from lateral shifts of the Gulf Stream path.

U.S. Department of Interior and Minerals Management Service. 1984. South Atlantic OCS Physical Oceanography (Years Three, Four and Five). Volumes 1 and 2. Report No.: MMS/AT/ES-82/01 and /02; -83/01 and/02; -84/14.

Abstract. Presents data from a 5-year program to study the physical oceanography of an area extending alongshore from Cape Hatteras to Cape Canaveral and offshore across the shelf and the Blake Plateau.

U.S. Department of Interior and Minerals Management Service. 1986a. Blake Plateau current measurement study. Final Report. Report No.: OCS/MMS-86/0082.

Abstract. Final report of study in the Gulf Stream to determine velocity, current and temperature variability, physical processes producing the variability, influence of the Gulf Stream on the physical characteristics of the South Atlantic continental shelf, and importance of eddy induced upwelling to primary productivity.

U.S. Department of Interior and Minerals Management Service. 1986b. North Carolina physical oceanography programs, Offshore Environmental Studies Program. OCS Report, MMS 85-0108, U.S. DOI, 12p.

Abstract. Compendium of descriptions of OCS physical oceanographic programs.

U.S. Department of Interior and Minerals Management Service. 1986c. South Atlantic OCS (Outer Continental Shelf) Circulation Model, Phase 3 (Revised). Report No.: DYNALYSIS-91; OCS/MMS-86/0120.

Abstract. Purposes of the study are to demonstrate that the General Circulation Model embodies the physics required to produce the observed Gulf Stream variability and to provide circulation fields for immediate application to satisfy Mineral Management Service oil spill modelling requirements.

U.S. Department of Interior and Minerals Management Service. 1987. Study of physical processes on the U.S. Mid-Atlantic continental slope and rise. OCS Study, MMS 87-0024, 3 volumes.

Abstract. Report describes three years of physical oceanographic research in the Mid-Atlantic Slope and Rise (MASAR) program, which was designed to allow MMS to assess potential impacts of oil exploration and production activities on the outer-continental shelf of the Mid-Atlantic region.

U.S. Department of Interior and Minerals Management Service Atlantic Continental Shelf Office. 1987. Study of Physical Processes on the U. S. Mid Atlantic Continental Slope and Rise. OCS Study. MMS-87-0024:.

U.S. Department of Interior and U.S. Fish and Wildlife Service. 1974. Variations in the shelf water front off the Atlantic coast between Cape Hatteras and Georges Bank. Prepared for Nat. Mar. Fish. Serv. Report on the Status of the Environment.

Abstract. Describes the variations of water masses along the continental shelf and slope of the Middle Atlantic Bight. Frontal zones were found to vary according to season and other factors and were based primarily on hydrographic parameters.

U.S. Department of Transportation and United States Coast Guard. 1971. Oceanographic observations along the East Coast of the United States, January-December, 1967. USCG Oceanogr. Rep. 38:149.

Abstract. Discusses aspects of nearshore oceanographic climatology using lightship data. Reports seasonal warming and cooling of the surface waters off Cape Fear.

U.S. Department of Transportation and United States Coast Guard. 1975. Oceanographic observations: Nova Scotia to Cape Hatteras, North Carolina (Oct.-Nov. 1969 and May-June 1970). USCG Rep. 373-666:248.

Abstract. Primarily hydrographic data obtained along an established nearshore station grid.

U.S. Department of Transportation and United States Coast Guard. 1978. Airborne radiation thermometer measurements from Cape Cod, Massachusetts to Miami, Florida. July 1970-June 1976. USCG Oceanogr. Rep. 373-76:86.

Abstract. Sea surface water temperature data are presented. Data collected are from opportunistic U.S. Coast Guard surveillance flights. Provides general overview of temperature distributions for the area.

U.S. Department of Transportation and United States Coast Guard Oceanographic Unit. 1975. Airborne Radiation-Thermometer Program: Surface-isotherms - Deg C., June 10-12, 18-20, 1975. Washington, D.C.

Abstract. Airborne reconnaissance of sea surface temperatures providing a series of nearly-synoptic maps of the Gulf Stream frontal region.

U.S. Environmental Protection Agency. 1982. Analysis of current meter records at the Northwest Atlantic 2800 Meter Radioactive Waste Dumpsite. Office of Radiation Programs. Report No.: EPA-520/1-82-002.

Abstract. EPA assessment of formerly used dumpsite on the Continental Rise during August 1976.

U.S. Navy Commander Naval Oceanography Command. 1989. U.S. Navy Regional Climatic Study of the United States Atlantic Coast and Associated Waters, NAVAIR 50-1C-555, 257 p.

U.S. Nuclear Regulatory Commission. 1982. Historical extreme winds for the United States: Atlantic and Gulf of Mexico coastlines. NRC Report, May 82, 160 pp.

Abstract. Annual wind data were extracted for the complete period of record for 53 locations along the Atlantic and Gulf of Mexico coastlines. Selected probability estimates were developed from an extreme value model for non-tropical storms and the Weibull model for tropical storms.

Valliamos, L. 1977. A report of the evaluation of the navigation project at Drum Inlet, NC. U.S. Army Engineer District, Wilmington. Corps of Engineers.:63.

Abstract. A year of wave data were collected at Drum Inlet (NC). Wave height probability distributions are also provided at Atlantic (NC) and Davis (NC).

Vastano, A.C., J.E. Schmitz and D.E. Hagan. 1980. Physical oceanography of two rings observed by the cyclonic ring experiment, Pt. 1, physical structure. J. Phys. Oceanogr. 10(4):493-513.

Abstract. Publication resulting from the ring experiment that focuses on ring interaction with the Gulf Stream and the spindown processes.

Vazquez, J. 1984. Propagation, Growth, and Predictability of Gulf Stream Meanders Northeast of Cape Hatteras. Master of Science Thesis. Univ. of Rhode Island, Kingston. 123 pp.

Vazquez, J. and L.-L. Fu. 1991. Observations on the influence of the meandering of the Gulf Stream on sea level using altimeter data and NOAA derived sst frontal positions. EOS, Trans. AGU. 72(51):78.

Abstract. The influence of the meandering of the Gulf Stream on sea level residual is studied using Geosat altimetry and the NOAA AVHRR charts of Gulf Stream North Wall positions between 11/86 and 12/88. Residuals relative to a two-year mean sea level in the area between 75°W to 60°W were gridded in space and time at a temporal resolution of 10 days and a spatial resolution of 1/4 degree. To generate a data set of sea level based only on the meandering of the Stream and not transport changes, a simple model was applied to the digitized paths of Gulf Stream North Wall positions. The sea level residuals derived from the model were gridded in space and time at the same resolutions as the altimeter data set with complex empirical orthogonal function (CEOF) analysis applied to both data sets to extract the spatially correlated signal. Longitude-time plots for each of the first 4 COEF modes were generated for both the model (simulated) and altimeter derived sea level residuals.

Vazquez, J. and D.R. Watts. 1983. Propagation of Gulf Stream meanders northeast of Cape Hatteras, observed by satellite infrared imagery and inverted echo sounders. EOS, Trans. AGU. 64(18):237.

Abstract. The covariance of Gulf Stream path displacements in a region up to 900

km northeast of Cape Hatteras exhibits a prominent 50-day periodicity associated with meanders.

Vazquez, J. and D.R. Watts. 1985. Observations on the propagation, growth, and predictability of Gulf Stream meanders. J. Geophys. Res. 90(C4):7143-7151.

Abstract. During a 3-year period, Gulf Stream positions determined by satellite infrared imagery on a grid northeast of Cape Hatteras have been correlated against "inlet" path parameters (displacement from the mean position, angle, and curvature) monitored by an array of inverted echo sounders (IES). By cross-spectral calculations between these measurements, we determined the downstream coherences, phase speeds, and spatial growth rates. The downstream path predictability from these inlet parameters was tested in a multiple input linear response model. The most energetic meanders, with periods of 33-50 days, remained highly coherent for 300 km downstream, roughly the dominant wavelength, with marginal coherence again at 500-575 km. Within 300 km of the inlet, the multiple coherence accounts for 55-65% of the total path-displacement variance, with displacement and angle being the best individual predictors in the first and last halves of this region, respectively.

Vazquez, J., V. Zlotnicki and L.-L Fu. 1990. Sea level variabilities in the Gulf Stream between Cape Hatteras and 50°W: a Geosat study. J. Geophys. Res. 95(C10):17957-17964, 18365.

Abstract. Sea level residuals relative to a 2-year mean sea level in the Gulf Stream downstream of Cape Hatteras are studied using Geosat altimetry between November 1986 and December 1988. Spectral slopes computed at four nominal locations along the Gulf Stream (72°W, 65°W, 60°W, and 55°W) range between -1.5 and -0.9. The energy in the annual cycle decreases eastward from around 40% of the total variance at 72°W to 20% of the total variance at 55°W. Maximum residual geostrophic sea surface velocities associated with the annual cycle were of the order of 70 cm/s. Comparison between the Gulf Stream path from sea level residual maps and the north wall edge observed from NOAA infrared (IR) imagery shows an RMS difference of 49 km between 75°W and 60°W longitude. Using the IR estimates for Gulf Stream position, sea level residuals were modeled by the meandering of a sea level front shaped as $0.5\ m \circ \tanh((X-X_0)/(50\ km \circ \sin\alpha))$. (18 Refs.).

Vemulakonda, S.R., A. Swain, J.R. Houston, P.D. Farrar and L.W. Chou. 1985. Coastal and Inlet Processes Numerical Modeling System for Oregon Inlet, North Carolina. CERC Tech. Rep. CERC-TR-85-6:114.

