ACCESS NUMBER: M11AC00001

STUDY TITLE: Satellite-tracked drifter measurements in the Chukchi and Beaufort seas
REPORT TITLE: Satellite-tracked drifter measurements in the Chukchi and Beaufort seas
CONTRACT NUMBERS(S): M11AC00001
SPONSORING OCS REGION: Alaska
APPLICABLE PLANNING AREA: Chukchi Sea and Beaufort Sea
FISCAL YEAR(S) OF PROJECT FUNDING: 2011-2015
COMPLETION DATE OF REPORT: April 2015
COST (by fiscal year): $226,741 (FY12); $233,151(FY12)
CUMULATIVE PROJECT COST: $459,892
PROJECT MANAGERS: Thomas J. Weingartner
AFFILIATION: University of Alaska Fairbanks
ADDRESS: School of Fisheries and Ocean Sciences, PO Box 757220, Fairbanks, AK 99775-7220
PRINCIPAL INVESTIGATOR*: Thomas Weingartner
KEY WORDS: Surface circulation, satellite-tracked drifters, Chukchi Sea, Beaufort Sea, continental shelves.

BACKGROUND:
This study was initiated to better understand the surface circulation in the Chukchi Sea, which is not well-measured by subsurface moorings. In particular the circulation here results from a large-scale pressure gradient that impels waters northward over the shelf while the prevailing winds oppose this motion. This implies that there may be a large velocity shear over the water column with surface waters heavily influenced by the wind and subsurface waters moving largely in response to the pressure field. Shallow-drogued satellite-tracked drifters as used here provide a means to assess the surface circulation.

OBJECTIVES:
The overall goal of this program was to evaluate the near surface currents and their response to winds in the northeast Chukchi Sea where hydrocarbon exploration is underway and future development may take place. In particular, we sought to determine if:

1. The surface (upper 1 m) and near-surface (10 -15 m) circulation field diverges and differs from the sub-surface circulation as captured by current meter measurements, and
2. The differences in the surface and sub-surface flows are related to the bathymetry, seasonally-varying winds, bathymetry and hydrographic conditions.

DESCRIPTION:
In August and/or September of 2011, 2012, and 2013 numerous satellite-tracked drifters were deployed in the northeast Chukchi Sea in conjunction with collaborators from the North Slope Borough. The drifters included non-drogued surface iSpheres (2012 only), 1-m drogued Microstar (MS) drifters, and 10-m drogued Surface Velocity Profiler (SVP) drifter. Drifter deployments were conducted with mixed drifter types in sets of 12 – 20 drifters and tracked until the drifters were beached, ceased operating, or trapped in sea ice. There was considerable interannual variability in trajectories. In 2012, nearshore (within 10 miles of the Chukchi coast) drifters moved northeastward through Barrow Canyon. After exiting Barrow Canyon, these drifters moved eastward onto the Beaufort Sea shelf or the Beaufort slope, or northwestward along the Chukchi Sea slope. Drifters deployed offshore in the northeast Chukchi Sea in 2011 and 2012 generally moved eastward toward the coast and eventually entered Barrow Canyon. After exiting Barrow Canyon they also moved eastward along the Beaufort shelfbreak (or shelf) or northwestward along the Chukchi shelfbreak. Many of the drifters that moved westward on the Chukchi shelfbreak eventually turned southward and back onto the northeast Chukchi Sea shelf. All of the drogued drifters which returned to the northeastern Chukchi Sea shelf stop transmitting in this region.

However, many of the iSphere drifters continued southward over the shelf in September and October and eventually came ashore in Ledyard Bay, along the coast of the Lisburne Peninsula. One iSphere was caught in the ice south of Pt. Hope and eventually crushed near the Siberian coast. The SVP drifters in 2012 had the greatest endurance and several were eventually trapped in, and drifted with, the sea ice for several months (through January-February) before being crushed or losing battery life. The ice carried these drifters as far afield as the western Chukchi Sea (near Wrangel Island) and the Mackenzie Shelf in the eastern Beaufort Sea. Several SVPs continued transmitting while locked in the landfast ice zone of the Beaufort Sea through winter and then made broad zonal excursions over this shelf in early summer before transmission was lost.

