Report On Studies To Monitor The Interaction Between Offshore Geophysica1 Exploration Activities And Bowhead Whales In The Alaskan Beaufort Sea, Fall 1982

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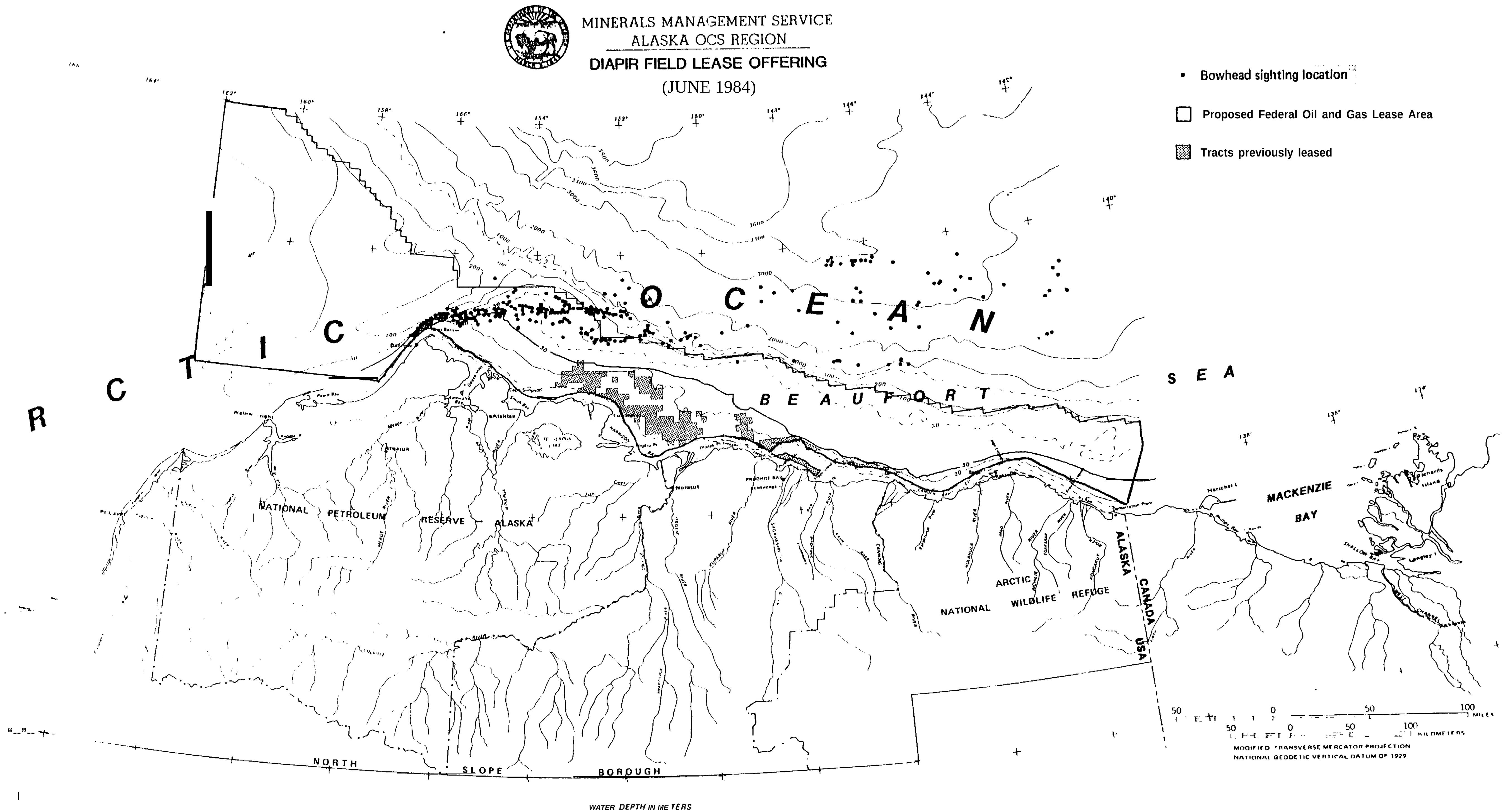
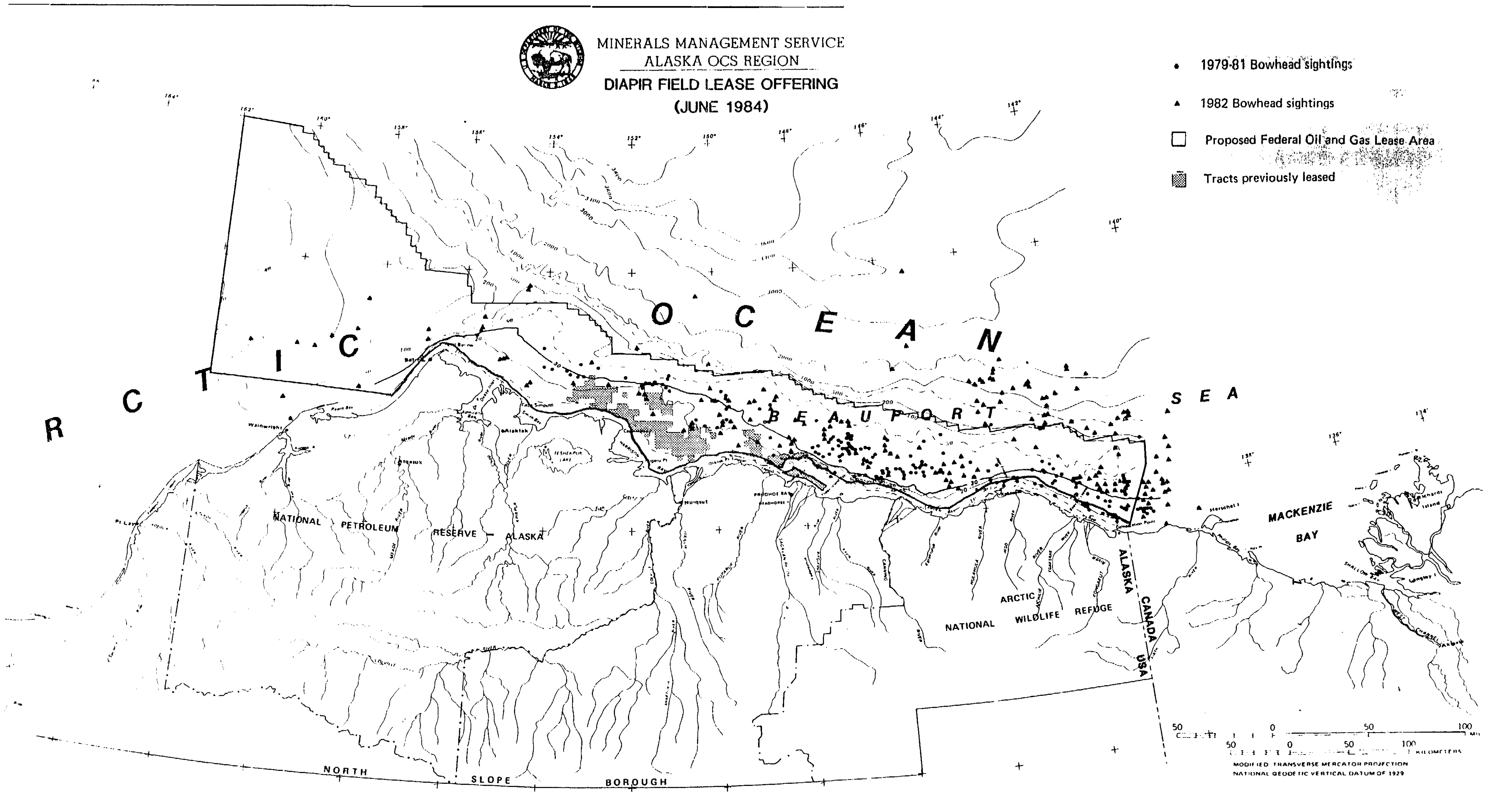


COMBINED DISTRIBUTION OF BOWHEAD SIGHTINGS. SPRING, 1979-1981



COMBINED DISTRIBUTION OF BOWHEAD SIGHTINGS; FALL, 1979-1982

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ABSTRACT

Out of concern about the potential effects of marine acoustic geophysical survey work on westward-migrating bowhead whales (Balaena mysticetus), the U.S. [Minerals Management Service (M MS), in consultation with the U.S. National Marine Fisheries Service (NMFS), implemented a program for monitoring and regulating such work in the Alaskan Beauf ort Sea during 1981 and 1982. In 1982 a twin-turbine, high-wing aircraft was used to survey systematical y blocks covering approximate y 1,400 km^2 near actively "shooting" seismic survey vessels. Direct visual observation was supplemented by the use of sonobuoys to listen to and record underwater sounds made by vessels, airguns, and whales. In addition to the systematic surveys, sustained behavioral observations of bowheads were made on an opportunistic basis, with the objective of identifying possible differences in behavior between whales exposed to seismic sounds and whales not exposed to seismic sounds. Daily summaries of field observations were reported to the MM S and NM FS; these were used for decision-making relative to regulation of seismic activities.

A total of 34 survey flights were initiated from August 27 to October 4, 1982. Although bowheads had been seen in the Alaskan Beaufort Sea as early as August 2 in other surveys, our first sighting was on September 14. By October 4, all seismic survey activity in the Alaskan Beaufort Sea had ended due to a combination of regulatory area closures and deteriorating ice conditions. Feeding behavior was observed as late as September 28, by which time westward migratory movements had also been observed.

No major changes in whale behavior (e.g. flight reactions) were observed which could unequivocally be interpreted as responses to seismic noise. A possible exception is the "huddling" behavior observed on September 14-15; our field interpretation of this behavior was that it may have been caused by the onset of seismic sounds. Tests of statistical significance were applied to data on number of blows per surfacing, mean blow interval per surfacing, surface times, and dive times. The mean surf ace time of "adults" (i.e. all whales other than cows and calves) in the presence and absence of seismic sounds was 1.673 s.d. 0.85 min. and 1.36 ± s.d. 0.59 min., respectively. This difference is statistically significant ($t = 1.988$, $df = 89$, $p < .05$). No statistically significant differences were detected for other behavioral

parameters in the presence and absence of seismic sounds. Animals compared. in these tests were "observed at essentially similar water depths (15-40 m). However, for our sample of observations, "adult" bowheads surfaced for longer periods, on average, in "deep" water (greater than 27.45 m) than in "shallow" water (27.45 m or less).

Although our results suggest some changes in behavior related to seismic sounds, the possibility that unquantif ied factors, could be 'correlative dictates caution in attempting to establish causative explanations from these preliminary findings. Since dive and surfacing characteristics may vary seasonally, geographically, and annually, observed differences should, at present, be considered an indication of the need for additional studies and larger sample" sizes, for specific comparisons. The biological significance of observed dif f erences in behavior remains unknown.

INTRODUCTION

Concern that sounds associated with marine acoustic geophysical survey work might have an unfavorable effect on the Bering Sea or Western Arctic stock of the endangered bowhead whale (Balaena mysticetus) led the Minerals Management Service (MMS), U.S. Department of the Interior, to monitor and regulate seismic exploration activities in the Beauf ort Sea west of the Alaska-Yukon (i.e. U.S.-Canada) border during the 1981 and 1982 fall migration periods (Figure 1). Procedures for the monitoring and control of seismic operations in the vicinity of bowhead whales were developed and implemented through interagency consultation between the MMS and the National Marine Fisheries Service (NMFS), U.S. Department of Commerce, under Section 7 of the U.S. Endangered Species Act (ESA).

In July 1981, in an amendment to a Biological Opinion of June 24 pertaining to the joint Federal/State oil and gas lease sale area, the NM FS concluded that acoustic geophysical activities could be conducted past August in a given season "if aerial surveys are being conducted that will identify when the whales are likely to be present in the project area, or would show whether the normal migration of the whales is being disrupted" (Stevenson, 198 1). In response to this recommendation, the Department of the Interior expanded its ongoing aerial survey effort (Ljungblad et al., 1980a, 1982a; Ljungblad, 1981) to include behavioral observations of bowheads in the vicinity of working seismic vessels, and to assure that the field investigators would maintain daily communications with MM S, NMFS, and industry representatives. The field research team itself had no regulatory or enforcement responsibility.

During both 1981 and 1982, efforts to observe geophysical vessel/whale interaction were coordinated with regional surveys of bowhead whale distribution> relative density, and habitat use (Ljungblad et al., 1982a, in preparation a). In 1982, separate aircraft were used for geophysical monitoring and regional surveys. Only the 1982 geophysical monitoring program is described and discussed in this paper.

BACKGROUND

Previous Observations

On September 26, 1979, seismic sounds and whale sounds were heard and recorded after a sonobuoy was dropped near two bowhead whales in the Alaskan Beaufort Sea (Ljungblad et al., 1980a). Although the potential for behavioral effects on whales from seismic noise associated with geophysical research had been recognized for some time, this was the first simultaneous recording of bowhead and airgun sounds. Since then, several observations of bowhead whales near seismic survey vessels have been reported.

A group of severi bowhead whales was observed within 13 km of an active seismic survey vessel (using sleeve expioders as the sound source) in the eastern Beaufort Sea on August 21, 1980 (Fraker et al., 1982, p. 195). The whales "were not behaving in any obviously disturbed manner" despite a reported received pressure level in the 100-200 Hz band of 135-146 dB referred to 1 micropascal at 1 m (Fraker et al., 1982, p. 195-6). Data on surface times, blow intervals, and number of blows per surfacing for this group of seven whales did not differ statistically from similar data obtained in the same general area on the day before and the day after this observation (see Fraker et al., 1982, Fig. 9).

On September 14, 1981, a group of 14 bowhead whales, including a distinctively pigmented adult accompanied by a calf, was observed in the presence of seismic sounds for 135 minutes (Ljungblad, unpublished data). Two seismic survey vessels were active in the area, one initially 19.5 km southwest of the whales and heading. east at 8.3 km/hr; the other initially about 135 km northwest of the whales and heading northeast. Seismic sounds recorded at 69°48'N, 140°32'W (ca. 11 km from the whales) were attributed to the nearer of the two vessels. The vessel, whales, and hydrophore were in water 26-30 m deep. Observers judged that most of the whales in this sighting were feeding throughout the period of observation. In addition, the calf breached near an adult whale (apparently its mother) several times. There was no overt change in behavior that could be attributed to acoustic disturbance. Bowhead sounds, including moans, purring, and occasional screeches, were recorded throughout the period of observation. These sounds were essentially similar to those previously recorded from bowhead whales in the absence of seismic sounds (Ljungblad et al., 1980b, 1982b), and there was no indication in this instance that the whales stopped or modified their calls in response to the seismic noise. Data on surface times and dive times recorded during the fall 1981 monitoring program are presented in Tables 1 and 2.

Limited experimental disturbance trials with a single airgun were conducted in the eastern Beaufort Sea on August 18-19, 1981 (Fraker et al., 1982). Results indicated "some tolerance" by bowheads of seismic sounds originating 2.5-5 km from them with a reported source level of about 222 dB re 1 micropascal at 1 m. Whales that were "echelon feeding" continued to do so, and the whales did not move quickly and purposefully away from the area. However, in one of the trials the whales significantly reduced their number of blows per surfacing and their surface time% stopped calling, and possibly decreased group size while the airgun was in operation. Fraker et al. did not consider these experiments conclusive.

On August 25, 1981, a concentration of at least seven small groups of milling and bottom-feeding bowheads was seen between 6-8 km and 20 km from an active seismic survey vessel (using sleeve exploders) in the eastern Beauf ort Sea (Fraker et al., 1982, p. 196). The calculated pressure level for seismic sounds at 8 km from the vessel was reported to be about 150 dB re 1 micropascal at 1 m. The authors concluded: "There is little evidence that surfacing and respiration characteristics were affected by the seismic noise..., although the absence of 'undisturbed' control data from this date prevents specific comparisons." Four of the whales nearest to the seismic survey vessel were approached in a small boat to within 300 m (Fraker et al., 1982, p. 184-5). The whales were initially "socializing and playing with a log". As the boat approached, they stopped socializing and playing and swam rapidly away. A posteriori tests showed significant changes in blow intervals (increased), surface time (decreased), and number of blows per surfacing (decreased) during close approach by the boat (Fraker et al., 1982, Fig.6). These tests showed that "even in the presence of continuous loud seismic noise, the approach of a small boat causes a pronounced fright response in bowheads" (Fraker et al., 1982, p. 185).

On July 24, 1981, 36 gray whales (Eschrichtius robustus) and three fin whales (Balaenoptera physalus) were observed within 68 km of an active seismic survey vessel in the Chukchi Sea (Ljungblad et al., 1982a, p.56). The gray whales were judged to be feeding, as evidenced by the frequent plumes of bottom sediment ("mud plumes") with which they were associated. Two sonobuoys were dropped: one near a group of 12 whales; the other near the seismic research vessel Arctic Star, ca 49 km distant from the whales. The timing of. airgun pulses recorded by the sonobuoys coincided with that of large bubbles seen near the stern of the boat. Thus, the Arctic Star was almost certainly the source of the sounds being monitored. There was no obvious reaction of the, whales to the seismic noise on this occasion.

Gilmore (1978) referred to behavior of migrating gray whales in the presence Of seismic exploration activities off southern California in January-February 1955. His observations were not conclusive concerning the presence or absence of responses by the whales. According to Gilmore, nearby seismic operations could have affected the whales adversely by eliciting "evasive swimming". He also referred to the possibility that the whales were exhibiting some degree of "learned indifference" due to exposure to seismic sounds before their arrival off San Diego.

Geophysical Exploration on the North Alaska Continental Shelf

Under the authority of the Outer Continental Shelf (OCS) Lands Act of 1953 (43 U.S.C. 1331-1343) and its subsequent amendments, the Secretary of the Interior is responsible for administering mineral exploration and development on the outer continental shelf. Geophysical exploration is regulated through issuance, by the Department of the Interior, of "Permits and Agreements for Outer Continental Shelf Exploration for Mineral Resources."

Geophysical exploration, using seismic open-water techniques, began in the Alaskan Beaufort Sea in 1964 (G.B. Shearer, MMS, Anchorage, personal communication). From 1964 to 1982, a total of approximately 40,200 km of marine geophysical data were acquired in the U.S. Beaufort Sea. The amount of seismic work completed in a year during this time has varied from zero to a few thousand kilometers. We are unable to report the "line miles shot" in any given year or by any particular company because such data are proprietary. The season available for this work is restricted almost entirely to the months of August and September, with occasional opportunities during late July and early October. Ice conditions prevent safe and efficient vessel-supported operations at all "other times of year.

Three companies - Western Geophysical Company of America of Houston, Texas; Energy Analysts Exploration "48" Inc. of Dallas, Texas; and Geophysical Service Inc. (GSI) also of Dallas - were active in the U.S. Beaufort Sea during the open-water season of 1982. Eleven marine seismic permits were issued in 1982 to five different companies. Two vessels from one company (GSI) and three from another (Western), or a total of five vessels, actually operated between Point Barrow and the Alaska-Yukon , border during the period of this study. Specifications for these vessels are given in Table 3.

Considerable additional seismic survey work was carried out in Canadian waters and in the Chukchi Sea west of Point Barrow during the 1982 season. There was no monitoring program such as ours in either area, although a variety of studies of bowhead behavior were conducted in the Canadian Beaufort Sea during August-September 1982 by LGL Ecological Research Associates, Inc. Seismic survey work in Canadian waters was conducted without restrictions relating to bowhead whales.

Seismic exploration vessels survey predetermined transect lines, the configurations and lengths of which are based on known or suspected geological formations (Clay and Medwin, 1977, p. 281; Coffeen, 1978). An energy puke with a very high peak amplitude is projected into the water at intervals of about eight to 15 seconds. Individual pulses are of short duration -generally less than one second. Major energy content of these pulses is in the low frequency ranges of 5-500 Hz. Maximum source levels for seismic survey sounds with a nonexplosive origin have been estimated as 230-240 dB re 1 micropascal at 1 m (Acoustical Society of America, 1981, Table 1, p. 19) or 248 dB re 1 micropascal at 1 m (Johnston and Cain, 1981, as cited in Fraker et al., 1982). These sounds have higher output power than any others associated with offshore oil and gas exploration or development in the Arctic (Acoustical Society of America, 1981, p. 26). Horizontal propagation characteristics of these signals are not well known.

Seismic survey sounds can be generated by an explosive charge, a spark discharge, a sleeve exploder, a vibrator, or an airgun array; the last of these is most commonly used in offshore exploration (Mayne and Quay, 1971; Dobrin, 1976, p. i23-125; Clay and Medwin, 1977, p. 281-283; Coffeen, 1978; Barger and Hamblen, 1980; L.D. Brooks in Acoustical Society of America, 1981, p. 72). Explosives are no longer used for marine geophysical operations in the Beaufort Sea. All vessels working in the U.S. Beaufort Sea during 1982 were using an array consisting of 12 to 24 airguns towed at a distance of 15-30 m from the vessel% stern at 4-8 m below the sea surface (e.g., Barger and Hamblen, 1980; Hoff and Chmelik, 1982). An active cable, 3,000 to 3,600 m long and with as many as 24,000 individual hydrophores built into it, is towed behind the airgun array. Reflections, or echoes, from submarine rock formations are received by the hydrophores and converted to digital signals which are recorded on magnetic tape for computer processing.

Selection and completion of transects by the vessels can be influenced by weather and ice conditions, proximity of other active seismic survey vessels (acoustic interference can be a 'problem when two vessels are shooting near each other), and the company's research objectives and priorities, The opening and closing of areas according to the M MS regulatory procedures (outlined below) inf luenced seismic survey programs in the Alaskan Beaufort Sea during August-September 1982. Although more vessels were available to acquire data in 1982 than in all previous' years (with the possible exception of 1981), fewer data were acquired than in some previous years due to bad ice conditions early in the season and area closures to protect bowhead whales late in the season (G. Shearer, in letter to RR, Nov. 22, 1982).

Development of Monitoring and Regulatory Procedures

Under Section 7 of the ESA, any proposed action by a Federal agency which may affect an endangered species requires the agency to initiate active consultation with the NMFS or the U.S. Fish and Wildlife Service, Department of the Interior (DOI). Proposals for offshore oil and gas lease sales by the DOI have led to consultation between the DOI and the NMFS, the Federal agency responsible for management of cetaceans. For proposed lease sales in the Beaufort Sea, consultation between the DOI's Bureau of Land Management/U.S. Geological Survey (later partially merged to form the Minerals Management Service, MMS) and the NMFS began formally on March 30, 1978.

The NMFS's "threshold examination" of August 25, 1978, stated that "insufficient information existed to conclude whether the lease sale [Sale BF] and resulting exploratory activity was or was not likely to jeopardize the continued existence of endangered bowhead and gray whales or result in the destruction or adverse modification of habitat that may be critical to them" (Leitzell, 1980), The same concern about insufficient information was expressed in the final Biological Opinion issued by the NM FS on November 6, 1979, and in subsequent modifications to that document.

A Biological Opinion dated June 24, 1980, concluded relative to geophysical exploration in the joint Beaufort Sea lease sale area:

> The NMFS has been informed by the USGS that no extensive geophysical exploration is expected in the lease

> area but the possibility exists that some exploration may be conducted to select optimum drill sites. At this time, our knowledge is inadequate to assess the magnitude of the effect on bowhead whales of noise from acoustic devices. The acoustic devices used during these activities could impact on bowhead whales in the area by altering behavior patterns in a manner similar to the demonstrated effect of noise from seasonal barge traffic in the Canadian Beaufort on beluga whales (Leitzell, 1980).

This Biological Opinion included "reasonable and prudent alternatives" that the NMFS believed would mitigate the impact of oil- and gas-related activities on bowhead whales. One of these was:

> The NMFS recommends that the DOI use its authority to prohibit acoustic geophysical activities in the lease area during the period from August through October, in order to fully protect bowhead whales during their fall migration...(Leitzell, 1980).

On July 30, 1981, the NMFS concluded that acoustic geophysical work in the Beaufort Sea joint sale area could continue after August 1. The following modification was made to the Biological Opinion of June 24, 1980:

> The NMFS recommends that the Department of the Interior use its authority to prohibit acoustic geophysical activities in the lease sale area from September 1 to October 31 east of Prudhoe Bay and from September 15 to October 31 west of Prudhoe Bay in order to fully protect the bowhead whale during its fall migration. Although these dates reflect the usual timing of the fall migration, the advent of the migration may vary from year to year, sometimes occurring earlier and sometimes later. The USGS should require permitters to suspend operations if the whales reach the project area prior to the September dates. The USGS could allow extensions of operations beyond the September dates if the whales have not yet reached the project area. We recommend that such extensions be granted only if aerial surveys are likely to be present in the project area, or would show whether the normal migration of the whales is being disrupted (Stevenson, 1981).

The most recent NMFS Biological Opinion prior to our 1982 study stated:

> ...NMFS believes that geophysical seismic operations in the Sale BF area during the fall migration should be allowed only when bowhead whales are not likely to be in the vicinity and be affected by operations. The whale migration should be monitored by aerial and other surveys to determine if whales are in the vicinity of seismic operations or if whales outside the vicinity of the operations are being disturbed (Gordon, 1982a).'

On May 19, 1982, the wording of the above "reasonable and prudent alternative" was changed to read "... seismic operations... should be allowed only when bowhead whales are not likely to be in the vicinity or if not in the vicinity are not being affected by operations" (Gordon, 1982b).

Monitoring and Regulatory Procedures

Our monitoring responsibilities during the 1982 fall migration season were:

> In the event that the contractor observes abnormal bowhead whale behavior which, in consultation with NMFS, is determined to be related to geophysical vessel operation, operators of geophysical vessels will be so notified. In such a circumstance, the contractor will tell the vessel operator the likely period of time that bowhead whales would be present within the zone of influence of the probable disturbing factor. It will not be the, contractor's responsibility to advise the geophysical vessel operator. as to possible remedial action related to vessel operation. Specific regulatory requirements for geophysical vessel operators will be attached to necessary permits (Ryland and DeRamus, 1982).

According to their permit specifications, seismic" survey vessel operators were required. to "shut down the seismic sound source" upon being notified by us that whales within their "zone of influence" were being disturbed, and to "remain shut down until the period of time has elapsed that the contractor estimates the whale(s) to be in the area" (Wunnicke, 1982 j Attachment 5). In addition, vessel operators were required to suspend seismic survey operations whenever bowhead whales were sighted from their vessels. Activities could resume only after the whales had "passed from sight". Operators were also required, as a condition of their permits, to notify us of any whales sighted from the vessels. The MMS exercised direct regulatory control of vessels through closure of certain areas to exploration, as judged necessary through ESA Section 7 consultation.

It was further stipulated that if for any reason we were unable to make observations once the fall bowhead migration "appear [ed] im minent", the estimated speed of migration and elapsed time since our last sighting would be used by appropriate officials to establish a geographic range within which seismic survey operations would be suspended pending the resumption of flights (Wunnicke, 1982, Attachment 5).

METHODS

Data Collection Procedures

An amphibious, high-wing, twin-turbine aircraft (Grumman Goose G21C, N642), specially equipped with observation "hubbies" on both rear doors and a sonobuoy chute, was dedicated to this project. A Global Navigation System 500A Series VLF computer was used for navigation. It is accurate to ± 0.37 mi (0.6 km) per hour of flying.

The aircraft and a crew of five (pilot, co-pilot, data recorder, and two principal observers) were based at Deadhorse, Alaska, near Prudhoe Bay, from August 27, 1982, to October 4, 1982. Each day we obtained the morning position, operational status, and weather conditions for all seismic vessels in the Beaufort Sea west of the international boundary (Table 4). Geophysical exploration companies received this information by radio from their respective vessels and passed it on to us in-person or by telephone.

Weather conditions permitting, we flew to the position of the easternmost, actively shooting vessel, located the vessel visually, and initiated a series of systematic transects covering approximately 1,400 km2 near the vessel (Figure 2). Normally, the first transect in the grid was an 18.5 km line oriented north-south, beginning at the vessel's position when initially sighted. Subsequent transects were parallel to the first and 37 km long; their centerpoints were at the same latitude as the southern end of the first transect. We attempted to fly a total of at least four of these 37 km transects, spaced about 9 km (i.e. 15 minutes of longitude) apart. Usually we worked from west to east in order to maximize our chances of intercepting relatively "unexposed" whales as they approached a sound source. However, when we knew or had reason to suspect whales were present in the direction of the vessel's, heading, we designed our transects to cover as much area as possible in that direction. Grid orientation was also influenced by local fog conditions.

A supply of sonobuoys was carried on board for recording seismic and whale sounds. Three types were used: AN/SSQ-41A with a frequency response {sensitivity) of 10 Hz to 6 kHz; AN/SSQ-41 B with a frequency response of 10 Hz to 20 kHz; and AN/SSQ-57A with a frequency response of 10 Hz to 20 kHz. Sounds received by the sonobuoy hydrophore were telemetered via VHF transmitter to a broadband receiver. (Modified USQ-42) on board the aircraft and recorded on a dual-track Nagra IV-SJ tape recorder (with a frequency response of 25 Hz to 10 kHz at 9.5 cm/s). These sounds could be heard on the crew's earphones while, simultaneously being recorded on one tape-track. Prior to field use, the sound recording system,. including the sonobuoy (only 57A and 41B were calibrated), receiver, and "tape recorder, was calibrated as a system at the Naval Ocean Systems Center Transducer Calibration Facility in San Diego [see Appendix I).

Sonobuoys were dropped routinely at two points in each survey grid. The first usually was dropped at the northern end of the first transect; the second, at the southern end of the second transect. By deploying the sonobuoys in this manner, we intended to record and measure sound energy levels for the seismic pulses at a shallower, more nearshore depth and at a deeper, more offshore depth. It was felt that such recordings would be useful in later analyses of seismic" sound propagation characteristics. Sonobuoys were also dropped opportunistically in areas near whales and active seismic survey vessels.

Verbal notes concerning whale behavior, surface and dive times, blow series, approximate whale sizes, inter-individual spacing and orientation, and sound production were recorded on. the second tape-track. Duration of specific behavioral parameters was measured with a stopwatch while listening to the taped replay in the laboratory. Surface times were considered to begin as the whale first came into view and considered to end as it flexed the peduncle to dive or as it sank below the surface, ending a blow series. Dive times were measured from the end of one surface time to the start of the next surface time.

Standard observation procedures for the transects were for one principal observer to be stationed on each side of the aircraft, maintaining a continuous watch. All members of the crew as well as occasional guests on board contributed to the watch for whales. Although we usually maintained a searching altitude of 305 m above sea level, we sometimes were forced to fly lower due to the cloud ceiling and other weather conditions. An airspeed of about 110 knots (204 km/hr) was maintained while searching and circling. The primary considerations in deciding whether or not to fly on a given day were safety and visibility; wind speed and sea state were secondary considerations. Poor or marginal weather conditions, aircraft maintenance requirements, and day length (diminishing during our study from approximately 17 hrs., twilight to twilight, on August 27 to less than 12 hrs. on October 3) were factors limiting total observation time. As a result, we occasionally flew when conditions on the sea surface were suboptimal for detecting and observing whales.

Data were entered and stored on board in a Hewlett Packard 85 computer, which provided both a printed paper copy of the data and a permanent record on tape-cassette. The associated software system consisted of four programs for updating: position update (32 entries), weather update (11 entries), and a short and a long rapid-sighting update (6 and 11 entries, respectively). The person assigned duties as data recorder devoted fulltime attention to this task.

Additional equipment on board included the following: two single-lens reflex cameras, both Olympus OM - 1 models, one with an 85-205 mm Vivitar zoom lens and the other with an 85-205 mm Olympus zoom lens; Ektachrome ASA-200 color slide film and Pan X ASA-400 black-and-white print film; one pair of Zeiss 8 x 20B binoculars; and a video recorder (Panasonic Omnipro) with a 75 mm lens (6:1 zoom ratio).