Abstract. Oregon Inlet is a large tidal inlet through the barrier island system of North Carolina. In 1970, Congress authorized the Manteo (Shallowbag) Bay project which had provisions to stabilize Oregon Inlet with two jetties, deepen the ocean bar channel to 20 ft, and bypass across the inlet sand intercepted by the jetties. This report describes the results of a numerical study to consider coastal and inlet processes in the region surrounding the inlet under existing and planned project conditions. To accomplish the objectives of the study, a system of numerical models called Coastal and Inlet Processes (CIP) Numerical Modeling System was developed. It included models for wave propagation, wave-induced currents and setup, sediment transport within and beyond the surf zone, and profile response (onshore-offshore transport). Results from a separate study

on numerical simulation of tides and storm surge for Oregon Inlet were utilized in the present investigation.

Vennell, M.R. 1988. Influence of a Steady Baroclinic Deep Ocean on the Shelf. Ph.D. Thesis. Woods Hole Oceanographic Institution. 202 pp. (NTIS Accession Number: PB89-198188/XAB)

Abstract. The degree to which a baroclinic deep ocean could be responsible for the mean flow on the shallow continental shelf is examined using steady, boundary forced models which incorporate bottom friction. One set of models, for a vertically well mixed shelf, includes the horizontal advection of density. The second set of models comprises a three-layer model without and a two-layer model with interfacial friction. It is found that near bottom flow has a short cross isobath scale due to the steep continental slope and consequently that the deep oceans lower water column could not be responsible for the observed mean flow. The cross isobath scale of flow in the upper deep ocean is predominantly determined by the oceans velocity profile. In a barotropic or near barotropic flow the upper water column follows the near bottom flow and therefore has little influence on the shelf. Using oxygen isotope data, Chapman et al. (1986) found that the Scotian shelf is the major source of Mid-Atlantic Bight shelf water. Their barotropic modeling results are extended to show that a baroclinic deep ocean also acts to hold shelf water on the shelf.

Vennell, M.R. and P. Malanotte-Rizzoli. 1990. The influence of a steady baroclinic deep ocean on the shelf: the vertically well-mixed case. J. Phys. Oceanogr. 20(4):489-505.

Abstract. Develops a model for vertically well-mixed flow on a shelf and examines forcing by the deep ocean. The authors study three specific examples, a wide inflow, a narrow inflow, and forcing by a Gulf Stream ring. Nearshore forcing is examined for a river outflow and an alongshore jet. (22 Refs.).

Von Arx, W.S., D.F. Bumpus and W.S. Richardson. 1955. On the fine-structure of the Gulf Stream front. Deep-Sea Res. 3:46-65.

Abstract. First characterization of "shingling" associated with the shoreward side of Gulf Stream meanders with a description of the wide range of scales of the phenomena. A shingle pattern is generated by the entrainment of a filament of shallow Gulf Stream water which is separated from the front and wrapped around a cyclonic meander.

Vukovich, F.M. 1970. Physical Oceanography Feasibility Study Utilizing Satellite Data. Part II. Detailed Sea-Surface Temperature Analysis Utilizing Nimbus Hrir Data. NOAA Final Rep. NOAA-E236-69N-1:80.

Abstract. A technique through which cloud-free and noise-free HRIR temperature data are obtained for 0.3 cloud cover or less, is described, and the analysis of the resulting data is compared with ground truth data. After the technique was applied, the HRIR data maintained a spatial resolution of approximately 20 nautical miles. The technique was applied to NIMBUS II and NIMBUS III HRIR data. The resulting temperature patterns off the North Carolina coast and in the BOMEX grid are presented. Ground truth data were obtained by the Duke University Marine

Laboratory's Research Vessel (R/V) EASTWARD, and the Cape Fear Technical Institute's R/V ADVANCE II. The technique shows a 1.0°C magnitude discrepancy existed between the processed HRIR and ground truth data.

Vukovich, F.M. 1972. Synoptic-Scale Air-Sea Interaction Study Using NOAA-1 SRIR Data. NOAA Final Rep. NOAA-72101833:91.

Abstract. The report presents the results of a study in which NOAA-1 SRIR data were used to examine two aspects of the air-sea interaction. These were: (1) the influence of the latent and sensible heat fluxes on the energy budget of synoptic-scale systems passing over the Gulf Stream; and (2) the detection of the influence of weather systems on the near-shore ocean. NOAA-1 sea-surface temperature data were used to compute the heat fluxes and to determine qualitatively near shore motions off the Virginia-North Carolina Coast. Procedures for computation of steady-state wind-driven currents and to obtain stream function values at the sea surface using satellite sea-surface temperature data are delineated in the appendices. The author concludes that there is a very fundamental need for oceanographic and meteorological data to support interpretation of satellite data.

Vukovich, F.M. 1974. The Detection of Nearshore Eddy Motion and Wind-Driven Currents Using NOAA 1 Sea Surface Temperature Data. J. Geophys. Res. 79(6):853-860.

Abstract. The influence of weather systems on the nearshore ocean were studied by using NOAA 1 sea surface temperature data. The study area was off the Virginia-North Carolina coast. Through time series analyses of the NOAA 1 sea surface temperature data, nearshore eddies were detected.

Vukovich, F.M. 1976. An investigation of a cold eddy on the eastern side of the Gulf Stream using NOAA 2 and NOAA 3 satellite data and ship data. J. Phys. Oceanogr. 6(4):605-612.

Abstract. A study of a cold eddy on the eastern side of the Gulf Stream was performed combining data from the NOAA 2 and NOAA 3 satellites and from the Cape Fear Technical Institute's R/V ADVANCE II. The satellite data were used initially to identify and locate the eddy in real-time. The location data obtained from the satellite imagery was used to plan an oceanic field program using the ADVANCE II to collect temperature and salinity data in the perturbation. The analysis of satellite data indicated that the cold eddy was elliptic in shape with the major axis varying from 180 to 120 km and a minor axis varying from 120 to 100 km. The analysis also suggested that the circulation of the eddy was entraining warm Gulf Stream water, strengthening the warm ring around the eddy. The subsurface analysis indicated that the cold eddy was characterized by a very pronounced dome of relatively cold, less saline water below 200 m. Above 200 m, the temperature and salinity were uniform, both vertically and horizontally.

Vukovich, F.M. 1990. A study of the variations of the Gulf Stream East of 75°W and their association with the transport in the Straits of Florida. Proceedings of the Joint Conference on Satellite Meteorology and Oceanography, London, England.

Abstract. The Gulf Stream south of Cape Hatteras is generally found at the Shelf Break. At Cape Hatteras, the Gulf Stream turns eastward and moves away from the coast. Large wave-like meanders develop on the Gulf Stream as the stream breaks down into turbulence. Many of these waves become unstable and produce large warm core rings (WCR) in the Slope Sea or cold core rings in the Sargasso Sea. These wave-like meanders have periods on the order of 7 to 21 days. Recently Casagrande (1987) noted that longer period oscillations also exist on the Gulf Stream system east and north of Cape Hatteras. These longer period oscillations are the focus of this paper. Nine years (1980-1988) of NOAA infrared imagery were utilized to study the long period oscillations on the Gulf Stream east of Cape Hatteras between 65°W and 75°W. The satellite data were combined with 7 years (1982-1988) of transport measurements in the Florida Current made by a submarine cable from Jupiter, Florida to Settlement Point in the Bahamas (Larsen and Sanford, 1985). No transport measurements from the cable were available before 1982.

Vukovich, F.M. and B.W. Crissman. 1975. Case study of exchange processes on the western boundary of the Gulf Stream using NOAA-2 satellite data and ship data. Remote Sens. Environ. 4:165-176.

Abstract. Eddies on the western boundary of the Gulf Stream off the southeast coast of the United States were studied using NOAA-2 IR data and data collected by the R/V DALLAS HERRING. The eddies in question had short life cycles (not much more than 72 hours) and were of small vertical extent (at most 60 m deep). These eddies appear to be the result of the steering of currents in shelf water toward the Gulf Stream boundary by the shoals found off the various capes from Cape Hatteras southward. This led to the penetration of a tongue of shelf water into the Gulf Stream and an eventual isolation of a lens of Gulf Stream water on the shelf.

Vukovich, F.M. and B.W. Crissman. 1978. Further studies of a cold eddy on the eastern side of the Gulf Stream using satellite data and ship data. J. Phys. Oceanogr. 8(5):838-845.

Abstract. A cold eddy was observed in late March and early April 1975 to encounter the eastern boundary of the Gulf stream and entrain warm Gulf Stream water into its outer fringes. Available evidence indicated that the entrainment of Gulf Stream water in the western and southern portions of the eddy enhanced the density stratification creating available potential energy which led to an increase in kinetic energy in those regions. A secondary, cold perturbation with a high-salinity core was detected south of the center of the cold eddy. It was not clear from the data whether the conversion of available potential energy into kinetic energy increased the kinetic energy of the cold eddy, produced the secondary perturbation, or both.

Vukovich, F.M. and B.W. Crissman. 1979. Aspects of Gulf Stream Western Boundary Eddies from Satellite and *in Situ* Data. NOAA, NESS Rep. NOAA-80070712:101.

Abstract. NOAA-5 infrared imagery were used to determine statistics of existing and developing eddies on the western boundary of the Gulf Stream. The satellite data were then combined with in situ data to study the physics and dynamics of both a new-born eddy and one which had been in existence for a considerable time. A simple linear model of flow over a topographic feature similar to the Charleston Bump was developed. The results of the study showed that, on the average, the perturbations are much more intense, have larger dimensions, and move slower when they are located immediately downstream of the Charleston Bump, a region where the bottom topography is influenced by the Blake Plateau, than when the eddies were located farther downstream in a region where the slope is steep. The results of the theoretical model compare well with observed data, suggesting that the perturbations may indeed be lee waves.

Vukovich, F.M. and B.W. Crissman. 1980. Some aspects of Gulf Stream western boundary eddies from satellite and *in situ* data. J. Phys. Oceanogr. 10(11):1792-1813.

