SHIPBOARD SURVEYS OF ENDANGERED CETACEANS IN THE NORTHWESTERN GULF OF ALASKA

by

John J. Brueggeman, Gregory A. Green, Ronald W. Tressler, and Douglas G. Chapman

Envirosphere Company
10900 N.E. Eighth Street
Bellevue, Washington 98004

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ABSTRACT

Shipboard surveys were conducted during June-July 1987 along 2,034 nmi of trackline south of the Alaska Peninsula to determine the abundance and distribution of endangered whales and other marine mammals. There were 150 observations of humpback whales, 122 of finback whales, 351 of Dan porpoises, 101 of killer whales, 12 of minke whales, 3 of harbor porpoises, and 170 of pinnipeds and sea otters. Humpbacks were primarily associated with the 50-fathom isobath, particularly near banks. Finbacks were associated with the 50- and 100-fathom isobaths, particularly near the Shelikof Strait submarine canyon and some banks. Humpbacks and finbacks were observed on one occasion feeding together, but their distribution generally did not overlap. The other species were widespread in the study area except for killer whales, which were observed together east of Kodiak Island. Abundance was estimated for humpbacks at 1,247 (±392 SE) and finbacks at 1,257 (±563 SE). Sample sizes were too small to estimate abundance for the other species. These results are similar to those developed for this area in 1985.

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INTRODUCTION

Seven species of endangered whales seasonally inhabit the northwestern Gulf of Alaska (Rice and Wolman 1982; Morris et al. 1983) .Humpback, finback, and possibly right whales feed in the outer continental shelf and slope waters during the summer and early fall, while the distribution of blue, sei, and sperm whales is more pelagic (Berzin and Rovnin 1966; Rice 1974). Gray whales pass through the Gulf of Alaska twice each year on their annual migration between breeding lagoons in Mexico and feeding grounds in the northern Bering and Chukchi seas (Braham 1984a). Small numbers of gray whales also feed in the nearshore areas of the Gulf of Alaska (Brueggeman et al. 1987) and along the north side of the Alaska Peninsula (Gill and Hall 1983).

The numbers of these whales in the Gulf of Alaska were severely reduced by commercial whaling. Although the North Pacific right whale was protected in 1937 the population has yet to recover: current estimates are that only a few hundred remain (Rice 1974; Rice and Wolman 1982). The population was so reduced by commercial whaling that only 20 right whales were harvested by shore-based whalers in the Gulf of Alaska between 1900 and 1937 (Brueggeman et al. 1986). Over 2,339 blue, humpback, finback, and sperm whales were taken between 1926 and 1937 by the Port Hobron shore-based whaling station, located on Sitkalidak Island (Brueggeman et al. 1985; Reeves *et al.* 1985). Virtually all of these whales were captured southeast of Kodiak Island over Albatross Bank. In addition, 5,325 animals of these four species were taken between 1912 and 1939 by the Akutan Island shore-based whaling station (Brueggeman et al. 1985; Reeves et al. 1985). Most of these whales were captured south of Unimak Pass, in the area including Davidson Bank. Soviet and Japanese pelagic whaling fleets further harvested blue and humpback whales from these waters until their protection in 1967 and finback and sei whales until their protection in 1976 (Rice and Wolman 1982). Population levels of North Pacific rorquals presently range from approximately 8-14% (1,200-2,100) of the estimated original humpback whale population to 32-4470 (14,620-18,630) of the original finback population (Bra ham 1984b; Darling and Morowitz 1986). The gray whale is the only endangered whale species that has apparently recovered to pre-exploitation levels.

Most of the existing information on endangered whale abundance, distribution, and habitat use patterns in the northwestern Gulf of Alaska has been derived from limited systematic surveys, opportunistic sightings, and historic whaling records. Aerial and vessel surveys have been conducted by the National Marine Mammal Laboratory (NMML) and other investigators (Braham *et al.* 1977; Rice and Wolman 1982; Leatherwood et al. 1983; Braham 1984a; Rugh 1984; Stewart et *al.* **1987)** supported through the NOAA/MMS Outer Continental Shelf Environmental Assessment Program (OCSEAP). While these efforts have contributed substantially to better understanding the biology of these species, the results remain inconclusive because of the large area surveyed, the complexity of survey logistics, and the small number and sporadic distribution of many of the endangered cetaceans.

In 1985, extensive aerial surveys were conducted by Brueggeman *et al.* (1987) to characterize the use of the northwestern Gulf of Alaska and southeastern Bering Sea by

endangered cetaceans and other marine mammals. That OCSEAP study resulted in over 25,000 nmi of survey effort, and the first estimates of humpback and finback whale abundances in this region. The present study is a follow-up to the 1985 surveys and was conducted between 18 June and 14 July 1987, aboard the NOAA ship *Miller Freeman*. The primary objectives of the study were to:

1) Characterize the abundance, distribution, and habitat use patterns of endangered whales summering in the Shumagin and Kodiak lease planning areas and the lower portion of the Cook Inlet Planning Area.

2) Compare the above findings with the 1985 aerial survey results to examine annual patterns of distribution and abundance.

3) Document sightings of other marine mammals encountered during the survey.

STUDY AREA

The study area is located south of the Alaska Peninsula on the outer continental shelf, and includes Davidson Bank, Sanak Bank, Shumagin Bank, Albatross Bank, Shelikof Strait, portions of Portlock Bank, and the inland waters of Kodiak Island (Figure 1). The continental shelf in the northwestern Gulf of Alaska is generally rock-bottomed with extensive reefs, island complexes, and submarine canyons. The shelf extends approximately 40 nmi from the mainland coast before dropping precipitously to almost 4,000 fathoms deep in the Aleutian Trench. Surveys were primarily conducted on the shelf.

The oceanography off the Alaska Peninsula is influenced primarily by the nearshore Alaska Coastal Current (ACC), and to a lesser degree by the Alaska Stream. The narrow ACC current, driven by snowmelt and runoff, travels southwestward along the south side of the Alaska Peninsula before entering the Bering Sea through Unimak Pass (Royer 1981; Schumacher and Moen 1983). The ACC is bifurcated by islands and submarine canyons at various locations; this separation, in turn, creates zones where shelf and current waters mix (Schumacher and Reed 1986). The much stronger Alaska Stream flows southwestward along the continental shelf edge, The persistent and heavy winds characteristic of the area influence these currents and, in turn, the biological oceanography in the study area. Average monthly wind speeds range between 13 and 16 knots, and are highest and most persistent during the winter.

The climate of the northwestern Gulf of Alaska is maritime and is seldom influenced by continental air masses. Both daily and seasonal air temperature extremes are confined to fairly narrow limits, and readings below O“F are very rare.