SIGNIFICANT CONCLUSIONS:

Linear regressions were used to examine the statistical relationship between drifter velocities and the local surface winds over six regions, defined on an ad hoc basis, as the Chukchi shelf, the inner Chukchi Sea shelf (Alaskan Coastal Domain; water depths <30m and exclusive of Barrow Canyon), within Barrow Canyon, the Chukchi-Beaufort continental slope, the Beaufort Sea shelf, and the Canada Basin. Only the iSphere drifters exhibited a strong statistical relationship in which the winds often explained more than 60% of the drifter velocity variance. For the MS drifters the winds explained >60% of the velocity variance only within the Alaskan Coastal Domain and the Beaufort Sea Shelf. The winds explained <30% of the velocity variance of the SVP drifters in all regions. The spatial differences in response likely reflect dynamical differences over the region. These differences can be ascribed to stratification, mesoscale motions associated with unstable meltwater fronts, instabilities in shelfbreak currents, and/or time-varying geostrophic currents within the regions. Drifters that entered the Canada Basin were entrained in eddies most likely spawned by shelfbreak current instabilities. There are also seasonal differences in the wind-driven response within the same general area of the shelf. We tentatively ascribe these differences to the absence/presence of fronts. Wind-current correlations among drifters far from fronts were substantially better than for those likely encountering fronts.

The 2013 trajectories were markedly different from those of 2012. Few escaped the northeastern Chukchi Sea, but instead most drifted westward in response to the prevailing strong northeasterly winds of August and September 2013. About 60% of the zonal velocity variance for drifters deployed south of Hanna Shoal was due to the winds, while wind-current regressions north of Hanna Shoal were substantially poorer. Relative dispersion characteristics based on clustered drifter deployments in 2012 and 2013 indicate anisotropic dispersion, with the zonal relative diffusivity being about twice that of the meridional diffusivity. Relative dispersion increases according to a $\text{time}^{2.5}$ power law after ~2 days, which is the Lagrangian decorrelation time scale.

STUDY RESULTS:

The drifter results reported here illustrate the rich complexity of the surface circulation of the Chukchi Shelf and its possible connections to the Arctic Basin and the Beaufort Sea. This complexity is a consequence of the spatial variability in stratification and bathymetry, which, when subjected to temporally varying winds produces a diversity of drifter (surface water) trajectories. By deploying drifters in a clustered manner we were also able to begin building a statistical climatology that quantifies relative dispersion. Relative dispersion describes how adjacent fluid parcels separate and move with respect to one another through time. It also captures small scale motions that are not well-resolved by other sampling techniques and/or numerical models. Hence the relative dispersion database that we are developing can be used to guide and evaluate numerical ocean circulation models that may be used in oil spill trajectory modeling.

STUDY PRODUCTS:

Weingartner, T., S. Danielson, P. Winsor, and E. Dobbins, Satellite-tracked drifter measurements in the Northeast Chukchi Sea. CMI Annual Review, November 2012, Fairbanks, AK.

Winsor, P., T. Weingartner, T., H. Statscewich, R. Potter, E. Dobbins, K. Martini, and S. Danielson, High-Resolution Observations of Hydrography and Circulation of the Chukchi Sea. Alaska Marine Science Symposium, January 2013, Anchorage, AK.

DeSousa, L., T. Weingartner, P. Winsor, S. Danielson, E. Dobbins, and C. Irvine, Interannual Variability in Surface Circulation in the Chukchi and Beaufort Seas: Satellite-tracked Drifter Measurements. Alaska Marine Science Symposium, January 2014, Anchorage, AK.

Irvine, C., K. Martini, L. DeSousa, P. Winsor, E. L. Dobbins, S. Danielson, and T. Weingartner, Satellite-tracked drifter measurements in the Chukchi and Beaufort Seas. Alaska Marine Science Symposium, January 2014, Anchorage, AK.

Weingartner, Thomas. Cayman Irvine, Peter Winsor, Liz Dobbins, Seth Danielson, Rachel Potter, Leandra de Sousa, Billy Adams, Robert Suydam, Willard Neatok, Warren Lampe, Leo Ferreira III, Guy Omnik, Henry & John Attunganna, Billy Sielak, Harris Aguvuluk, Lee Kayotuk, and Ian Kayotuk. A Lagrangian View of the Chukchi and Beaufort Seas. University of Alaska Institute of Marine Science Seminar, September 2014, Fairbanks, AK.