We regarded detection of whales along our 165-200 linear km grid in the vicinity of an active seismic survey vessel as a high priority. Thus, we did not generally spend long periods circling animals as they were sighted on our transects. Rather, we noted whale positions and tried to return to them for detailed behavioral observations after completing the grid. We also considered opportunities to observe "undisturbed" whales immediately before and/or after a seismic survey vessel was shooting to be a high priority. Such opportunities were largely a matter of chance, but we tried to anticipate them whenever possible. Many of our behavioral observations were made on days when the option of flying grids near vessels was precluded due to weather conditions or the fact that no vessels were shooting inside our study area.

Behavioral observations were made primarily as we circled above whales. When weather conditions were suitable, we established an altitude of about 450 m in order to reduce the likelihood of affecting the whales' behavior with aircraft noise during prolonged observations. Except when a good reference marker, such as an ice floe, was already available on the water, we attempted to drop our own markers at points where whales dived. Flouroscene dye. in weighted plastic bags and weighted 1-m strips of orange plastic were used in most instances. For each sighting, we tried to record the animals' heading and type of behavior. In general, we used the terminology and definitions established by Würsig et al. (1982) for bowhead whale behavior in the eastern Beaufort Sea. Spatial relationships among members of a group were recorded. We usually dropped a sonobuoy in the vicinity of the whales to record their phonations as well as ambient and vessel-generated sounds. Immediately before abandoning an animal or group of animals, we often descended to an altitude of 60-152 m and tried to obtain high-quality photographs of distinctive markings for individual whale identification. The video recorder was used by the co-pilot to record whale. behavior for subsequent laboratory viewing and analysis.

During August-October 1982, another study team aboard a different aircraft (Grumman Goose G21G, N780) performed broader, regional surveys by flying sets of random north-south transects in 12 blocks covering the area bounded by the north coast of Alaska on the south, 72°N or the pack ice edge on the north, the Canadian border on the east (141°W), and Point Barrow on the. west (156°30'W) (Ljungblad, Moore, and Van Schoik, in preparation a). An additional (13th) block in the Chukchi Sea included an area extending from Point Barrow to about 110-120 km west and to 280 km south. That team% flights, intended to document broad-scale distribution, relative density, and habitat use of endangered species, began August 1, 1982, and continued past the end of our study period (October 4). Bowhead sightings made by the other study team were reported daily to us and to appropriate Federal officials in Anchorage. This information helped to guide our decisions about where to concentrate the monitoring efforts.

Data Analysis

Four behavioral parameters - mean blow interval per surfacing, number of blows per surfacing, surface time, and dive time - were used to test for significant differences related to presence or absence of seismic sounds as well as to other factors such as water depth, relative whale size, and inter-individual associations.

Individual whales were classified as "adults", "cows", and "calves." Cows were recognized by their close association with a whale approximately one-half or less of their own length, and calves by their small size and often by their close association with a whale approximately two or more times their own length. To some extent, calves could also be recognized by their somewhat lighter pigmentation. "Adults" were defined as all whales not classified as cows or calves. Water depth at the position where a whale was observed was dichotomized as "deep" (greater than 15 fathoms, or 27.45 m) or "shallow" (15 fathoms, or 27.45 m, or less). A whale was classified as "interacting" if it was within one whale-length (ca 15 m) of another whale; "noninteracting" if it was more than one whale-length from the nearest whale. An observation was scored as "seismic" only if repeated seismic shots were detected using a sonobuoy dropped near the whales being observed. Verification that a geophysical vessel was operating somewhere in the Alaskan Beaufort Sea was made possible by radio or other communication with the geophysical companies. If the seismic sounds began, ended, or were interrupted during a series of behavioral observations, all events observed immediately before shooting began or after it stopped were classified as "nonseismic".

The data were carefully screened prior to analysis to insure that only appropriate and well documented events were used. For example, all the data on a wounded whale observed September 17 (Ljungblad, Reeves, and Clarke, in preparation b) were omitted because they were considered to represent abnormal behavior. Data obtained when no sonobuoy was in the water to verify the presence or absence of seismic sounds were also omitted. For occasions in which the first or last blow in a series was not observed, the surface time, adjacent dive time, and number of blows in the surfacing period were considered suspect and therefore were not used in the analysis.

Parametric (Student's t) and nonparametric (Wilcoxon T or Mann-Whitney U) two-sample tests were performed on the data to test for differences in behavioral parameters between dichotomous conditions (seismic vs. nonseismic, deep vs. shallow, interacting vs. noninteracting) and among classes of whales ("adults", cows, calves). Sample sizes were often too small to determine normality of distribution, so both parametric and nonparametric test results were presented. The principal null hypothesis was: "There is no difference between bowhead behavior (as represented by one of the four behavioral parameters) in the presence and in the absence of seismic sounds." Corresponding null hypotheses were tested for other dichotomous conditions and for each class of whale. For the aggregated data from all days, 45 tests were performed. With, a p-value of .05, it can be expected that there will be 5% or 3 (rounded up from 2.25) false positive results.

Although it would have been preferable to test differences in the behavior of individual whales under different conditions (e.g. seismic vs. nonseismic), this proved impractical because sample sizes for individual 'whales under different conditions were too small. Sample sizes for certain days were large enough to permit within-day and between-day comparisons, but in order to make meaningful seismic vs. nonseismic comparisons, it was necessary to lump data for all classes of whales at all depths and without regard to their status as 'interacting" or "noninteracting."

We recognize that our treatment of the data has not exhausted the available approaches to test for. significant differences. In future studies of this type, perhaps in multi-year analyses which incorporate. the data presented herein, a multivariate approach that includes total dive and surfacing sequence characteristics under "seismic" and "nonseismic" conditions may prove useful.

RESULTS

Monitoring

Between August 27 and October 3, we initiated 34 survey flights, the mean duration of which was 2 hr 21 min (range: 11 min to 4 hr 30 rein) (Appendix II). Bowhead whales were sighted on 14 of these flights, and we spent a total of approximately 18 hr 46 min making behavioral observations. A total of 16 grids were begun near seismic survey vessels; 10 of these were completed. "Only 9 sightings were made during the grid surveys covering areas near seismic survey vessels. The majority of our sightings were made either en route to or from vessel positions or while searching specific areas (especially along the 15-40 m isobath) where, on the basis of previous experience (Ljungblad, 1981; Ljungblad et al., 1980a, 1982a), we expected bowheads to occur in relatively high density.

Ice was usually absent in our study area throughout the month of September. The pack ice edge was estimated to have remained at least 75-100 km offshore at all times. Some broken pieces of first-year fast ice were grounded in shallow areas along the coast. At times ice interfered with the work of seismic survey vessels, but we have no reason to think it directly influenced the movements or behavior of whales in the study area during the period of August 27 to October 3. At no time did we observe ice of more than 2/10 coverage outside the barrier islands.

Bowheads were first sighted on September 14, at ca 700 12'N, 144°37'W or directly west of Barter Island, although our companion aircraft (N780) reported sightings on September 8 at ca 7 1°34'N, 145°37'W. Whales were not seen traveling rapidly and consistently toward the west until September 28, but a genera] westward trend in bowhead distribution had clearly begun by the second week of September. We consider the 1982 nearshore fall migration to have begun at approximately the end of the first week in September, which is consistent with scientific observations (Ljungblad, 1981; Ljungblad et al., 1980a, 1982a) and Kaktovik whaling results of previous years (Table 5).

Our final sighting was made on October 2, while monitoring construction noise at Tern Island in outer Prudhoe Bay. A single bowhead was seen swimming rapidly west ward at ca 70°29'N, 147026'W, and bowhead sounds were heard several times from the sonobuoys being used to monitor the construction noise. Our study terminated on October 4, because by this time all seismic survey vessels had either docked in Prudhoe Bay for the winter or left the Alaskan Beaufort Sea (Table 4). Regional surveys (by the other survey team aboard N780) continued until October 17, when ice coverage in the entire Alaskan Beauf ort Sea was close to 10/10. Their sightings made on October 6 at 70°22'N, 142°45'W (3 whales), October 12 at 7 1°35'N, 156°45'W (one whale), and October 14 at 69°45'N, 1390W (one whale) indicate that the migration through the Beaufort Sea was nearing completion (Ljungblad, Moore, and Van Schoik, in preparation a).

Acoustic Measurements

A total of 53 sonobuoys was dropped during the study; nine (17 percent) failed to transmit. Water depth at the points where sonobuoys were dropped ranged from about 13 m to about 92 m. The peak frequencies of seismic sounds recorded in this study often shifted from one pulse to the next. This variability was unexpected, and it suggests the potential for an additional source of variability in animal response, assuming there is a correlation between behavior and the frequency content of introduced sounds. A sample of peak frequencies of seismic sounds recorded in this study indicates a range between at least 127 Hz and 475 Hz (Table 6). This frequency range is within that of documented bowhead whale sounds (20 Hz to 4 kHz: Ljungblad et al., 1980b, 1982b; 30 Hz to 2 kHz: Wursig et al., 1982, p.115-118).

Although it had been our intention to present herein the received pressure levels of seismic and whale sounds recorded in this study, we became aware while analyzing the acoustic data of certain unforeseen problems in sonobuoy sensitivity. The sonobuoy calibration procedures and results are given in Appendix I. Detailed analysis of seismic, whale, and ambient sounds recorded by Naval Ocean Systems Center personnel in the Alaskan Beaufort Sea in 1978-1982, including those recorded during the 1982 geophysical monitoring program, will be presented elsewhere (Ljungblad and. Schmidt, in preparation).

Area Closures to Seismic Exploration

1981

In 1981, it had been agreed that after September 1, if no monitoring frights were made east of Prudhoe Bay during any 48-hr period, then seismic survey activity would be suspended until flights were resumed. A similar 72-hr limit was applied west of Prudhoe Bay. This suspension procedure was invoked twice during September 1981, flights being delayed due to aircraft maintenance problems in one instance and to weather in the other. On both occasions, the areas were reopened for seismic survey work once flights were resumed. By September 28, ice conditions had become so severe that seismic survey work ended.

1982

The addition of a second aircraft to the monitoring and research effort reduced the need for regulatory action due to lack of flights in 1982. Regional surveys included offshore areas not covered in previous years and resulted in a bowhead sighting ca 83 km north of Barter Island on August 2. This sighting, especially when supplemented by additional sightings north of "Demarcation Bay on August 2-8 (Ljungblad, Moore, and Van Schoik, in preparation a), was interpreted as possible evidence of an early offshore start to the westward fall migration. Thus, Alaskan waters east of Barter Island were closed to seismic survey operations from August 7 to September 9. Restrictions east of Barter Island were lifted on September 9, although oral notification that certain nearshore areas remained closed was subsequently given to the survey companies.

A series of further restrictions were imposed between September 13 and September 25 (Table 7). Only a few programmed survey lines (i.e. transects laid out for seismic testing by the geophysical companies or their clients) remained uncompleted outside the closed areas after the September 25 notification. As indicated in Table 4, two vessels continued to operate in the U.S. Beaufort Sea after September 28, but their operations terminated on or about October 2 because of ice conditions and/or a shortage of programmed survey lines outside the closed areas.

Behavioral Observations

Sustained behavioral observations were made on six days {September 14, 15, 17, 23, 24 and 25), when sighting conditions were good and whales could be found. Whale distribution was concentrated along the 15-40 m isobath, and sightings tended to be clumped. It is important to stress that migratory movements were not the only type of behavior seen in the Alaskan Beaufort Sea during the month of September. As late as September 28, when some whales were swimming rapidly to the west, at 70°26'N, 146°20'W six bowheads were observed, one of which was swimming open-mouthed with rostrum exposed above the sea surface. This was interpreted as evidence of feeding, probabl y skim f ceding (Würsig et al., 1982, p. 71), near the surface. Probable water-column feeding was observed on the same day, as evidenced by a concentration of about 20 animals swimming in no consistent direction and diving steeply in a small area between 70°16'N, 144041'W and 700181N, 144°57'W. Particularly. when combined with evidence from stomach contents of whales killed in September and October by Kaktovik whalers (Marquette et al., 1982, Table 7), these observations suggest that the bowhead migration through the western Beaufort Sea involves episodes of feeding and searching for food as late as the end of September and, in some years, into early October.

Group size varied from one to 14 animals, although loose aggregations of 20 or more individuals were seen at times within a radius of 8-10 km. Other than the obvious association between cows and calves, we saw no direct physical interaction between whales which could be considered sexual or agonistic. However, groups of two to five whales frequently were seen swimming together, surfacing synchronously, and making occasional physical contact (usually snout to snout or snout to tail). We interpreted most of what we saw as traveling (possibly searching for food), feeding, or resting behavior.

September 14, 1982

On September 14, we were forced to abandon our plan of flying a grid near the GSI Mariner because of heavy local fog. Researched near the area where we believed the Mariner to be, ca 70°20'N, 144°W. A concentration of bowheads was sighted at 70°11'N, 144°37'W, or within 33 km of the Mariner's position at 1530 hrs. (70°20'N, 143°51'W). Sonobuoys dropped near the whales verified that, at the time of initial sighting (1433 hrs), the vessel was not shooting., We estimated about 1 8 whales within a radius of 2-3 km. Initially, the whales were single and in groups of 2-3 and 6-7 individuals separated by distances of 1/4-1 km. Some whales were surfacing synchronously; others, non-synchronously. They did not seem to be oriented in any particular direction.

At 1502 hrs., or about 1/2 hr.. after the initial sighting, the Mariner began shooting. Seismic sounds were recorded at a peak frequency of 170 Hz, 33 km from the vessel in water depths of 16-17 m. By 1530 hrs. the loosely associated concentration of bowheads had coalesced into a single, closely packed group of" 12-14 individuals (Fig. 3),' with about 4-6 outliers within 1 km of this group. The group surfaced almost synchronously, and its members remained on the surface in close contact with one another while blowing. Much touching occurred, and the orientations of the whales' snouts seemed to converge, although they did not form a circle. Surface time for the group as a whole was about 4-5 minutes, and dives lasted about 10-12 minutes. However, we were not able to identify individuals and thus could not determine accurate dive or surface times. Our observations in this instance were qualitative and not quantitative. We heard whale sounds intermittently (at a peak frequency of 830 Hz), and a number of underwater blows occurred while the group was. below the surface. Refueling requirements forced us to leave the whales after approximately 1 hr. 40 min. of observations. Our field interpretation of this series of observations was that the onset of seismic noise may have elicited a response from the whales which we labeled "huddling" or "bunching". Appropriate MMS and NMFS officials were advised of these observations upon our return to Deadhorse. Vessel operators were not directly advised that a disturbance had occurred because of our uncertainty about causal relationships (see Discussion).

September 15, 1982

On September 15, we encountered 18 bowheads along the 70°31'N latitude line, between 146°W and 147°W longitude, while en route to the position of the Mariner. The vessel was not shooting when we sighted (at 700 12'N, 144°47'W) and established radio contact with her at 1107 hrs. The crew intended to begin shooting later in the day. We located a second concentration of whales at 70°14'N, 144°30'W, consisting of 6-9 individuals. A sonobuoy verified the absence of seismic sounds at the time of initial sighting. We observed the whales for slightly more than an hour. The animals were generally stationary at the surface and alone or in groups of 2-3 individuals.

After refueling at Barter Island, we returned to the same area and found a concentration of about six whales at 700 18'N, 144°36'W at 1257 hrs. A sonobuoy confirmed that the Mariner was now shooting. Her position, as given to us by radio, was 70°21'N, 145°09'W, at 1335 hrs. Seismic sounds at a peak frequency of 120 Hz and whale sounds at a peak frequency of 660 Hz were recorded near the whales, in water depths of about 27-28 m. The whales in this instance were tightly bunched, in an orientation similar to that of "huddling" bowheads the previous day.

Quantitative Analysis:

Some. data were collected on surface, dive, and respiration variables during both periods of observation (Appendix II, Flights 13 & 14; Table 8; Fig. 4). Differences in these characteristics in the presence and in the absence of seismic sounds were not statistically significant.

September 17, 1982

On September 17, we began a grid survey near the Mariner but terminated this survey during the first transect. A struck bowhead, towing a whaling float, was seen during this transect, and we immediately dropped a sonobuoy and began circling the animal. Our behavioral observations of the struck whale are presented elsewhere (Ljungblad, Reeves, and Clarke, in preparation b). We do not consider the behavior of this whale to be a sample unit of the major population of interest, i.e. that of unstruck bowheads. Thus we did not include parameter values from it in statistical analyses herein. However, since behavioral data on struck bowheads are rarely obtained, we decided to devote survey time to observing this animal. At the time of initial sighting, the struck whale was 7-8 km north of the Mariner and directly in her path. The Mariner was shooting at the time, and seismic shots were recorded near the whale at a peak frequency of 212' Hz. After we had made the decision to study this whale and had spent more than an hour doing so, four other bowheads were sighted in the vicinity of the struck whale. One pair was about 3 km west of the Mariner; another pair about 6-7 km west of the Mariner. The former pair was not moving while at the surface, and these two whales' heads were in contact. This pair of whales was closer to a shooting seismic' vessel than any other whales we have observed. No obvious response was apparent, but our observations were brief. Since our attention was drawn to the struck whale at the time, we were unable to document quantitatively the behavior of these other whales.

September 23, 1982

On September 23, we had an opportunity to observe a concentration' of' about 13 whales, including two well-marked individuals, in the presence and absence of seismic sounds (Appendix II, Flight 22). We focused our attention on three loosely associated animals which were generally stationary or moving slowly just beneath the sea surface, allowing us to keep them in sight during much of their. "down" time. Extensive white patches on the caudal peduncle of one large and. one medium-size individual improved our chances of sighting them through ca 1 m of water. The third animal was' a calf which remained by itself but within 2 km of the other two.

The Western Aleutian, about 41 km north of the whales and heading south at 8-9 km/hr, was shooting intermittently during our 2 1/2 hrs. of behavioral observations. No overt change in whale behavior was noticed during this time. The whales appeared to be resting, making very shallow dives, or moving very slowly, with no close physical interaction. Seismic sounds were recorded near the whales (41 km from the Western Aleutian) at a peak frequency of 217 Hz. Whale sounds recorded in the same area at the same time had a peak frequency of 340 Hz.

Quantitative Analysis:

A sample of respiration data was collected in the presence and in the absence of seismic sounds (Appendix H, Flight 22). However, the subsample of data in the absence of seismic sounds. was too small to make meaningful comparisons with the subsample in the presence of seismic sounds for this day.

September 24

The Western Polaris was the only seismic survey vessel shooting in the Alaskan Beaufort Sea at the time we began surveying on this day. After flying a grid survey near it in the morning, we spent the afternoon searching for whales and making behavioral observations. A concentration of about 20 bowheads was located within an 8-10 km radius of 71°02'N, 148°40'W shortly after 1500 hrs. At this time and location there were no seismic sounds received by our sonobuoy. One group of 6-7 bowheads was observed (at 1510 hrs) in an orientation similar to that seen on previous days, when it was termed "huddling" and suspected of being a response to disturbance.

Quantitative Analysis:

A series of behavioral observations of these 20 whales was made before the Western Polaris resumed shooting at 1600 hrs. In the laboratory, we compared data from the same whales collected in the absence of seismic sounds to data collected in the presence of seismic sounds (Appendix II, Flight 24; Table 8; Fig. 5). On average, blow frequency per surfacing and time at the surface were greater during the period immediately after the Western Polaris began shooting than before it was shooting. Differences in number of blows per surfacing and surface time were significantly different ($t = 2.289$, $df = 17$, $p<.05$ for blows per surfacing; $t= 2.695$, $df = 20$, $p<.02$ for surface time; Student's t-test). This result is inconsistent with observations made by Fraker et al. (1982, p. 198-203, Fig. 11 and Appendix 5) during their experimental disturbance trials of August 18, 1980, when the whales (in water 23-28 m deep) significantly reduced their number of blows per surfacing and their surface times in apparent response to airgun noise. The whales we were watching were in water approximately 30 m deep.

September 25

After being forced to abort a planned grid survey near the Krystal Sea because of fog, we flew toward the Western Aleutian, whose reported a.m. position was 70°35'N, 145°W. En route we sighted a concentration of about 10-20 bowheads within a 5 km radius of ca 70°50'N, 149° 15'W. The whales were oriented in various directions and remained stationary or moved slowly while at the surface blowing. They usually lifted the flukes when diving. We judged the whales to be milling and feeding during "a 2 ½ hr period of observation (from 1105 to 1340 hrs). Water depth at the site was 18-

19 m. One or several of the smaller whales appeared brown on the head, and may have been mud-covered or sloughing skin. Seismic sounds in the 200-455 Hz band were recorded. We were unable to attribute these sounds to a particular vessel. The Western Aleutian was about 157 km, the Krystal Sea 154 km, and the Western Polaris 117 km from the whales. All three reportedly were shooting on this day.

During this observation period an important series of observations was made of two well-marked cows - "Stripe", with a prominent white linear scar on the back and "Scratch", with a conspicuous network of narrow scratch marks on the back - and their calves, both less than half the mother's length' and recognized on the basis of their close associations with either cow. A third, but solitary, calf possibly was present in the same area. These 4-5 whales remained in a small area (ca 1 km2) for at least two hours, and none of the other whales entered the area during this time. Dye markers and a sonobuoy dropped at 7 1°04'N, 148°42'W provided excellent reference points enabling us. to observe the behavior and moveme'nt of these 4-5 whales. The Western Aleutian was shooting between 1105 hrs., when, our observations began, and 1315 hrs., when the sonobuoy indicated that shooting stopped; observations continued until 1340 hrs. Because of the coincident timing of the Western Aleutian's shutdown (as reported to us by the company upon our return to Deadhorse) and the cessation of strong seismic sounds heard via the sonobuoy, we assumed that this vesssel was the source of the most prominent acoustic signals during the observation period.

Whale sounds were heard frequently throughout the period of observation- There was no obvious change in the behavior of the whales. We were impressed by the fact that the four readily identified individual whales dived repeatedly in the same small area for more than two hours.

Quantitative Analysis:

For this day we were able to compare a relatively large sample of data collected in the presence of seismic sounds with a small sample collected in the absence of seismic sounds, referring to the same group of whales (Appendix II, Flight 25; Table 8; Fig. 6). On average, blow frequency per surfacing and time at the surface were greater immediately after the Western Aleutian stopped shooting than while it was shooting. This result is inconsistent with the previous day's observations, but on this day the differences were not statistically significant. The water depth was more shallow (18-19 m vs. 30 m) on the 25th than on the 24th. It is important to bear in mind that the nature of the comparisons differed on the 24th and the 25th. On the 24th, the "nonseismic" observations were made before the Western Polaris began shooting; whereas, on the 25th they were made immediately after a period of ensonification. It is possible that, in the former case, the startup of seismic sounds could have caused a startle response; in the latter case it is possible that the whales would have continued to display disturbed behavior for a period after the seismic sounds stopped.

Between-day comparisons for September 15, 24, and 25 are shown in Figures 7 and 8.

General Quantitative Results

A summary of the aggregate sample of quantitative data for the entire month of September 1982 is shown in Table 9 and Figures 9- 12 and results of significance tests on these data are presented in Table 10. These results suggest that a number of factors may contribute to observed differences in, behavior between various categories of bowheads. In particular, cows accompanied by calves appear to have consistently different numbers of blows per surfacing, dive times, and surface times from "adults" not accompanied by calves. Water depth also appears to have some effect on the length of surface times. This factor was also identified as a potential influence on surface times by Würsig et al. (1982, p.97).

Overall, the most significant result of our analysis is that surface times for the aggregate sample of "adults" increased in the presence of seismic sounds (Table 10; Fig. 11). This is contrary to the experimental results obtained by Fraker et al. (1982). However, it is consistent with our results for September 24, when the same group of whales was observed on the same day in the presence and absence of seismic sounds (Table 8; Fig. 5).

DISCUSSION

Two factors significantly limited our opportunities to study the interaction between bowhead whales and geophysical survey operations. One was the lack of experimental control over vessel operations. We could not ask operators to start or to stop shooting at our convenience in order to test responses of the whales under observation. A second factor was the progressive shutdown of areas to seismic operations as the westward migration by bowheads proceeded during the second half of

September (Table 7). In effect, the monitoring and reconnaissance aspects of our mission conflicted with its research aspect. As large numbers of whales (potential research subjects) moved into the study area, measures were taken to restrict geophysical survey operations. Thus, repeated and prolonged observations of bowheads in close proximity to operating geophysical vessels were frequently prevented.

In attempting to assess the effects of seismic and other industrial noise on whale behavior, the available set of indicators is small. Changes in swimming direction or speed, behavioral mode, group size, inter-individual distance, and respiration characteristics (such as mean' blow interval, surface time, dive time, and number of blows per surf acing) have been recorded and analyzed as measures of disturbance (Fraker et al., 1982). However, without experimental control over the sources of potential disturbance, it is difficult to ensure that observed or apparent changes or differences in these indicators are causally related to a particular source of disturbance. At times, they could just as likely be related to shifts from one behavioral mode to another (e.g., from feeding, to resting; resting to traveling), to nuances within a mode (e.g., changing from one courtship phase to another; a rapid vs. slow or deep vs. shallow pass through a concentration of prey), or to differences in water depth, prey depth, size and composition of the group, and the like.

Several studies have shown that avoidance of or sensitivity to human activity in ungulates differs between hunted and unhunted populations (e.g. Behrend and Lubeck, 1968; Batcheler, 1968; Dorrance et al., 1975). This may also be true of baleen whales. In evaluating the sensitivity of bowheads in the Beaufort Sea to industrial disturbances, an additional and possibly interactive factor to consider is that the population is a hunted one. Wariness associated with hunting may be induced and perhaps interacts with other behavioral sensitivities.

The possibility that our observations were influenced by unrecognized sources of disturbance needs to be borne in mind. Fraker et al. (1982) and Ljungblad et al. (1982a) commented on the lack of consistency in bowhead responses to low-flying aircraft. It is generally known that certain aircraft flying at certain altitudes cause whales to dive prematurely. If the whales in our study were reacting to the survey aircraft, then measurements of surface time and blows per surfacing may have been biased. However, because aircraft noise was present during all of our observations, it can be regarded, to some extent, as a "constant" which should not necessarily bias the seismic vs. nonseismic comparisons. A degree of subjectivity is unavoidable in assessing whether whales are or are not being disturbed by the observation platform, especially when the platform is a twin-engine aircraft flying Iow enough to permit accurate and detailed observation of the animals. Our effort to maintain an altitude of 450 m or more while collecting behavioral data should have minimized the extent to which aircraft disturbance affected our results.

Judging by the fright or flight responses of bowheads to close approach by vessels, including in one instance a geophysical survey vessel with its sleeve-exploders on board and not in operation (Fraker et al., 1982, p. 183), the passage of a geophysical survey vessel near or through a concentration of whales may itself be disruptive, particularly at distances of less than 3 km.

Marler and Hamilton (1966, p. 642) defined habituation as "the process by which responsiveness to innocuous stimuli becomes temporarily or permanently eliminated". For ungulates, at least, there is ample evidence that the animals habituate to certain kinds of disturbance, particularly ones which are repetitive and predictable (e.g., l-licks and Elder, 1979; Miller and Gunn, 1980; Dorrance et al., 1975). Norris et al. (1978, p. 68) reported that oceanic dolphins repeatedly herded and "pursed" by tuna seiners seem to develop "adaptive" responses which are not displayed by naive dolphins outside the principal fishing grounds (also see Au and Perryman," 1982). It has been suggested that bowheads react, or at least react more obviously, to the "novel stimulus" created by the start-up of seismic pulses, then resume their pre-disturbance activity as they habituate to the sounds (Fraker et al., 1982, p. 224). Although we did not see whales leave an area rapidly or change their course abruptly in what could be interpreted as a response to seismic sounds, our data are not appropriate for addressing the question of whether bowheads do or do not habituate to seismic sounds.

Our qualitative observations and categorization of "huddling" behavior need to be interpreted with caution and are not to be construed as definite evidence that bowheads coalesce, or tighten group structure, in the presence or at the onset of loud seismic sounds. Our data are inconclusive in this respect. It is necessary to bear in mind that close approach by vessels has been seen to cause the opposite reaction in bowheads, i.e., an increase in inter-individual distance (Fraker et al., 1982). Nishiwaki (1962) described and illustrated an occasion in which the largest individual in a group of 20-30 sperm whales (Physeter macrocephalus) was shot from a modern whaling catcher boat. "The instant the biggest whale was hit all the individuals of the herd made a circle like a Marguerite flower centering around the biggest whale." The whales remained in this formation, with heads together and flukes slapping the surface, as one after another was shot. Nishiwaki likened this behavior to that of zebras which he claimed form a defensive circle and kick with their hind legs at attacking lions. Silverman (1979) described what she called "circle or semi-circle formation" by narwhals (Monodon monoceros); the whales "form a circle with heads' pointing towards the centre and heads elevated slightly above the surface." She did not correlate this behavior with disturbance but implied that it may be related in some way to aggressive "f rental or head on attacks" among adult males.

The "huddling" we observed did not appear to serve as display (the whales were not slapping the surface with their flippers or flukes), aggression (the whales were rafting, almost motionlessly or sexual behavior' (c.f. Everitt and Krogman, 1979). Possibly this close physical association served some social purpose in the presence of an unfamiliar noise. Observations reported by Ljungblad, Moore, and Van Schoik (in preparation a) indicate that bowheads also may have reacted to a low aircraft overpass by orienting head to head in close formation. It is, still speculative to regard huddling as a specific response to acoustic stimuli; it could also represent the surface segment of a synchronous dive sequence, possibly involving water-column or echelon feeding (see Würsig et al., 1982, for definitions), or a defensive reaction to unseen natural events such as the approach of predators. In further studies of bowhead behavior, it will be useful to note the circumstances under which huddling is observed and to obtain better quantitative data with which to evaluate its significance.

CONCLUSION

Most studies of responses of wild ungulates to human disturbance have focused on the monitoring of changes in overt behavior, movements, distribution home range and habitat use (e.g., Dorrance et al., 1975; Richens and Lavigne, 1978; Eckstein et al., 1979; Klein, 1974; Ferguson and Keith, 1982). Several efforts have also been made to monitor disturbance-related increases in activity and heart rate of wiid ungulates (Batcheler, 1968; MacArthur et al., 1979; also see Ames, 1978, for a study of acoustically caused changes in heart and respiration rates of domestic sheep). As pointed out by Ferguson and Keith (1982): "Although there seems to be a tacit assumption that such responses are detrimental to individuals and populations, they have rarely been linked to changes in reproduction, survival or any other demographic parameters." While it may be desirable to avoid causing discomfort or annoyance to the animals (primary effects), any reduction in their numerical abundance or physical condition, i.e., their biological fitness (secondary effects) (Norris and Reeves, eds., 1978; Janssen, 1978), would be, in our view, of more serious consequence.

Attempts have been made to define and measure stress levels in wild, oceanic dolphins which. are chased, captured, and released, often repeatedly, in the eastern tropical Pacific tuna fishery (Stuntz and Shay, 1979; Stuntz, 1980). However, there has been little success in documenting the mortality caused in this fishery by captive myopathy or the capture stress syndrome. The difficulty of studying free-ranging bowhead whales means that even baseline data on their demography and behavior are a challenge to collect and interpret. At present, the possibilities are remote for physiological monitoring of bowheads, whether under controlled, experimental conditions or in the wild, free-ranging state. Assuming that such characteristics as present population size and composition, recruitment rate, migratory behavior, and distribution can be determined with an acceptable level of precision, adequate long-term monitoring may permit detection of favorable or unfavorable trends in these. However, it may still be impossible to identify or isolate a specific cause or set of causes for such trends. Eskimo whaling, seismic survey operations, drilling noise, tanker traffic, industrial support activities, and oil spillage may, individually or cumulativel y, affect the bowhead population (Geraci and St. Aubin, 1980, 1982; USDI, 1982; and others).