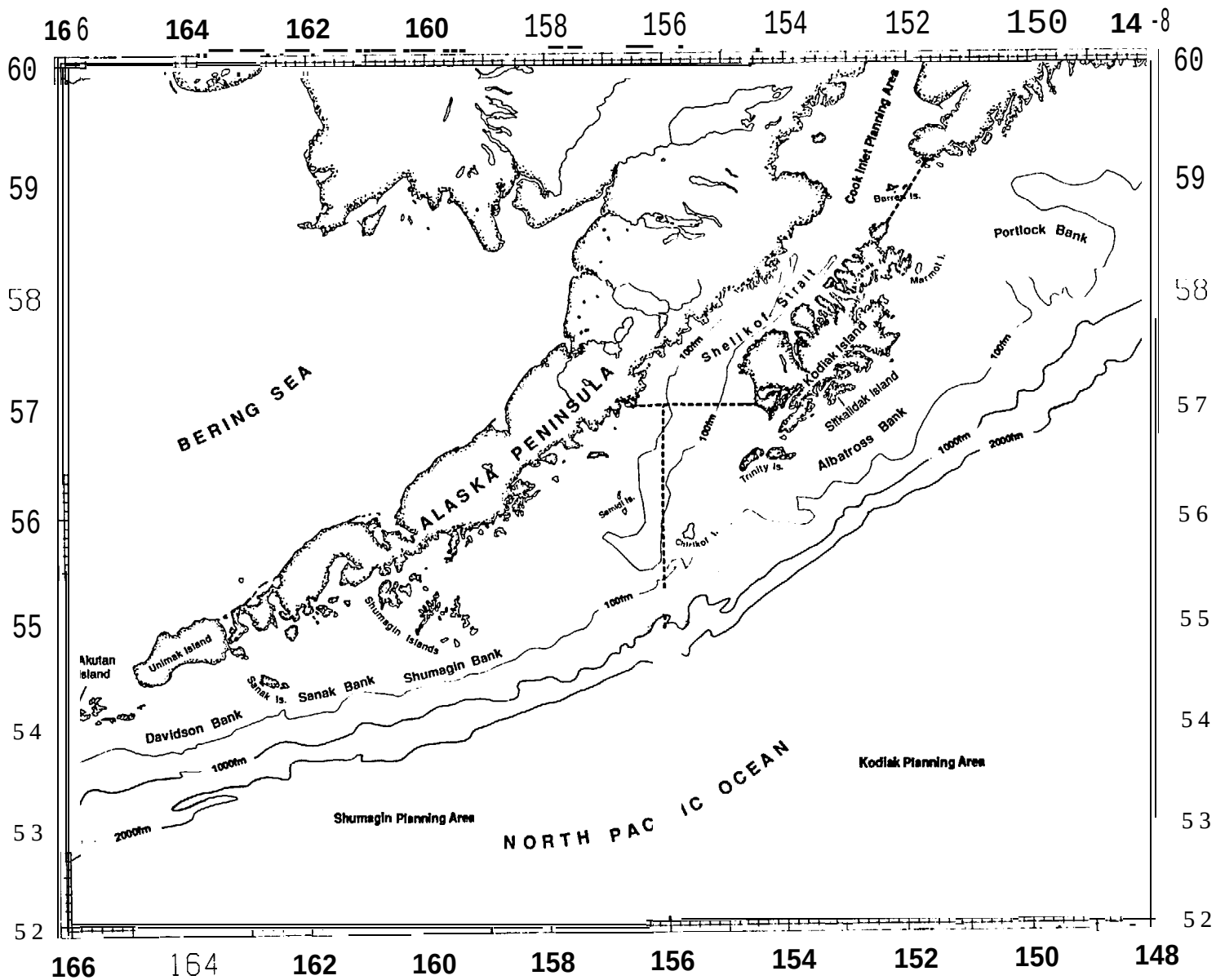


Figure L-Study area map showing place names and planning areas mentioned in the text.

METHODS

Survey Design and Procedures

This study was conducted simultaneously with a NMFS/PMEL study to investigate dispersal of larval walleye pollock produced in Shelikof Strait. Larval pollock were surveyed by conducting net tows at 145 stations systematically distributed across the outer continental shelf south of the Alaska Peninsula from Unimak Pass and to beyond Kodiak Island. Tow stations were distributed along transect lines located perpendicular to the coast. Marine mammals were surveyed along transect lines traveled between tow stations. The survey area encompassed most of the Shumagin and Kodiak planning areas and the southern half of the Cook Inlet Planning Area. Survey legs between stations were approximately 15 nmi in length.

Surveys for marine mammals were conducted by a single observer from the ship's flying bridge, 40 ft above the water line. The observer recorded data on animal sightings, environmental conditions, and location. Information on ship position, water depth, water temperature, and wind speed were provided to the observer by the officer on duty via walkie-talkie. The ship's speed between stations was generally 10-12 knots. The observer viewed a 45-degree area centered on the bow of the ship. Viewing was terminated when seas reached a Beaufort 6. To reduce the effects of fatigue, observers switched watches every 4 hours. For each group of marine mammals observed, sighting information included: group size, species, radial angle from the direction of travel by the ship, distance from ship estimated in 0.25-nmi intervals, direction of travel, number of calves, and an estimation of whether the sighting was probably a duplicate of a recent sighting. The radial angle was measured with a compass mounted on a stand and the distance was estimated with a sighting gauge graduated in 0.25-nmi intervals. Environmental information included sea state according to the Beaufort wind scale with sea state descriptors (Black and Adams 1983), visibility, and glare. Definitions of visibility and glare conditions are provided in Appendix A. Environmental conditions were evaluated by the observers at the beginning and end of each leg and whenever conditions changed. The position of the ship was recorded when environmental data were collected and when a marine mammal was sighted. Position was recorded to a tenth of a minute of latitude and longitude.

Three types of surveys were conducted during this study: systematic, random, and deadhead. Systematic surveys were the tracklines connecting the tow stations. Random surveys were conducted when traveling west to east from the end of one systematic survey line to the beginning point of the next one. Deadheads were off-effort surveys conducted when the ship was stopped or viewing conditions were unacceptable. Only random and systematic survey data were used in density and abundance analyses. Deadhead survey data were used in characterizing distributions of each species.

Analytical Procedures

Humpback and finback densities were estimated using a non-parametric Fourier series line transect estimator (Burnham *et al.* 1980). The set of perpendicular distances of whale groups from the transect line was used to develop a probability density function, which is the conditional probability of observing an object given that the object is a certain distance from the transect line (Burnham *et al.* 1980). The value of this function for perpendicular distance relative to O (on the trackline, where the probability is 1.0) can then be used to calculate a density based on the number of groups observed along a known length of trackline. Line transect sampling and Fourier series estimators are the standard approaches for estimating cetacean abundance (Hay 1982; Brueggeman *et al.* 1987).

Line-Transect Assumptions

The line-transect procedure was based on the following assumptions:

1) Either the population is distributed randomly within the study area or the transect line is located randomly.

2) All groups directly on the transect line are detected.

3) Groups do not move in response to the observer prior to being detected.

4) All distance and angle measurements are made without error.

5) Sightings are independent events.

Requirements for accurately estimating marine mammal density from a ship include:

1) The group size does not affect the group's probability of being observed.

2) Survey conditions (weather, visibility) do not influence the sightability of whales.

The degree to which the above assumptions were fully satisfied is unclear because of the difficulties involved in surveying mobile marine mammals. However, the following survey and analytical procedures were implemented to reduce biases in the results.

The first assumption was satisfied by traveling transect lines that were randomly located throughout the study area. The second assumption, that all groups directly on the line are detected, was probably satisfied because of the slow speed of the survey ship and the size of the larger whales. However, it is likely that some groups on the line were submerged and were not detected by the observers during the survey. The effect of missed animals on the density estimate was uncertain because studies were not conducted to develop site-specific correction factors. Failure to detect all whales probably resulted in estimates that were lower than actual numbers.