Abstract. NOAA-5 infrared images were used to determine statistics of existing and developing perturbations on the western boundary of the Gulf Stream. The satellite data were combined with oceanographic data to study both a new-born eddy and one that had been in existence for a considerable time. On the average, the perturbations are much more intense, have larger dimensions, and move more slowly when located immediately downstream of the Charleston Bump, a region where the flow in influenced by the Blake Plateau, than when located farther downstream in a region where the slope is steeper.

Vukovich, F.M. and G.A. Maul. 1982. Preliminary estimates of surface vorticity and divergence in Gulf Stream western boundary perturbations using satellite and buoy data. In Proceedings of the Workshop on Gulf Stream Structure and Variability Held at Research Triangle Park, North Carolina on 1-2 April 1982.

Abstract. Estimates of surface divergence, surface vorticity, and terms in the equation for the time rate of change of vorticity at the surface in a Gulf Stream western boundary perturbation were derived using satellite SR and free-drifting buoy data.

Vukovich, F.M. and G.A. Maul. 1983. An observation of the surface circulation in a Gulf Stream frontal perturbation. Geophys. Res. Lett. 10(7):591-594.

Abstract. Discusses passage of a free-drifting buoy through a Gulf Stream frontal perturbation from 3-16 June 1979 into a warm filament on the shoreward side.

Vukovich, F.M., B.W. Crissman, M. Bushnell and W.J. King. 1979. Gulf Stream Boundary Eddies off the East Coast of Florida. J. Phys. Oceanogr. 9(6):1214-1222.

Abstract. Combining satellite and *in situ* data, a characterization of eddies is made in terms of translation speed and areal extent.

Vukovich, F.M., B.W. Crissman, L.J. Pietrafesa, G.S. Janowitz and R.H. Weisberg. 1984. Effects of wind and Gulf Stream events on the currents off the coast of North Carolina as it relates to oil-spill risk potential. Final Report, Contract No. 14-12-0001-30152. Mineral Management Service by Triangle Institute, Research Triangle Park, NC, 59 pp.

Vukovich, F.M., J.W. Dunn and B.W. Crissman. 1991. Aspects of the evolution of the marine boundary layer during cold-air outbreaks off the southeast coast of the United States. Mon. Weather Rev. 119(9):2252-2279.

Abstract. Remote sensing and *in situ* measurements that were obtained in February 1986 were combined with the results from a boundary-layer model to study aspects of the evolution of the marine boundary layer (MBL) during two cold-air outbreaks off the southeast coast of the United States. Maximum total heat fluxes occurred over the Gulf Stream northeast of Cape Hatteras where very cold, dry air encountered the Gulf Stream and where the wind speeds were very large. Maximum 6-h values for the total heat flux were as high as 2015 W/m^2. The magnitude of the area-average heat flux in the MBL was influenced not only by the surface air and dewpoint temperatures and the surface wind speeds off the coast but also by the area covered by Gulf Stream water. The heat flux distribution off the coast rapidly produced large horizontal temperature and humidity differences over distances on the order of 100 km.

Wagner, S.E. and A.R. Sherlock. 1986. Annotated Bibliography of the Atlantic Remote Sensing Land-Ocean Experiment (ARSLOE). CERC Tech. Rep. CERC-86-4:36.

Abstract. The Atlantic Remote Sensing Land-Ocean Experiment (ARSLOE) was conducted during October and November 1980 at the US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility located at Duck, North Carolina. ARSLOE consisted of experiments which were related to ocean waves, remote sensing of ocean fronts, and remote sensing of land cover. This annotated bibliography presents a compilation of published literature which describes the experiment, the measurements made, and the analyses conducted since termination of the experiment.

Wahl, E.W. and R.A. Bryson. 1975. Recent changes in Atlantic surface temperatures. NOAA Tech. Rep. 254(5495):45-46.

Abstract. Interprets the observed decrease in surface temperatures near the Grand Banks as due to the southward shift of the axis of the Gulf Stream and its replacement with water from the Labrador Current.

Wahls, H.E. 1973. A survey of North Carolina beach erosion by air photo methods. NCSU Center for Mar. Coastal and Studies Rep. 73-1:31.

Abstract. This report includes results of the original study (Stafford, 1968) as well as new data for the time interval since the publication of the original report.

Wai, M.M.-K. and S.A. Stage. 1989. Dynamical analyses of marine atmospheric boundary layer structure near the Gulf Stream oceanic front. Quarterly Journal of the Royal Meteorological Society. 115(485):29-44.

Abstract. The effects of the sea surface temperatures front at the edge of the Gulf Stream on the marine atmospheric boundary layer (MABL) are investigated using a numerical model to study the modification effects of an oceanic front on the MABL structure. The situation simulated is flow from over cold shelf water to over the warm water of the Gulf Stream. The initial temperature and humidity profiles of the air are specified to be near neutral over the cold water and are therefore typical of undisturbed conditions. (27 Refs.).

Walker, R.E. 1976. Wave statistics for the North Atlantic Ocean, 1970. Bedford Institute, Dartmouth, Nova Scotia, Atl. Ocean. Lab., Dept. Environ. 228.

Abstract. Useful summary of wave statistics that can be applied in a summary of wave climatology within the Atlantic OCS.

Walsh, J.J. 1990. Simulation analysis of moored fluorometer time series from the Mid-Atlantic Bight during 1987-1990. Department of Energy. DOE/ER/60285-4:42.

Abstract. The goal of the previous research during 1987-1990 within the DOE (Department of Energy) Shelf Edge Exchange Processes (SEEP) program in the Mid-Atlantic Bight was to understand the physical and biogeochemical processes effecting the diffusive exchange of the proxies of energy-related, by-products associated with particulate matter between estuarine, shelf, and slope waters on this continental margin. As originally envisioned in the SEEP program plan, SEEP-III would take place at Cape Hatteras to study the advective exchange of materials by a major boundary current. One problem of continuing interest is the determination of the local assimilative capacity of slope waters and sediments off the eastern seaboard of the US to lengthen the pathway between potentially harmful energy by-products and man. At basin scales, realistic specification of the lateral transport by western boundary currents of particulate matter is a necessary input to global models of carbon/nitrogen cycling. Finally, at these global scales, the generic role of continental margins in cycling greenhouse gases, e.g. CO_2, CH_4, and N_2O, is now of equal interest. This continuing research of model construction and evaluation within the SEEP program focuses on all three questions at local, regional, and basin scales. Results from SEEP-I and II are discussed as well as plans for SEEP-III. 14 figs., 3 tabs.

Walsh, J.J. and W.E. Esaias. 1985. Collection and Simulation Analysis of Moored Fluorometer Time Series from the Mid-Atlantic and South Atlantic Bights. Appendix 1. Satellite Detection of Phytoplankton Export from the Mid-Atlantic Bight During the 1979 Spring Bloom. Department of Energy. DOE/ER/60285-1:77.

Abstract. Analysis of CZCS imagery confirms shipboard and aircraft observations of resuspension of near-bottom chlorophyll within surface water (1 to 10 m) by northwesterly wind events in the mid-Atlantic Bight. As much as 8 to 16 mu g Chl/l are found during these wind events from March to May, with a seasonal increase of algal biomass until onset of stratification of the water column. Rapid sinking apparently occurs after cessation of the wind events such that the predominant surface chlorophyll pattern is approx. 0.5 to 1.5 mu g/l over the

continental shelf during the spring bloom. Without enhanced primary production during a wind event, the annual photosynthetic input of carbon would be approx. 270 g $C/m^2/yr$. Perhaps half of the chlorophyll increase observed by satellite during a wind event represents *in situ* production of that 4 to 5 day time interval, with the remainder attributed to accumulation of algal biomass previously produced, sunk out, resuspended, and enroute to the shelf break during these offshore transport events. At least 16 to 40 g $C/m^2/yr$ may be exported as ungrazed phytoplankton carbon from shelf waters to continental slope sediments. 32 refs., 37 figs., 3 tabs.

Walsh, J.J., D.A. Dieterle and W.E. Esaias. 1986a. Satellite Detection of Phytoplankton Export from the Mid-Atlantic Bight during the 1979 Spring Bloom. NASA Tech. Memo. NASA-TM-88782:53.

Abstract. Analysis of Coastal Zone Color Scanner (CZCS) imagery confirms shipboard and *in situ* moored fluorometer observations of resuspension of near-bottom chlorophyll within surface waters (1 to 10 m) by northwesterly wind events in the mid-Atlantic Bight. As much as 8 to 16 micrograms chl/l are found during these wind events from March to May, with a seasonal increase of algal biomass until onset of stratification of the water column. Rapid sinking or downwelling apparently occurs after subsequent wind events, however, such that the predominant surface chlorophyll pattern is approx. 0.5 to 1.5 micrograms/l over the continental shelf during most of the spring bloom. Perhaps half of the chlorophyll increase observed by satellite during a wind resuspension event represents in-situ production during the 4 to 5 day interval, with the remainder attributed to accumulation of algal biomass previously produced and temporarily stored within near-bottom water. Present calculations suggest that about 10% of the primary production of the spring bloom may be exported as ungrazed phytoplankton carbon from mid-Atlantic shelf waters to those of the continental slope.

Walsh, J.J., D.A. Dieterle and M.B. Meyers. 1986b. Simulation Analysis of the Fate of Phytoplankton within the Mid-Atlantic Bight. NASA. NASA-CR-177265:62.