Related informal presentations were made to the oil industry and to residents of the communities of Barrow, Pt. Lay, Wainwright, Nuiqsuit, and Kaktovik in collaboration with the NSBW-Shell Baseline Studies Program.

Weingartner, T., C. Irvine, E. Dobbins, S. Danielson, L. de Sousa, B. Adams, R. Suydam, and W. Neatok (2015), Satellite-tracked Drifter Measurements in the Chukchi and Beaufort Seas. Final Report. OCS Study BOEM 2015-022, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region, 171 p.

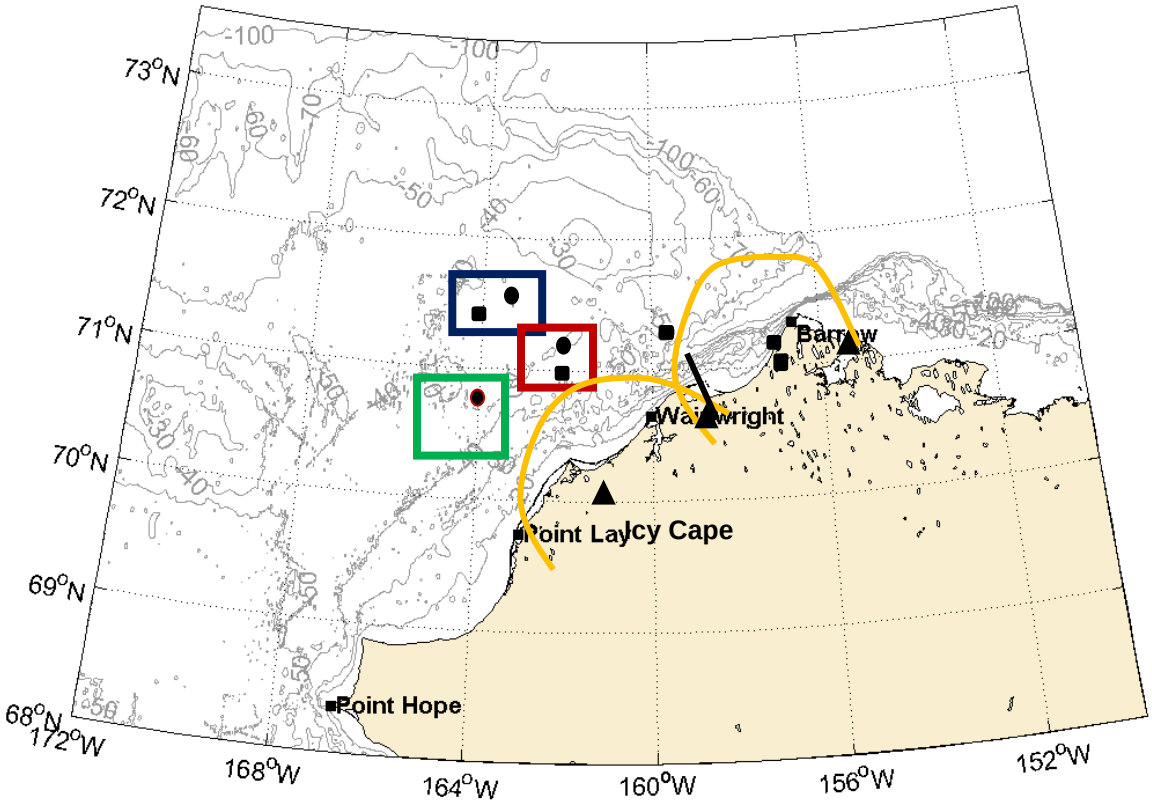

Figure 1. Bathymetric map of the Chukchi Sea showing the approximate location of the Statoil (dark blue box), Burger (red box), and Klondike (green box) prospects. Approximate locations of UAF drifter releases in 2011 (circles) and 2012 (squares) are shown. The approximate locations of NSBW drifter deployments in 2012 are shown by triangles. The orange arcs show the approximate radar masks for HFRs at Pt. Lay, Wainwright, and Barrow. The solid black line extending northwest from Wainwright encompasses an array of six subsurface moorings present during the 2011 period.