It was difficult to assess the assumption that the whales did not move in response to the vessel prior to being detected. Whales could have dived in response to the ship or they could have moved in some direction, which would have changed their perpendicular distances from the transect line. However, the shape of the detection curve of observed perpendicular distances showed no evidence of movement by large whales away from the transect line.

The assumption that measurements were free of error depended upon accurate estimates of the sighting angle and the straight-line distance to the point where the whales were first detected. The angle between the transect line and the vector from the vessel to the group was estimated with a large map compass mounted on the bridge rail. The distance from the vessel to the whale was estimated using a sighting gauge calibrated to read 0.25-nmi intervals of distance. The measurements were taken by trained observers familiar with this procedure. In addition, the sightability curves of perpendicular distances were truncated as recommended by K. Burnham (pers. commun.) to reduce the effect of long-distance measurements, which are typically less accurate, on the f(0). This helped produce a better fit of the detection curve to the data and reduced errors from these sources of bias in the estimate of f(0) (Burnham *et al.* 1980).

Because a group of whales, rather than each individual, was considered an observation, only in cases where two or more groups were close together was the independence of observations uncertain. Modest violations of this assumption do not affect the density estimate but do affect the variance of the density estimate (Burnham *et al.* 1980). The effects of weather and visibility conditions on the observer's ability to detect whale groups were investigated by conducting Chi-square analyses (Zar 1984) of observed and expected numbers of groups during various Beaufort sea states and visibility conditions. Any transect segments during which conditions significantly affected the observer's ability to detect whales were eliminated from further analyses. We also examined f(0) estimates to test the effect of different sighting conditions on sightability.

Line-Transect Calculations

Estimates were developed for the density and total number of whales in each planning unit and summed for all planning units. A variance was calculated for each estimate. The calculation procedures are described below.

The density of groups in each planning unit was estimated by the equation:

$$D_G = \frac{n\,f(0)}{2L} \qquad \text{(Equation 1)}$$

where D_G is the density of groups (number/nmi^2), n is the number of groups observed, f(0) is the value of the probability density function on the trackline, and L is the trackline length (nmi). Program TRANSECT (Laake *et al.* 1979) was used to calculate f(0).

The total number of whales in a planning unit was calculated using the equation:

$$N_I = D_G \, A \, \overline{G} \qquad \text{(Equation 2)}$$

where N_I = number of individuals, A = area of study (nmi^2), and G is the mean group size.

An estimate of the sampling variance for abundance of whales in each planning area was derived by the equation:

$$V(N_I) = A\,Z\,\left[D_G^2\,V(\overline{G}) + \overline{G}^2\,V(D_G) - V(\overline{G})\,V(D_G)\right] \qquad \text{(Equation 3)}$$

where

$$V(\overline{G}) = \frac{\sum_{i=1}^{n} G_i^2 - \frac{\left(\sum_{i=1}^{n} G_i\right)^2}{n}}{n\,(n-1)} \qquad \text{(Equation 4)}$$

where n = number of groups and G = size of each group, and

where $V(D_G) = D^2(CV^2(f(0)) + CV^2(n))$

and CV^2 (f(0)) is the square of the coefficient of variation of f(0), and $CV^2(n)$ is the square of the coefficient of variation of the number of groups observed.

The total number of whales for the entire study area was estimated by adding the planning unit abundance estimates. The variance associated with the total estimate was calculated by the equation:

$$V(N_T) = V(f(0))\overline{G}^2 \left(\sum_{i=1}^{k} \frac{A_i n_i}{2L_i}\right)^2 + (f(0))^2 V(\overline{G}) \left(\sum_{i=1}^{k} \frac{A_i m_i}{2L_i}\right)^2 + \qquad \text{(Equation 5)}$$

$$(f(0))*G*\left(\sum_{i=1}^{k}\left(\left(\frac{A_i}{2L_i}\right)^2 V(n_i)\right)\right)$$

where V(f(0)) is the variance of f(0), k is the number of planning units, A_i is the area within planning unit i, n_i is the number of groups observed in planning unit i, L_i is length of trackline in planning unit i, and $V(n_i)$ is the variance of the number of groups observed in planning unit i as calculated from the following equations.

$$V(n_i) = \frac{L\left(\sum_{i=1}^{R}\left(l_i\left(\frac{n_i}{T_i} - \frac{N}{L}\right)^2\right)\right)}{R-1} \qquad \text{(Equation 6)}$$

where R = number of line segments and L = total trackline length, l_i = length of segment i, n_i = number of groups observed on segment i.

A group density was also calculated for the combined planning areas. The value was calculated by summing the group abundance estimates for each planning area and dividing that number by the total area in the study. The variance of this point estimate was calculated as:

$$V(D) \square V(f(0)) \left(\sum_{i=1}^{k}\sum^{\kappa} \frac{n_i}{2L_i}\right)^2 + (f(0))^2 \left(\sum_{i=1}^{k}\left(\frac{V(n_i)}{(2L_i)^2}\right)\right)$$

$$V(f(0)) \left(\sum_{i=1}^{k}\left(\frac{V(n_i)}{(2L_i)^2}\right)\right) \qquad \text{(Equation 7)}$$

where $V(n_i)$ is from Equation 6.

The results of our analyses are reported in English units of measure, since the nautical charts for the study area and the data from the navigation systems aboard the ship were in English units.

RESULTS AND DISCUSSION

Species Composition and Effort

Ten species of marine mammals, including 642 cetaceans, 89 pinnipeds, and 71 sea otters (Table 1) were observed along 2,034 nmi of random and systematic trackline (Figure 2) surveyed in the study area during June and July 1987. An additional 118 cetaceans, 8 pinnipeds, and 2 sea otters were observed along 353 nmi of deadhead surveys. Because the effort was not constant during deadhead surveys, these observations were used only to describe the general distribution of a species. Approximately two-thirds of the marine mammals were sighted in the Kodiak-lower Cook Inlet planning areas, where 55% of the effort was achieved.

Two of the six cetacean species observed in the survey are listed by the Federal Government as endangered throughout their range. A total of 69 groups of 150 humpback whales were recorded, of which 90% were observed in the Kodiak-lower Cook Inlet planning areas (the two planning areas were pooled because only a small portion of the Cook Inlet Planning Area was surveyed). In addition, 58 groups of 122 finback whales were recorded, approximately 59% of which were observed in the Shumagin Planning Area. Of the four nonendangered species, Dan porpoises (351) and killer whales (101) were the most abundant. Nineteen unidentified baleen whales and three unidentified porpoises were also observed in the survey.

Table I.–Species composition and number of marine mammals observed in the three planning areas, June-July 1987.