Abstract. A time-dependent, three-dimensional simulation model of wind-induced changes of the circulation field, of light and nutrient regulation of photosynthesis, of vertical mixing as well as algal sinking, and of herbivore grazing stress, is used to analyze the seasonal production, consumption, and transport of the spring bloom within the mid-Atlantic Bight. The particular case (c) of a 58-day period in February-April 1979, simulated primary production, based on both nitrate and recycled nitrogen, with a mean of 0.62 g C m^2/day over the whole model domain, and an export at the shelf-break off Long Island of 2.60 g chl m^2/day within the lower third of the water column. About 57% of the carbon fixation was removed by herbivores, with 21% lost as export, either downshelf or offshore to slope waters, after the first 58 days of the spring bloom. Extension of the model for another 22 days of case (c) increased the mean export to 27%, while variation of the model's parameters in 8 other cases led to a range in export from 8% to 38% of the average primary production. Spatial and temporal variations of the simulated algal biomass, left behind in the shelf water column, reproduced chlorophyll fields sensed by satellite, shipboard, and *in situ* instruments.

Walsh, J.J., C.D. Wirick, L.J. Pietrafesa, T.E. Whitledge and F.E. Hoge. 1986c. High Frequency Sampling of the 1984 Spring Bloom within the Mid-Atlantic Bight: Synoptic Shipboard, Aircraft, and *In situ* Perspectives of the Seep-I Experiment. NASA Tech. Memo. NASA-TM-88765:56.

Abstract. Moorings of current meters, thermistors, transmissometers, and fluorometers on the mid-Atlantic shelf, south of Long Island, suggest a cumulative seaward export of perhaps 0.35 g C/m^2/day between the 80 and 120 m isobaths during February-April 1984. Such a horizontal loss of algal carbon over the lower third of the water column would be 23 to 78% of the March-April 1984 primary production. This physical carbon loss is similar to daily grazing losses from zooplankton of 32-40% of the algal fixation of carbon. Metabolic demands of the benthos could be met by just the estimated fecal pellet flux, without direct consumption of algal carbon, while bacterioplankton needs could be served by excretory release of dissolved organic matter during photosynthesis. Sediment traps tethered 10 m off the bottom at the 120 m isobath and 50 m above the 500 m isobath caught as much as 0.16 to 0.26 g C/m^2/day during March-April 1984, in reasonable agreement with the flux estimated from the other moored instruments.

Walsh, J.J., D.A. Dieterle and M.B. Meyers. 1988a. A simulation analysis of the fate of phytoplankton within the Mid-Atlantic Bight. Cont. Shelf Res. 8(5-7):757-787.

Abstract. A time-dependent, three-dimensional simulation model of wind-induced changes of the circulation field, of light and nutrient regulation of photosynthesis, of vertical mixing as well as algal sinking, and of herbivore grazing stress, is used to analyze the seasonal production, consumption, and transport of the spring bloom within the Mid-Atlantic Bight. The model's case (c) of a 58-day period in February-April 1979, simulated "new" primary production, based on just nitrate, with a mean of 0.31 g C/m^2/day over the whole model domain. About 57% of this total shelf carbon fixation was removed by herbivores, with 21% lost as export, either downstream towards Cape Hatteras or offshore to slope waters, after the first 58 days of the spring bloom. Extension of the model for another 22 days of case (c) increased the mean export to 27%, while variation of the model's parameters in eight other cases led to a range in export from 8 to 38% of the average "new" primary production. Spatial and temporal variations of the simulated algal biomass, left behind in the shelf water column, reproduced chlorophyll fields sensed by satellite, shipboard, and *in situ* instruments.

Walsh, J.J., C.D. Wirick, L.J. Pietrafesa, T.E. Whitledge, F.E. Hoge and R.N. Swift. 1988b. High-frequency sampling of the 1984 spring bloom within the Mid-Atlantic Bight: synoptic shipboard, aircraft and *in situ* perspectives of the SEEP-I experiment. Cont. Shelf Res. 8(5-7):529-563.

Abstract. Moorings of current meters, thermistors, transmissometers, and fluorometers on the Mid-Atlantic shelf, south of Long Island, suggest a seaward export of perhaps 0.20 mg Chl/m^3/day at depths of 75-81 m, between the 80- and 120-m isobaths during February-April 1984. Using C/Chl ratio of 45/1, such a horizontal loss of algal carbon over the lower third of the water column would be 19-67% of the March-April 1984 primary production within the overlying euphotic zone. This possible physical carbon loss is similar to daily grazing

losses to zooplankton of 32-40% of the algal fixation of carbon. Metabolic demands of the benthos could be met by just the estimated fecal pellet flux, without direct consumption of the remaining algal carbon. Similarly bacterioplankton metabolism could be fueled by excretory release of dissolved organic matter during photosynthesis, rather than by consumption of particulate carbon. Sediment traps tethered 10 and 70 m off the bottom at the 120-m isobath caught as much as 0.10-0.16 g C/m^2 during March-April 1984. This presumed vertical flux is about one-third to one-half of the horizontal flux of 0.30 g C/m^2/day estimated over the lower 33 m of the water column at the 100-m isobath. These estimates suggest that about 50% of the carbon export at the shelf-break might be derived from the adjacent overlying water column, with the remainder from lateral injections of near-bottom particles originating on the inner shelf.

Walsh, J.J., D.A. Dieterle, W.W. Gregg and J.R. Pribble. 1989. Simulation Analysis of Moored Fluorometer Time Series from the Mid-Atlantic Bight: Progress Report, FY 1988-1989. Department of Energy. DOE/ER/60285-6:122.

Abstract. A two-layered baroclinic circulation model and a 21-layered biochemical model are used to explore the consequences of Loop Current-induced upwelling and terrestrial eutrophication on 'new' production within the Gulf of Mexico. During a quasi-annual penetration and eddy-shedding cycle of the Loop Current, the simulated seasonal changes of incident radiation, wind stress, and surface mixed layer depth induce an annual cycle of algal biomass that corresponds to *in situ* and satellite time series of chlorophyll. The simulated nitrate fields match those of shipboard surveys, while fallout of particulate matter approximates that caught in sediment traps and accumulating in bottom sediments. Assuming an f ratio of 0.06--0.12, the total primary production of the Gulf of Mexico might be 105--210 g C/m^2/yr in the absence of anthropogenic nutrient loadings, i.e., 2--3 fold that of oligotrophic regions not impacted by western boundary currents. Less than 25% of the nitrogen effluent of the Mississippi River may be stored in bottom sediments, with most of this input dispersed in dissolved form beneath the pycnocline, after remineralization of particulate detritus within several production cycles derived from riverine loading. At a sinking rate of 3 m/day however, sufficient phytodetritus survives oxidation in the water column to balance estimates of bottom metabolism and burial at the margins.

Wang, D.-P. 1979. Low-frequency sea level variability on the Middle Atlantic Bight. J. Mar. Res. 37(4):683-697.

Abstract. Low-frequency sea level fluctuations on the Mid-Atlantic Bight, from Cape Cod to Cape Hatteras, and their relations to wind forcing were examined over a one-year (1975) period. The dominant sea level fluctuations occurred at time scales of 4 days, and they were coherent over the entire Bight. On the other hand, sea levels were not coherent between the southern (south of Chesapeake Bay) and northern part at shorter time scales. Local wind forcing was important from Cape Cod to Cape May; most of the sea level change was driven by the alongshore (northeast-southwest) wind. In addition, the east-west wind set up a large surface slope between Nantucket and Sandy Hook. The wind set-up may be due to the bent coastline around Sandy Hook; the frictional effect may also play a role. South of Cape May, the local alongshore wind forcing was dominant at time scales shorter than 3.3 days (in winter). At longer time scales, contributions from free shelf waves was significant. A southward phase propagation of 600 km/day

was found between Cape May and Cape Hatteras, which is consistent with the shelf wave model. The dominance of free waves apparently was due to the lack of coherent wind forcing of Cape May.

Wang, D.-P. 1982. Effects of continental slope on the mean shelf circulation. J. Phys. Oceanogr. 12(12):1524-1526.

Abstract. Re-examination of earlier theory on mean shelf circulation in a homogeneous ocean suggests that the mean southwestward flow of the Mid-Atlantic Bight is driven by an inflow from the Georges Bank.

Wang, J.D. 1987. Hurricane effects on surface Gulf Stream currents. Ocean Eng. 14(3):165-180.

Wang, J.D., V. Kourafalou and T.N. Lee. 1984. Circulation on the continental shelf of the southeastern United States. Part 2: Model development and application to tidal flow. J. Phys. Oceanogr. 14(6):1013-1021.

Abstract. Model is adapted to the South Atlantic Bight and applied to predict tidal and wind-driven currents under vertically well-mixed conditions that are characteristic for the winter months.

Wang, W. 1991. The Gulf Stream Downstream of Cape Hatteras: Model/Data Comparisons. Ph.D. Thesis. University of North Carolina at Chapel Hill. 116 pp.

Abstract. One year of simulation from a selected model realization of the Naval Oceanographic and Atmospheric Research Laboratory Limited-Area, North Atlantic Model (1/8 degree horizontal resolution) has been compared with historical observations in the Gulf Stream region and with data from the UNC/URI Gulf Stream Dynamics Experiment (1983-1985) and the URI Pegasus Program (1980-1983) conducted in the Gulf Stream near 73°W. The comparisons covered a variety of aspects of Gulf Stream variability and were carried out in two parts: basinwide comparisons and regional comparisons. The basinwide comparisons focused on climatological features of the Gulf Stream system over mush of the model domain, including Gulf Stream mean position and path variability (meandering activity), statistics of Gulf Stream rings, eddy kinetic energy fields, and Gulf Stream transport. The regional comparisons focused on characteristics of the Gulf Stream current near 73°W, including velocity and path meander spectra, path features, coherence between meandering motion and local deep ocean flows, kinematic parameters (i.e., transport, width, and axis speed), and cross-stream structure. Agreements and disagreements between the observations and the model realization are discussed. In addition, model-produced, small-amplitude, approximately 6 day meanders northeast of Cape Hatteras have been investigated for their resemblance to often-observed, near-weekly period meanders of the Gulf Stream along the Carolinas and downstream of Cape Hatteras. The various comparisons conducted in this study provide a reference for future model/data comparison studies.