Alarm or flight reactions, changes in respiration rate, or shifts in mode (e.g., from feeding to traveling, from resting to rapid swimming)--all short-term responses that can be assessed qualitatively and at times quantitatively—are not necessarily indicative of independent or related physiological effects that would lead to a reduction in population size or biological fitness. However, as pointed out by USDI (1982, p. xiv), given the present endangered status of bowheads, "it is possible that what may appear as [a] minor fluctuation in short-term norms may have long-term? significant implications to the welfare of the population." Conversely, the absence of these short-term, observable responses does not necessarily mean the whales are undisturbed or unaffected. Short-term behaviora! responses or lack of responses to seismic survey activity, such as have been reported by LGL (Richardson, cd., 1982) and by us in this paper, are interesting but, to date, inconclusive when judged as indicators of long-term impact. Studies of long-term causal relationships between noise or human activity and the status or health of most wildlife populations require great effort and considerable expense; in a practical sense, such problems may not be researchable in the foreseeable future.

Although our results suggest some changes in behavior related to seismic sounds, the possibility that unquantified factors could be correlative dictates caution in attempting to establish causative explanations from these preliminary findings. Since dive and surfacing characteristics may vary seasonally, geographically, and. annually, observed differences should, at present, be considered an indication of the need for additional studies and larger sample sizes, for specific comparisons. The biological significance of observed differences in behavior remains unknown.

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Table 1. Dive times and surface times of bowhead whales in the Alaskan Beaufort Sea, September - October 1981. DV = dive time; SF = surface time. Asterisk (*) refers to a cow accompanied by a calf.

Date	Whale no.	DV	SF	DV	SF	DV	SF	DV	SF	DV	SF	DV	SF	DV	SF	seismic sounds present yes/no
12 Sept	1	12:20	:43	5:20	1:50	5:00	1:55	9:25	2:50	9:30	2:00					
	2		:33													
	3		:39													
	4		1:30													yes
	5		1:30													
	6		1:34													
	7		3:30													
14 Sept	9*		2:12	14:18	1:15	11:40	2:35	16:05	2:00	11:40	3:15	12, 15	4, 45			
	10		1:40													yes
	11		2:50													
17 Sept	13		7:00													
	14		:50													
	15		5:20													yes
	16		3:40													
	17		:45													
	18		2:10													
20 Sept	19		2:20	14:30	2:30	14:10	3:20	19:00	2:30	18:40	2:10	17:30	1:50			
	20	7:45	2:20													
	21		3:30	10:00	3:00	14:57	2:00	11:22	3:00							
	22		2:20	9:10	3:00	33:20	1:05									no
	23		2:50													
	24		1:15													
	25		1:00													
	26		1:05													
22 Sept	27	10:28	1:19	11:40	3:39	14:00	2:27	9:19	1:40	11:37	2:42	8:40	2:21	10:18	2:01	no
28 Sept	28	15:00	1:43	13:36	1:54	32:15										no
	29	29:56	1:00	11:38												
	30		3:45													
29 Sept	31		1:30	26:10	2:20											
	32		:15	22:30	1:11											
	33	10:18														
	34		1:20													
	35		:55													no
	36		:25													
	37		:55													
	38		1:05													
	39		:20													
2 Ott	40		1:20	12:40	2:45	11:50	2:25	14:41	2:55	13:15	2:52					no
	41		1:25													
5 Ott	42	12:23	2:26	5:58	1:32	13:43	1:55									
	43		2:30	14:50	2:40											
	44	13:10	2:55	13:15	2:55											
	45	12:08														

Table 2. Summary statistics for the principal dive and surface times in all 1981 bowhead whales.

	surface time (min)			dive time (rein)		
	x	s.d.	n	x	s.d.	n
All whales 1981	2.13	1.20	84	13.9	6.14	47
all adults	2.11	1.21	77	14.0	6.47	42
all cows with calves	2.43	1.12	7'	13.2	.1.95	5
All whales in the presence of seismic sounds	2.41	1.68	27	10.8	3.55	10
all adults in the presence of seismic sounds	2.35	1.83	21	8.32	3.12	,5
all cows with calves in the presence of seismic sounds	2.62	1.10	6	13.2	1.95	5
All whales in the absence of seismic sounds	2.00	.87	57	14.7	6.44	37
all adults in the absence of seismic sounds	2.01	.87	56	14.7	6.44	37
all cows with calves in the absence of seismic sounds	1.33	-	1			

TABLE 3: Characteristics of seismic survey vessels working in the western Beaufort Sea during the period of 27 August -3 October 1982.

Vessel Name	Beam (ft)	Length (ft)	Type of Engines	Horsepower Rating	Screw	Type of Sound Device	Source Level of Device [1]	Maximum Speed of Vessel (kts)	Shooting Speed (kts)
Western Polaris	32	150	12V 149 Det. Diesel	1350	Twin	Airgun array	30 bar meters[2] = 250 dB	10	4.5
Arctic Star	30	100	16V71 Det. Diesel	980	Twin	Airgun array	20 bar meters[2] = 246 dB	9	4.5
Western Aleutian	32	150	12V 149 Det. Diesel	1350	Twin	Airgun array	30 bar meters[2] = 250 dB	10	4.5
Krystal Sea	40	135	Two Diesel Cats	850 each	Twin	Airgun array	1190 cu. in. of air or 22 bar meters[3] = 247 dB	11	3.5-4.5
Mariner	30	119	Two Diesel Cats 343	700 each	Twin	Airgun array	1410 cu. in of air or 24 bar meters[3] = 248 dB	7	4.7

1 - Sound pressure levels are converted from bar meters (i.e. bars at 1 m) to dB re 1 micropascal at 1 m.

2- Provided by Western Geophysical Co. Personnel in Deadhorse, September 1982.

3- Provided by Murray Roth, Geophysical Service Inc., telecon with Reeves, October 26, 1982.

DATE (month/day1982)

Vessel																																							
Arctic Star	position	Long. W		15330	15225	15327	15520	15608	15530	15245	15700	15200	15240	7108 15310	7100 15415	7100 15415	7115 15321	7104 15430	7115 15540	7115 15540	7102 15412	7100 15430	7110 15430	7108 15435	7110 15435	7110 15435	7110 15435	Chukchi Sea	7116 15528	7139 15436	7110 15515	7055 15303	7102 14917	north of West Dock	West Dock	West Dock			
	Active	x=yes o=no	x	x	x	x	x	x	x	x	x	x	x	o	o	o	o	o	o	o	x	x	x	x	o	o	o	o	x	x	o	o	o	o	o	o			
Western Aleutian	A.M. position	Lat. N Long. W	7102 15130	7115 15130	7045 15100	7110 15045	7100 14930	7100 15015	7115 14945	7045 15030	7107 15007	7115 15030	7100 15015	7110 14915	7120 15303	7120 15320	7137 15355	7130 15305	7115 15300	7105 15330	7110 15400	7108 15330	7030 14830	7052 14800	7105 14908	7105 14908	7103 14920	7053 14647	7103 14745	7057 14825	7035 14500	7050 14450	7052 14407	Barter Island	7030 14400	7030 14500	7030 14445	7030 14500	West Dock
	Active	x=yes o=no	x	x	x	x	x	x	x	x	x	x	x	x	x	o	x	x	x	x	x	x	x	x	o	o	o	o	x	o	x	x	x	o	x	x	x	o	o
Western Polaris	A.M. position	Lat. N Long. W																						7145 15605	7134 15424	7134 15424	Chukchi Sea	Chukchi Sea	7116 15350	7120 15230	7120 15150	7122 15543	Chukchi Sea	Chukchi Sea	Chukchi Sea	Chukchi Sea	Chukchi Sea	Chukchi Sea	West Dock
	Active	x=yes o=no																						x	o	o	o	o	x	x	x	x	x	o	o	x	x	o	o
Krystal Sea	A.M. position	Lat. N Long. W	7119 15540	7124 15618	7120 15617	7118 15615	7122 15621	Martin and Cooper	7122 15612	7115 15510	7106 15422	7100 15404	Elson Lagoon	7106 15255	7108 15244	Simp Lagoon	Point Barrow	7122 15605	Point Barrow	7122 15650	7110 15721	Chukchi Sea	Chukchi Sea	Chukchi Sea	Chukchi Sea	Chukchi Sea	Chukchi Sea	Point Barrow	Point Barrow	Point Barrow	7100 15333	7106 15346	7006 15402	Harrison Bay	West Dock	West Dock	West Dock	West Dock	West Dock
	Active	x=yes o=no	x	x	x	x	x	x	x	x	x	o	x	x	x	o	o	x	x	x	x	x	x	x	x	o	o	o	o	x	x	x	o			o	o	o	o
GSI Mariner	A.M. position	Lat. N Long. W																		7020 14400	7020 14439	7020 14826	7044 14708	West Dock	West Dock	West Dock	West Dock	West Dock	7047 14512	Hersch Island	Hersch Island	7037 14251	7041 14221	7033 14243	7040 14420	7033 14322	7018 14312	7034 14149	Canada
	Active	x=yes o=no																		x	x	x	x	o	o	o	o	o	x	o	o	x	x	x	x	x	o	x	o

Table 4. Morning position and daily operational status of seismic survey vessels in the Alaskan Beaufort Sea, August 28 - October 3, 1982. Source: personal communications from geophysical research companies - Western Geophysical Company of America and Geophysical Service, Inc. (Note: the two right-most digits of the position are minutes; the left-most two or three digits are degrees). West Dock is at Deadhorse, Prudhoe Bay.

TABLE 5: Dates of reported first and last strike or capture of bowhead whales, by year, at Kaktovik, Barter Island, Alaska.

Year	Dates	Reference
1974	10 September - "before" 24 September	Fiscus and Marquette, 1975
1975	None taken	Marquette, 1976
1976	20 September -27 September	Marquette, 1976
1977	29 September -2 October	Marquette, 1979
1978	15 September -26 September	Braham et al., 1980
1979	20 September - 11 October	Johnson et al., 1981
1980	14 September -4 October	Marquette et al., 1982
1981	8 September -22 September	Dronenburg et al., 1982
1982	15 September -23 September	D. Stewart, pers. comm.

TABLE 6: Characteristics of a selected sample of seismic sounds recorded in the Alaskan Beaufort Sea in 1982.[1]

Date	Flight #	Seismic Source	Distance from sonobuoy	Peak Frequency (Range)	Peak Frequency (mean)
Sept 3	4	Western Aleutian	29 km	172-310 Hz	243 Hz
Sept 8	8	Western Aleutian	18 km	127-137 Hz	136 Hz
Sept 14	11	GSI Mariner	33 km	145-210 Hz	169 Hz
Sept 15	14	GSI Mariner	18 km	192-265 Hz	226 Hz
Sept 23	21	GSI Mariner	33 km	160-207 Hz	182 Hz
Sept 28	27	GSI Mariner	18 km	175-287 Hz	210 Hz
Sept 7	7	Arctic Star	33 km	255-475 Hz	320 Hz
Sept 24	23	Western Polaris	18 km	140-160 Hz	151 Hz

[1]Seismic source positions determined by VHF radio confirmation and indicate probable source of geophysical sounds.

TABLE 7: Summary of policy decisions concerning restriction of seismic survey operations in the Alaskan Beauf ort Sea, August - October 1982. Source: Shearer (1982).

Date	Nature of Action	Area Affected
Aug. 7, 1982	Shutdown - all operations.	All U.S. waters east of Barter Island.
Sept. 9, 1982	Lifting of August 7 shutdown	All U.S. waters east of Barter Island except -
	Shutdown of August 7 remained in force	All waters south of 70 °30'N between 143°W and 144°W; all waters south of 7 1°10'N and east of 143°W.
Sept. 13, 1982	Shutdown - all operations.	All waters south of 70°30'N and east of 143°W.
Sept. 15, 1982	Shutdown - all operations.	All waters south of 70°30'N between 141°W and 145°W.
Sept. 17, 1982	Shutdown - all operations.	AH waters south of 71010’N between 149°W and 150°W; south of 7 1°N between 148°W and 149°W; south of 70°50'N between 147°W and 148°W; south of 70°40'N between 146°W and 147°W; and south of 70°30'N between 141°W and 146°W.
Sept. 20, 1982	Shutdown - all operations.	All waters south of 71010’N and east of 152°W (in addition to the September 17 closures).
Sept. 25, 1982 (by Sept. 27 letter from NMFS)	Shutdown - all operations.	All waters south of 7 1°45'N between 152°W and 157°W; south of 71°30’N between 150°W and 152°W; south of 71010’N between 148°W and 150°W; south of 7 1°N between 146°W and 148°W; south of 70°45'N between 145°W and 146°W; south of 70°30'N between 141°W and 145°W.

Table 8. Summary statistics, by day, for the principal surfacing, respiration, and dive variables of bowheads in the presence and absence of seismic sounds. Data are presented only for those days in which the same "group" of whales was observed under both conditions (seismic and nonseismic) and the data includes all classes of whales, including "adults", cows and calves.

	Mean blow interval (see)			Number of blows per surfacing			Surface time per surfacing, (rein)			Dive time (rein)		
	x	sod.	n	X	s.d.	n	x	s.d.	n	x	s.d.	n
September 15 seismic	12.10	2.75	8	5.75	1.89	4	1.20	.41	5	-	-	-
September 15 nonseismic	11.03	2.36	18	7.36	2.95	14	1.33	.57	15	4.48	.74	3
September 24 seismic	13.09	3.51	15	11.20	4.02	10	2.45	.90	13	-		
September 24 nonseismic	12.94	2.92	12	"7.00	3.97	9	1.49"	.77	9	-		-
September 25 seismic	11.58	2.36	26	8.10	1.92	21	1.55	.47	23	13.72	5.20	7
September 25 nonseismic	12.00	3.09	8	9.00	1..69	8	1.95	.85	8	10.12	4.73	8

Table 9. Summary statistics for the principal surfacing, respiration, and dive variables in 1982 bowheads.

	Mean blow interval per surfacing (sec)			Number of blows per surfacing			Surface time per surfacing (min)			Dive time (min)		
	x	s.d.	n	x	s.d.	n	x	s.d.	n	x	s.d.	n
All adults[1]	13.22	3.79	113	7.18	3.33	80	1.56	.78	90	7.09	4.14	20
interacting[2]	12.01	2.83	31	7.33	4.09	21	1.58	.97	26	7.79	3.73	4
noninteraciting[3]	13.67	4.02	82	7.12	3.05	59	1.56	.69	64	6.92	4.33	16
shallow[4]	13.11	3.78	53	6.57	2.72	42	1.33	.67	42	6.83	4.07	19
deep[5]	13.31	3.83	60	7.84	3.82	38	1.77	.81	48	-		1
seismic[6]	13.60	4.16	72	7.36	3.46	50	1.67	.85	59	7.57	4.55	14
nonseismic[7]	12.54	2.97	41	6.87	3.14	30	1.36	.59	31	5.98	3.02	6
All cows with calves	14.11	5.92	20	8.41	1.18	17	1.8[illegible]	.51	18	12.11	4.99	16
interacting	15.23	6.50	15	8.62	1.12	13	2.00	.50	14	10.88	5.41	9
noninteracting	10.74	[illegible]23	5	7.75	1.26	4	1.41	.22	4	13.68	4.25	7
shallow	14.11	5.92	20	8.41	1.18	17	1.87	.51	18	12.04	5.16	15
deep					-	-						1
seismic	14.38	6.67	15	8.33	1.37	12	1.91	.58	13	13.65	4.87	9
nonseismic	11.78	1.37	5	9.60	.55	5	1.75	.29	5	10.12	4.73	7
All calves	12.42	5.43	28	8.36	2.63	22	1.71	.86	26	-		
interacting	12.76	5.89	13	8.33	3.20	12	1.72	.95	13	-		
noninteracting	12.13	5.19	15	8.40	1.90	10	1.69	.81	13	-		
shallow	11.96	4.93	27	8.36	2.6[illegible]	22	1.71	.86	26	-		
deep			1	-	-	-	-	-	-	-		
seismic	11.90	4.39	24	8.16	2.61	19	1.63	.78	23	-		
nonseismic	15.53	7.7[illegible]	4	9.67	2.89	3	2.28	1.45	3	-		

[1] excluding cows with calves

[2] interacting = within 15 m of another whale, while both are at surface

[3] noninteracting = not within 15 m of another whale, while both are at surface

[4] shallow = in depths of 27.45 m (15 fathoms) or less

[5] deep = in depths of greater than 27.45 m (15 fathoms)

[6] seismic = in presence of seismic sounds

[7] nonseismic = in absence of seismic sounds

Table 10. Variables showing significant differences using parametric (Student's t) and nonparametric (Wilcoxon T or Mann-Whitney U) two-sample statistical tests. Data from Table 7.

	X	x̄	s.d.	n	Y	x̄	s.d.	n	Parametric Result t	Parametric Result df	Parametric Result p	Nonparametric Results Z	Nonparametric Results p
Mean Blow Interval per Surfacing	All interacting adults (within 15 m of another adult)	12.01 sec	2.83	31	All noninteracting adults (not within 15 m of another adult)	13.67 sec	4.02	82	2.464	112	P < .02	-2.10	P < .036
	All interacting cows with calves (within 15 m of another whale.)	15.23 sec	6.50	15	All noninteracting cows with calves (not within 15 m of another whale)	10.74 sec	.23	5	2.672	19	P < .02	-2.53	P < .011
Blows per Surfacing	All adults	7.18	3.33	80	All cows with calves	8.41	1.18	17	2.638	96	P < .01	2.48	P < .013
	All adults in the absence of seismic sounds	6.87	3.14	30	All cows with calves in the absence of seismic sounds	8.60	.55	5	2.782	34	P < .01	1.51	P < .131
Surface Time	All adults in the presence of seismic sounds	1.67 min	.85	59	All adults in the absence of seismic sounds	1.36 min	.59	31	1.988	89	P < .05	-1.51	P < .131
	All adults in deep water	1.77 min	.81	48	All adults in shallow water	1.33 min	.67	42	2.867	89	P < .01	-2.65	P < .008
	All adults	1.56, min	.78	90	All cows with calves	1.'87 min	.51	18	2.077	107	P < .05	2.14	P < .032
	All cows with calves in the absence of seismic sounds	1.75 min	.29	5	All adults in the absence of seismic sounds	1.36 min	.59	"31	2.282	35	P < .05	1.74	P < .082
	All interacting cows with calves (within 1.5 m of another whale)	2.00 min	.50	14	All noninteracting cows with calves (not within 15 m of another whale)	1.41 min	.22	4	3.369	17	P < .01	-2.34	P < .019
Dive Time	All adults	7.09 min	4.14	20	All cows with calves	12,11 min	4.99	16	3.228	35	P < .005	2.96	P < .003
	All adults in the presence of seismic sounds	7.57 min	4.55	20	All cows with calves in the presence of seismic sounds	13.65 min	4.87	16	2.998	22	P < .01	2.58	p< .010

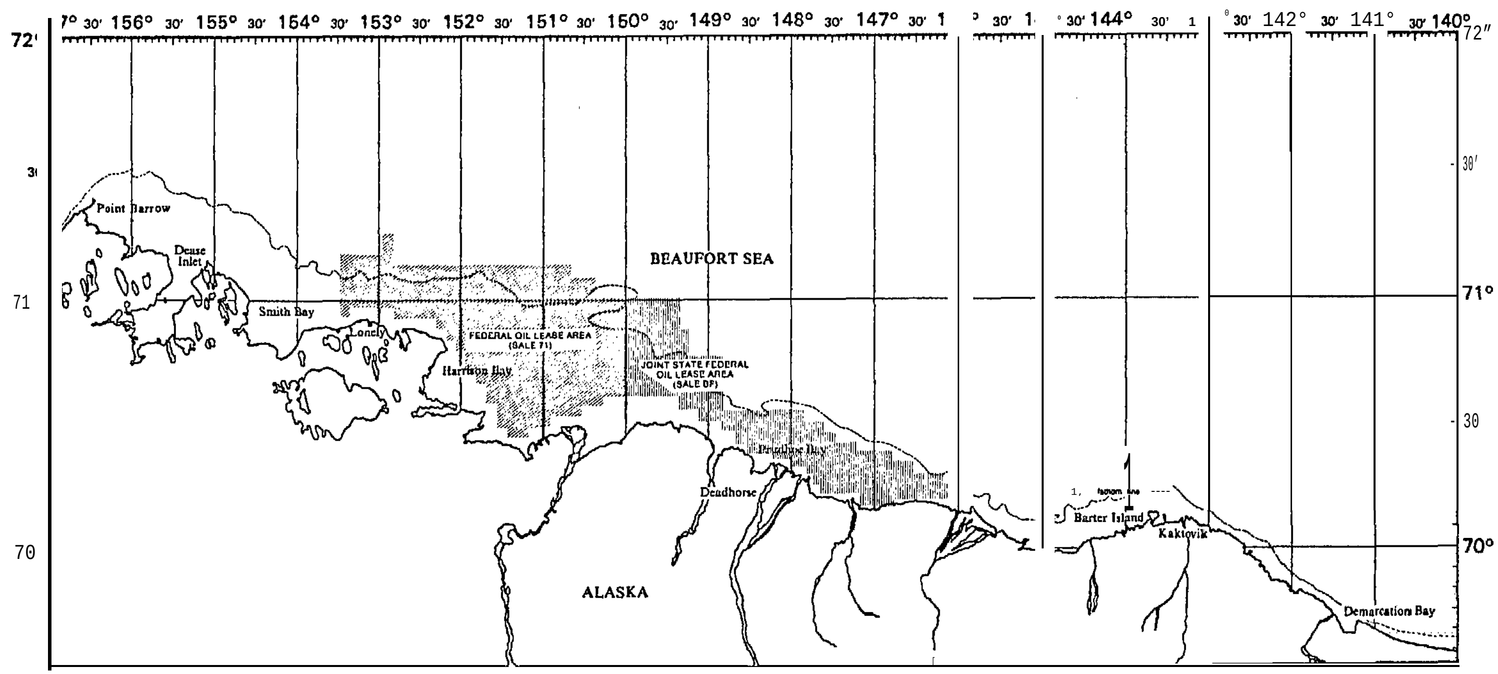


Figure 1. Study area in the Alaskan Beaufort Sea.

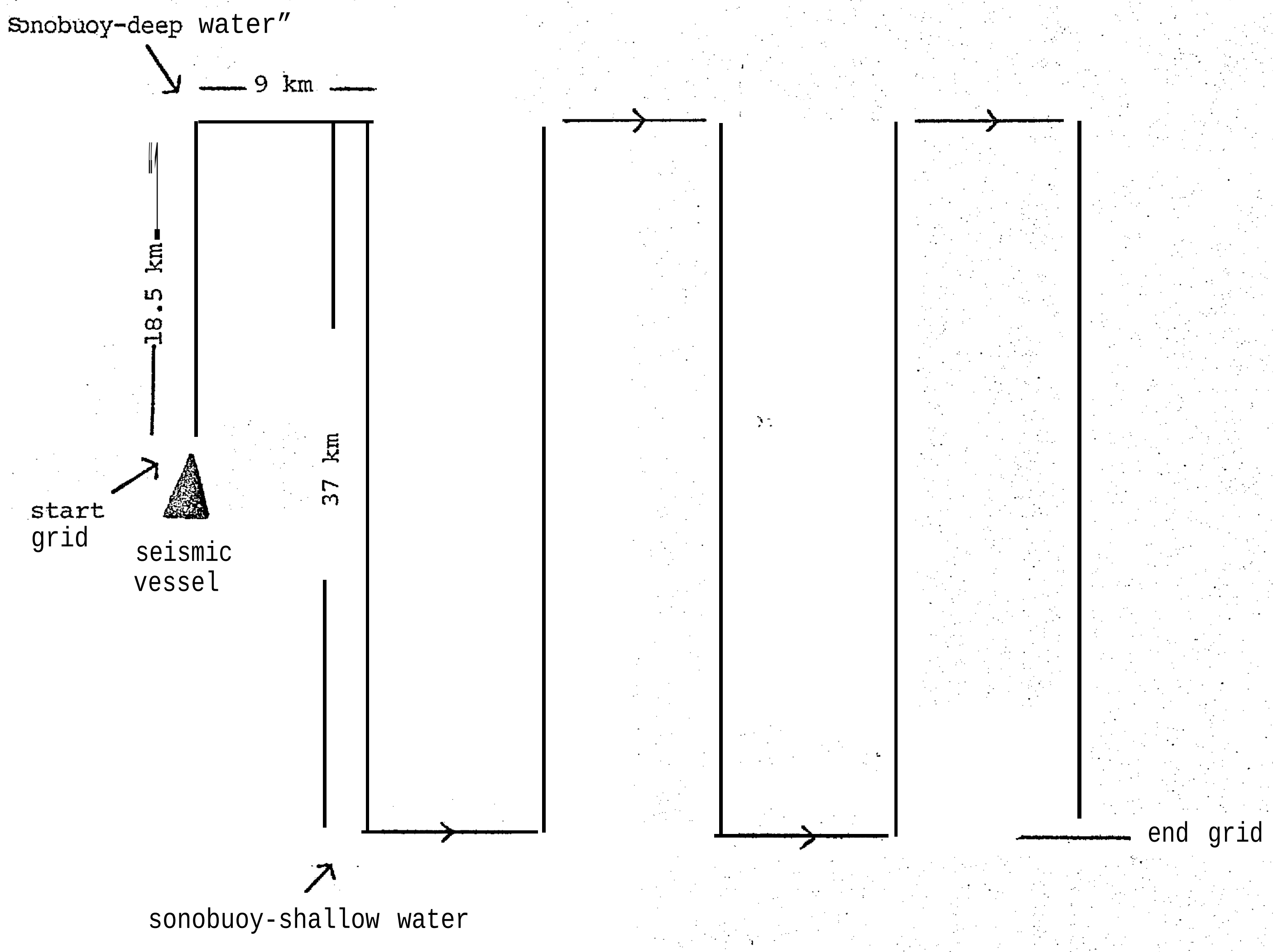


Figure 2. Idealized grid survey pattern for seismic survey vessel monitoring program.

Figure 3. A group of 12-14 bowhead whales at 70°11'N, 144°37’10, in the Alaskan Beaufort Sea, September 14, 1982.

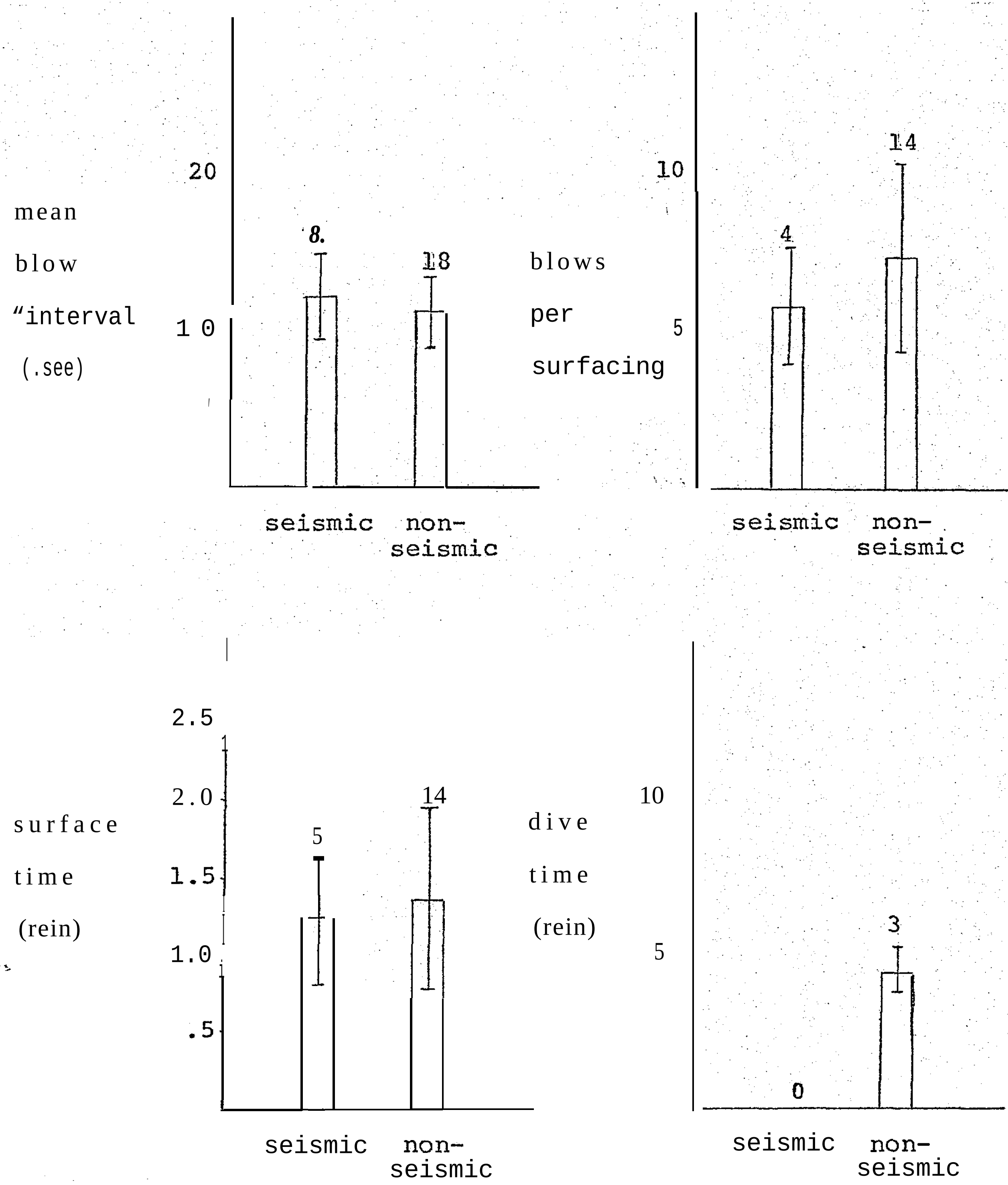


Figure 4. Summary of the principal surfacing, respiration, and dive characteristics for all classes of bowhead whales, including "adults", cows, and calves, 15 September 1982. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size.