Species	Shumagin (921 nmi)[a]		Kodiak and Lower Cook Inlet[b] (1,113 nmi)		Total (2,034 nmi)	
	Individuals	Groups	Individuals	Groups	Individuals	Groups
Cetacea						
Mysticeti						
Minke whale *(Balaenoptera acutorostrata)*	3 (l)'	2 (1)	7 (1)	6 (1)	10 (2)	8 (2)
Finback whale *(Balaenoptera physalus)*	63 (9)	30 (5)	32 (18)	16 (7)	95 (27)	46 (12)
Humpback whale *(Megaptera novaeangliae)*	15	6	112 (23)	52 (11)	127 (23)	58 (11)
Unidentified baleen	2 (1)	2 (1)	14 (2)	10 (1)	16 (3)	12 (2)
Odontoceti						
Killer whale *(Orcinus orca)*	o	0	101	2	101	2
Harbor porpoise *(Phocoena phocoena)*	0	0	3	3	3	3
Dan porpoise *(Phocoenoides dalli)*	110 (44)	29 (17)	178 (19)	72 (7)	288 (63)	101 (24)
Unidentified porpoise	2	1	o	o	2	1
Subtotal	195 (55)	70 (24)	447 (63)	161 (27)	642 (118)	231 (51)
Carnivora-Pinnipedia						
Otariidae						
Northern sea lion *(Eumetopias jubatus)*	29	1	25	17	54	18
Northern fur seal *(Callorhinus ursinus)*	17 (4)	13 (3)	17 (4)	16 (4)	34 (8)	29 (7)
Phocidae						
Harbor seal *(Phoca vitulina)*	o	0	1	1	1	1
Subtotal	46 (4)	14 (3)	43 (4)	34 (4)	89 (8)	48 (7)
Carnivora-Mustelidae						
Sea otter *(Enhydra lutris)*	13	9	58 (2)	34 (2)	71 (2)	43 (2)
Total	254 (59)	93 (27)	548 (69)	229 (33)	802 (128)	322 (60)

[a] Total distance surveyed on random and systematic surveys.
[b] The Kodiak and Cook Inlet planning areas were pooled.
[c] Additional number observed on deadhead surveys.

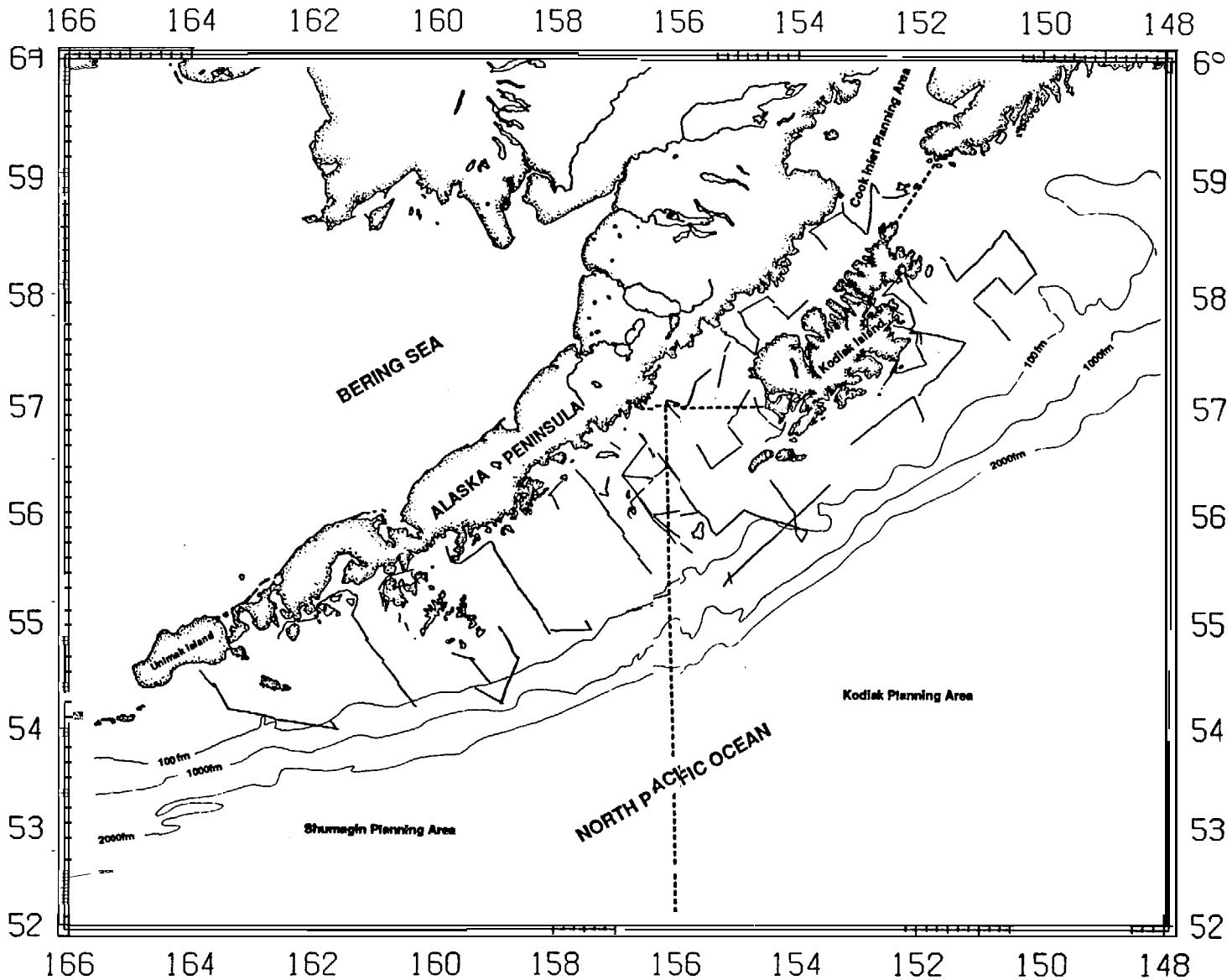


Figure 2.–Locations of systematic and random tracklines surveyed during June-July 1987 shipboard survey.

Three species of pinnipeds were recorded in the planning areas. Northern sea lions (54) were the most common pinniped, followed by northern fur seals (41) and harbor seals (1). The ship surveys avoided the shallow nearshore water where sea lions and harbor seals were most abundant.

Because environmental conditions affect the probability of detecting a whale, the survey data were examined for trends in the number of observations relative to Beaufort sea state and visibility (Figure 3). Chi-square analysis indicated that fewer humpback and finback whale groups than expected were observed when the sea state was Beaufort 5 or greater or when the visibility was poor or unacceptable ($p < 0.05$). Consequently, all quantitative analyses were based on data collected during excellent to fair risibilities and O to 4 Beaufort sea states, conditions which occurred on 1,577 nmi of the survey effort. This set of conditions is referred to as acceptable sighting conditions in the following sections of the report.

Humpback Whale

A total of 69 groups of 150 humpback whales were observed during this study. Six groups of 15 humpback whales were observed along 921 nmi of tracklines in the Shumagin Planning Area, and 52 groups of 112 humpbacks observed along 1,113 nmi of tracklines in the Kodiak-lower Cook Inlet planning areas during systematic and random surveys. An additional 11 groups of 23 humpbacks were observed on deadhead surveys in the Kodiak-lower Cook Inlet areas. Figure 4 shows the locations of all humpback whale sightings.