Wang, W. and J.M. Bane. 1989. The SYNOP Pilot Experiment, Current Meter Data Report, November 1986 to March 1987 Mooring Period. UNC Tech. Rep. CMS 89-2:28.

Ward, E.G., D.J. Evans and J.A. Pompa. 1977. Extreme wave heights along the Atlantic Coast of the United States. Presented at: Ninth Annual Offshore Technology Conference Houston, TX, 2:315-324.

Abstract. Hindcast study of a large set of severe storms for the Georges Bank, Baltimore Canyon, and Georgia Embayment areas. Produced extreme wave statistics for these regions that are the basis of design criteria for offshore structures under severe wave loads.

Ward, E.G., D.J. Evans and J.A. Pompa. 1978. Extreme wave heights along the Atlantic coast of the United States. J. Petrol. Technol. 30(12):1607-1705.

Abstract. Follow-up paper to Ward, Evans, and Pompa (1977) where more complete documentation for the hindcast model is provided.

Warner, T.T., M.N. Lakhtakia, J.D. Doyle and R.A. Pearson. 1990. Marine atmospheric boundary layer circulations forced by Gulf Stream sea surface temperature gradients. Mon. Weather Rev. 118(2):309-323.

Abstract. The Penn State/NCAR mesoscale model is initialized with calm winds, a barotropic temperature pattern, and a uniform surface pressure in studies of the response of the marine atmospheric boundary layer (MABL) to realistic differential fluxes of heat and moisture at the sea surface in the vicinity of the Gulf Stream. A maritime sounding from the GALE data region during Intensive Observation Period 2 (IOP 2) is used to define the initial vertical structure of the temperature and humidity fields. The sensitivity of the MABL to two sea surface temperature patterns is tested. (29 Refs.).

Warren, B.A. 1976. Structure of Deep Western Boundary Currents. Deep-Sea Res. 23:129-142.

Abstract. Deep western boundary currents are wider by about an order of magnitude than such currents of the upper water as the Gulf Stream. Their structure is discussed within the framework of a linear, continuously stratified model with lateral diffusion of density and momentum. They are treated as boundary layer corrections to interior fields, where the interior field is presumed given by observation, and the density-depth variation at the western boundary is taken (also from observation) as a prescribed boundary condition. A level bottom is assumed. For parameter values appropriate to the deep ocean, the lateral diffusion of density severely limits the geostrophic velocities and thus requires a relatively broad flow field. For a mixing coefficient of 1.2×10^7 cm^2/s^2 and suitable boundary conditions, a detailed calculation for the deep current at Lat. 28°S in the western South Pacific reproduces the scale and other gross features of the density field there and accounts qualitatively, in terms of the associated flow field, for prominent features in the distributions of dissolved oxygen and silicate.

Wash, C.H., S.M. Heikkinen, C.-S. Liou and W.A. Nuss. 1990. A rapid cyclogensis event during GALE IOP 9. Mon. Weather Rev. 118(2):375-391.

Abstract. A cyclone that developed explosively during Intensive Observation Period (IOP) 9 of the Genesis of Atlantic Lows Experiment (GALE) is studied.

Detailed surface analysis is conducted based on operationally available data, late reporting ship observations and GALE special observations to determine the surface storm track and deepening rate. GALE dropsonde and rawinsonde data are used to supplement the normal upper-level database, and are alanyzed by a research version of the Navy Operational Regional Analysis and Prediction System (NORARS) using optimal interpolation analysis.

Watts, D.R. 1981. Charting the flow of the Gulf Stream. Maritimes. 25(4):10-13.

Watts, D.R. 1983. Gulf Stream Variability. pp. 114-144. In A.R. Robinson, ed. Eddies in Marine Science. Springer-Verlag, New York.

Watts, D.R. 1985. Proceedings of the Gulf Stream Workshop Held at West Greenwich, Rhode Island on 23-26 April 1985. Univ. R.I., Grad. School Oceanogr. Tech. Rep. :581.

Abstract. Topics included: Modeling of the Gulf Stream System - Local dynamics and non-local effects; Recent Gulf Stream Theoretical Work and Pertinent Observations; Data Assimilation, Mesoscale Dynamics and Dynamical Forecasting; Two Recent Views of the Gulf Stream East of Cape Hatteras; Modification of an Intense Oceanic Current system Flowing into a Region of Cooling; Bimodality in the Gulf Stream; Isopycnal RAFOS Floats and the Dynamics of Gulf Stream Meanders; Sea-surface Height by GEOSAT-A Altimetry; Structure of the Gulf Stream as Derived from an EOF Analysis; Gulf Stream Envelope and Mean Path between 75° and 58°; Maximum Gradient Inverse for the Gulf Stream System; Frontal Geostrophic Dynamics; Analysis of Gulf Stream Mean Flow Energetics off Charleston, S.C.; Nonlinear Waves and Coherent Vortex Structures in Barotropic Beta-Plane Jets; Spatial Structure of Gulf Stream Current Variability Downstream of the New England Seamount Chain; Recirculation and the Deep Gulf Stream; Eddy-resolved Ocean Circulation Related to the Gulf Stream Region; Partial Solutions for Inertial Western Boundary Current with Continuous Stratification; Time Scales and Structure of Topographic Rossby Waves and Meanders in the Deep Gulf Stream.

Watts, D.R. 1991a. Equatorward currents in Temperatures 1.8-6.0 C on the Continental Slope in the Mid-Atlantic Bight. pp. 183-196. In P.C. Chu and J.C. Gascard, eds. Deep Convection and Deep Water Formation in the Oceans. Elsevier, Amsterdam.

Watts, D.R. 1991b. A Synoptic View of the Gulf Stream. Maritimes. 35:3-6.

Watts, D.R. and W.E. Johns. 1982. Gulf Stream meanders: Observations on propagation and growth. J. Geophys. Res. 87:9467-9476.

Abstract. Early application of inverted echo sounder data to track the Gulf Stream near Cape Hatteras and provide a comprehensive description of its dynamics. Time series of lateral displacements of the front, shown accurate to ±8 km, have been collected along three sections spaced 100, 150, and 200 km downstream (NE) of Cape Hatteras, North Carolina, for a period of 12 months. These records are highly coherent at all periodicities longer than 4 days. The meanders exhibited rapid growth at periods longer than 4 days, doubling in variance in each 50-km step downstream.

Watts, D.R. and H. Kontoyiannis. 1986. Deep-ocean bottom pressure and temperature sensors report: methods and data. Univ. R.I., Grad. School Oceanogr. Tech. Rep. URI/GSO-TR-86-8:119.

Abstract. Report documents ocean bottom pressure data collected under the Gulf Stream northeast of Cape Hatteras in depths of 3300 m to 3900 m using Digiquartz sensors. The lower drift of this type of sensor opens many possibilities for study of low-frequency dynamic pressure signal in the deep ocean.

Watts, D.R. and D.B. Olson. 1978. Gulf Stream ring coalescence with the Gulf Stream off Cape Hatteras. Science. 202:971-972.

Abstract. A cyclonic ring, which had separated from the Gulf Stream 7 months earlier and traveled 500 kilometers westward, collided with the stream in September 1977. Within 3 days the ring and stream joined to form a sharp S-shaped meander. Shipboard expendable temperature probes and four bottom-moored inverted echo sounders were used to obtain synoptic descriptions of the rejoining process.

Watts, D.R., K.L. Tracey and A.I. Friedlander. 1989. Producing accurate maps of the Gulf Stream thermal front using objective analysis. J. Geophys. Res. 94(C6):8040-8052.

Abstract. The objective analysis (OA) method is adapted in order to map the Gulf Stream thermal front, and resulting output maps are verified against independent data. This extension of the OA method involves removing the mean field and normalizing the variance prior to performing the objective analysis; both of these fields are restored afterward. In this way, the mapped field decays to an appropriate mean field far away from the measurement sites, and the statistics of the normalized perturbation field are homogeneous, as is required by the OA method. The authors test the sensitivity of the adapted OA method to variations in four control parameters; mean field, correlation function, standard deviation field, and input sampling interval. (16 Refs.).

Wayland, R.A. and B.P. Hayden. 1985. Cyclone tracks and wave climates at Cape Hatteras, North Carolina. U. of Virginia. Dept. of Enviro. Sci. Report No.: TR-31. 73 pp.

Abstract. Overview of data set spanning 1942-1984 of tropical and extratropical cyclone tracks to determine the magnitude and duration of the water waves that will be produced along the mid-Atlantic coast.

Wayland, R.J. 1991. Mean and turbulent structure of the marine atmospheric boundary layer during cold air outbreaks of different intensities: observational and modelling analyses (GALE 86). Ph.D. Thesis. North Carolina State University. 388 pp.

Abstract. Aircraft, surface, upper air and satellite measurements have been used to observe the evolution and growth of the convective Marine Atmospheric Boundary Layer (MABL) offshore of North Carolina in close proximity to the Gulf Stream, during the intense cold air outbreak of 28 January 1986 and the moderate event of 12 February 1986, as part of the Genesis of Atlantic Lows Experiment (GALE).

Air mass modification processes, driven primarily by the ocean-atmosphere exchanges of surface turbulent sensible and latent heat fluxes, caused the overlying air mass to warm and moisten as it advected over the warmer waters of the eastern United States continental shelf. Maximum observed near-surface (about 50 m ASL) total (sensible + latent) heat fluxes were 1045 $W \cdot m^{-2}$ and 811 $W \cdot m^{-2}$ over the core of the Gulf Stream, for 28 January and 12 February 1986, respectively. Near-Surface heat flux values decreased both east and west of the core of the Stream, primarily in response to changes in the air-Sea Surface Temperature (SST) difference. The observed changes in the overlying air mass occur almost instantaneously as the ambient flow traverses different underlying SST conditions.