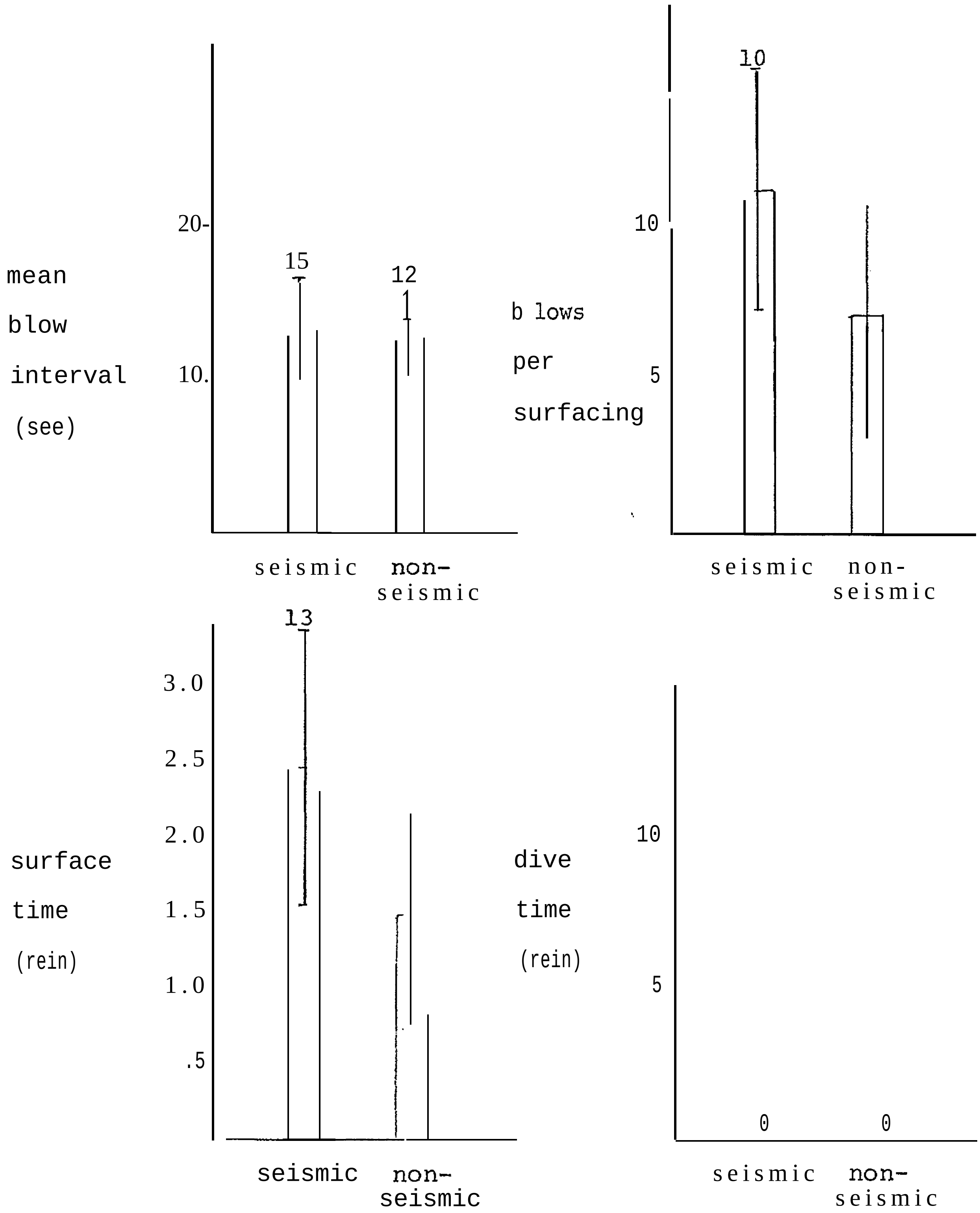


Figure 5 . Summary of the principal surfacing, respiration, and dive characteristics for all classes of bowhead whales, including "adults", cows, and' calves, 24 September 1982. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size.

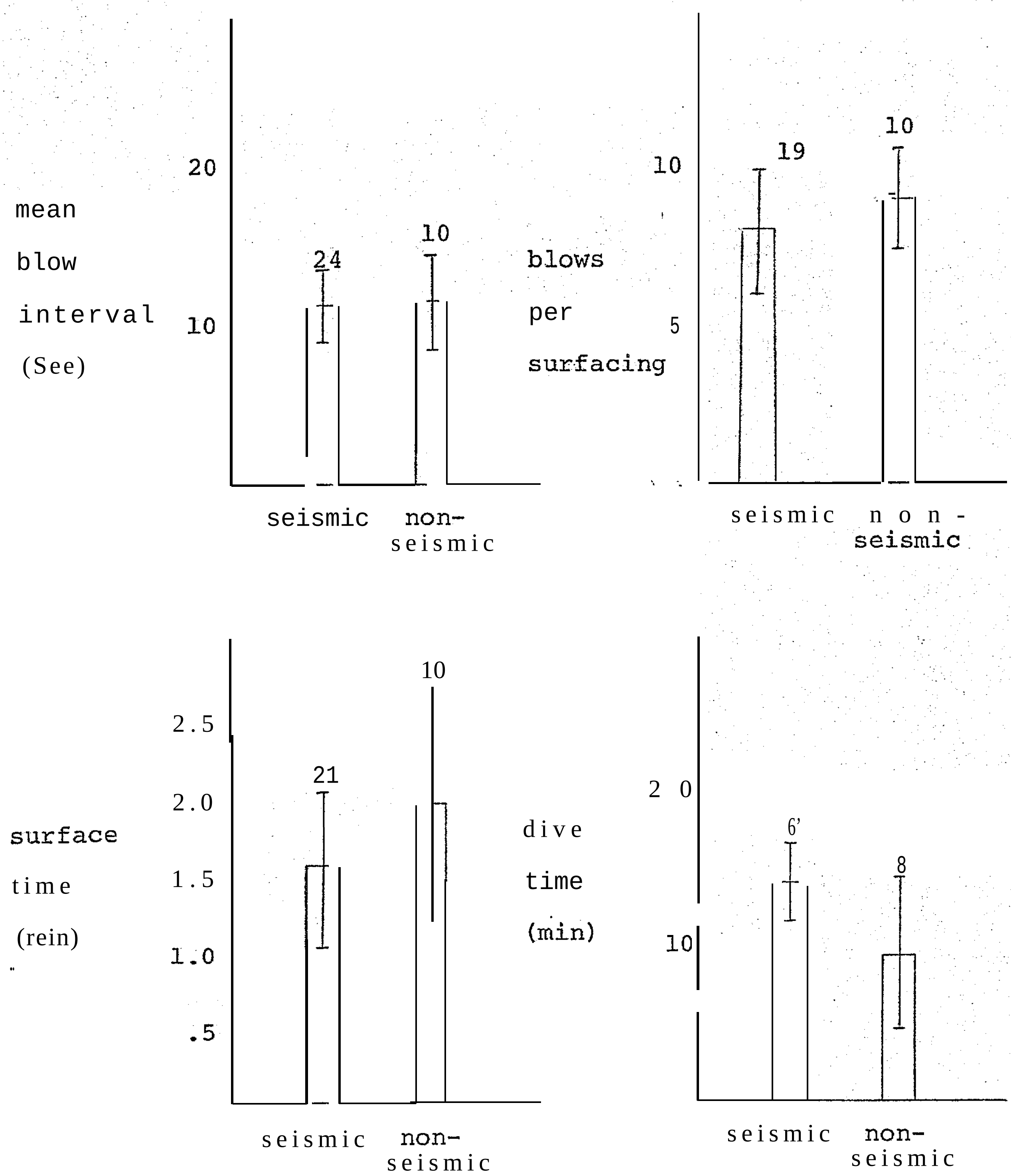


Figure 6. Summary of the principal surfacing, respiration, and dive characteristics for all classes of bowhead whales, including "adults", cows, and calves, 25 September 1982. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size.

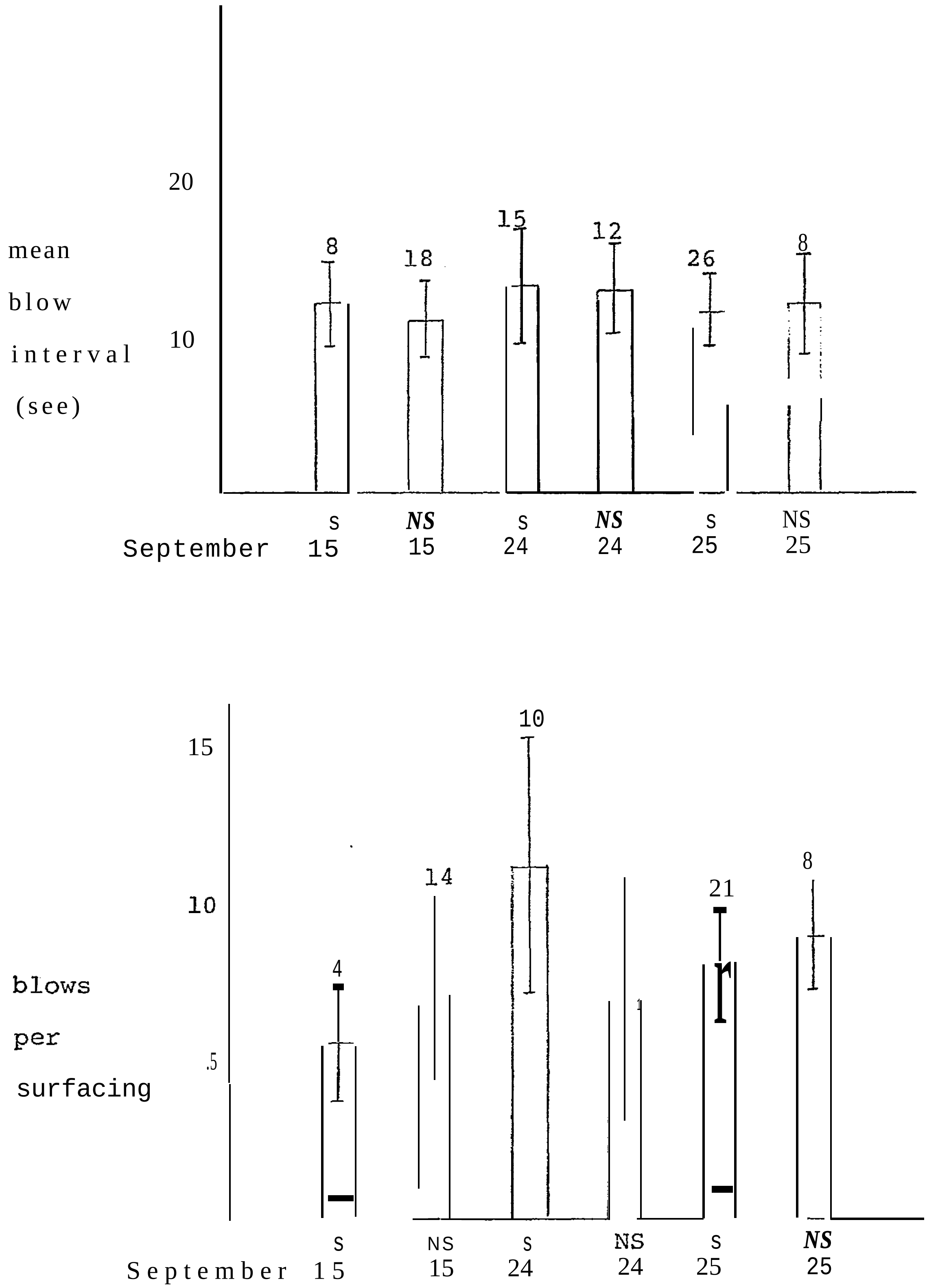


Figure 7. Mean blow interval per surfacing and mean blows per surfacing for whales observed 15, 24, and 25 September 1982. Data are for all classes of whales, including "adults", cows, and calves. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size. S = seismic; NS = nonseismic.

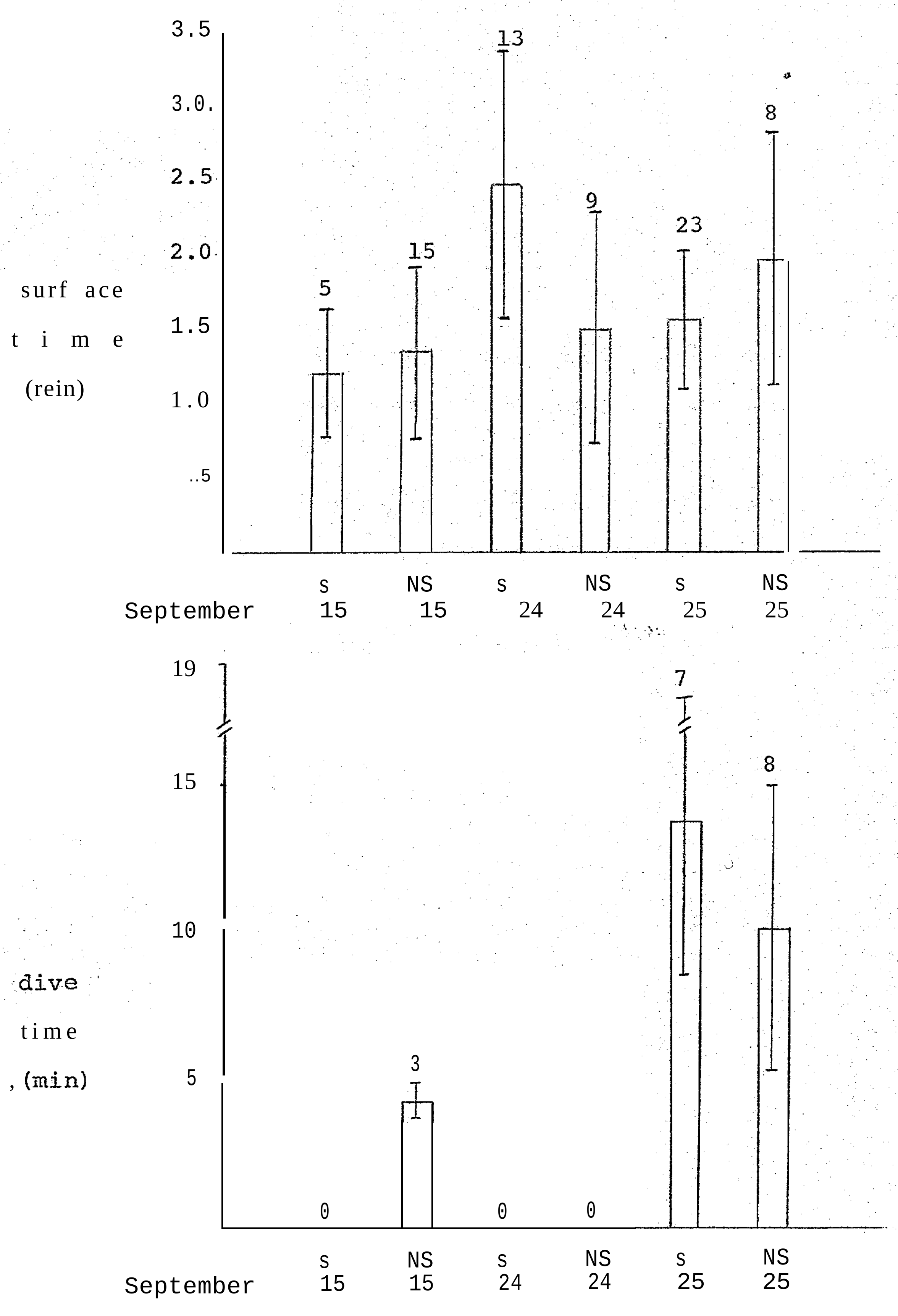


Figure 8. Mean surface and dive times for whales observed 15, 24, and 25 September 1982. Data are for all classes of whales, including "adults" , cows, and calves. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size. S = seismic; NS = nonseismic.

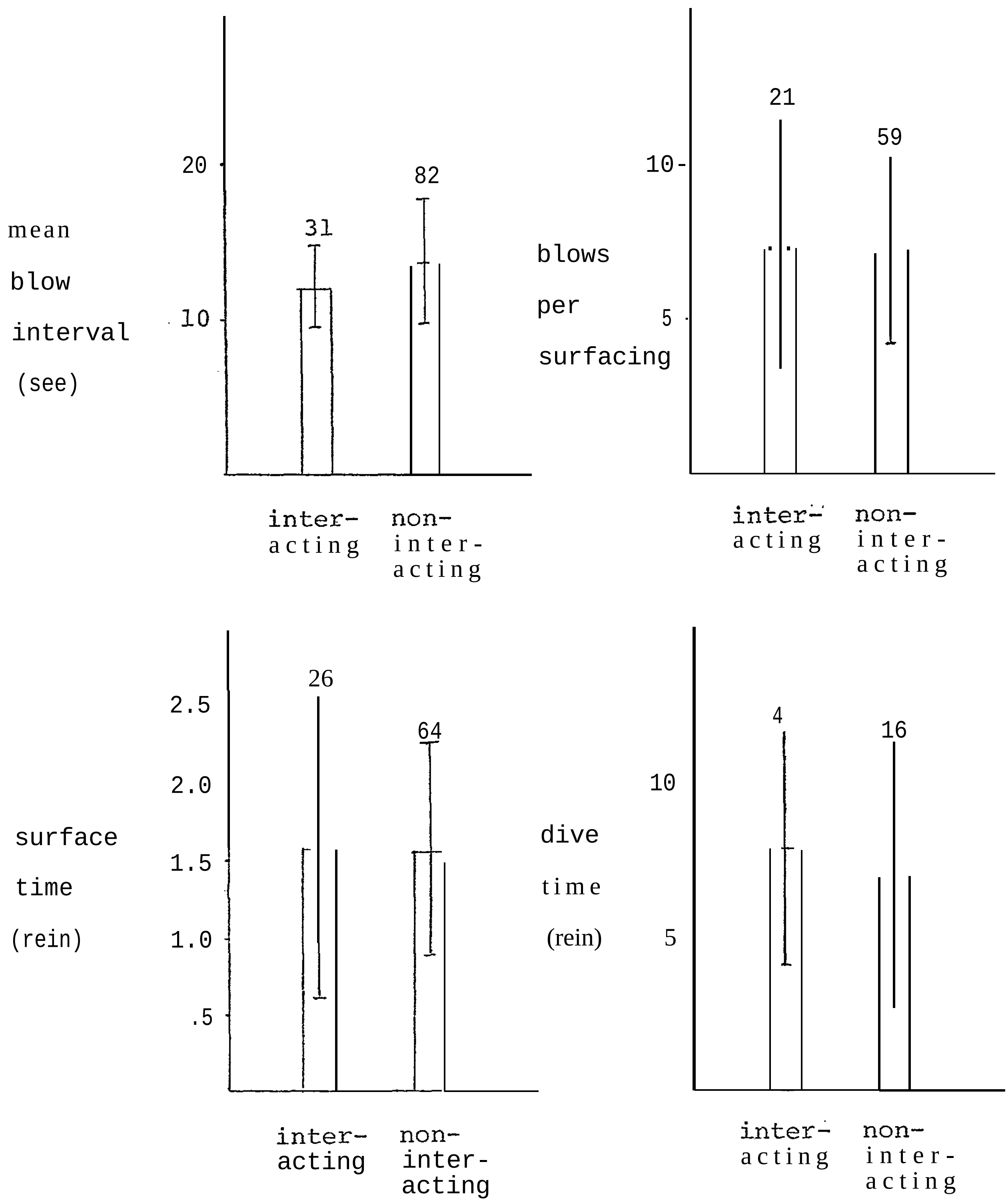
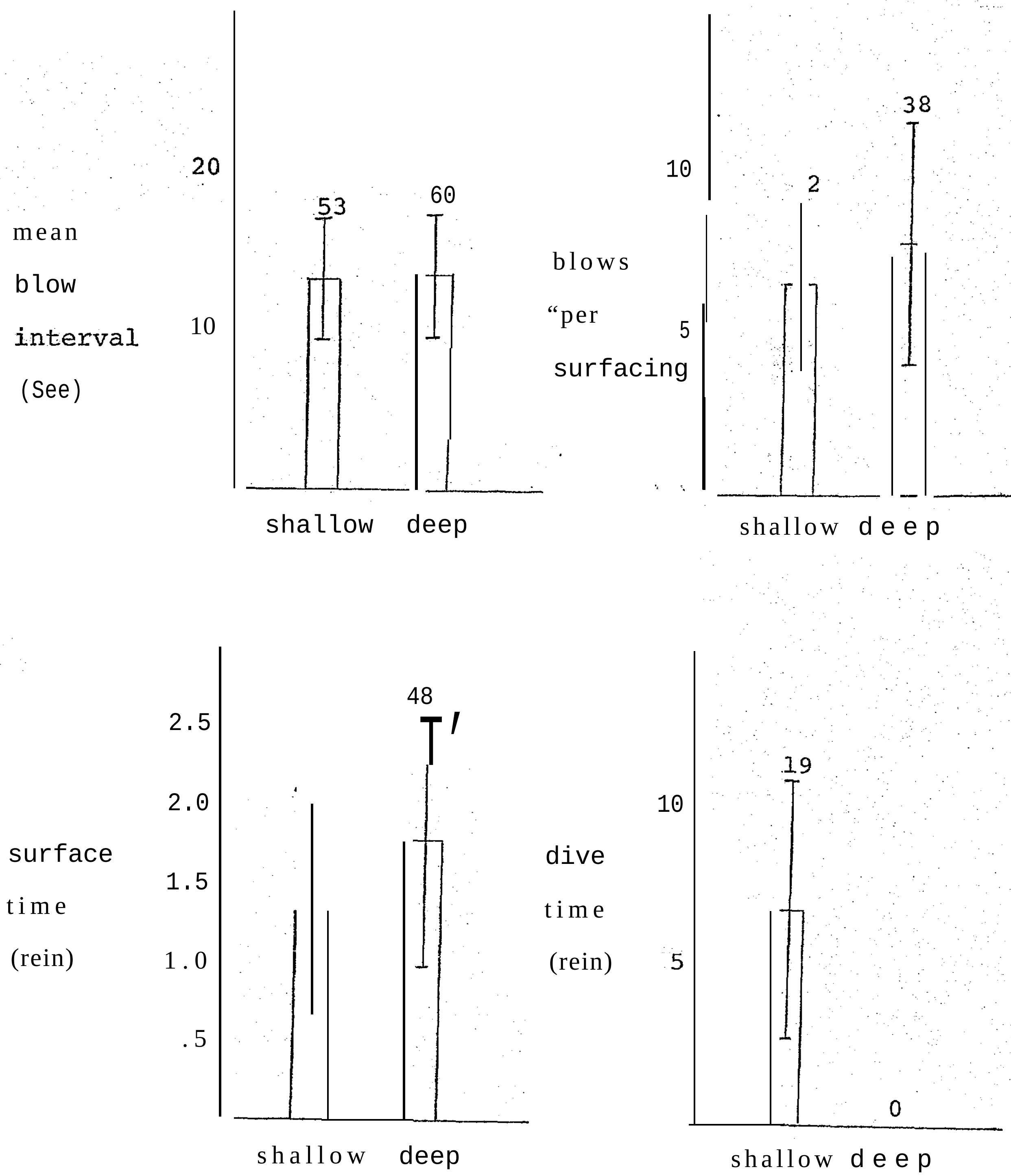


Figure 9. Summary of the principal surfacing, respiration, and dive characteristics of all 1982 bowhead whales classified as “adults”, under “interacting” and "noninteracting" conditions. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size.



FigureIO. Summary of the principal surfacing, respiration -and dive characteristics of all 1982 bowhead whales classified as ‘[adults”, under “shallow” and “deep”. conditions. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size.

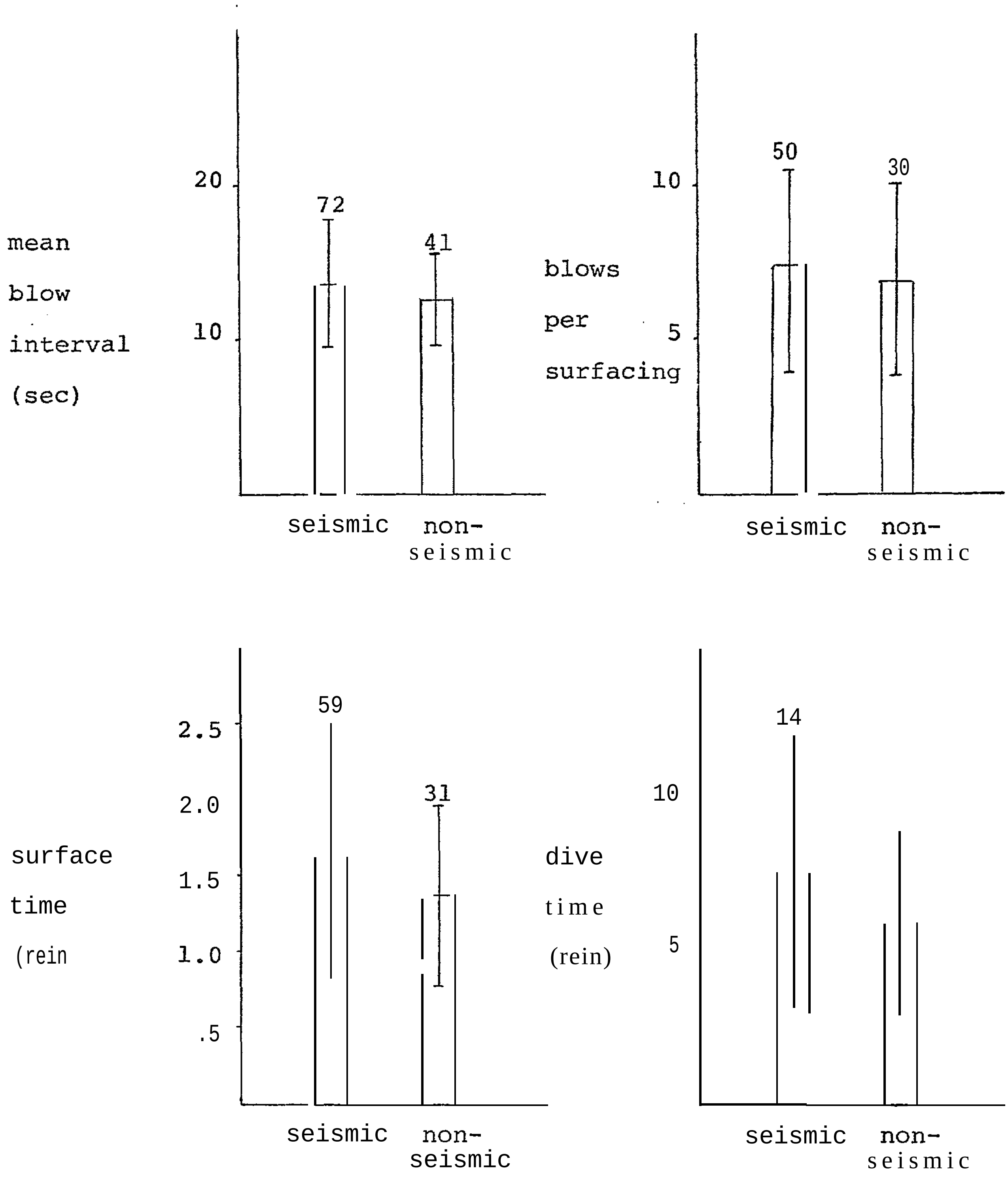


Figure 11. Summary of the principal surfacing, respiration, and dive characteristics of all 1982 bowhead whales classified as "adults", under "seismic" and "nonseismic" conditions. The vertical line in each column represents one standard deviation on either side of the mean-and the number is the sample size.

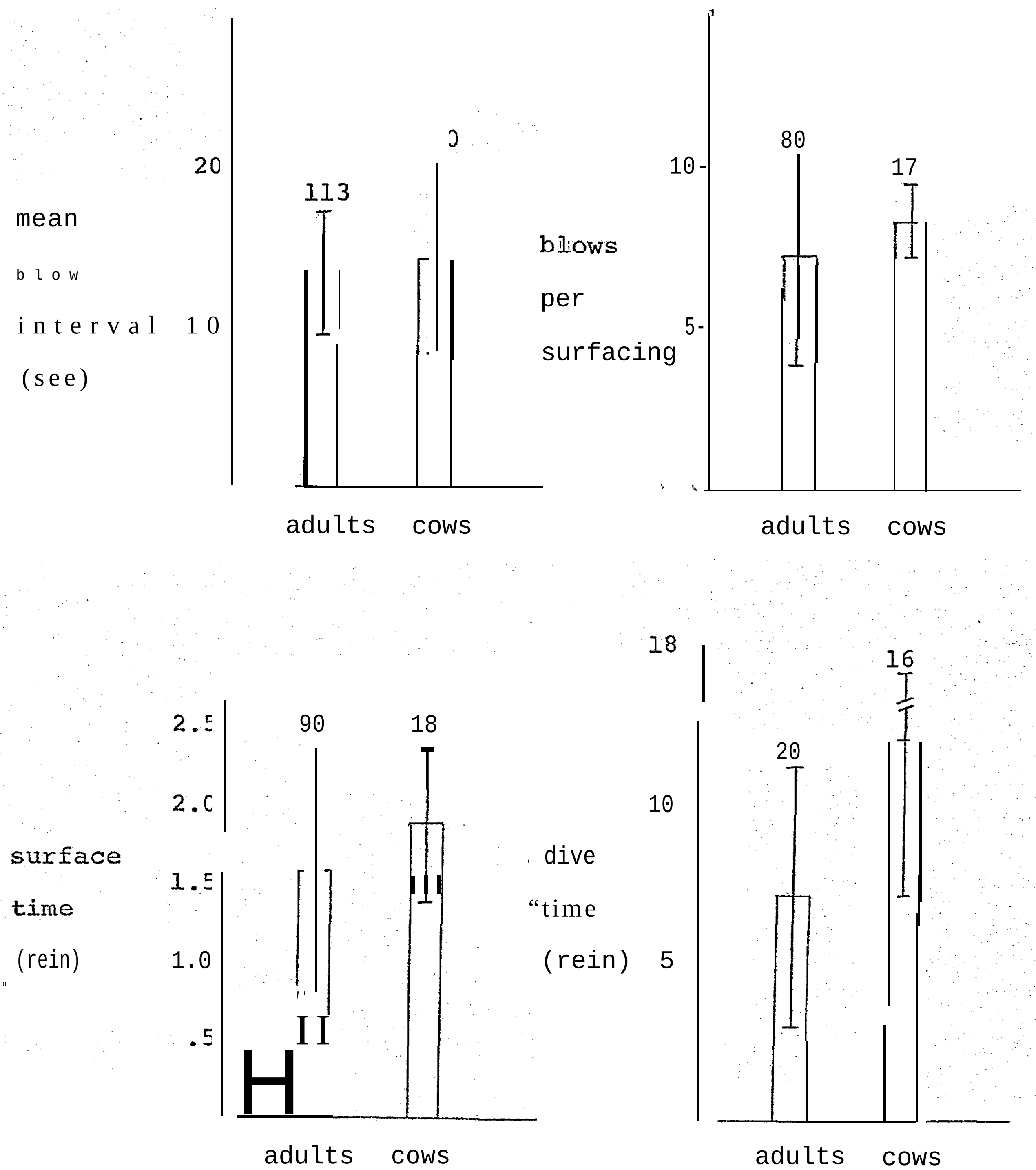


Figure 12. Summary of the principal surfacing, respiration, and dive characteristics of all 1982 bowheads whales classified as "adults" and as cows accompanied by calves. The vertical line in each column represents one standard deviation on either side of the mean and the number is the sample size.

APPENDIX I

Use of Sonobuoys in Recording High-Intensity Underwater Sounds

Sonobuoys have become sophisticated underwater listening and sound detection systems. During their development, the main objective has consistently been to achieve an ultimate degree of sensitivity y, i e., a capability to detect very low-level sounds at great distances. Unfortunately, we have found that, in attempting to monitor high-energy seismic sounds at relatively close range, sound pressure levels frequently exceed the capabilities of presently available sonobuoys, resulting in amplitude distortion and system overloading.

This appendix describes attempts to use two types of sonobuoy - AN/.SSQ-41 B and AN/SSQ-57A (see Table A-1) - to monitor seismic sounds under field conditions. The methods used to determine maximum sound pressure levels to which these sonobuoy systems can be exposed before amplitude distortion and overloading begin to occur are also described.

Initial Calibration prior to Field Use

An entire sound receiving system, including a modified USQ-42 VHF sonobuoy receiver, a Nagra IV-SJ tape recorder, and a sonobuoy, was calibrated as a system at the Naval Ocean Systems Center (NOSC) Transducer Calibration Facility. The 41 B sonobuoy was selected as the test unit. It was placed in a test tank in line with a 3-9 projector (frequency response of 10 Hz to 10 kHz) at a separation distance known to place it outside the near field effects. A swept (1 O Hz to 10 kHz) signal was projected at the sonobuoy hydrophore to establish the frequency sensitivity response curve of the system. A known sound pressure level, of a continuous wave (CW) frequency, was then projected at the sonobuoy while the Nagra peak meter was observed in order to establish a sound pressure level reference. By compensating for changes in Nagra gain settings, differences in sonobuoy, gain, and system frequency responses, it was thought that realistic measured received levels could be determined.