The distribution of humpback whales seen during acceptable sighting conditions ($n = 56$) in the planning areas was not uniform ($p < 0.05$), as they were heavily concentrated in the Kodiak-lower Cook Inlet areas (Figure 5). Observed numbers of humpbacks exceeded expected numbers ($p < 0.05$) between 150° and 154°W. Over 89% of the groups were observed in this area, whereas only 33% of the total effort was achieved there (Table 2). Most of these sightings were recorded over Portlock and Albatross banks on the seaward side of Kodiak Island (Figure 4).

Humpback whale groups were not uniformly distributed by water depth ($p < 0.05$) (Figure 6, Table 3). Nearly 93% of the humpback whale groups were observed in water depths between 25 and 100 fathoms, where 64% of the survey effort occurred (Table 3). Chi-square analysis indicated that numbers of humpback groups were higher than expected in waters 25-50 fathoms deep and lower than expected in waters greater than 100 fathoms deep. Frequent observations of humpbacks near the 50-fathom isobath coincide with the findings of the 1985 surveys (Brueggeman *et al.* 1987).

Humpbacks occupied the summer feeding grounds in clusters of small groups. The mean group size for humpback whales in the survey was 2.04 ± 0.15 SE ($n = 56$). Over 8770 of the groups included between one and three animals (Figure 7), and group sizes of two were the most common (43%). The largest group size observed was five. Many of the groups

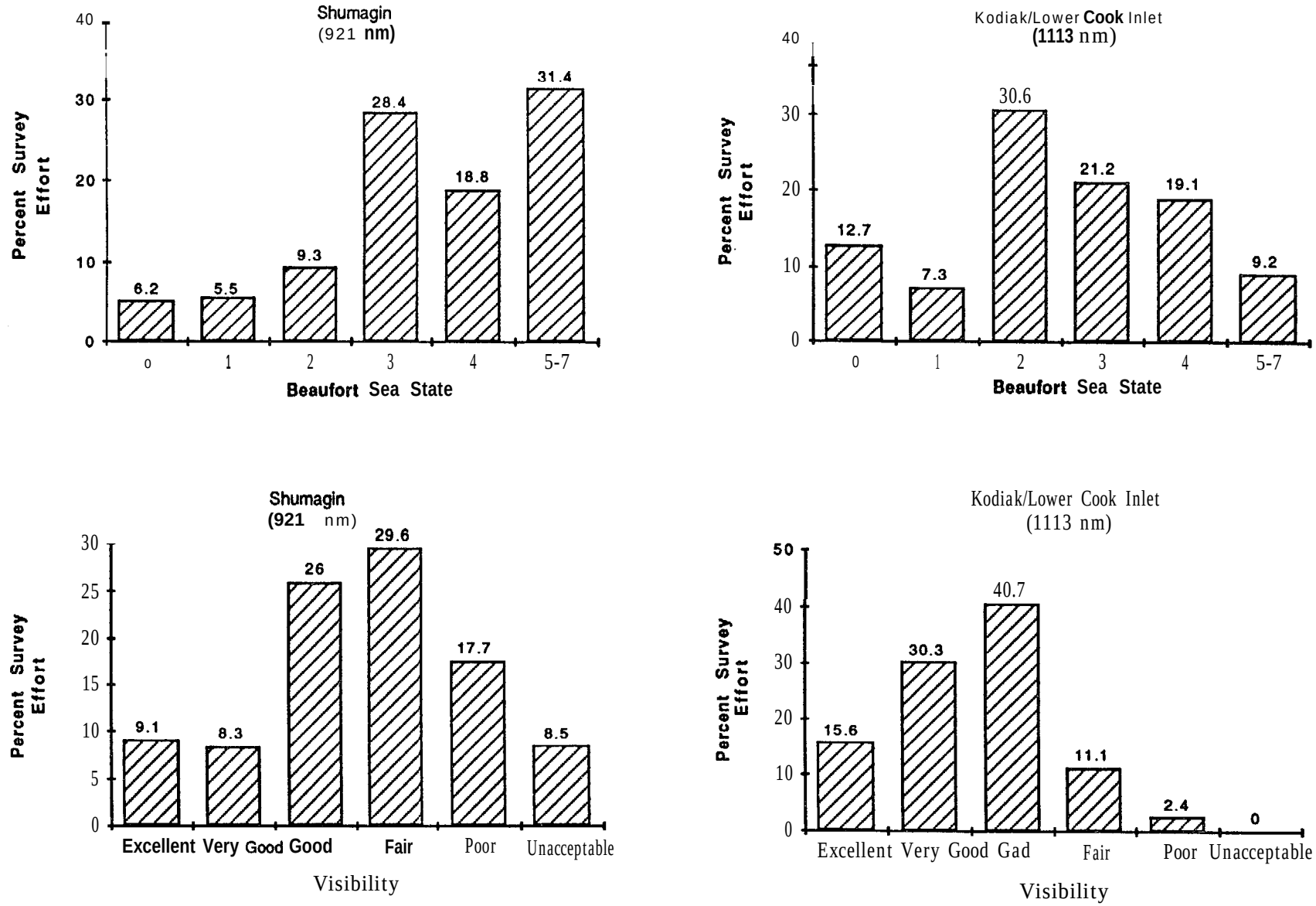


Figure 3.-Percentage of survey effort by Beaufort sea state and visibility in the Shumagin and Kodiak-lower Cook Inlet planning areas, 1987.