Wayland, R.J. and B.P. Hayden. 1984. Classification of Coastal Environments, Shorezone Profile Dynamics. University of Virginia, Department of Environmental Sciences. TR-29:76.

Abstract. Principal components analysis was used to quantify subaerial and subaqueous summer to winter nearshore morphological change on the North Carolina coast near Duck. The first two eigenvectors explained 61.1% of the total variance. E1 (35.4% of the variance) is a profile rotation and E2 (25.7% of the variance) is a bar/trough function. Two major periods of change were found. High pressure systems in October and extratropical cyclones in November were the weather systems implicated in these changes. These storms caused the profiles to become dissipative. Steepness declined and two bars replaced a single bar profile form. A relationship between pre-existing morphology and subsequent changes in the equilibrium bar/trough morphology was observed during the storm period. Wave characteristics (height, period, steepness, direction, and breaker type) could not be associated with profile changes. The simultaneous offshore sediment movement across three well-defined zones of the shorezone suggest that shore-normal edge waves may be the dominant causative agent for these changes.

Wayland, R.J. and S. Raman. 1989. Mean and turbulent structure of a baroclinic marine boundary layer during the 28 January 1986 cold-air outbreak (GALE 86). Boundary-Layer Meteorology. 48(3):227-254.

Abstract. Aircraft (NCAR Electra), ship (R/V Cape Hatteras), buoy (NCSU Buoy 2) and satellite (NOAA-7 and 9) measurements have been used to observe the structure of the marine boundary layer (MBL) offshore of Wilmington, North Carolina, during the intense cold-air outbreak of 28 January 1986, as part of the Genesis of Atlantic Lows Experiment (GALE). (34 Refs.).

Weatherly, G.L. 1972. A study of the bottom boundary layer of the Florida Current. J. Phys. Oceanogr. 2:54-72.

Weatherly, G.L. and E.A. Kelley Jr. 1985. Two views of the Cold Filament. J. Phys. Oceanogr. 15(1):68-81.

Abstract. Presents both local and regional views of the Cold Filament, which is postulated to be a part of an abyssal western boundary current in the North American Basin associated with a southern source of Antarctic bottom water.

Weber, A.H. and J.O. Blanton. 1980. Monthly mean wind fields for the South Atlantic Bight. J. Phys. Oceanogr. 10(8):1256-1263.

Abstract. A total of 339389 marine weather observations have been analyzed to produce monthly mean wind fields for the South Atlantic Bight. The results of plotting wind vectors on a one half degree latitude by one half degree longitude grid yields four traditional seasonal flow regimes (winter, spring, summer and fall) and an additional regime designated as mariners' fall. These seasonal wind regimes are discussed and related to the monthly mean ocean circulation in the Bight.

Webster, F.A. 1961. A description of Gulf Stream meanders off Onslow Bay. Deep-Sea Res. 8:130-143.

Abstract. Application of surface current observations to describe periodic time variation in the position of the Stream. The surface front associated with the Gulf Stream appears to meander in a skewed fashion with wave lengths of about 100 km. This cyclonic meander is associated with a negative horizontal eddy viscosity demonstrating that eddy energy is transferred to the mean flow.

Weisberg, R.H. and L.J. Pietrafesa. 1982. Surface wind field analysis in the South Atlantic Bight. North Carolina State Univ., Raleigh. Tech. Rep. 82-5.

Abstract. Linear mean square estimation is applied to a shore station near Charleston, South Carolina and transfer functions for winds are generated for a series of offshore stations.

Weisberg, R.H. and L.J. Pietrafesa. 1983. Kinematics and correlation of the surface wind field in the South Atlantic Bight. J. Geophys. Res. 88(C8):4593-4610.

Abstract. Application of coastal surface winds to infer the offshore wind field through correlation analysis and kinematical considerations. Wind correlations at individual stations and between stations are found to be seasonally modulated. Some assessment of predictability is made.

Wells, D.R. 1967. Beach equilibrium and second-order wave theory. J. Geophys. Res. 72(2):497-504.

Abstract. The skewness of the probability distribution of the horizontal water velocity of second-order gravity waves is derived in order to investigate the stability of sand beaches. It is shown that if the distribution is skewed toward the beach, sand may accumulate; whereas if it is skewed away from the beach, sand may be swept seaward. A neutral line is defined where the skewness is zero, and computations show that it cannot occur shoreward of the point where the depth-to-wavelength ratio is approximately 0.090. These results explain in a precise manner some observed beach equilibrium phenomena.

Wells, K.W. and I.E. Gray. 1960. Summer upwelling off the northeast coast of North Carolina. Limnol. Oceanogr. 5:108-109.

Abstract. Upwelling events were noted in the study area with associated changes

in productivity parameters.

Werner, F.E., J.O. Blanton, D.R. Lynch and D.K. Savidge. No Date. A numerical study of the continental shelf circulation on the U.S. South Atlantic Bight during the autumn of 1987. Cont. Shelf Res.

Weston, D.P. 1972. Macrobenthos-sediment relationships on the continental shelf off Cape Hatteras, North Carolina. Cont. Shelf Res. 8:267-286.

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Whitcomb, V.L. 1970. Oceanography of the Mid-Atlantic Bight in support of ICNAF (International Commission for the Northwest Atlantic Fisheries).

Abstract. Summary paper describing the oceanography of the Middle Atlantic Bight. Intended to relate fisheries productivity to oceanographic characteristics.

Whitford, D.J. 1988. Wind and Wave Forcing of Longshore Currents Across a Barred Beach. Ph.D. Thesis. Naval Postgraduate School. 223 pp. (NTIS Accession Number: AD-A201 076/7/XAB)

Abstract. Previous investigations of longshore currents have included simplifying assumptions and restriction (such as a planar beach, a steady and depth uniform flow, spatially-variant bed shear stress and turbulent momentum exchange, and the exclusion of surface wind stress. These assumptions are quantitatively investigated by calculating the relative importance of each term in the longshore momentum balance with an emphasis on the relative importance of wind forcing across the barred nearshore. Wind and wave forcing of longshore currents across a barred beach are examined using both a numerical model and field measurements. A local momentum balance was measured at various locations across the surf zone during the SUPERDUCK experiment held at the USACE CERC Field Research Facility, Duck, N.C. in October 1986. A moveable sled was instrumented with pressure, current, and wind sensors to measure the various terms in the longshore momentum equation. Stability-dependent atmospheric drag coefficients for the surf zone are determined from wind stress measurements acquired just beyond the surf zone and wind speed measurements acquired from an anemometer atop the 9 m sled mast. Breaking waves were visually identified and electronically marked on the data tapes.

Wiebe, P.H. 1982. Gulf Stream rings. Sci. Am. 246:60-70.

Abstract. General review paper describing the character of Sargasso Sea rings by focussing on Ring Bob, which formed in 1977, as an example case study.

Wiebe, P.H. and T.M. Joyce. 1992. Introduction to interdisciplinary studies of Kuroshio and Gulf Stream Rings. Deep-Sea Res. 39:v-vi.

Abstract. Gives an overview of the papers contained in the Warm-Core Rings supplementary issue.

Wiebe, P.H., N.J. Copley and S.H. Boyd. 1992. Coarse-scale horizontal patchiness and vertical migration of zooplankton in Gulf Stream warm-core ring 82-H. Deep-Sea Res. 39:S247-S278.

Abstract. A 1-m^2 MOCNESS with 20 nets was used to make a series of tows in Gulf Stream meander/ring 82-H (September/October 1982) including two 0-100 m undulating "towyos". One towyo, made at dusk in the core of 82-H (of Sargasso Sea/Gulf Stream origin) permitted study of the effect of diel migration on the spatial variability of copepod and euphausiid species abundance, and species composition in a region of low physical variability.

Wigley, R.L. and R.B. Theroux. 1981. Atlantic continental shelf and slope of the United States; macrobenthic invertebrate fauna of the Middle Atlantic Bight region; faunal composition and quantitative distribution. U.S. Geol. Surv. Prof. Pap. 0529-N:N1-N198.

Abstract. This report provides a broad view of the quantitative composition of macrobenthic invertebrates inhabiting the Middle Atlantic Bight (Cape Hatteras, North Carolina, to Cape Cod, Massachusetts). Analyses of the fauna deal primarily with: Taxonomic composition, geographic distribution, relationships with water depth, bottom sediment type, sediment organic carbon, and annual range in bottom water temperature. Faunal quantities are expressed in terms of density (number per square meter of bottom area) and biomass (weight per square meter).

Wilder, H.B., T.M. Robison and K.L. Lindskov. 1978. Water Resources of Northeast North Carolina. USGS Water Res. Investigations. USGS/WRI-77-81:125.

Abstract. Associated with economic development of northeast North Carolina are several water-related problems. The solution to these problems depends in part on adequate knowledge of the hydrology of this 8,930 square mile coastal area. Although it is hydrologically the least studied area of North Carolina, enough is known to present this reconnaissance-level picture of its water resources. Average annual precipitation on the area is about 50 inches. Of this amount, about 34 inches returns to the atmosphere via evapotranspiration, about 15 inches leaves the area as runoff, and about one inch leaves through ground-water outflow. No large streams originate within the area, but major streams entering from the north and west bring in three times as much streamflow as originates within the study area. The flat, low-lying terrain does not offer opportunities for extensive development of surface-water supplies through the use of reservoirs. Much of the surface water is contaminated by saltwater from the ocean. Ground water occurs in three major aquifers, all of which contain both freshwater and saltwater.

Wilk, S.J. 1977. Biological and Fisheries Data on Bluefish, Pomatomus saltatrix (Linnaeus). National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA-78061511:65.