Data Acquisition and Analysis

Attempts were made to record seismic and biological sounds in the field on 53 occasions during the monitoring and behavioral studies in fall 1982 (see text and Appendix II). Of the sonobuoys deployed, 5396 were 57A, 29% were 41 B, and 18% were

41A. The last of these (41A) provides automatic gain control which adjusts for increased signal levels. The recordings made with 57A and 41 B sonobuoys were played back in the laboratory to measure frequencies and received levels of seismic and biological sounds. Appropriate gain corrections were made to establish what were assumed to be actual received levels.

During spectral analysis,, there appeared to be some degree of amplitude distortion on most seismic recordings. This amplitude distortion ranged from barely discernible to total clipping. Greene (1982) noted this same situation. The exact cause of the distortion was uncertain, so it was decided to return *to* the Transducer Calibration Facility to recalibrate the recording system in an effort to isolate the problem.

Recalibration after Field Use

Because most of the sonobuoys used in the field were 57A, this unit was selected for testing. The calibration procedures were tine same as those used 'in the initial pre-field calibration, with the 57A sonobuoy set at 0 dB of gain.

The resulting frequency response curve agreed with that" established previously for the 41B sonobuoy, except for a positive 10 dB cliff erence due to the differing sensitivities between the two units.

After verifying the frequency response curve of the system, fixed CW f requencies from 100 Hz to 1 kHz were projected, in 100 Hz increments, at the 57A . hydrophore. Results were erratic but inconsistent in comparison to the earlier tests using the 41E3 sonobuoy. Consequently, a number of further tests, using both 4 1B and 57A sonobuoys, were undertaken.

These additional tests were conducted in a tank with a diameter. of 4 m and a depth of 1.5 m. A sound source, provided by SEACO, Inc., was used to project CW tones of, 600 Hz and 1 kHz, with a sound pressure level at 1 meter of 130 dB re 1 micropascal. The 57A unit, set at -20 dB of attenuation, was tested by placing the hydrophore 1 m from the sound source and noting the reference level indicated on the Nagra peak meter. The hydrophore was then moved to a distance of 2 m from the source, and the reference level was observed to drop by 6 dB. At 3 m, it dropped an additional 4 dB. Thus, the reduction in the received level was found to be in accordance with "the inverse square law" for spreading loss. The attenuation setting of the 57A unit was changed to O dB, and amplitude distortion occurred at the 1, 2, and 3 m distances afforded by the small tank.

When the 57A sonobuoy was replaced with the 41 B unit, amplitude distortion occurred at 1 meter. Beyond 2 m, received levels agreed with those indicated for 57A once gain corrections were made to account for the 10 dB difference in sensitivity between the two units.

These tests demonstrated that the 57A sonobuoy, at a -20 dB attenuation setting, is capable of receiving sound pressure levels of 130 dB re 1 micropascal at 1 m, at a frequency of 1 kHz. When a 57A sonobuoy is set at O dB of attenuation, sound pressure levels in excess of 110 dB will cause amplitude distortion, non-linearity, and erroneous estimates of received level. The 4 1B sonobuoy cannot be used to monitor levels greater than 119 dB re 1 micropascal at 1 m.

Both sonobuoys were tested subsequently in San Diego Bay. Ambient noise and marine traffic caused continuous amplitude distortion with the 57A sonobuoy set at O dB of attenuation. The 41B sonobuoy, although 10 dB less sensitive than the unattenuated 57A, also was overloaded by signal levels in the bay.

Laboratory Bench-Tests

A series of tests was performed in the laboratory to determine the maximum received levels to which 41B and 57A sonobuoys can be exposed before amplitude distortion and nonlinearity occur. During these tests, the following factors were considered:

1. Hydrophore sensitivity (dBv re 1 micropascal) versus frequency.
2. System gain (41B and 57A sonobuoys, receiver, and recorder), frequency response, and dynamic range.
3. Differences in hydrophore sensitivities (minus 88 and/or minus 98 dB re 1 micropascal units are presently used).
4. Overall gain capabilities of the 41B and 57A units, either fixed or adjustable by -20 dB.
5. Increasing gain of the sonobuoy as the frequency is increased.
6. The pressure levels at which amplitude distortion or saturation occurs, for both 41B and 57A sonobuoys.

Frequency sensitivity tests of 57A and 41B sonobuoys were performed by injecting a series of fixed CW frequencies, of a known low-level amplitude, into the sonobuoy preamplifier, while observing the receiver and Nagra outputs. Input levels were then increased at each frequency (i.e.., 1 kHz, 800 Hz, 600 Hz, 400 Hz, 200 Hz, and 50 Hz) until amplitude distortion was observed at the output of the receiver. By example, the relative frequency responses and sensitivity of the 57A system at 200 Hz with full gain setting (O dB) were sensitive to input levels below 30 microvolts (minus 90 dBv). The 57A system began to distort at input levels exceeding 600 microvolt (minus 64 dBv). The 200 Hz minimum and maximum sensitivities represent sound pressure levels of 98 dB and 124 dB, respectively, measured in decibels (dB) with respect to a micropascal at 1 m. (Note: The sonobuoy transducer tested has a response of minus 188 dB re 1 micropascal.)

Similar tests were conducted with the 41B system., Based on these tests, the results shown in Figure A-1 represent the maximum received sound pressure levels referenced to dB re 1 micropascal at 1 m, over a frequency range of 50 Hz to 1 kHz, that can be measured using 41B and 57A sonobuoys at different gain settings.

Conclusions

After extensive tests of the 41B and 57A sonobuoys, it is apparent that the pre-field calibrations were just below or at the level which will cause amplitude distortion to occur, resulting in nonlinearity of the received recorded levels. High sound pressure levels cannot be recorded accurately using unmodified 41B and 57A sonobuoys. Of the two systems, the 57A is the more desirable. When set at -20 dB of attenuation, it can record and measure received sound pressure levels at or below 130 dB re 1 micropascal at 1 m at 1 kHz to 156 dB re 1 micropascal at 1 m at 50 Hz (see Figure A-i).

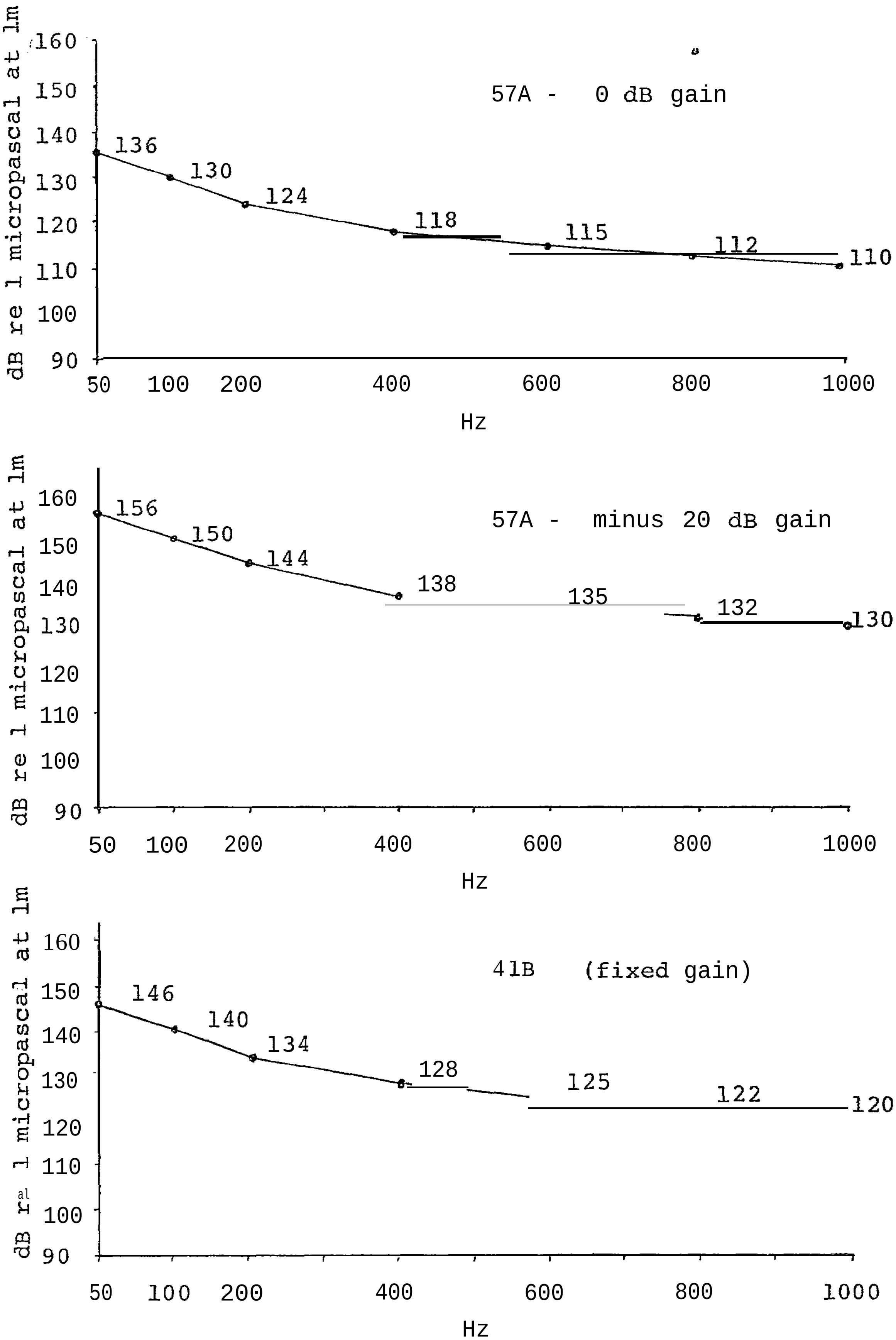


Figure A-1. Maximum received sound pressure level versus frequency for 57A and 41B sonobuoys.

AN/SSQ-41B SONOBUOY

PREFLIGHT SELECTIONS - DEPTH - SHALLOW OR DEEP
OPERATING LIFE - 1, 3 OR 8 HOURS

Description	LOFAR, passive, omnidirectional
Function	Search, surveillance
Applicable Specification	MIL-S-22793D(AS)
Average Weight	16.6 lb (7.53 kg)
Activation Time (after splash)	Up to 3
Transmitter	31 channels
RF Power	1 watt
Sensor Type	Single element
Acoustic Frequency Range	10 to 10,000 Hz; FY 77 and later, 10 to 20,000 Hz
Sensitivity	116 ±3 dB relative to 1 uPa at 100 Hz = ±19 kHz carrier deviation; FY 77 and later, ±2 dB
Operating Depth	60 ft (18.3 m) 1000 ft (304.8 m)
Descent Time (in water)	30 sec 200 sec
Directivity	Omni in both horizontal and vertical plane, ±1 dB
Power Source	Seawater-activated battery
Operating Life	1, 3 or 8 hours preselectable
Scuttling	Not longer than 30 hours
Launch Envelope	E envelope
Position Marker	None
Processor and Display	- Radio Receiving Sets: AN/ARR-52A, -72, -75, -76 - Aircraft Data Processors: AN/AQA-4, -5, -7, -7(V), OL-82/AYS, AN/ASA-20, -26
Manufacturers	- Hermes 36180 or H (may not use code) - Magnavox 37695
Production Status	Since 1975
Operating Environmental Conditions:	
Launch Air Temperature	-20^{o} to $+55^{o}$C
Seawater Temperature	0^{o} to $+35^{o}$C
Wind Velocity	30 knots
Sea State	5
Maximum Launch Altitude & Airspeed	25,000 ft; 370 knots IAS at 1850 ft

AN/SSQ-57A AND 57A(XN-5) SONOBUOY

PREFLIGHT SELECTIONS - OPERATING LIFE - 1, 3, OR 8 HOURS
DEPTH - 60 OR 300 FEET (AN/SSQ-57A ONLY)
ACOUSTIC SENSITIVITY - 0 OR -20 DB SEE NOTE

Description	Passive, omnidirectional
Function	Measurement of intensity of underwater acoustical energy
Applicable Specification	MIL-S-81478A(AS)
Average Weight	- Rotochute 18 lb (8.16 kg) - Parachute 15 lb (6.80 kg)
Activation Time (after splash)	Up to 3 minutes
Transmitter	31 channels
RF Power	1 watt
Sensor Type	Piezoelectric, single element
Acoustic Frequency Response	10 to 20,000 Hz (calibrated on the AN/SSQ-57A)
Sensitivity	+6 ±2 dB or +26 ±3 dB relative 1 ubar at 440 Hz = ±19 kHz carrier deviation - selectable before launch
Operating Depth	AN/SSQ-57A: 60 or 300 ft (18.3 or 91.4 m) AN/SSQ-57A(XN-5) 1000 ft (304.8 m)
Descent Time (in water)	AN/SSQ-57A: 30 sec or 100 sec AN/SSQ-57A(XN-5): 300 sec
Directivity	AN/SSQ-57A and AN/SSQ-57A/(XN-5): Omni-directional in both horizontal and vertical planes
Power Source	Seawater-activated battery
Operating Life	1, 3, or 8 hours preselectable
Scuttling	Not longer than 30 hours (20 hr on AN/SSQ-57A(XN-5))
Launch Envelope	- B envelope - E envelope, FY-76 and later
Position Marker	None
Processor and Display	Radio Receiving Sets: AN/ARR-52A, -72, -75, -76 Aircraft Data Processors: AN/AQA-4, -5, -7, -7(V), OL-82/AYS, AN/ASA-20, -26
Manufacturers	- Sparton 82268 or 56118 - Magnavox 37695
Production Status	- AN/SSQ-57A - Since 1971 - AN/SSQ-57A (XN-5) 1973 only
Operating Environmental Conditions:	
Launch Air Temperature	-20^{o} to $+55^{o}$C
Seawater Temperature	-2^{o} to $+35^{o}$C
Wind Velocity	30 knots
Maximum Launch Altitude & Airspeed	- 10,000 ft, 250 knots IAS - FY-76 and later, 25,000 ft; 370 kts IAS at 1850 f

NOTE

The acoustic sensitivity may be adjusted before launch. The sensitivity selection may be set for a maximum (0.0) or set to attenuate (-20). The attenuate position is used to attenuate high sea state noise or to prevent an acoustic overload resulting from high input signal strengths.

Table A-1. Specifications for Sonobuoys 41B and 57A. From: Sonobuoy Reference Guide (Sonobuoy Pocket Ready Reference Guide), NAVAIR 28-SSQ-500, Nov. 30, 1978.

APPENDIX II

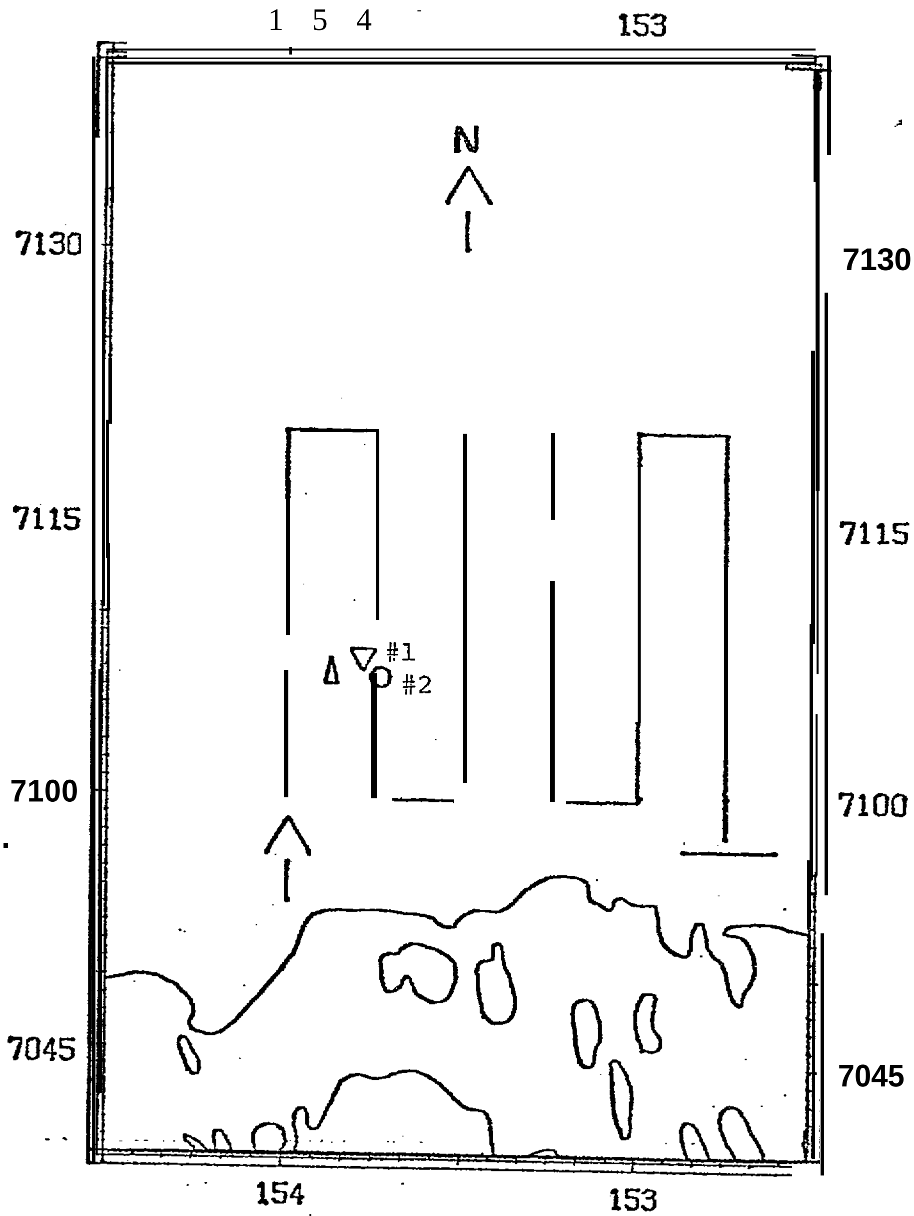
Summary of Flights and Raw Behavioral Data, Fall 1982

Key to maps :

- △ seismic vessel
- ▭ 41A sonobuoy dropped during systematic survey
- ▬ 41A sonobuoy dropped in the presence of whales
- o 41B sonobuoy dropped during systematic survey
- ● 41B sonobuoy dropped in the presence of whales
- v 57A sonobuoy dropped during systematic survey
- ▼ 57A sonobuoy dropped in the presence of whales
- ❑ Estimated number and central position of whales seen before or after systematic survey or during behavioral studies
- O Estimated number and central position of whales seen during systematic survey
- <— Start and direction of survey
- -L End of survey
- —— Grid flown
- ---- Intended grid

Key to raw data behavior comments :

- FE feeding, or suspected feeding
- SD synchronous dive
- ST stationary
- SW swimming



Flight #1
28 Aug 1982 1145-1500 hours

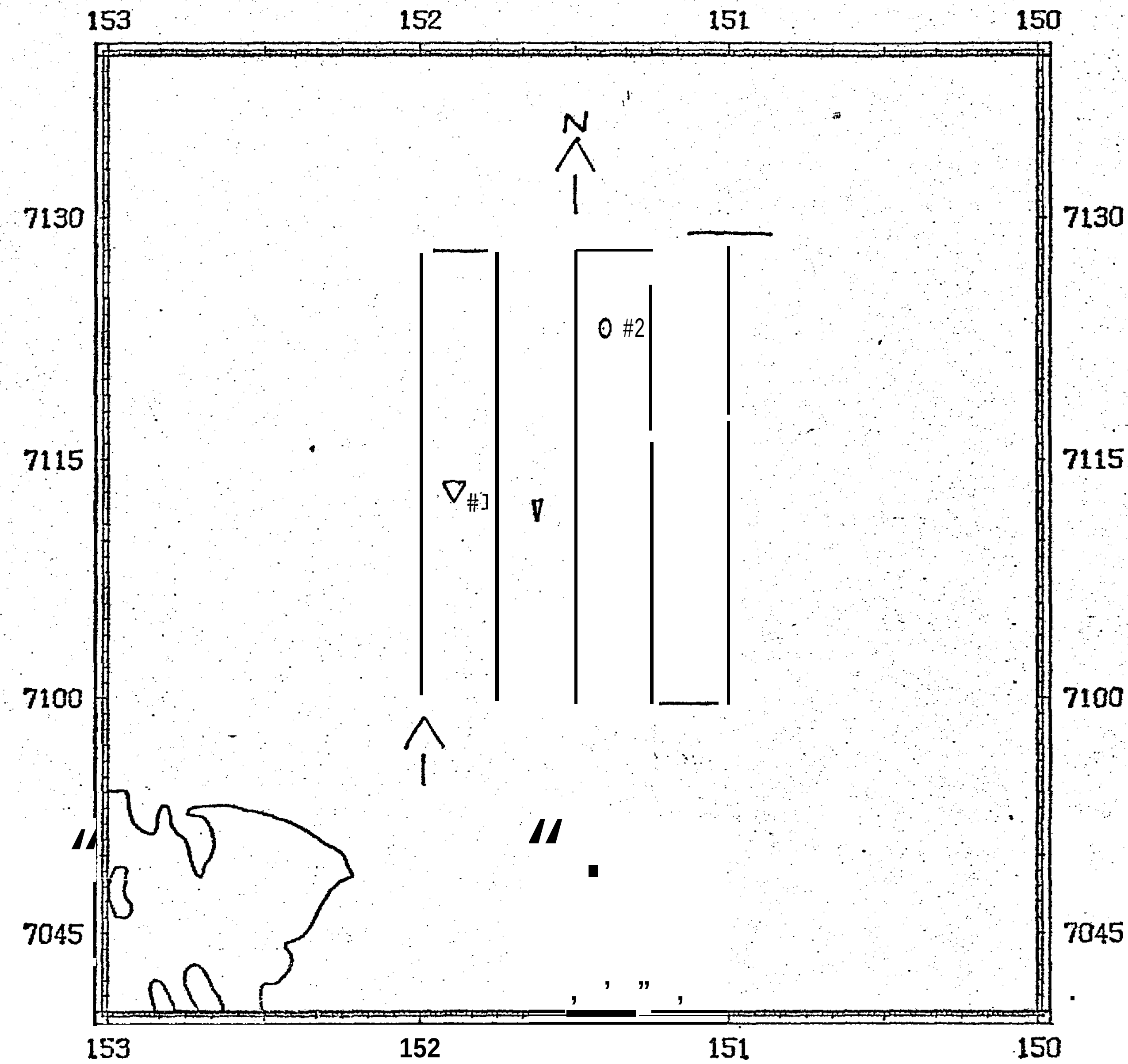
Seismic vessel: Arctic Star
status : not" shooting
Vessel heading: 015°
Vessel speed: 4.5 knots
Weather: 10V7 overcast, 5-10 mile visibility, 4-6 knot winds, Beaufort 2
Altitude survey flown: 60-183 m
Objective: grid survey

Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	no	no	9	18
#2 041B	no	? no	9	18

Whales seen: No

Comments: No vessels working .



Flight #2
29 Aug 1982 0.950-1305 hours

Seismic vessel: Western Aleutian
Status : shooting "
Vessel heading: 1 8 0 °
Vessel speed: 4.5 knots
Weather: patchy fog, 3-5 mile visibility, 4-6 knot winds, Beaufort 2
Altitude. survey flown: 183 m
objective: grid survey

Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	no	no	15	20
#2 O 41B	no	no	28	53

Whales seen: No

Comments: Western Aleutian active during time of survey; sonobuoys did not work.

Flight #3

1 Sept1982 1016-1046 hours

Seismic vessel: N/A

Status: N/A

Vessel heading: N/A

Vessel speed: N/A

Weather: heavy fog, visibility less than 1 mile, 5-10 knot winds, Beaufort 2

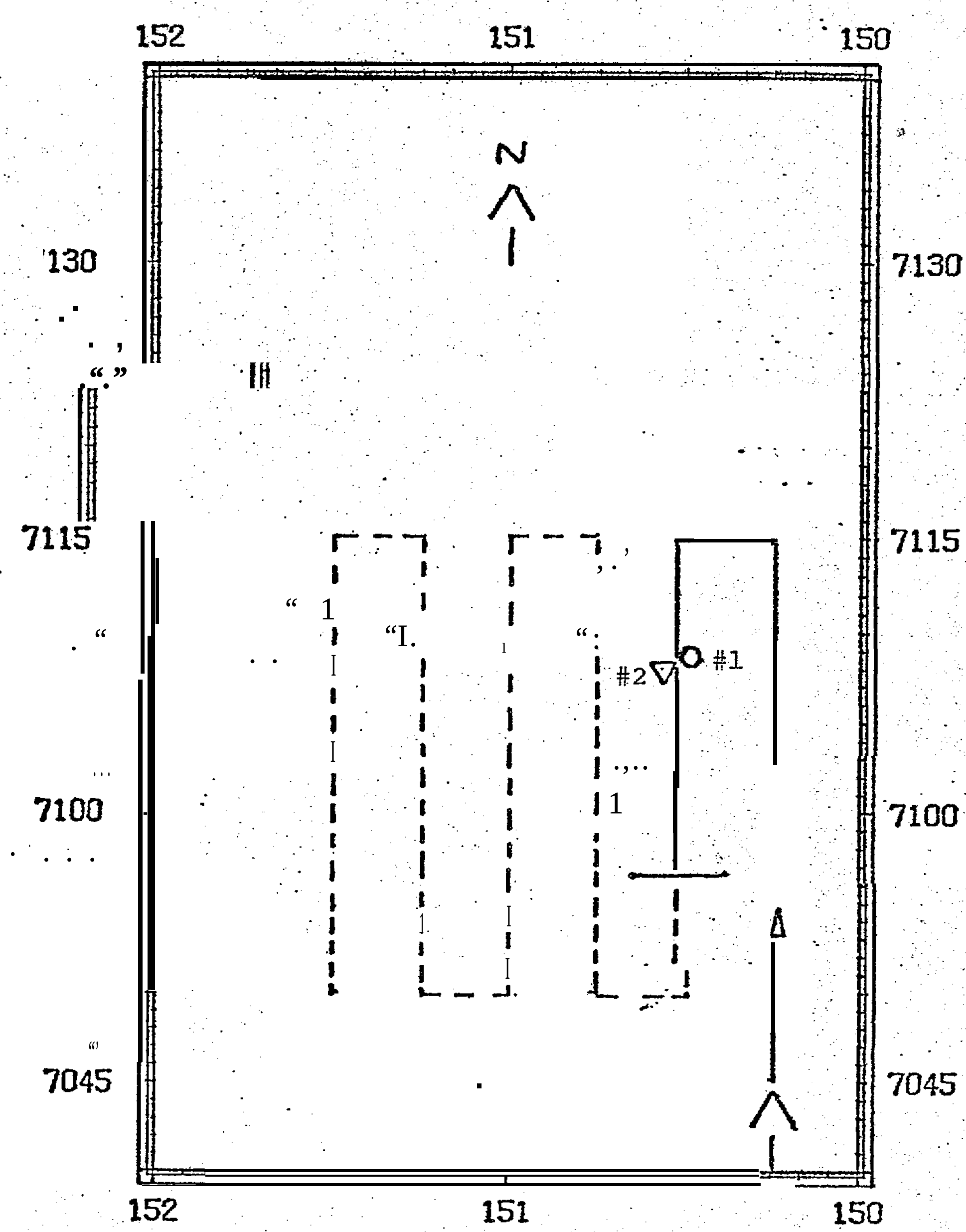
Altitude survey flown: 153-305 m

Objective: grid survey

Sonobuoys dropped: 0

Whales seen: No

Comments: Flight aborted due to adverse weather conditions .



Flight #4
3 Sept 1982 1017-1207 hours

Seismic vessel: Western Aleutian
Status: shooting
Vessel heading: 360°
Vessel speed: 4.5 knots
Weather: patchy fog to heavy fog, visibility less than one mile, Beaufort 2
Altitude survey flown: 457 m
Objective: grid survey

Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale "sounds" yes/no	Km from seismic source	Water depth (m)
#1 O 41B	yes	no	32	33
#2 ▽ 57A	yes	no	30	33

Whales seen: No

Comments: Intended grid not completed due to heavy fog.

Flight #5

3 Sept 1982 1638-1732 hours

Seismic vessel: N/A

Status: N/A
Vessel heading: N/A
Vessel speed: N/A

Weather: heavy fog, visibility less than one mile. 4-6 knot winds, Beaufort 2

Altitude survey flown: 457 m

Objective: grid survey

Sonobuoys dropped: 0

Whales seen: No

Comments: Abbreviated flight due to heavy fog.

Flight #6

5 Sept 1982 1339-1350 hours

Seismic vessel: N/A

Status: N/A
Vessel heading: N/A
Vessel speed: N/A

Weather: heavy fog, visibility less than one mile, 20-25 knot winds, Beaufort 4

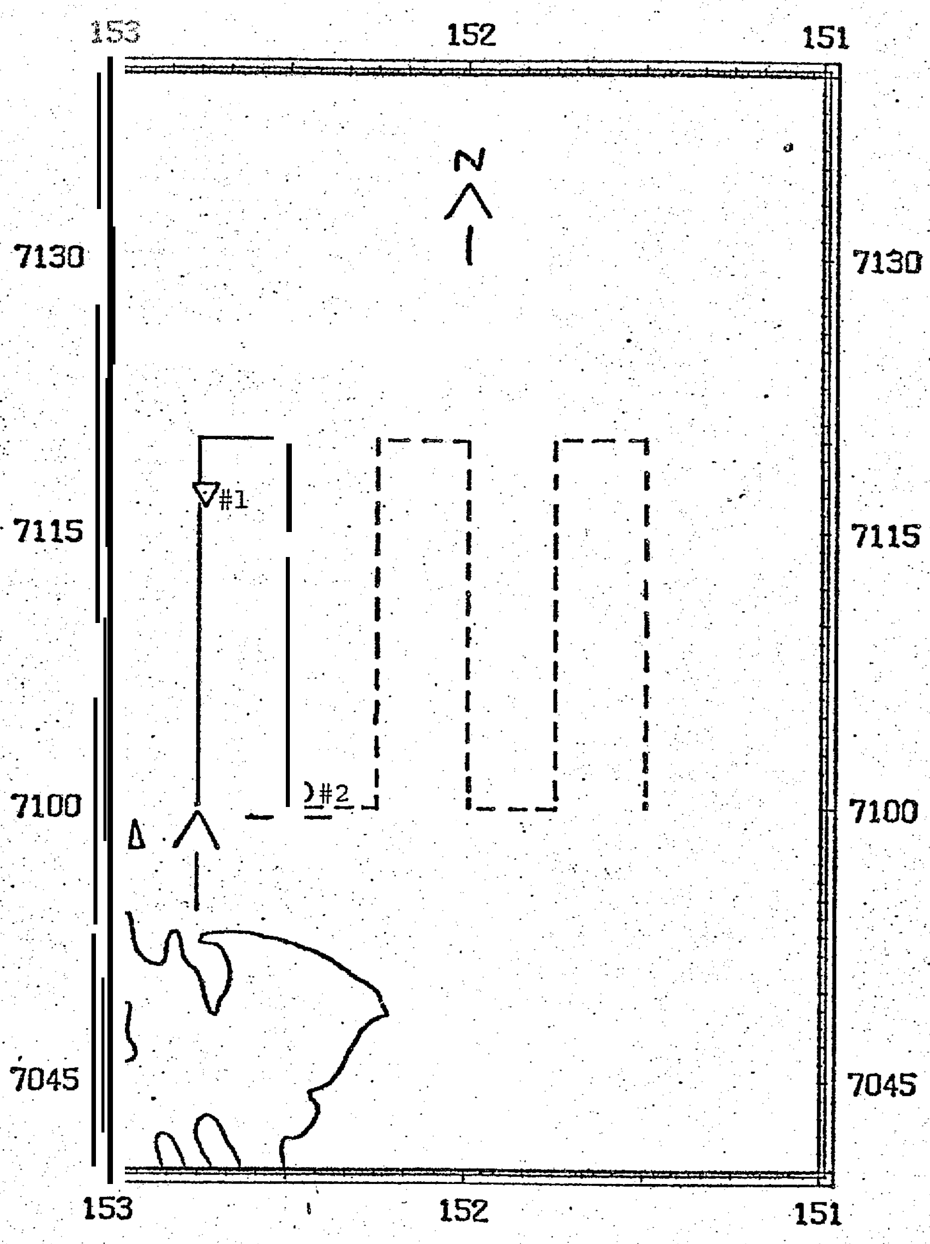
Altitude survey flown: 91 m

Objective: grid survey

Sonobuoys dropped: 0

Whales seen: No

Comments: Aborted flight due to adverse weather conditions.