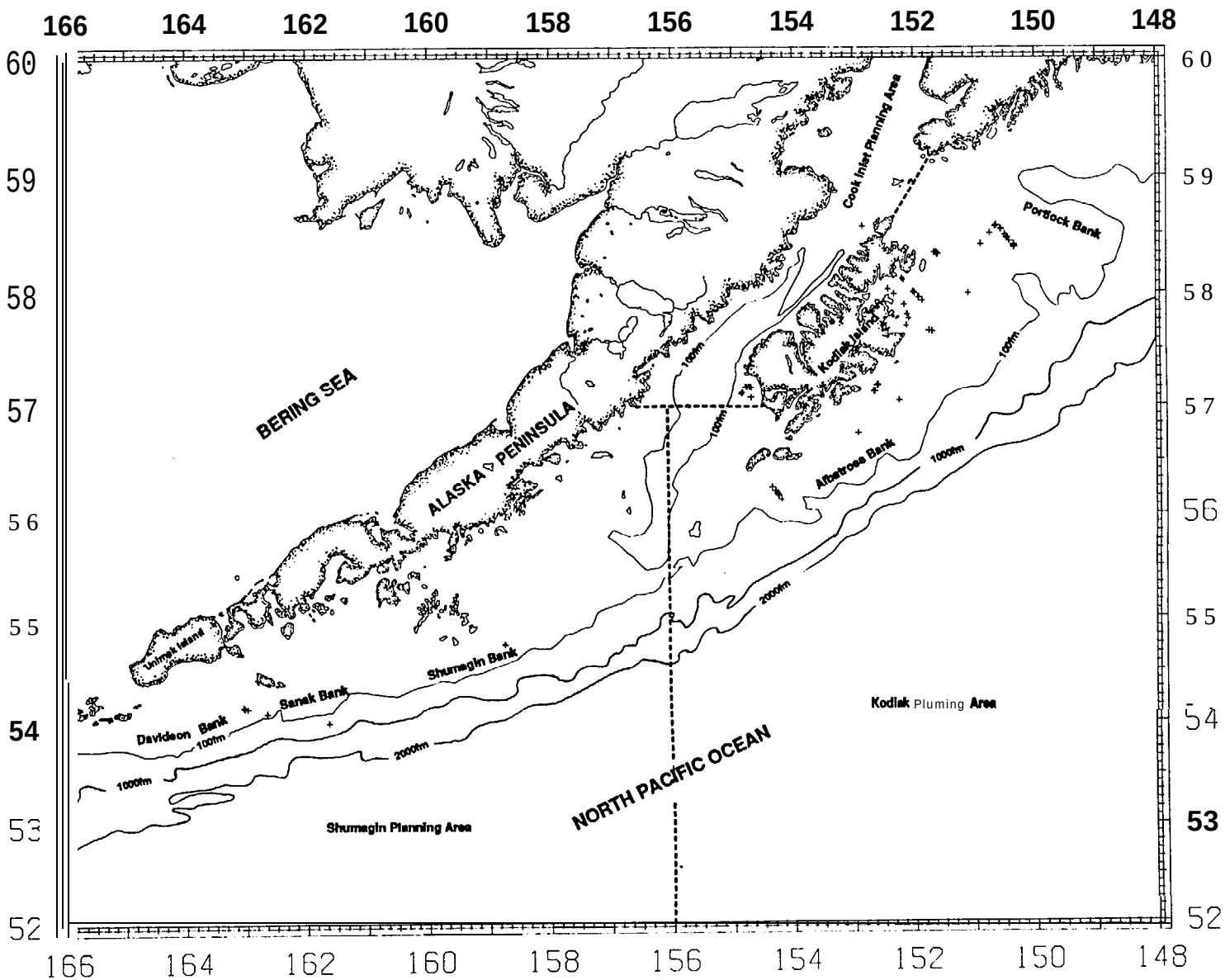
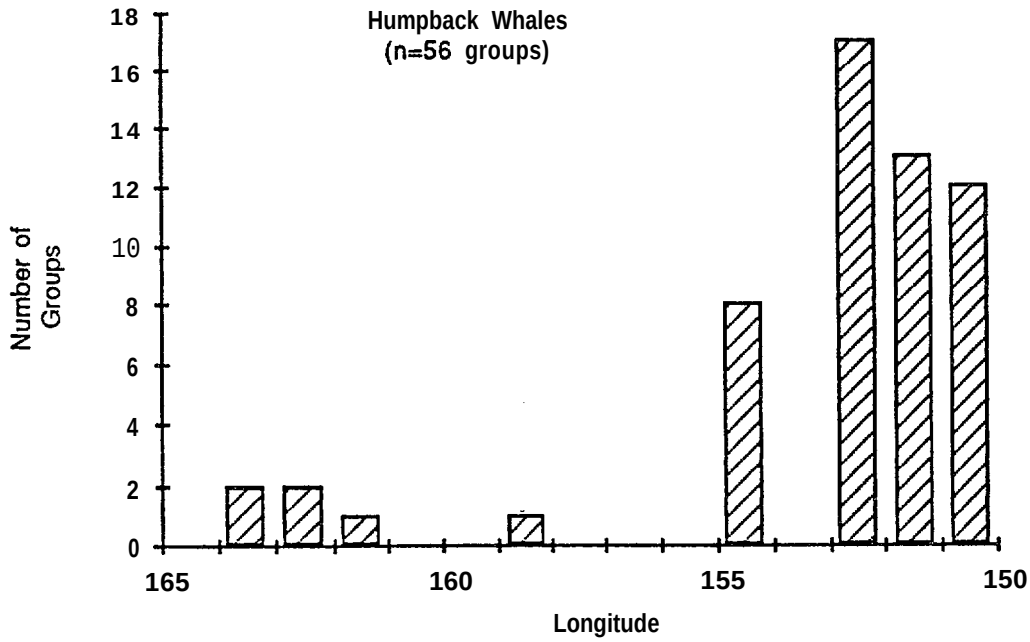


Figure 4.-Locations (+) of humpback whale sightings recorded during June-July 1987 shipboard survey.



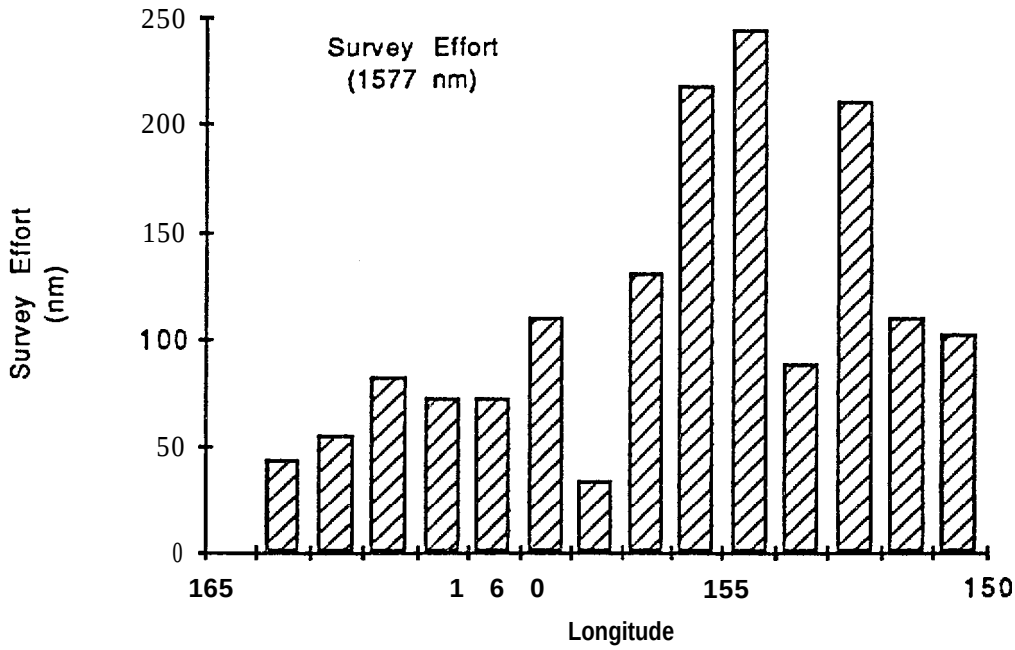


Figure 5.–Survey effort and number of humpback whale groups observed by longitude degree during random and systematic surveys.

Table 2.–Relative occurrence of humpback whale groups by longitude.