Abstract. This synopsis of biological and fisheries data on the bluefish, Pomatomus saltatrix, is based on existing literature. Information is given on the nomenclature, taxonomy, morphology, distribution, bionomics and life history, population structure, exploitation, protection and management of these fish which are found in two major areas along the United States east coast: one offshore

near the inner edge of the Gulf Stream from southern Florida to North Carolina; the other in the Middle Atlantic Bight (i.e., Cape Hatteras to Cape Cod).

Wilkerson, J.D. and M.D. Earle. 1990. A study of differences between environmental reports by ships in the voluntary observing program and measurements from NOAA buoys. J. Geophys. Res. 95(C3):3373-3385.

Abstract. Four years of weather observations, including oceanographic observations, from ships in the World Meteorological Organization Voluntary Observing Program were compared with common parameters measured simultaneously by Noaa moored buoys when ships were within 100 km of buoy stations. Common parameters were wind speed, wind direction, atmospheric pressure, surface air and sea temperatures, wave height, and wave period. Several types of difference statistics were computed from the resulting data base containing as many as 63,354 pairs of ship-buoy reports for forty-seven buoy station locations. Statistical results are provided to quantify accuracies of ship observations.

Willey, J.D. and L.P. Atkinson. 1982. Natural fluorescence as a tracer for distinguishing between piedmont and coastal plain river water in the nearshore waters of Georgia and North Carolina. Estuarine Coastal Shelf Sci. 14(1):49-59.

Abstract. Natural fluorescence, dissolved silica and salinity were investigated as possible tracers to distinguish between piedmont river and coastal plain river waters discharged into the ocean off North Carolina and Georgia. In the Georgia study area, dissolved silica was not suitable for use as a tracer because silica concentrations were variable and did not mix conservatively with seawater. In the North Carolina study area, dissolved silica concentrations exhibited too much short-term variability for tracer use. In both areas, natural fluorescence was a suitable tracer. Additional investigations relevant to tracer application were made of the method for determining natural fluorescence; these include dependence on temperature of analysis, pH dependence, sample storage effect, sensitivity, correlation with total organic carbon and possible interferences from chlorophyll a, lignin sulfonates, detergents, petroleum and iron.

Williams, A.B., G.S. Posner, W.J. Woods and E.E. Deubler Jr. 1973. A Hydrographic Atlas of Larger North Carolina Sounds. UNC Sea Grant Pub. UNC-SG-73-02:129.

Abstract. An atlas of figures, tables, and short text provides a summary of salinity-temperature data for coastal North Carolina in files of the University of North Carolina Institute of Marine Sciences. Mean monthly surface and bottom isohalines and isotherms are depicted in a series of 48 figures. Monthly means and extremes for salinity-temperature values are listed in tables for 76 fixed stations.

Williams, R. and L. Armi. 1991. The planetary boundary layer of the deep western boundary undercurrent. Deep-Sea Res. 38(3):393-399.

Abstract. Current meter observations of the deep western boundary undercurrent of the North Atlantic at 4800 m show a near-bottom turning and speed defect characteristic of a planetary boundary layer.

Williams, R.G. and F.A. Godshall. 1977. Summarization and Interpretation of Historical Physical Oceanographic and Meteorological Information for the Mid-Atlantic Region. NOAA Final Rep. NOAA-78011611:307.

Abstract. The results of an environmental study of the Mid-Atlantic region of the Outer Continental Shelf are described. The Mid-Atlantic region is the area extending northward from 38°N to 41°N between the coast and the 2,000 m isobath. The main body of oceanographic data consist of salinity-temperature depth (STD) and Nansen casts, supplemented by ship-drift observations and current meter records. The surface wind field, which plays an important role in determining the movement of spilled oil and other pollutants, is dealt with in detail. The physical characteristics of the water masses in the Mid-Atlantic region, whose structure and variability are particularly relevant to the dispersion and advection of pollutants is discussed and circulation features are analyzed.

Wimbush, M. 1976. The physics of the benthic boundary layer. pp. 3-10. In I.N. McCave, ed. The Benthic Boundary Layer.

Wimbush, M. 1981. *In situ* observation of natural sediment disturbance. EOS, Trans. AGU.

Winant, C.D., R.C. Beardsley and R.E. Davis. 1987. Moored wind, temperature and current observations made during Coastal Ocean Dynamics Experiments 1 and 2 over the northern California continental shelf and upper slope. J. Geophys. Res. 92:1569-1604.

Windom, H.L. and R.G. Smith Jr. 1985. Factors Influencing the Concentration and Distribution of Trace Metals in the South Atlantic Bight. pp. 141-152. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. The concentrations and distributions of iron, manganese, cadmium, copper, nickel, and zinc in South Atlantic Bight shelf waters appear to result from the mixing of river and oceanic waters, the latter with a chemistry similar to Western North Atlantic Water from a depth of 500-600 m. Superimposed on the mixture of the two end-members are other inputs and removal. Other significant inputs of cadmium, copper, nickel, and zinc are atmospheric transport and release from nearshore suspended and bottom sediments. Release from nearshore sediments (suspended and/or bottom) appears to be significant for all metals studied. First-order removal with respect to salinity appears to control iron, zinc, and, perhaps, manganese concentrations. Accumulation in shelf sediments may account for iron and zinc removal, but manganese lost from solution may be advected off the shelf in suspended particles.

Wittman, P.A., L.J. Pietrafesa and G.S. Janowitz. 1985. The thermal transition of the Carolina Capes. Cont. Shelf Res.

Worthington, L.V. 1971. Water Circulation in the Caribbean Sea and its relationship to North Atlantic Circulation. pp. 181-191. In Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions. UNESCO, Paris.

Worthington, L.V. 1976. On the North Atlantic circulation. Johns Hopkins Oceanogr. Studies No. 6. The Johns Hopkins Univ. Press. Baltimore. 110 pp.

Abstract. Basic review text that describes many significant features of the circulation off the eastern U.S. Coast including the so-called "Worthington" gyre associated with Gulf Stream recirculation.

Worthington, L.V. and W.R. Wright. 1970. North Atlantic Ocean Atlas, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

Wright, L.D., J.D. Boon III, M.O. Green and J.H. List. 1986. Response of the mid shoreface of the southern Mid-Atlantic Bight to a "northeaster". Geo-Marine Letters. 6:153-160.

Abstract. An instrumented, bottom-mounted, tripod deployed off Duck, North Carolina, at a depth of 8 m provided time series of pressure, benthic currrents, suspended sediment concentrations and bed-level changes prior to and during a typical northeast storm. A strong jet-like southerly-setting current generated by the northeaster was accompanied by downwelling and strong bottom agitation by wind waves. A total bed-level change of over 15 cm was recorded. After a phase of bed erosion, the bed accreted rapidly. Side-scan imagery supports the inference that offshore or alongshore migration of quasi-discrete sediment lobes may have produced the observed pulse-like accretion.

Wright, L.D., J.D. Boon, S.C. Kim and J.H. List. 1991. Modes of cross-shore sediment transport on the shoreface of the Middle Atlantic Bight. Mar. Geol. 96(1/2):19-51.

Abstract. The mechanisms responsible for onshore and offshore sediment fluxes across the shoreface zone seaward of the surf zone were examined in a 3-year field study. The study was conducted in the southern part of the Middle Atlantic Bight in the depth region 7-17 m using instrumented tripods supporting electromagnetic current meters, pressure sensors, suspended sediment concentration sensors, and sonar altimeters. The observations embraced fairweather, moderate energy, swell-dominated, and storm conditions. Cross-shore mean flows ranged from near zero during fairweather to > 20 cm/s during the storm; oscillatory flows were on the order of 10 cm/s during fairweather and 100 cm/s during the storm. Suspended sediment concentrations at about 10 cm above the bed were < 0.1 kg/m^3 under fairweather conditions, 1-2 mg/m^3 under moderate swell conditions, and > 5 kg/m^3 during the storm.

Wright, L.D., R.T. Guza and A.D. Short. 1982. Dynamics of a high-energy dissapative surf zone. Mar. Geol. 45:41-62.

Abstract. Pressure and horizontal current (u, v) time series were measured at different positions across the inner 150 m of a wide (≈500 m) surf zone of a microtidal high wave-energy beach. Incident waves had average heights of 3-4 m with maxima of 5 m and periods of 12 to 15 sec. Bores of broken waves diminished in height at a nearly constant rate as they progressed across the surf zone. Shoreward decay of wave energy at incident wave frequencies was accompanied by shoreward growth of infragravity energy. Near the beach the infragravity oscillations had heights on the order of 1 m. Cross-spectra show that the

infragravity oscillations were standing in the shore-normal direction. From the relative magnitudes of infragravity versus incident wave currents, it is inferred that the surf beat may be an order of magnitude more important than incident waves to the transport of sediment in the inner surf zone.

Wright, W.R. 1976. Physical oceanography. Chapter 4, Summary of environmental information on the continental shelf -Canadian/U.S. border to Cape Hatteras, N.C. The Research Institute of the Gulf of Maine. 4 volumes NTIS No. PB 284001/AS.

Abstract. Literature review conducted for the Bureau of Land Management. This review was an update of the TRIGOM study completed in 1974. A thorough summary of the physical oceanography of the study region is provided.

Wright, W.R. and C.E. Parker. 1976. A volumetric temperature-salinity census for the Middle Atlantic Bight. Limnol. Oceanogr. 21(4):563-571.

Abstract. Interpretation of historical hydrographic data to determine the approximate relative volume of water associated with various water masses. Determination specifies about half of the volume of shelf water from Cape Cod to Cape Hatteras lies in a thin surface wedge, and seasonal variation in the various water masses is shown.

Wu, S. 1991. Impact of the Charleston Gyre on onshore nutrient transport downstream of the Charleston Bump. EOS, Trans. AGU. 72(51):63.