Flight #7
7 Sept1982 1132-1432 hours

Seismic vessel: Arctic Star

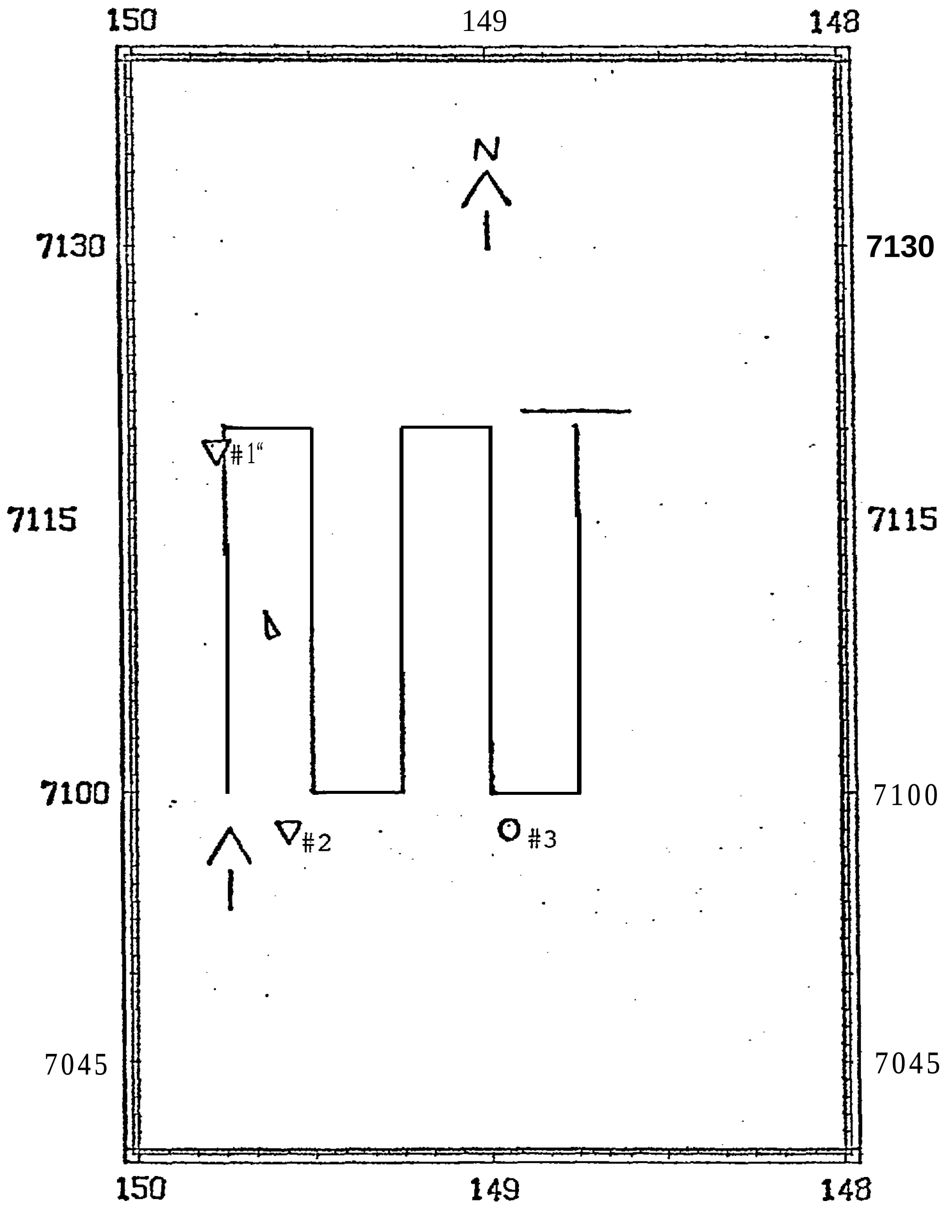
status : shooting
Vessel heading: 360°
Vessel speed: 4.5 knots
Weather: patchy fog to heavy ***fog*** , visibility from less than one mile to 10 miles, 7-10 knot winds, Beaufort 3
Altitude survey flown: 91 m
Objective: grid survey

Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽57A	yes	no	39	23-24
#2 041B	yes	no	18	13-14

Whales seen: No

Comments: Intended grid not completed due to heavy fog.



Flight #8
8 Sept 1982 0944-1223 hours

Seismic vessel: Western Aleutian
status : shooting
Vessel heading: 330°
Vessel speed: 4.5 knots
Weather: patchy fog, visibility from 2 miles to unlimited, 4-6 knot winds, Beaufort 2
Altitude survey flown: 304 m
Objective: grid survey

Sonobuoys dropped: 3

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	yes	no	18	31
#2 ▽ 57A	yes	no	18	20
#3 O 41B	yes	no	43	23

Whales seen: No

Flight #9

8 Sept 1982 1350-1522 hours

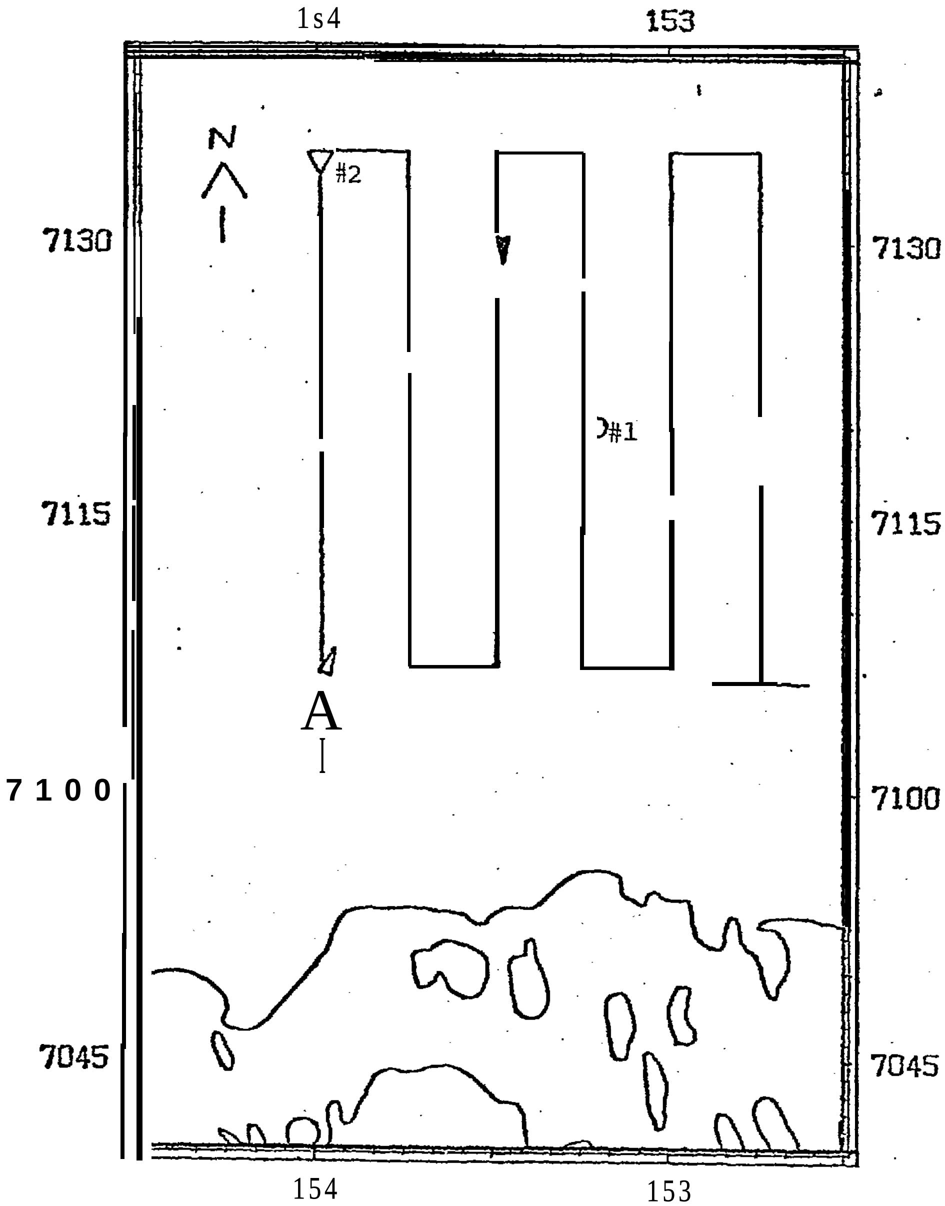
Seismic vessel: N/A
Status.: N/A
Vessel' heading: N/A
Vessel speed: N/A
Weather: patchy fog, visibility from 2 miles to unlimited, 4-6 knot winds, Beaufort 2
Altitude survey flown: 273 m
Objective: search survey

Sonobuoys dropped: 1

Sonobuoy type	Seismic sounds yes/fro,	Whale sounds yes/no	Km from seismic source.	Water depth (m)
#1 41A	no	no	-	-

Whales seen: No

Comments: None



Flight #10
11 Sept1982 1315-1722 hours

Seismic vessel: Western Aleutian

Status: shooting
Vessel heading: 180°
Vessel speed: 4.5 knots
Weather: overcast, patchy fog, visibility from less than one mile to unlimited, winds 17-21 knots, Beaufort 5
Altitude survey flown: 152-305 m
Objective: grid survey

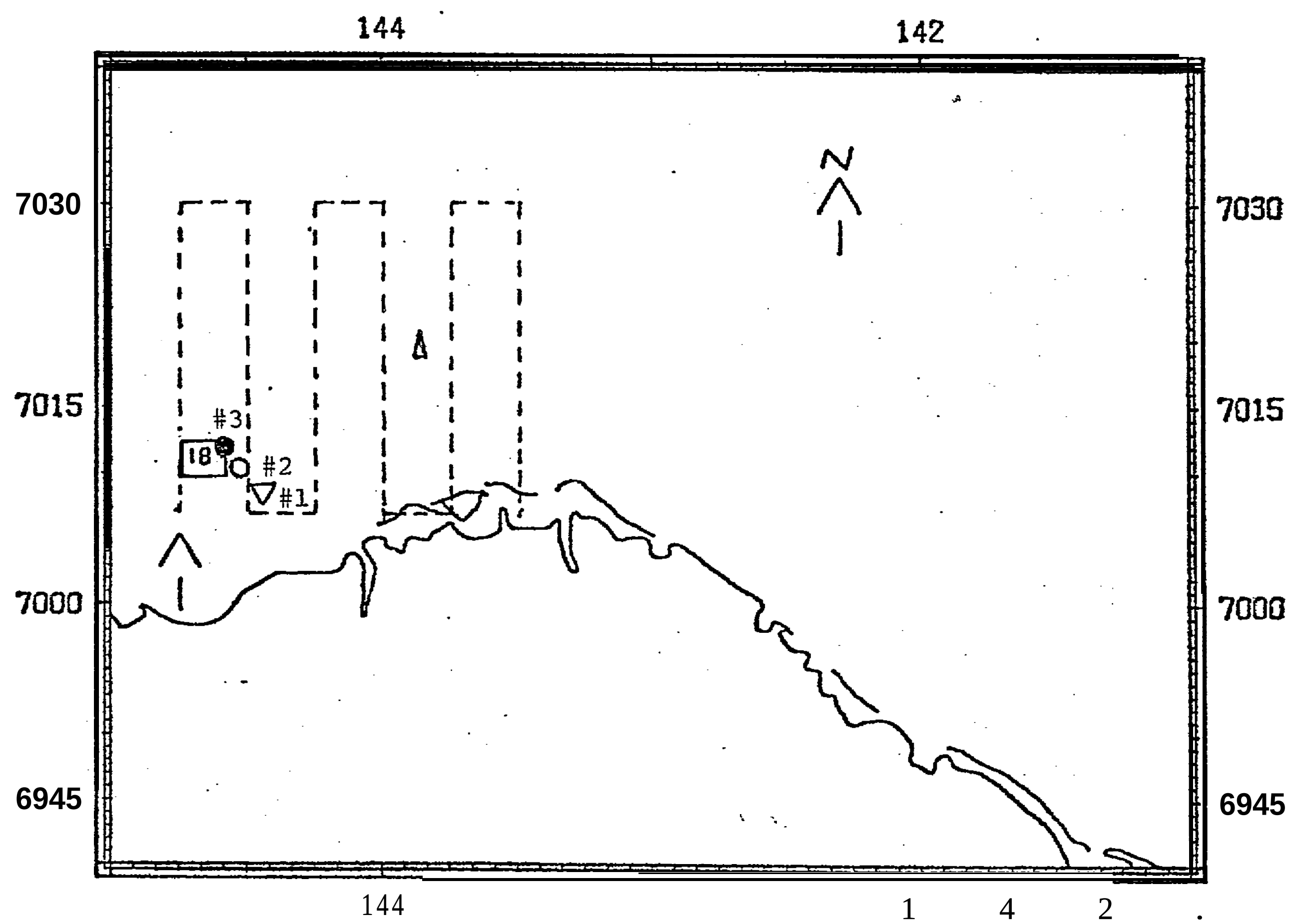
Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ○ 41B	yes	no	20	33
#2 ▽ 57A	yes	no	22	42

Whales seen: No

14 SEPT 1982 FLT 11

Whale No.	Blow series (rein: sec elapsed) 1	2	3	4	5	6	7	8	9	10	11	Full Blow Sequence Yes(Y) or No(N)	Total Surface Time min:sec	Total Dive Time min:sec	Interacting (within one Body Length) Y or N	Adult=A Cow=CC Calf=C	Heading	Behavior Comment	Seismic Sounds Y or N	Distance from Nearest Active Seismic Vessel (km)	Water Depth at Whale Position (m)	Aircraft Altitude (m)
51	:00	:10	:18	:28	:36	-	1:02					Y	1:07		N	A		ST	N	-	35	427
52	:00	:25										N			N	c	s		N	-	35	427
53	:00	:10	:22	:37								Y	:44		N	A			Y	28	26	427
54	:00	:09	:13	:21	:40							Y	:49		Y	A		ST,FE	Y	28	26	427
55	:00	:11	:21	:38								Y	:46		Y	A		'ST, FE	Y	28	26	427
56	:00	:11										N			Y	A	E	FE	Y	28	2 6	427
57	:00	:08	:18	:27	:34	:43	:52	1:03	1:27	1:44	1:56	N			Y	A	E	SW	Y	28	26	427
58	:00	:19										N			Y	A	E		Y	28	26	427
59	:00	:17	:30									Y	:30		Y	A	W		Y	28	26	427
60	:00	:08	:17	:26	:36	:45	:55					Y	1:03		Y	A			Y	28	26	427
61	:00	:13										N			Y	A			Y	28	26	427



Flight #11
14 Sept 1982 1355-1629 hours

Seismic vessel: Mariner

Status: shooting
Vessel heading: 360°
Vessel speed: 4.7 knots

Weather: patchy fog, unlimited visibility, 7-10 knot winds, Beaufort 3
Altitude survey flown: 427 m
Objective: grid survey", behavioral studies

Sonobuoys dropped: 3

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	no	no	33	16-17
#2 ○ 41B	no	no	33	16-17
#3 ● 41B	yes	yes	33	16-17

Whales seen: Yes

Water depth at whale positions: 18 = 19 m
Total # of whales seen: 18
Total # of cow/calf pairs: 1
Total # of calves: 2

Comments: Intended grid not completed due to heavy fog and behavioral observations. Sonobuoys 1 and 2 malfunctioned.

Flight #12
14 Sep 1982 1652–1800 hours

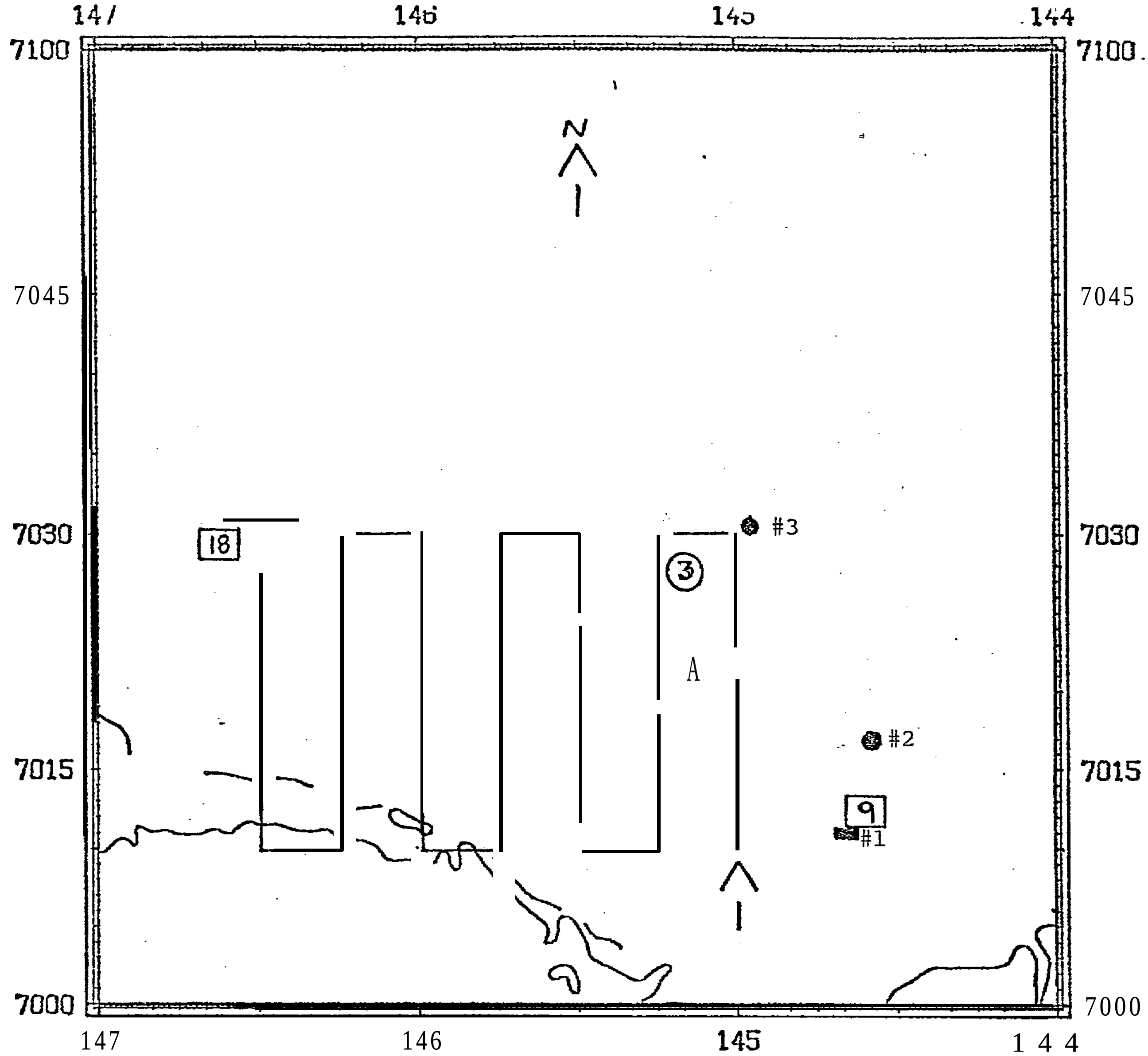
Seismic vessel: N/A
Status: N/A
Vessel heading: N/A
Vessel speed: N/A
Weather: overcast, patchy fog, unlimited visibility, 4-6 knot winds, Beaufort 2
Altitude survey flown: 609 m
Objective: transit from Barter Island to Deadhorse

Sonobuoys dropped: O

9. Whales seen: No

15 SEPT 1982 FLT 13 & 14

Whale No.	Blow series (min: sec elapsed) 1	2	3	4	5	6	7	8	9	10	11	Full Blow Sequence	Total Surface time	Total Dive Time	Interacting (within one body length)	Adult=A Cow=CC		Behavior mme	Seismic Sounds	Distance from Nearest Active Seismic	Water Depth at Whale	Aircraft Altitude
62	:00	:07										N			N	A	E	FE	N	-	37	457
63	:00	:14	:22									N			N	A	N	FE	N	-	37	457
64	:00	:08	:23	:40	:47	:59	1:12					Y	:23		N	A		FE	N	-	27	457
65	:00	:14										N			N	A	W	SW,FE	N	-	27	457
66	:00	:07	:16	:26								N			N	A	W	SW,FE	N	-	27	457
67	:00	:08	:21	:34	:4°	:°2	:	1:22	1:36	1:50		Y	2:02		N	A	SE	SW,FE	N	-	27	457
68	:00	:11										N	:20		N	A	E	FE	N	-	27	457
65	:00	:11	:25	:37	:52	:°3	:14	1:26	:40	:53		Y	≥:03	4:38	Y	A		SW,FE	N	-	27	457
66	:00	:08										Y	:11	5:08	Y	A		FE	N	-	27	457
69	:0	:11	:23	:33	:43	:53	:°7	1:19				Y	1:36	3:41	N	A		SW,FE	N	-	27	457
70	:°0	:07	:7	:27	:38	:50						Y	1:04		N	A	NW	FE	N	-	27	457
71	:°0	:09	:-	:31	:41	:52	:₀3	1:13	:24			Y	1:34		N	A		ST,FE	N	-	27	457
72	:°0	:06	:20	:29	:41							Y	:50		N	A		FE	N	-	27	457
73	:°0	:1	:22									Y	1:32		N	A		FE	N	-	27	457
74	:°0	:9	:32	:56	:09							Y	1:09		Y	A		ST,FE	N	-	27	457
75	:°0	:2	:24	:36	:44	:49	1:00	1·11	1:20	1:30	1:38	Y	:50		Y	A	E	FE	N	-	27	457
76	:°0	:2	:26	:39	:52	:04	1:15	1.26	1:38	1:51	2:09	Y	2:09		Y	A		FE	N	-	27	457
77	:°0	:0	:21	:32	:41	:53						Y	1:10		Y	A		FE	N	-	27	457
78												Y	1:00		N	A		FE	N	-	27	457
79	:00	:12	:23	:35	:47							N			N	A	E		Y	9	37	457
80	:00	:11	:24									N			N	A			Y	9	37	457
81	:00	:09	:19	:29	:39	:50	:63					Y	:22		Y	A	NW		Y	9	37	457
82	:00	:10	:25	:46								N	:07		Y	A	NW		Y	9	37	457
83	:00	:11	:23									Y	:42		Y	A	NW		Y	9	37	457
83	:00	:10	:20	:29	:39							N			N	A	W		Y	9	37	457
84			:2									Y	:02		N	A	W		Y	9	37	457
85			:46	:19	:27	1:37						Y	:48		N	A	E		Y	9	37	518
87	:00	:19										N			N	A	NW	SW	N	-	49	518
88	:00	:16	:30	:40	:53	1:06						N			N	A	NW	ST	N	-	49	518



Flights #13 & #14
15 Sept1982 1002-1659 hours

Seismic vessel: Mariner
Status: shooting f-rem 1230-1430
Vessel heading: 360°
Vessel speed: 4.7 knots
Weather: clear, unlimited visibility, 4-6 knot winds, Beaufort 2

Altitude survey flown: 457 m
Objective: grid survey, behavioral studies

Sonobuoys dropped: 3

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 41A	yes	no	24	1 8
#2 41B	yes	yes	9	27-28
#3 41B	yes	no	18	42

Whales seen: Yes

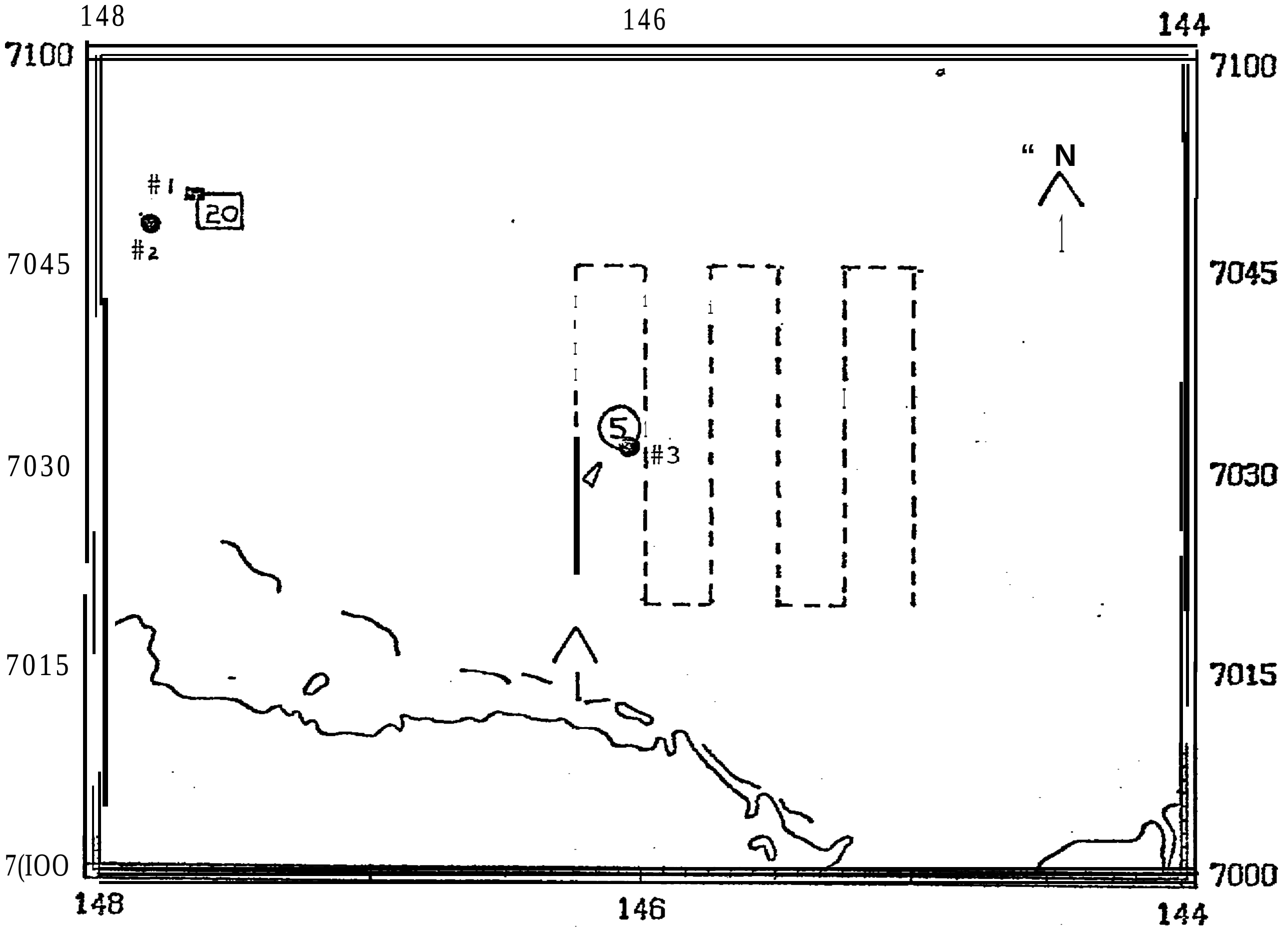
Water depth at whale positions: 3 = 42 m; 9 = 24m; 18 = 31 m

Total # of whales seen: 30
Total # of cow/calf pairs: 4
Total # of calves: 4

17 SEPT 1982 FLT 15 & 16

Whale No.	Blow series (min: sec elapsed) 1	2	3	4	5	6	7	8	9	10	11	12	13	Full Blow Sequence Yes(Y) or No(N)	Total Surface time min:sec	Total Dive Time min:sec	Interacting (within one body length) Y or N	Adult=A Cow=CC Calf=C	Heading	Behavior Comment	Seismic Sounds Y or N	Distance from Nearest Active Seismic Vessel (km)	Water Depth at Whale Position (m)	Aircraft Altitude (m)
89	.		:00	:17	:35									N			N	A	NE	SW	N		40	4 2 6
90	:00	:13	:24											Y	:48		N	A	SE	SW	N		40	426
91	:00	:13	:28											Y	:48		N	A	SE	SW	N		40	426
92	:00	:09	:20	:32	:39	:46	:54	1:04	1:14					Y	"1: 29		N	A	W	SW	N	-	40	4 2 6
93														N	1:01		N	A	w	ST	Y	78	40	367
94	:00	:11												N			N	A		ST	Y	78	40	367
95														N	1:45		N	A	E	ST	Y	78	40	367
96	:00	:08	:16											N			N	A'	W	SW	Y	78	40	367
97	:00	:19												N			N	A	W	SW	Y	78	40	367
98														N	1:49		N	A		ST	Y	78	40	367
99	:00	-	"- :4B	1:10	1:21	1:34								Y	1:42		N	A	SW	SW	Y	78	40	367
100	:00	:11	:22	:51										Y	1:18		Y	A		ST	Y	78	40	367
101														N	:31		Y	A	NE		Y	78	40	367
102														w	1:57		Y	A	w	ST	Y	78	40	367
103	:00	:33	:41	:45	:56	1:32	1:45							Y	1:58		N	A	E		Y	78	40	367
104														N	1:52		N	A	E		Y	78	40	367
105*	:00	:20	:36	:51	1:06	1:22	1:38	1:56						Y	2:08	4:07	N	A	w	SW	Y	7	40	367
105*	:00	:21	:36	:51	1:06	1:23	1:36	1:50	2:07	2:25	2:41	3:00		Y	3:10	5:38	N	A	W	Sw	Y	7	40	367
105*	:00	:17	:33	:47	1:02	1:17	1:34	1:51	2:07	2:24	2:38	2:53	3:09	Y	3:18	9:02	N	A	W	SW	Y	7	40	3 6 7
105*	:00	:20	:36	:50	1:05	1:20	1:36	1:51	2:09					Y	2:24	4:29	N	A	W	ST	Y	7	40	36?
105*	:00	:16	:33	:47	1:00	1:15	1:29	1:41	1:56	2:11	2:27	2:42	2:58	"	3:08	9:00	N	A	W	SW	Y	7	40	367
105*	:00	:17	:31	:45	1:00	1:14	1:30	1:47	2:02	2:17	2:32	2:50	3:00	Y	3:19	7:50	N	A	W	Sw	Y	/	40	367
105*														N	4:30	9:31	N	A			Y	7	40	367

* Whale No. 105 is the struck whale



Flights #15 & #I6
17 Sept1982 1110-1838 hours

Seismic vessel: Mariner

Status: shooting from 1235 hours
Vessel heading: 022°
Vessel speed: 4.7 knots

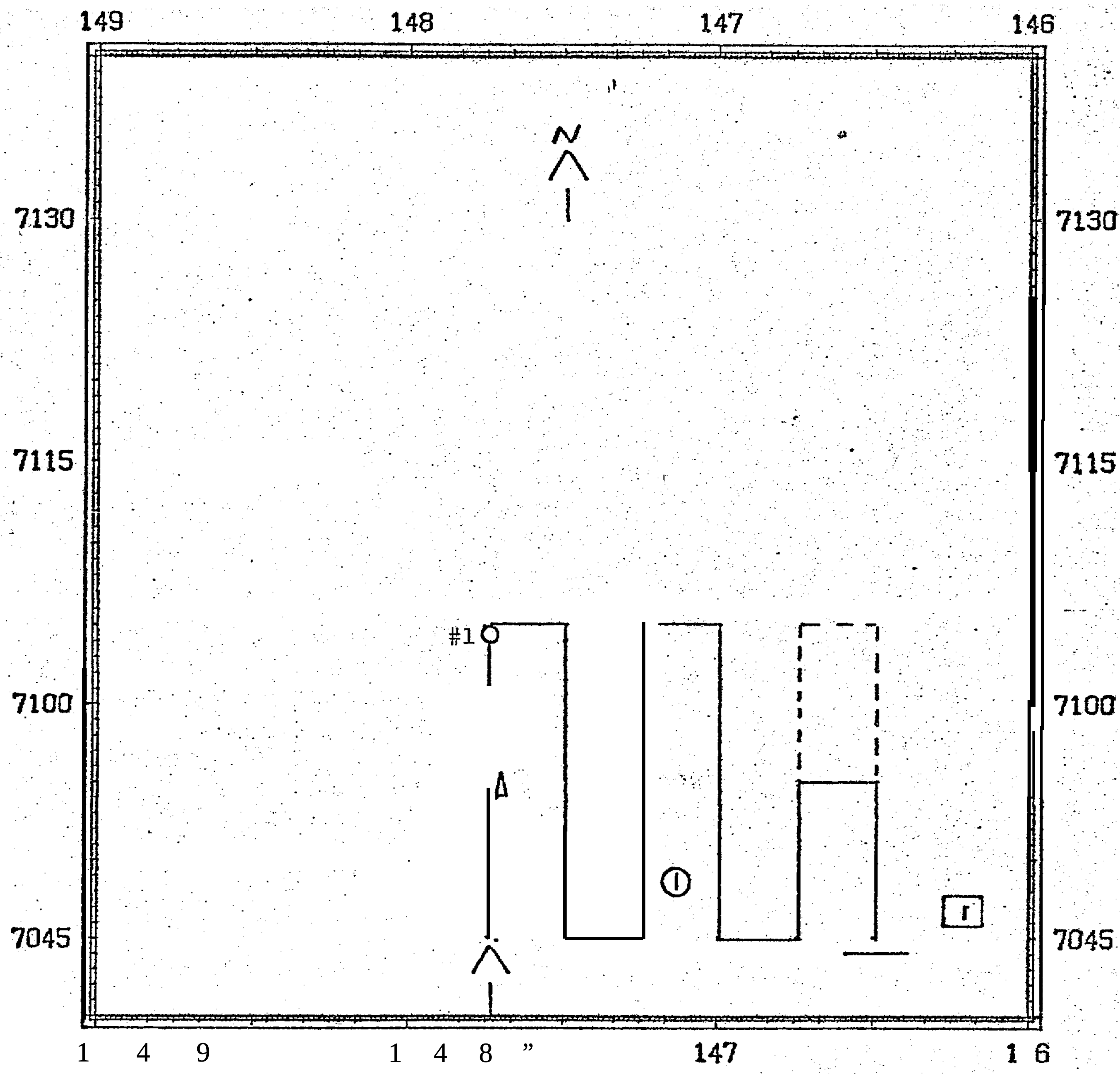
Weather: partly cloudy, unlimited visibility, 4-6 knot winds, Beaufort 2
Altitude survey flown: 411 m
Objective: grid survey

Sonobuoys dropped: 3

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ■ 41A	yes	no	50	40
#2 ● 41B	yes	no	52	40
#3 ● 41B	yes	no	7	36-37

Whales seen: Yes
Water depth at whale positions: [20] = 40 m; (5) = 36-37 m
Total # of whales seen: 25
Total # of cow/calf pairs: 2
Total # of calves: 2

Comments: Intended grid not completed due to behavioral circling of struck whale.