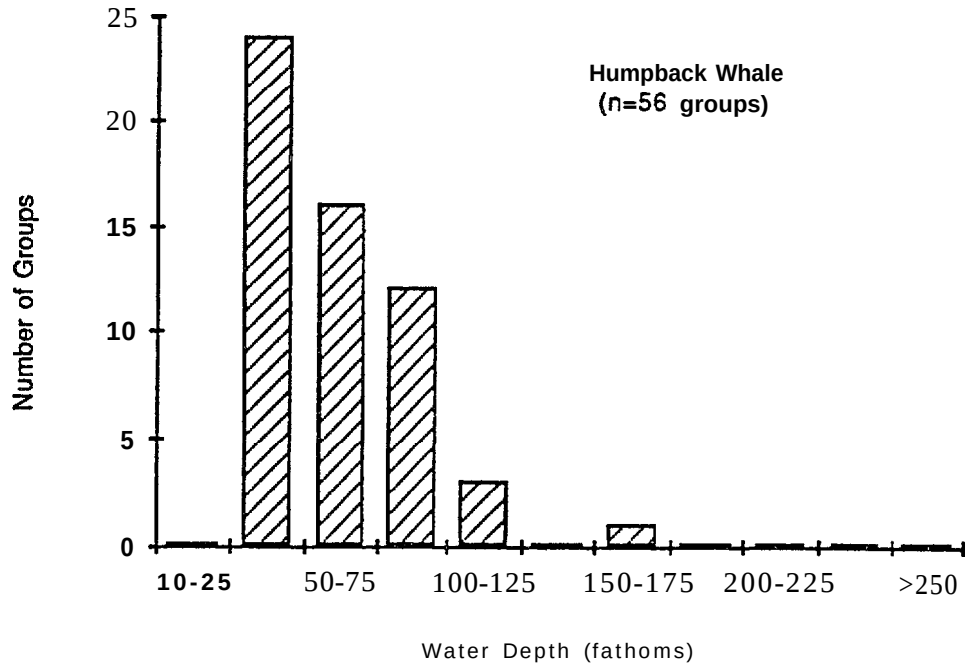
Longitude	Effort[a] (nmi)	Number of Groups Observed	Number of Groups Expected[a]	x'	Preference[c]
1500-1520(W)	214[d]	25	7.6	39.84	+
152°-1540	299	17	10.6	3.86	+
154°-1560	461	8	16.4	4.30	–
156°-1580	164	0	5.8	5.80	–
158°-1600	184	1	6.5	4.65	–
160°-1620	155	1	5.5	3.68	0
162°-1640	1 0 0	4	3.5	-007	0
Total	1,577	56	56	62.2[d]	

[a] Effort included random and systematic surveys during Beaufort O-4 and fair to excellent visibility.
[b] Expected number of groups based on proportion of effort within each longitudinal zone.
[c] + indicates preference; – indicates avoidance; and O indicates no selection ($p < 0.05$, $X^2_{0.05,1} = 3.841$).
[d] $X^2_{0.05,6} = 12.592$.

were observed in close proximity (<3 nmi) to other groups. The 1985 surveys recorded a similar figure for mean group size (1.72 ± 0.14 SE) and a similar percentage of groups with one to three animals (96%).

The majority of humpbacks observed appeared to be summering in the area, as the 23 groups of humpbacks evaluated did not exhibit the consistent directional orientation which would indicate a major movement pattern (Figure 8). Furthermore, photographic studies by Hall (1979), Rice and Wolman (1982), and Baker *et* al. (1985, 1986) further suggest that humpbacks summering in Alaska display strong fidelity to specific locations and seldom move between aggregation areas.

The behavior of the humpback whales was classified into five categories, recorded as information incidental to the surveys (Figure 9). The majority (68%) of the 51 whale groups evaluated were observed either traveling (a rapid directional movement) or in a fluke-raised dive. The remaining whales were observed milling, breaching, or feeding, categories which each accounted for 14% or less of total behavior. It was difficult for observers to accurately evaluate the behavior of the whales from the ship, especially feeding behavior observed from a long distance or in choppy seas.



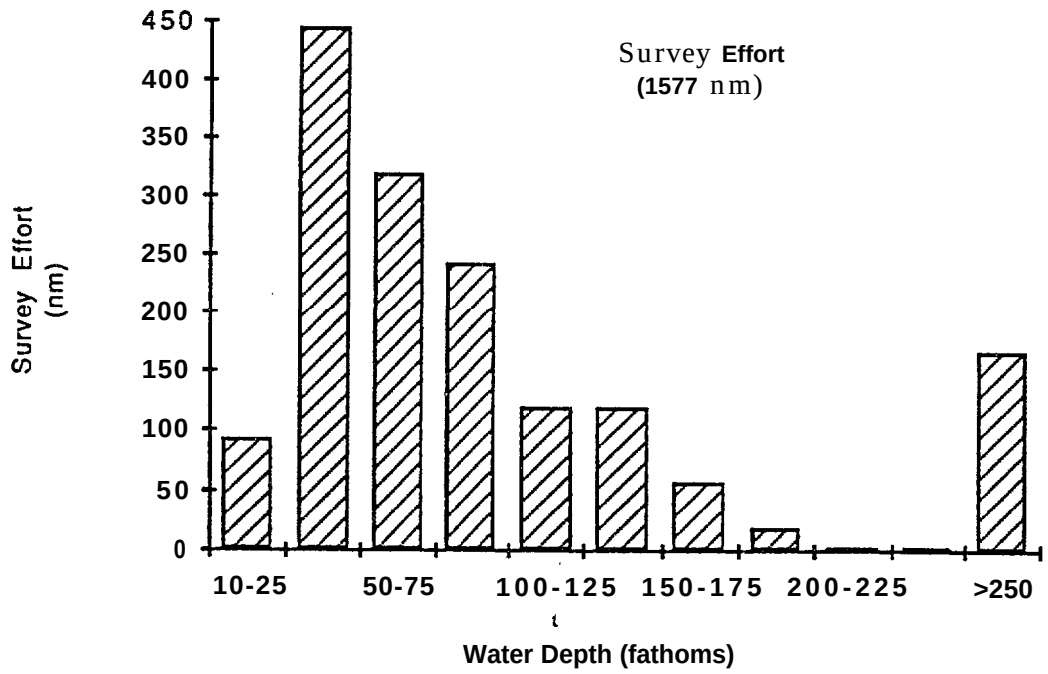


Figure 6.-Survey effort and number of humpback whale groups observed by depth class.

Table 3.-Relative occurrence of humpback whale groups by water depth.

Water depth (fathoms)	Effort[a] (nmi)	Number of groups			
		Observed	Expected[b]	x'	Preference[c]
10-25	91[d]	o	3.2	3.20	0
25-50	444	24	15.8	4.26	+
50-75	318	16	11.3	2.00	0
75-1oo	242	12	8.6	1.34	0
≥100	482	4	17.1	1004	–
Total	1,577	56	56	20.84[d]	

[a] Effort included random and systematic surveys during Beaufort O-4 and fair to excellent visibility.
[b] Expected number of groups based on proportion of effort within each depth class.
[c] + indicates preference; – indicates avoidance; and O indicates no selection ($P < 0.05$, $X^2_{0.05,1} = 3.841$).
[d] $X^2_{0.05,4} = 9.488$.