Abstract. The analysis of data from the Genesis of Atlantic Low Experiment (GALE) has shown a significant transport of nutrient rich slope water onto the shelf, downstream of the Charleston Bump. This transport is comparable with the transport occurring at other times of the year. There are several mechanisms which may contribute to the cross-shelf nutrient transport. One being, the onshore intrusion of Gulf Stream frontal eddies and the upwellings associated with them. Additionally, previous studies have demonstrated the impact of intense atmospheric events (such as cold air outbreaks). More recent data taken from field experiment 'Winter 90' have shown substantial onshore nutrient transport in the same area. However, unlike the Genesis of Atlantic Low Experiment, the nutrient transport during 'Winter 90' experiment occurred during a milder period of time with few or no significant cold air outbreaks. It is therefore likely that processes, other than intense atmospheric forcings, are causing onshore nutrient transport. We present the hydrographic and current data collected from Winter 90 to suggest that the cyclonically rotating Charleston Gyre may play a role in the events of onshore nutrient transport. Because of its persistence, the Charleston Gyre may also be an important factor in similar events occurring at other times of year.

Wunsch, C. 1969. Progressive internal waves on slopes. J. Fluid Mech. 35(part 1):131-144.

Abstract. The refraction of progressive internal waves on sloping bottoms is treated for the case of constant Brunt-Väisälä frequency. In two dimensions simple, explicit expressions for the changing wavelengths and amplitudes are found. For small slopes, the solutions reduce to simple propagating waves at

infinity. The singularity along a characteristic is shown to be removable, though the solutions are now inhomogeous waves. The viscous boundary layers of the wedge geometry are briefly considered with the inviscid solutions remaining as interior solutions. A theory valid for small slopes is obtained for three-dimensional waves. The waves are refracted in the usual manner, turing parallel to the beach in shallow water.

Wyrtki, K., L. Magaard and J. Hager. 1976. Eddy energy in the oceans. J. Geophys. Res. 81(15):2641-2646.

Abstract. Provides maps of eddy kinetic energy at the sea surface for the North Atlantic Ocean showing a locus of maximum energy roughly aligned with the Gulf Stream.

Xeu, H. and J.M. Bane Jr. 1991. Simulated Responses of the Gulf Stream to a Strong Cold Air Outbreak in the Winter. EOS, Trans. AGU. 72(51):91.

Abstract. A two-dimensional (x-z) model with the imbedded Mellor-Yamada level 2 1/2 turbulence closure scheme is utilized to study the enhancement of oceanic mixing associated with cold air outbreak events off the southeast coast of United States. Of particular interest is the application to the Gulf Stream and its adjacent waters during January 25-30, 1986. Model results show that the base of the oceanic mixed layer descends more than 40 meters; and the sea surface temperature reduces more than 1°C everywhere across the Stream by releasing heat from ocean to the atmosphere. Circulations with magnitude of a few cm/sec occur in the mixed layer. The adjustment velocities of the deeper current to both the density and pressure fields are extremely small compared to the typical Gulf Stream jet velocity. A heat budget calculation shows an approximate balance between the integrated heat fluxes through air-sea interface and the heat loss from the upper ocean, which indicates localized oceanic responses to such atmospheric forcing and the quickness of convective mixing in comparison to other processes.

Yerofeyev, A.Y. and I.D. Lozovatskiy. 1990. Analytic approximation of the density probability distribution for Richardson numbers in the pycnocline for statistically independent fluctuations in the density and current velocity. Oceanol. 29(6):677-681.

Abstract. Few-parameter laws for the probability distribution in the ocean pycnocline are considered in order to describe typical empirical probability distributions for the square of the Vaisala frequency $P(N)^2$ and the square of the current velocity gradient $P(\Psi^2)$ and an analytic expression is obtained for the Richardson number distribution P(Ri) which is based on a proof of the possibility of using in a number of cases the hypothesis of statistical independence between the fine-structure inhomogeneities in the $N^2(z)$ and $\Psi^2(z)$ profiles. A comparison of the theoretical calculations and the experimental data has shown their satisfactory agreement for the upper part of the main pycnocline in the Florida current, the Gulf Stream, the Sargasso Sea, and the northwest tropical Atlantic. (12 Refs.).

Yoder, J.A. 1985. Environmental Control of Phytoplankton Production on the Southeastern U.S. Continental Shelf. pp. 93-103. In L.P. Atkinson, D.W. Menzel and K.A. Bush, eds. Oceanography of the Southeastern U.S. Continental Shelf. Vol. Coastal and Estuarine Sciences 2. American Geophysical Union, Washington, D.C.

Abstract. Different processes affect the rate and dynamics of primary production across the southeastern U.S. continental shelf of the South Atlantic Bight. Within relatively low salinity waters near the coast, primary production is relatively constant throughout the year and is sustained by nutrients emanating from rivers and salt marshes that line the coast. High turbidity of coastal waters limits the amount of light available for photosynthesis. Gulf Stream-induced upwelling at the shelf break and intrusion of upwelled waters across the shelf are the dominant processes affecting the dynamics of phytoplankton production on the middle and outer shelf. During colder months of the year, upwelled waters generally do not penetrate far across the shelf, and thus phytoplankton blooms and high rates of production are restricted to the outer shelf. Subsurface intrusions of nutrient-rich water penetrate across the shelf during warmer months of the year when the shelf is stratified, particularly in the northernmost and southernmost regions of the South Atlantic Bight. Phytoplankton production and biomass are more than 10 time higher within intrusions than in surrounding resident shelf waters.

Yoder, J.A. 1991. Role of Gulf Stream frontal eddies in forming phytoplankton patches on the outer southeastern shelf. Limnol. Oceanogr. 1:385-404.

Yoder, J.A., L.P. Atkinson, T.N. Lee, H.H. Kim and C.R. McClain. 1981. Role of Gulf Stream frontal eddies in forming phytoplankton patches on the outer southeastern shelf. Limnol. Oceanogr. 16:1103-1110.

Abstract. Ship observations of Gulf Stream frontal excursions along the southeast U.S. OCS indicate that anomalously cold cyclonic events were associated with nutrient-rich North Atlantic Central Water from recent upwelling.

Young, R.A., T.J. Merrill, T.L. Clarke and R.J. Proni. 1982. Acoustic profiling of suspended sediments in the marine bottom boundary layer. Geophys. Res. Lett. 9(3):175-178.

Abstract. An acoustic (3 MHz) backscattering profilometer has been developed for study of sediment transport in the bottom boundary layer. Laboratory experiments indicate reasonable correlations between backscattering intensity and mass concentrations for well-sorted fine to coarse quartz sands typical of those found in marine sediments. Departure of the calibration curves from their expected values is thought to be due to the non-spherical shape of the quartz grains. Field experiments on the inner shelf using the profilometer combined with velocity profiles show individual profiles (taken at 1 Hz) during erosion events are characterized by highly variable concentrations. Surface wave groups rather than individual waves appear to be correlated with groups of profiles with high concentrations extending 25-100 cm above bottom. Averaging produces smooth profiles which fit well log-normal distributions predicted by steady flow suspended load theories.

Zeigler, J.M. and M.A. Patton. 1974. A Socio-Economic Environmental Baseline Summary for the South Atlantic Region Between Cape Hatteras, North Carolina and Cape Canaveral, Florida. Volume IV. Geological Oceanography. U.S. Dept. Interior, BLM Rep. No. BLM/YM/ES-74/8:213.

Abstract. This report provides an overview of coastal and marine geology for the southeastern United States. The report summarizes significant regional literature, 1974, and previous; an extensive bibliography and selected abstracts are included. The objective of the report is to provide information relevant to the impact of petroleum leasing, exploration, and development, and production, for the region.

Zhang, B. 1988. GEOSAT/ERM altimeter data analysis for the determination of global oceanic mesoscale variability. Ph.D. Thesis. The University of Texas at Austin. 160 pp. (Advisor: Tapley, BD; DAI 50/02B, p.654; AAC8909772)

Abstract. Obtaining a basic description of the global mesoscale variability is fundamental to an improved understanding of ocean dynamics. Satellite altimetry which measures the distance between the spacecraft and the sea surface is becoming an important tool for acquiring global, synoptic measurements of the dynamic topography of the oceans. The radial orbit error has been the major limitation to the satellite altimeter oceanographic studies. The goal of this dissertation is to develop methods for reducing radial orbit error and to apply these methods to Geosat altimeter data. The conventional crossing arc technique has been widely applied to satellite geodesy and oceanography. An efficient and generalized method is developed here which is applicable to both single and dual satellite crossover measurements. Evaluations of the radial orbit error show that the operational Geosat Exact Repeat Mission (ERM) orbits have crossover rms residuals and the predominating radial orbit error occurs at the frequency of once per revolution (40,000 km wavelength). Based on this orbit error analysis, a new technique has been developed for extracting global mesoscale variability from collinear satellite altimeter profiles which have large radial orbit error. Long wavelength radial orbit error is suppressed by taking the derivative of each altimeter profile. Root mean square (rms) slope variability as low as 0.2 are found in the Southeast Pacific and maximum slope variations up to 6-8 are found in major western boundary currents (e.g. Gulf Stream, Kuroshio, Falkland and Agulhas) and in the Antarctic Circumpolar Current (ACC) systems. The global rms variability map shows previously unknown spatial details that are highly correlated with sea floor topography. At mid-latitudes, the variability is generally high in deep water (>3000 m) and low in shallow water (<3000 m). Eddy kinetic energy associated with the Gulf Stream and Kuroshio Current is also examined. Good agreement with previous altimeter results is obtained in both magnitude and spatial distribution.

Zimmerman, H.B. and C.D. Hollister. 1970. Contour currents on the continental rise. EOS, Trans. AGU. 51:336.

Abstract. Investigation of current speeds indicate that western boundary currents are the most significant factor controlling deposition on the continental rise.