Flight #17
18 Sept1982 1316-1558 hours

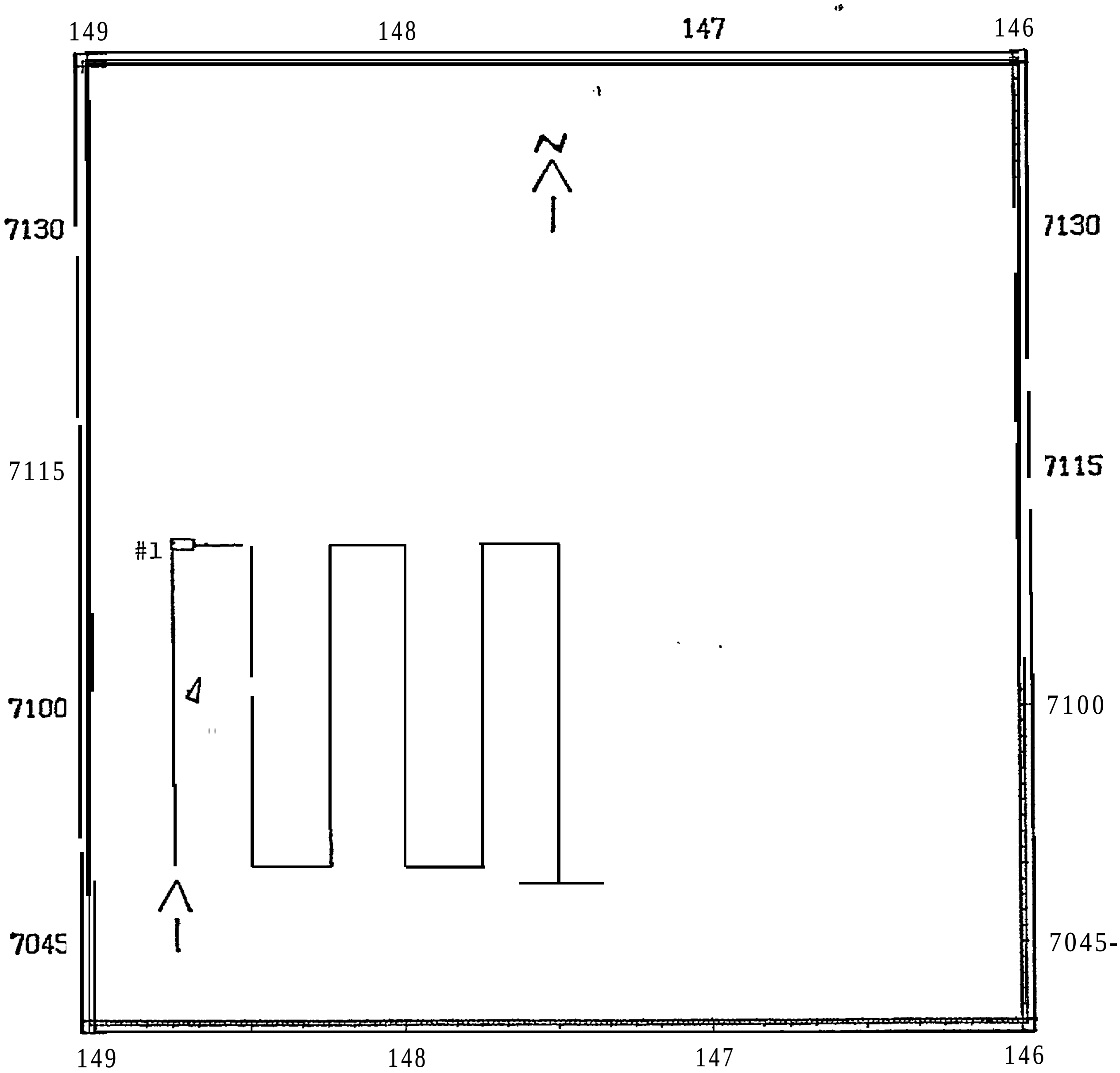
Seismic vessel: Western Aleutian
Status: shooting
Vessel heading: 350°
Vessel speed: 4.5 knots
Weather: overcast, unlimited visibility, 11-17 knot winds, Beaufort 4
Altitude survey flown: 3.35 m
Objective: grid survey

Sonobuoys dropped: 1

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 O 41B	yes	no		40

Whales seen: Yes
Water depth at whale positions: 1 = 45-46m; 1 =58 -59m
Total # of whales seen: 2
Total # of cow/calf pairs:0
Total #of calves: 0

Comments: Intended grid not completed due to fog.



Flight #18
21 Sept 1982 1116-1509 hours

Seismic vessel: Western Aleutian
Status: not shooting
Vessel heading: 030°
Vessel speed: 4.5 knots
Weather: heavy fog to partly cloudy, visibility from 2 miles to unlimited, 17-20 knot winds, Beaufort 5
Altitude survey flown: 152 m
Objective: grid survey

Sonobuoys dropped: 1

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m
#1 41A	no	no	18	26

Whales seen: No

Flight #19
22 Sept 1982 1035-1232 hours

Seismic vessel: Western Aleutian
Status: not shooting
Vessel heading: -
Vessel speed: 4.5 knots
Weather: clear to dense fog, visibility from less than one mile to unlimited, 7-11 knot winds, Beaufort 3
Altitude survey flown: 152 m
Objective: grid survey, search survey

Sonobuoys dropped: 1

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 41A	no	no	65	18

Whales seen: No

Comments: Search survey along barrier islands.

Flight #20
22 Sept 1982 1440-1607 hours

Seismic vessel: N/A
Status: N/A
Vessel heading: N/A
Vessel speed: N/A
Weather: clear, low-lying dense fog, unlimited visibility, 7"-11 knot winds, Beaufort 3
Altitude survey flown: 305 m
Objective: grid survey

Sonobuoys dropped: 2

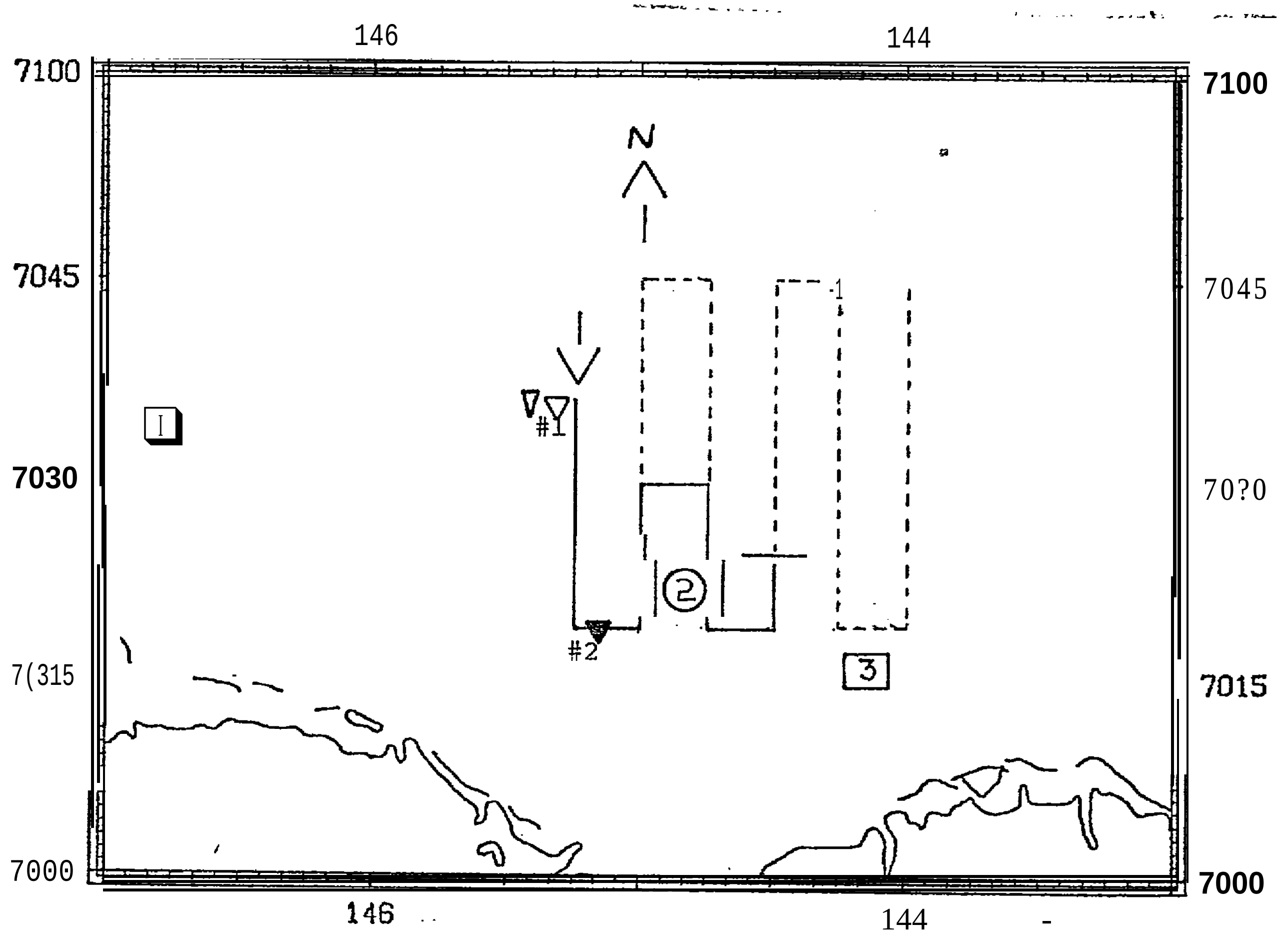
Sonabuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 41A	no	no		25
#2 41B	no	no		29

Whales seen: No

Comments: All vessels not working.

23 SEPT FLT 21

Whale No,	Blow series (rein: sec elapsed) 1 2 3 4 5 6 7 8 9 10 11	Full Blow Sequence Yes(Y) or No(N)	Total Surface Time min:sec	Total Dive Time min:sec	Interacting (within one) Body Length) Y or N	Adult=A Cow=CC Calf=C	Heading	Behavior Comment	Seismic Sounds Y or N	Distance from Nearest Active Seismic Vessel (km)	Water Depth at Whale Position (m)	Aircraft Altitude (m)
25	:00 1:17 1:301:41 1:54 2:08	Y	2:16		N	A	N	SW	Y	56	33	457
26	:00 :13 :27 :39 :521:041:181:30 1:441:582:10	Y	2:42		Y	A	NW	ST	Y	56	33	457
27	:00 :13 :25 :37 :49 1:051:17 1:31 1:45 1:5B	Y	2:23		Y	A	NW	ST	Y	56	33	457
28	:00 1:00 1:22 1:34 1:45 1:58	Y	2:14		N	A	N	SW	Y	56	33	457
29	:00 :06 :12 :19 :27	Y	:56		N	A	E	ST	Y	43	37	451
30	:00 :11 :22 :33 :46 :531:081:17	Y	1:32		N	A	E		Y	43	37	457
31	:00 :10 :22 :32 :42 :54 1:06 1:18 1:301:39 1:52	Y	2:05		N	A	W	ST	Y	43	37	457
32		N		12:10	N	A	S		Y	43	37	457
33	:00 :11 :26 :43 1:00	Y	1:35		N	A	W	SW	Y	43	.37	457
34	:00 :15 :23	N			N	A	W		Y	176	35	457



Flight #21
23 Sept 1982 0948-1213

Seismic vessel: Mariner
Status: shooting
Vessel heading: 195°
Vessel speed: 4.7 knots
Weather: clear to patchy fog, visibility from 3 miles to unlimited, 4-6 knot winds, Beaufort 2
Altitude survey flown: 457 m
Objective: grid survey

Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	no	no	2	47-48
#2 ▼ 57A	yes	no	33	27-28

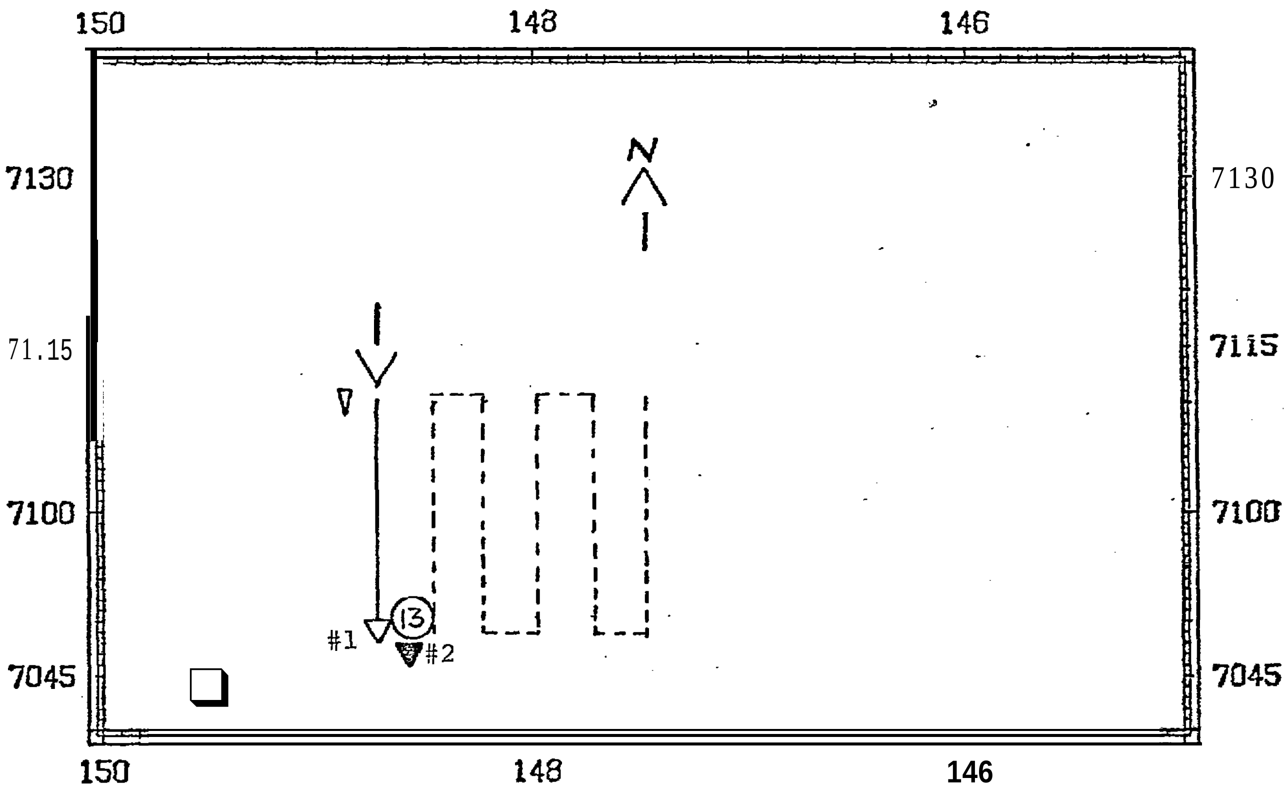
Whales seen: Yes
Water depth at whale positions: ② = 36-37m; [1] = 36-37m; [3] = 26 m

Total # of whales seen: 16
Total # of cow/calf pairs: 2
Total # of calves: 2

Comments: Intended grid not completed due to heavy fog. Sonobuoy #1 saturated .

31 SEPT 1982 FLT 22

Whale No.	Blow series (min: sec elapsed) 1	2				6	7			10	11	12	13	14	15	Full Blow Sequence Yes(Y) or No(N)	Total Surface time min:sec	Total Dive Time min:sec	Interacting (within one body length) Y or N	Adult=A Cow=CC Calf=C	Heading	Behavior Comment	Seismic Sounds Y or N	Distance from Nearest Active Seismic Vessel km	Water Depth at Whale Position	Aircraft Altitude (m)
39	:00	:15	:51													N			N	A			Y	37	26	451
40	:00	:13	:23	:38												Y	:49		N	A	N	SW	Y.	37	26	457
39	:00	:16	:30	:45	1:05											Y	1:05	4:00	M	A			V	31	26	457
39	:00	:19	:36	:53												Y	1:56	8:27	N	A			N	-	26	670
40	:00	:13	:25	:36	:47	:59	1:15									Y	1:20	10,51	N	A			N	.	26	670
39	:00	:14	:31	:45	:59	1:15	1:33									Y	1:33	3:08	N	A	N		H	-	26	670
39	:00	:19	:36	:49	1:04	1:20	1:33									Y	1:33	8:43	Y	A		SW	Y	37	26	670
40	:00	:15	:27	:41	:55	1:07	1:12									Y	1:12	12:40	Y	A		SW	Y	37	26	670
39	:00	:22	1:27	1:40	1:57	2:13	2:35									Y	2:35	4,42	N	A	SE	SW	Y	37	26	670
40	:00	,13	:28	:40	:54	1:22	1,36									Y	1:36	15,34	H	A			Y	37	26	670
39	:00	:12	:27	:43	1:00											Y	1:00	11:10	N	A			Y	31	26	610
39	:00	:18	:35	:42	:53	1:09										Y	1:09	6,05	N	A	SE		Y	41	26	670
41	:00	:08	:16	:25	:34											Y	:34		N	C	SW		Y	41	26	670
40	:00	:12	,27	:40	:55	1:09	1:22									Y	1:22	12,35	N	A	S		Y	43	26	6?0
39	:00	:17	:30	:46	:59	1:16	1:32									Y	1:32	5:08	N	A			Y	43	26	670
42	:00	,13														N			N	A			Y	43	26	610
43	:00	:09	:20	:31	:43											N			Y	A			Y	43	26	670
44	:00	:09	:20	:31	:43											N			Y	A			Y	43	? 6	670
40	:00	:13	:27	:41	:57	1:11	1:26	1:41	1:56	2:12						Y	2:16		N	A			Y	43	26	670
39	:00	:16	:25	:41	1:11											Y	1:11		N	A	U		Y	43	26	670
39	:00	:20	:32	:45	1:00	1:22	1:38									Y	1:38	2:19	N	A			Y	43	26	670
41	:00	:07	:16	:24	:32	:39										N			H	C			Y	43	26	670
45	:00	:11	:21	:31	:42	:54	1:05	1,16	1:42	1:51						Y			N	A			Y	43	26	670
46	:00	:08	:20	:31	:56	1:10	1,24	1:38	1:56	2:11	2:29	2:45	3:00	3:14		Y	3:40		Y	A		ST	Y	43	26	670
47	:00	:12	:23													Y	:23		Y	A			Y	43	26	670
39	:00	:19	,34	:43	:57											Y	:57		N	A			Y	43	26	670
39	:00	:14	:27													Y	:27	1:42	N	A			Y	43	26	670
4a	:00	:07	,17	:27	:38											N			Y	A			Y	43	26	610
49	:00	:09	:21	:31												N			Y	A			Y	43	26	670
39	:00	:13	,31													Y	:31	6,48	N	A	NW		Y	43	26	670
39																N		2:22	N	A			Y	43	26	670
50	:00	:11	:25	:39	:51	1:08	1:22	1:38	1:53	2:09						Y	2:09		N	A			Y	43	26	670



Flight #22
23 Sept 1982 1326-1756 hours

Seismic vessel: Western Aleutian
Status: 'shooting at 1500 hours
Vessel heading: 180°
Vessel speed: 4.5 knots
Weather: clear, visibility unlimited, 1-3 knot winds, Beaufort 1

Altitude survey flown: 457 m
Objective: grid survey, behavioral studies

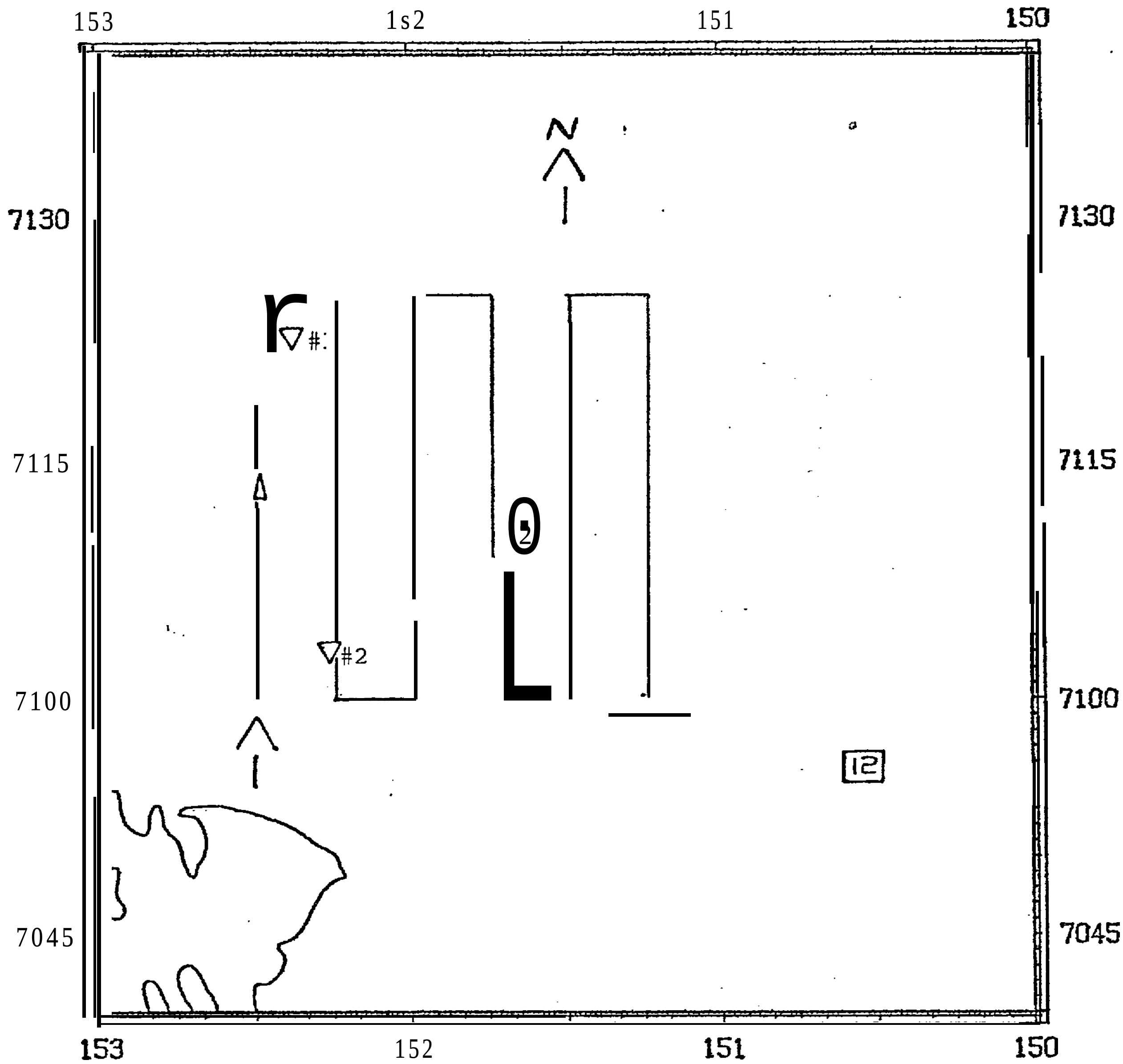
Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	no	no	38	25-26
#2 ▼ 57A	yes	yes	38	25-26

Whales seen: Yes
Water depth at whale positions: [12] = 15-16m; (13) = 38-39 m
Total # of whales seen: 25
Total # of cow/calf pairs: 1
Total # of calves: 3

Comments: Intended grid not completed due to behavioral circling.
Sonobuoy #1 malfunctioned.

'-----1



Flight #23
24 Sept1982 0953-1320 hours

Seismic vessel: Western Polaris
Status: shooting
Vessel heading: 330°
Vessel speed: 4.5 knots
Weather: clear, unlimited visibility, 1-3 knot winds, Beaufort 1

Altitude survey flown: 457 m
Objective: grid survey

Sonobuoys dropped: 2

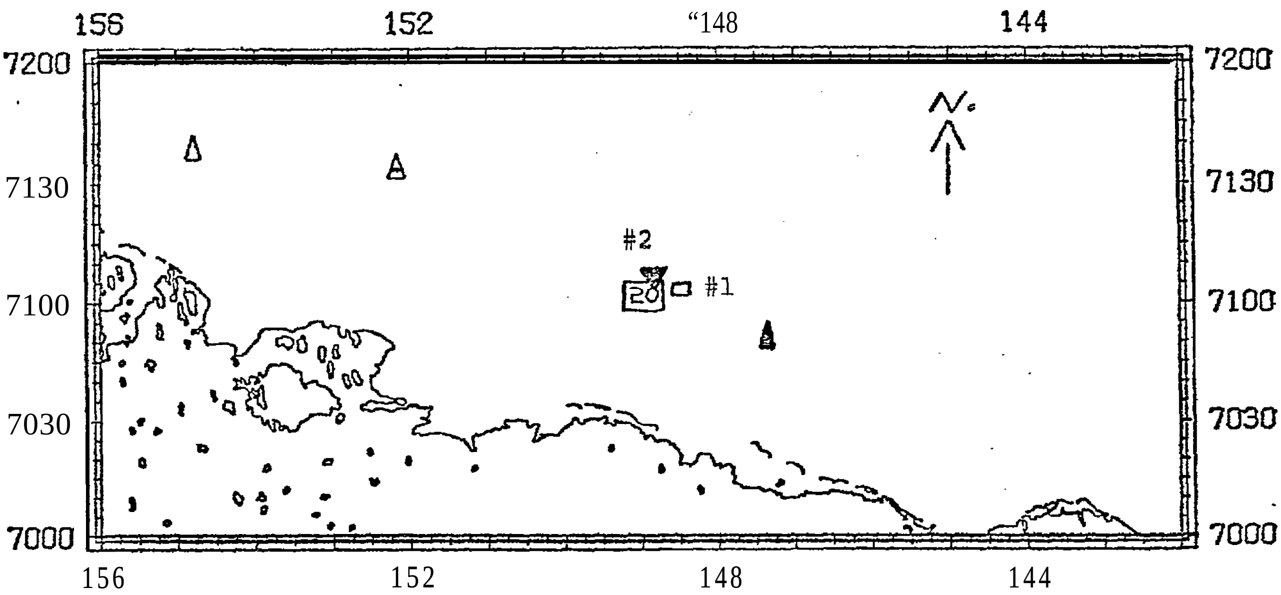
Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽57A	yes	yes	18	91
#2 ▽57A	yes	no	18	18

Whales seen: Yes
Water depth at whale positions: (2) = 19 m; [12] = 14 m
Total # of whales seen: 14
Total # of cow/calf pairs: 0
Total # of calves: 0

24 SEPT 1982 FLT 24

Whale No.	Blow series (min: sec elapsed) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
106	:00	:12	:23	:36	:49													
107	:00	:15	:32	:51	1:12													
108	:00	:12	:24															
109	:00	:13	:23	:33	:40	:47	:59											
110	:00	:11	:26															
111	:00	:15	:31	:47														
112	:00	:10	:19															
112	:00	:09	:24	:37	:50													
113	:00	:14	:29	:49	1:17	1:37	1:51											
114	:00	:09	:18	:28	:38	:49												
115	:00	:09	:19	:32	:43	:56	1:07	1:19	1:32	1:44	1:55	2:10	2:23					
116	:00	:11	:21	:30	:43	:55	1:07	1:19	1:30	1:44	1:56	2:09	2:22	2:37				
117	:00	:16	:30	:44	:57	1:11	1:28	1:49	2:09	2:31	2:54	3:05	3:22	3:45	3:59			
118	:00	:07	:24	:37	:49	:55	1:00	1:07	1:13	1:20								
119	:00	:08	:21	:35	:49	1:03	1:81	1:32	1:46	2:03	2:15	2:30						
120	:00	:12	:21	:34	:44	:56	1:08	1:20	1:31	1:40	1:51	2:02	2:14					
121	:00	:10	:18	:29	:43	:55	1:07	1:19	1:31	1:42	1:58							
122	:00	:19	:37	1:00	1:26	1:53	2:14											
123	:00	:06	:17	:34	:44	:52	1:02	1:11	1:27	1:44	2:08	2:20	2:29	2:40	2:50	[illegible]	[illegible]	[illegible] [illegible]
124	:00	:14	:23															
125	:00	:11	:21	:30	:39	:48	:58	.	-	1:47	1:57	2:07	2:17	2,28				
126	:00	:12	:23	:39	:46	:58	-	-	1:41	1:53	2:04	2:18	2:30	2:42				
127	:00	:10	:20	:21	:32													
128			:00	: 12	:23													
129	:00	:23	:36	:51														
130	:00	:11	:21	:30	:41	:55	1:05	1:16	1:28	1,36	1:51	2:01	2:13	2:25				
131	:00	:24	:34	:44	1:07	1:17												
132																		

Whale No.	Full Blow Sequence Yes(Y) or No(N)	Total Surface time min:sec	Total Dive Time .1", sec	Interacting (within one body length) Y or N	Adult=A COW-CC Calf=C	Heading	Behavior Comment	Seismic Sounds Y or N	Distance from Nearest Active Seismic Vessel (km)	Water Depth at Whale Position(m)	Aircraft Altitude (m)
106	Y	1:01		N	A	SW		N		37	457
107	N			N	A	W	SW	N		37	457
108	Y	1:29		N	A	SW		N		37	457
109	Y	1:02		N	A			N		37	457
110	N			N	A			N		37	457
111	N			N	A	NW	SW	N		37	457
112	Y	:33		N	A	NW		N		37	457
112	Y	1:05		N	A			N		37	457
113	Y	1:55		N	A			N	-	37	457
114	Y	:59		N	A			N	-	37	457
115	Y	2:32		N	A		ST	N	-	37	457
116	Y	2:48		N	A			N	-	37	457
117	Y	4:21		N	A			Y	155	37	457
118	Y	1:27		N	A			Y	155	37	457
119	Y	2:46		N	A	S	SW	Y	155	37	457
120	Y	2:21		N	A	S	SW	Y	155	37	457
121	Y	2:06		N	A		SW	Y	155	37	457
122	Y	2:23		N	A		SW	Y	155	37	457
123	Y	3:43		Y	A			Y	155	37	457
124	N	1:50		N	A			Y	155	37	457
125	N	2:45		Y	A			Y	155	37	457
126	N	2:53		Y	A			Y	155	37	457
127	Y	1:07		Y	A			Y	155	37	457
128	N			N	A			Y	155	37	457
129	N			N	A		ST	Y	155	37	457
130	Y	2:35		N	A	SW		Y	155	37	457
131	Y	1:35		N	A	SW		Y	155	37	457
132	N		13:05	Y	CC		ST	Y	155	37	457



Flight #24
24 Sept 1982 1430-1811 hours

Seismic vessel: Western Aleutian
Status: not shooting
Vessel heading: 330°
Vessel speed: 4.5 knots
Weather: clear, unlimited visibility, 1-3 knot winds, Beaufort 1
Altitude survey flown: 457 m
Objective: grid survey, behavioral studies

Sonobuoys: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▭ 41A	yes	no	135	
#2 ▼ 57A	yes	no	135	44

Whales seen: Yes
Water depth at whale-positions: [20] = 30 m
Total # of whales seen: 20
Total # of cow/calf pairs: 2
Total # of calves: 2

Comments: Intended grid not completed due to behavioral circling.

Δ Arctic Star - 222 km distant - active

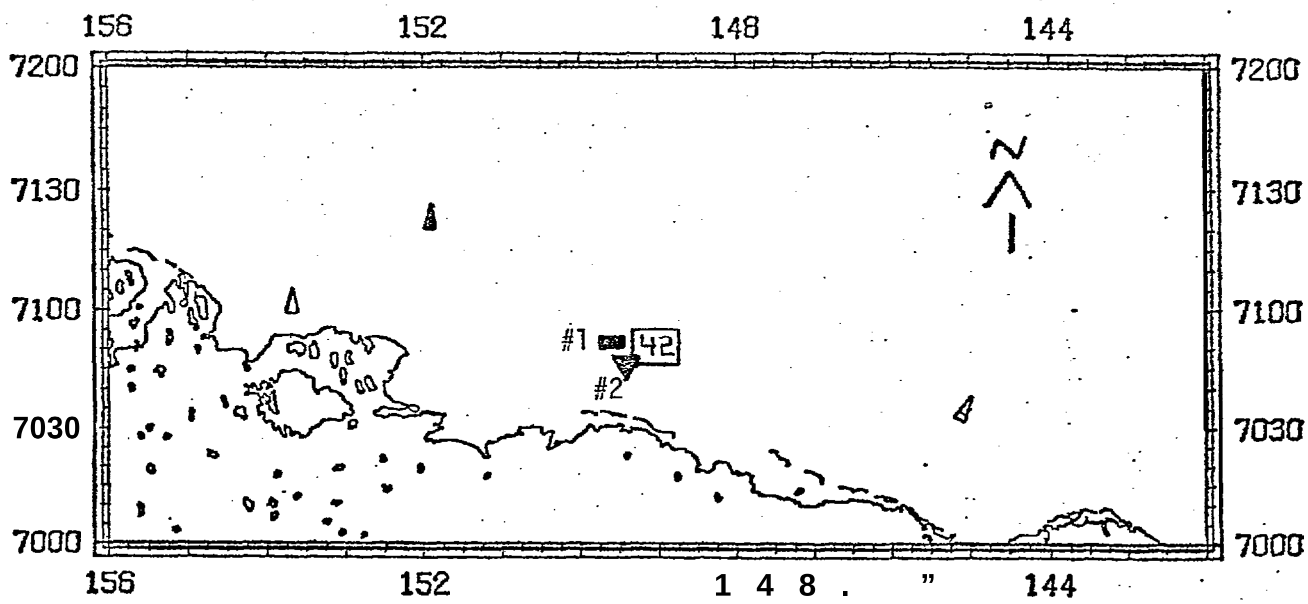
Δ Western Polaris - 135 km distant - active

▲ Western Aleutian - 56 km distant - inactive

All vessel positions and status confirmed

25 SEPT 1982 FLT 25

Whale No.	Blow series (min: sec elapsed) 1	2	3	4	5	6	1	8	9	10	11	12	13	Full Blow Sequence Yes(Y) or No(N)	Total Surface time min:sec	Total Dive Time min: sec	Interacting (within one body length) Y or N	Adult=A Cow=CC Calf=C	Heading	Behavior. Comment	Seismic Sounds Y or N	Distance, from Nearest Active Seismic Vessel (km)	Water Depth at Whale position	Aircraft Altitude (m)
1	:00	:37												N			Y	CC	NE	SW	Y	729	21	457
2														N	1:07		N	C			Y	1 29	21	457
3														N	1:36		N	C	NW	SW	Y	129	21	457
4	:00	:10	:18	:25	:34	:42	:54	1:01	1:10	1:44	1:54			Y	2:01		N	C		SW	Y	129	21	457
5	:00	:17	:33	:48	1:02	1:16	1:29	1:43	1:54					Y	2:14		Y	CC	NE	ST	Y	129	21	457
6	:00	:28	:45	:58	1:52									Y	2:04		Y	C	NE	ST	Y	129	21	457
7	:00	:15	:29	:43	:56	1:12	1:17	1:31	1:46	2:43				Y	3:19		Y	CC	NW	SW	Y	129	21	457
8	:00	:08	:17	:32	:44	:53	2:02	2:10	2:21	2:29		2:38		't	3:06		Y	C	NW	SW	Y	129	21	457
9	:00	:10	:24	:40	:56	1:31	1:51							Y	2:17		Y	CC	NE		Y	129	21	457
10	:00	:04	:11	:25	:37	:45	:53	:59	1:15	1:30	1:46	2:03		Y	2:18		Y	c	NE		Y	129	21	457
11	:00	:05	:15											N	1:02		N	c		ST	Y	1 2 9	21	457
12	:00	:07	:12	:18	:26									Y	1:10		Y	c			Y	129	21	457
13	:00	:05	:12	:58	1:02	2:24	2:29	2:39	2:55	3:19				Y	,3:48		N	c			Y	129	21	457
14	:00	:14	:21											N		11:20	N	cc			Y	129	21	457
15	:00	:15	:39	:48	:58	1:07	1:16	1:23	1:32					Y	1:39		N	c			Y	129	21	457
16	:00	:03	:13											N			N	C			Y	129	21	457
17	:00	:10	:21	:31	:41									N	:59		Y	CC		so	Y	129	21	457
18	:00	:16	:26											N	:59		Y	c		so	Y	1 2 9	21	457
19	:00	:17	:27											N			N	c			Y	129	21	457
14	:00	:12	:26	:39	:53	:05	1:19	1:32						Y	1:43		Y	cc	NE		Y	129	21	457
20	:00	:12	:20	:29	:38	:47	:54	1:04						't	1:09		Y	c			Y	129	21	457
9	:00	:12	:27	:42	:52	:04	1:20	1:35	1:45					Y	1:56		Y	cc			Y	129	21	457
10	:00	:07	:22	:54	1:09									Y	1:19		Y	c	NE		Y	129	21	457
14	:00	:11	:22	:36	:48	:00	1:11	1:22	1:33	1:44	1:56			Y	2:10	13:44	Y	cc	NW	ST	Y	129	21	457
20	:00	:11	:18	:30	:37	:46	:53	1:02	1:12	1:20	1:42	1:50		Y	1:54		Y	c	N	SW	Y	129	21	457
9	:00	:14	:28	:42	:56	:08	1:17							Y	1:41	15:57	Y	cc		ST	Y	129	21	457
10	:00	:14	:17	:24										Y	:30		Y	c		SW	Y	129	21	457
21	:00	:08	:16	:30	:57	:10	1:21							Y	1:33		N	C	N	SW	Y	129	21	457
9	:00	:15	:27	:38	:53	:07	1:20	:33	1:44					Y	1:56	11:26	Y	CC		SW	Y	129	21	457
10	:00	:06	:19	:29	:37	:46	:55	:04						Y	1:11		Y	c		ST	Y	129	21	4 5 7
14	:00	:14	:25	:35	:45	:55	1:05	:16						Y	1:25	21:33	N	cc	SW	ST	Y	129	21	457
20	:00	:11	:20	:34	:58	:08	1:18							Y	1:27		N	C		ST	Y	129	21	457
22	:00	:08	:17	:26	:35	:44	:59	:18	1:34	1:41	2:23			Y	2:41		N	C	S E	ST	Y	1 2 9	21	457
9	:00	:13	:28	:41	:56	:11	1:24	:40						Y	2:00	17:33	Y	cc	SW	ST	Y	129	2 1	457
10	:00	:13	:22	:33	:40	:52	1:04							Y	1:15		Y	c		ST	Y	129	21	457
14	:00	:12	:22	:31	:42	:53								Y	1:10	14:21	N	cc		SW	Y	129	21	457
20	:00	:15	:25	:38	:44	:50	1:07	1:21						Y	1:34		N	C		SW	Y	129	21	457
14	:00	:13	:24	:36	:48	:57	1:07	1:17	1:29					Y	1:42	12:12	N	CC		ST	N	-	21	457
9	:00	:08	:21	:30	:42	:54	1:04	1:15						Y	1:22	7:52	N	CC		ST	N	-	21	457
9	:00	:12	:28	:43	:58	1:11	1:27	1:41						Y	2:02	3:52	Y	CC		ST	Y	1 57	21	457
10	:00	:09	:17	:25	:33	:42	:51	1:00	1:19	:27				Y	1:32		Y	c		SW	Y	157	21	457
23	:00	:09	:27	:35	:43	:51	:59	1:08						Y	1:17		N	c		SW	N		21	457
14	:00	:12	:26	:37	:51	1:05	1:16	1:31						Y	1:54	12:45	Y	CC	W	ST	N	-	21	457
9	:00	:11	:21	:32	:43	:55	1:04	1:14	1:25					Y	1:38	8:14	Y	CC	N	ST	N	-	21	457
10	:00	:11	:24	:33	:45	:53	1:27	1:49	1:57	;:27	3:01	3:28	3:43	Y	3:57		Y	c	N		N	-	21	457
9	:00	:13	:29	:42	:51	1:09	1:26	1:37	1:48					Y	2:09	1:21	Y	cc		ST	N	-	21	457
24			:00	:07	:14	:24	:34	:44						Y	1:37		N	C			N	-	21	457
14														N		15:38	N	CC			N	-	2 1	457
9														N		12:49	N	cc			N	-	21	457



Flight #25
25 Sept 1982 1005-1411 hours

Seismic vessel: Western Aleutian

status : shooting until 1315 hours
Vessel heading: 030°
Vessel speed: 4.5 knots

Weather: clear, unlimited visibility, 1-3 knot winds, Beaufort 1
Altitude survey flown: 457 m
Objective: grid survey, behavioral studies

Sonobuoys dropped: 2

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▬ 41A	yes	yes	157	27-28
#2 ▼ 57A	yes	yes	157	27-28

Whales seen: Yes

Water depth at whale positions: [42] = 19 m
Total # of whales seen: 42
Total # of cow/calf pairs: 2
Total # of calves: 3

Comments: No survey grid flown due to heavy fog around seismic vessels.

- Western Aleutian - 157 km distant - active
- Krystal Sea - 154 km distant - active
- Western Polaris - 117 km distant - active

All vessel positions and status confirmed

Flight #26

27 Sept 1982 1237-1250 hours

Seismic vessel: N/A

Status: N/A
Vessel heading: N/A
Vessel speed: N/A

Weather: heavy fog, less than one mile visibility
Altitude survey flown: 91.4 m
Objective: grid survey

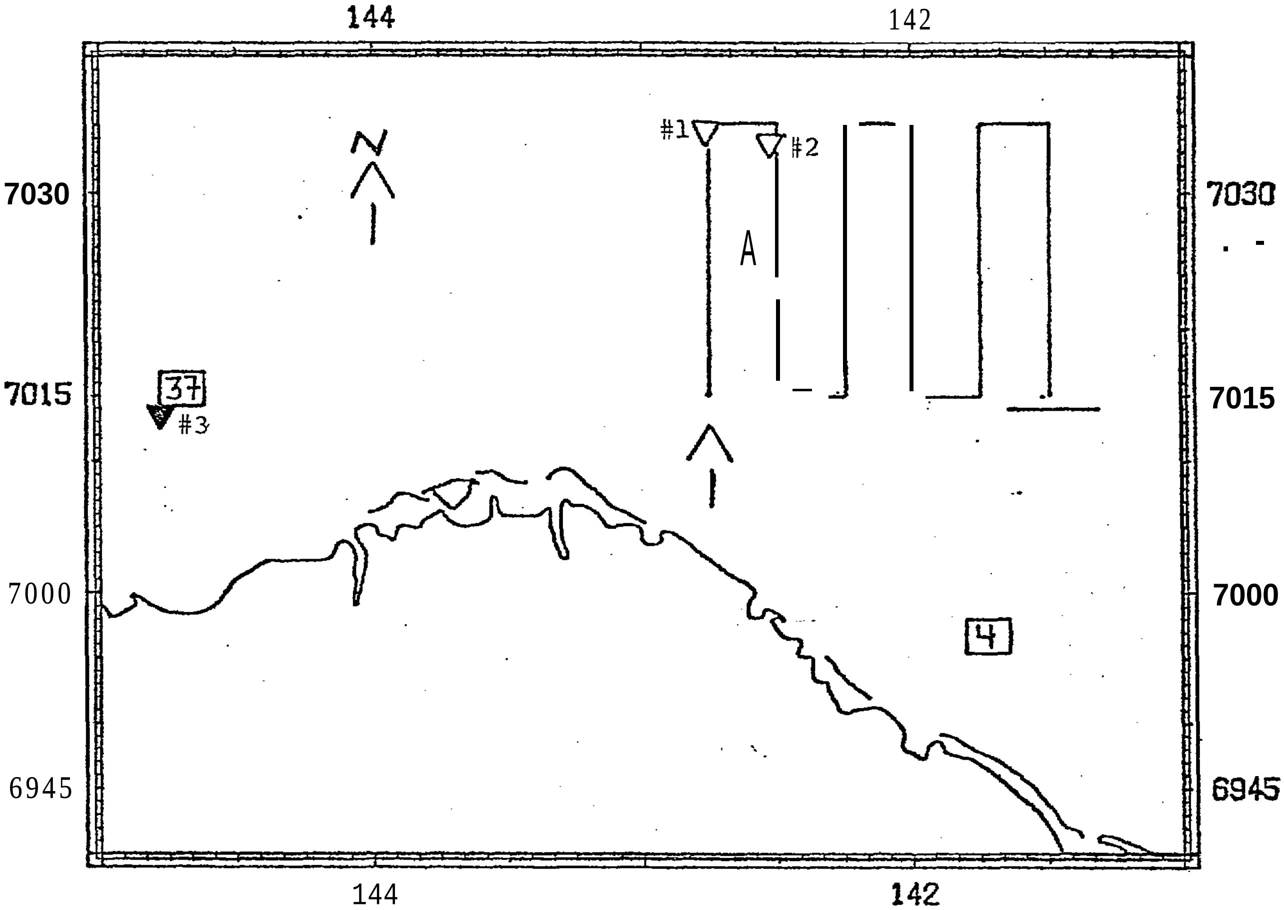
Sonobuoys dropped: 0

Whales seen: No

Comments: Flight aborted due to heavy fog.

28 SEPT 1982 FLT 27 & 28

Whale No.	Blow series (min: sec elapsed)						Full Blow Sequence	Total Surface Time	Total Dive Time	Interacting (within one) Body Length)	Adult=A Cow=CC Calf=C	Heading	Behavior Comment	Seismic Sounds	Distance from Nearest Active Seismic Vessel (km)	Water Depth at Whale Position (m)	Aircraft Altitude (m)
	1	2	3	4	5	6	Yes(Y) or No(N)	min:sec	min:sec	Y or N				Y or N			
133		:00	:14	:29	:41	:57	N			N	A	E	SW	N	-	29	244



Flights #27 & 28
28 Sept1982 1043-1725 hours

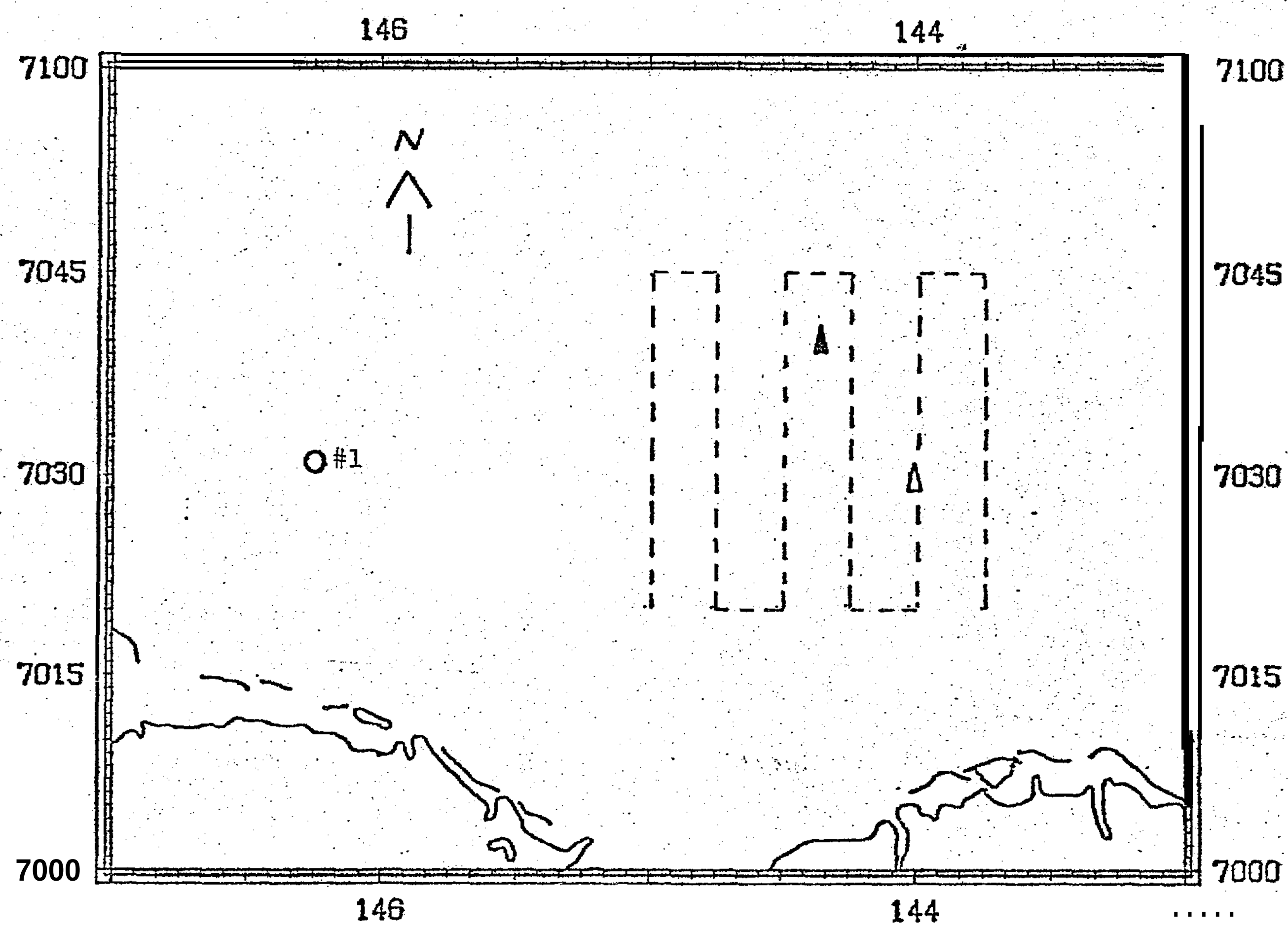
Seismic vessel: Mariner
Status: "shooting
Vessel heading: 330°
Vessel speed: 4.7 knots
Weather: clear to patchy fog, visibility from 3 miles to unlimited, 7-10 knot winds, Beaufort 3
Altitude survey flown: 305 m
Objective: grid survey, behavioral studies

Sonobuoys dropped: 3

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	no	no	18	55
#2 ▽ 57A	yes	no	18	55
#3 ▼ 57A	no	no	83	3 3

Whales seen: Yes
Water depth at whale-positions: 37 28 m; 4 = 28 m
Total # of whales seen: 41
Total # of cow/calf pairs: 0
Total # of calves: 1

Comments: Sonobuoys #1 and #3 malfunctioned-



Flight #29
29 Sept 1982   1038-1237 hours

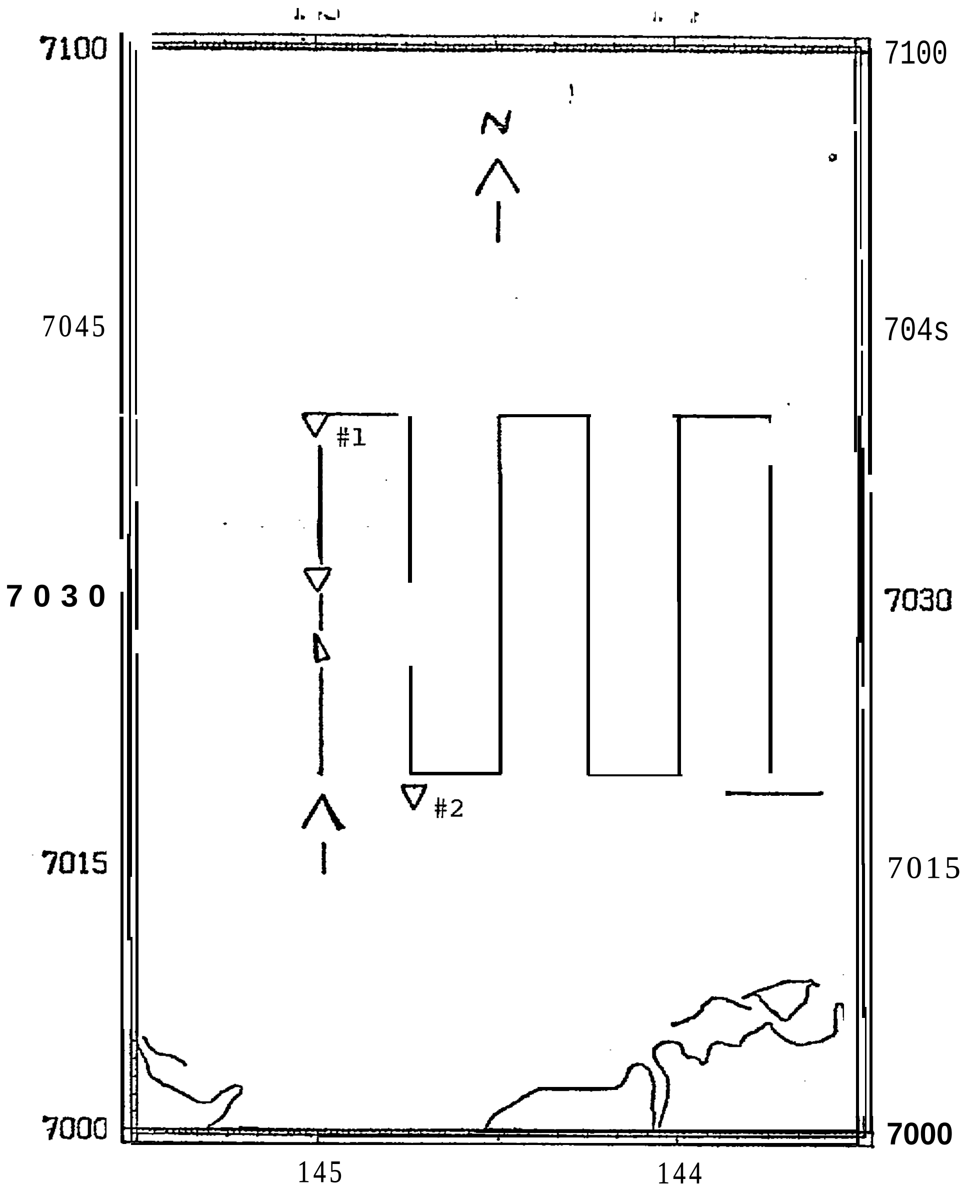
"Seismic vessel: Mariner
Status: shooting
Vessel heading: 360°
Vessel speed: 4.7 knots
Weather: patchy fog, visibility from 2 miles to unlimited, 17-20 knot winds, Beaufort 5
Altitude survey flown: 189 m
Objective: grid survey

Sonobuoys dropped: 1

Sonobuoy type	Seismic sounds yes/no	Whale-sounds yes/no	Km from seismic source	Water depth (m)
#10 41B	no	no	74	36..

Whales seen: No

Comments: Intended grid not completed due to heavy fog.



Flight #30
30 Sept 1982 1110-1415 hours

Seismic vessel: Western Aleutian
Status: shooting
Vessel heading: 330°
Vessel speed: 4.5 knots
Weather: overcast to heavy fog, visibility unlimited, 35-40 knot winds, Beaufort 6
Altitude survey flown: 457 m
Objective: grid survey

Sonobuoys dropped: 3

Sonobuoy tupe	Seismic sounds yes/no	Whale sounds yes/no	Km from seismic source	Water depth (m)
#1 ▽ 57A	yes	no	18	27-28
#2 ▽ 57A	yes	no	18	24
#3 ▽ 57A	no	no	2	

Whales seen: No

Comments: Sonobuoy #3 saturated.

Flight #31

1 Ott 1982 1034-1105 hours

Seismic vessel: N/A

status : N/A

Vessel heading: N/A

Vessel speed: N/A

Weather: fog, ice, visibility less than one mile

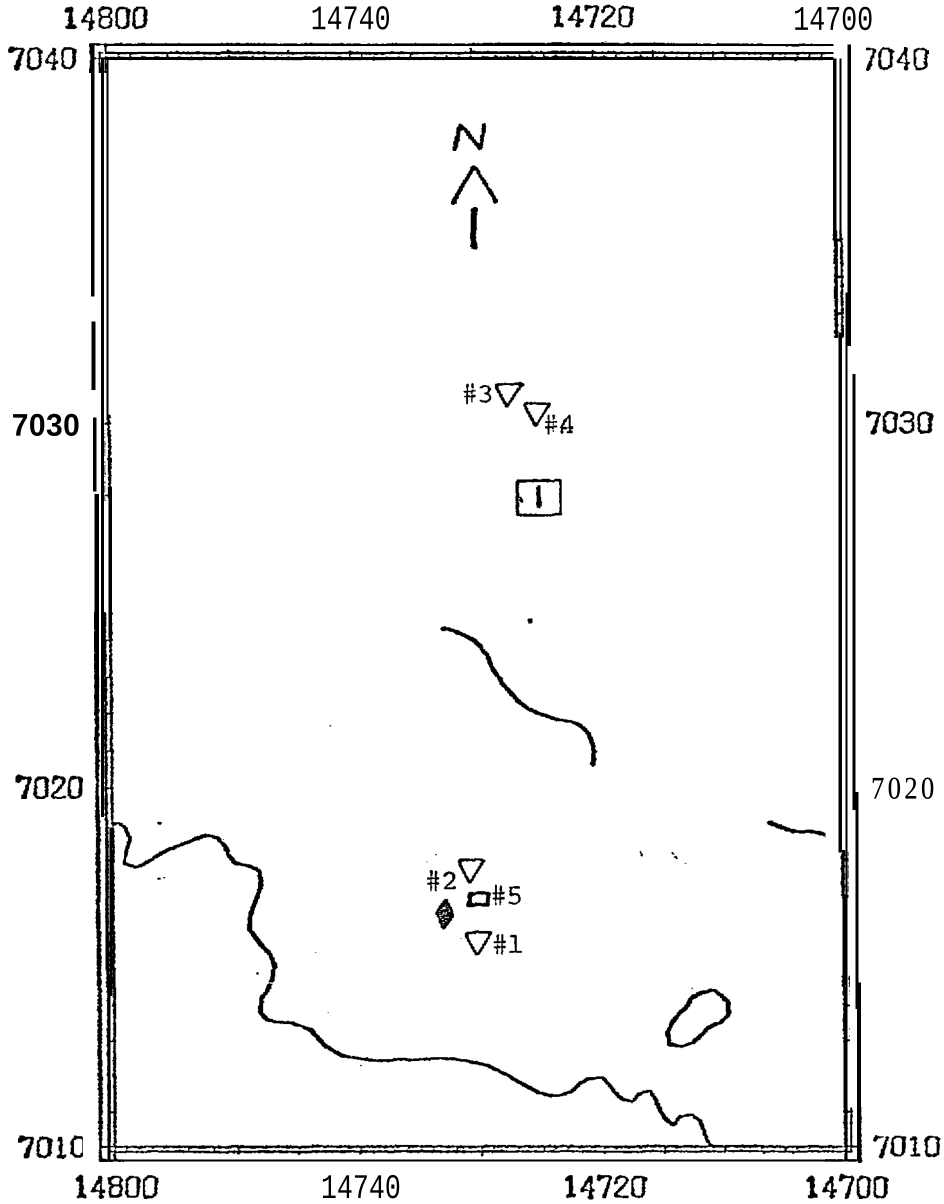
Altitude survey flown: 1.52 m

Objective: grid survey

Sonobuoys dropped: 0

Whales seen: No

Comments: Aborted flight due to icing conditions.



Flights #32, 33, & 34
2 Oct 1982 1104-1221; 1404-1618; 1708-1737 hours

Seismic vessel: N/A
Weather: heavy fog, 1-2 mile visibility', 7-10 knot winds, Beaufort 3
Altitude survey flown: 152 m
Objective: monitor construction noise from artificial island (Tern Island)

Sonobuoys dropped: 5

Sonobuoy type	Seismic sounds yes/no	Whale sounds yes/no	Km from noise source	Water depth (m)
#1▽ 57A		no	1	5-6
#2▽ 57A		no	6	5-6
#3▽ 57A	*N/A*	no	30	18-19
#4▽ 57A		no	30	18-19
#5□ 41A		no	1	5-6

Whales seen: Yes
Water depth at whale position: [1] = 16 -17 m
Total # of whales seen: 1
Total # of cow/calf pairs: 0
Total # of calves: 0

Comments: ◆ represents Tern Island.