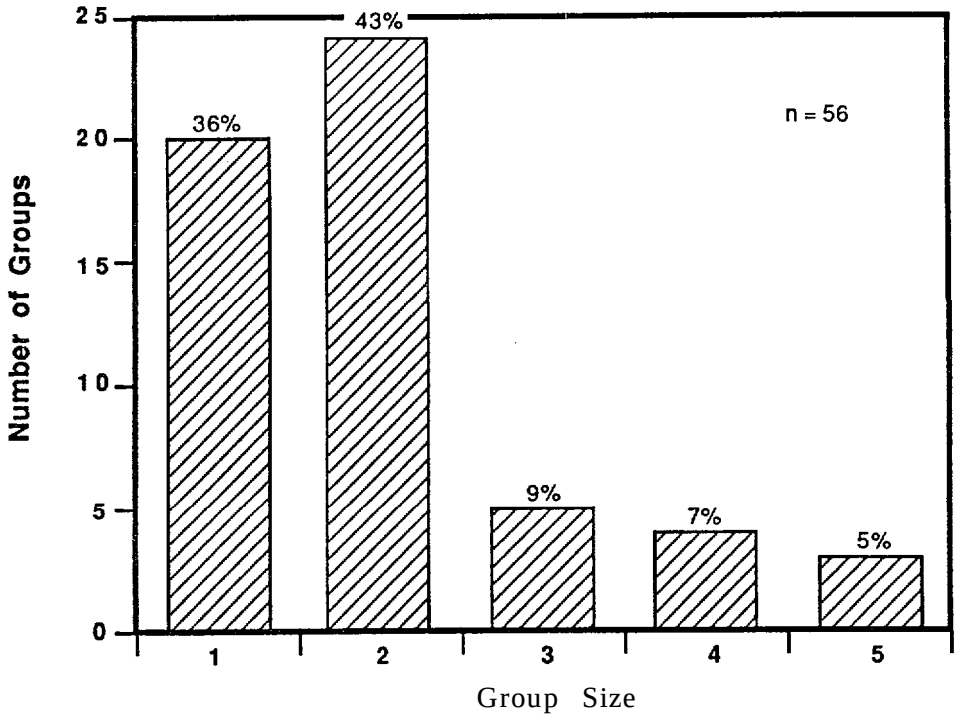


Figure 7.-Group size of humpback whales observed, 1987.

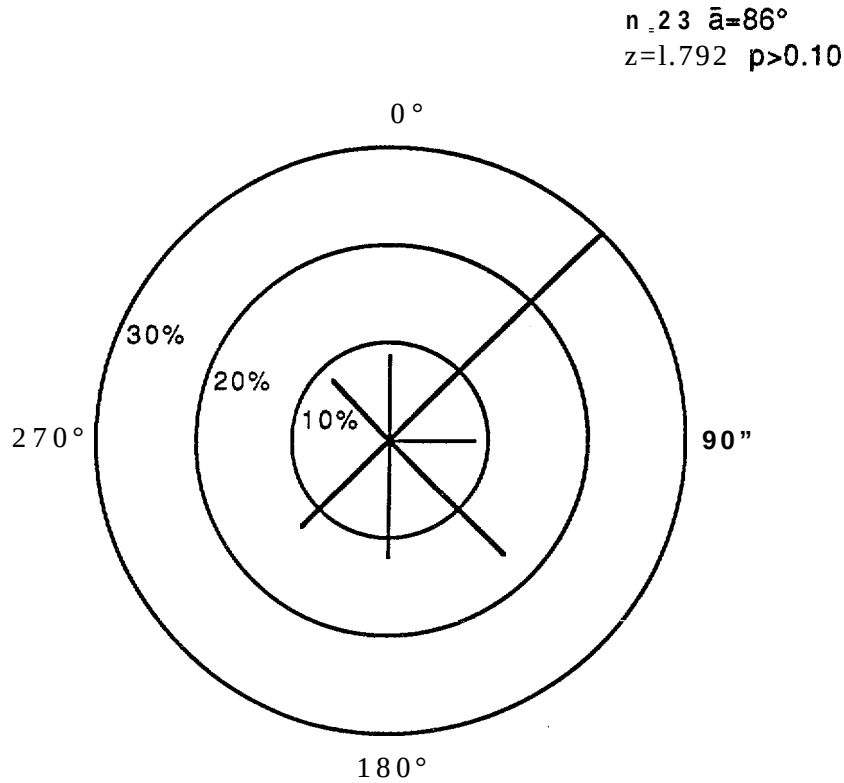


Figure 8.-Directional analysis of humpback whales, 1987.

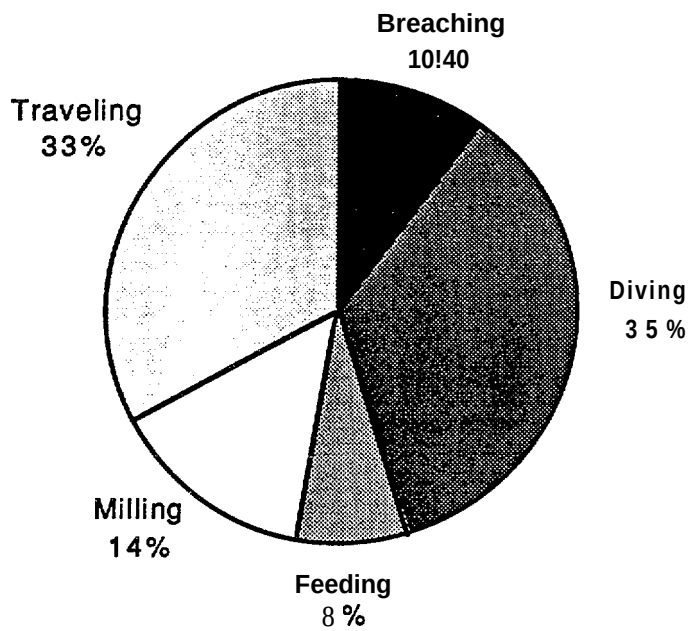


Figure 9.-Observed humpback whale behavior of 51 groups, 1987,

Density and Abundance

Humpback whale density and abundance estimates (Table 4) for the Shumagin and Kodiak-lower Cook Inlet planning areas were derived from systematic and random survey data only. The data were further screened to include only whales observed during fair to excellent visibility conditions and Beaufort sea states between O and 4. Too few whales *were* observed under each visibility or sea state category to analyze them separately according to each condition. Since no significant difference ($p > 0.05$) was found between f(0)'s for Beaufort O-2 and f(0)'s for Beaufort 3-4, the data from all of these conditions were pooled.

The f(0) was calculated by combining the perpendicular distances recorded from both humpback and finback whale sightings in order to increase sample size. Combining sightings for the two species assumes that humpbacks and finbacks have equal probabilities of detection, which may not be true. However, both species have prominent blows, large body sizes (50 vs. 65 ft), and generally occur in small groups. The difference in average group size for the two species, 2.04 ± 0.15 SE (n = 56) for humpbacks and 1.87 ± 0.15 SE (n = 45) for finbacks, was not significant ($p < 0.05$). The f(0) values for each species were also not significantly different ($p < 0.05$). Therefore, we assumed the sightabilities of the two species were similar enough to justify combining them into a pooled estimate of f(0). Hay (1982) and Brueggeman *et al.* (1987) also combined humpback and finback whale sighting data to calculate an f(0) to estimate abundance, since they felt the two species had similar sighting cues.

The Fourier series fit of the perpendicular distances for combined humpback-finback sightings is given in Figure 10. The set of perpendicular distances was truncated at 2.16 nmi (mean plus 2 standard deviations) to improve the fit by eliminating the longest distance estimates (K. Burnham, pers. commun.). These are generally the least accurate distances to estimate from a survey platform. The truncation reduced the total number of combined humpback-finback whale distances from 101 to 98. The longest perpendicular distance deleted was 3 nmi. Based upon the shape of the detection curve, there did not appear to be a significant movement of the whales away from the transect line prior to being observed, as shown by the high probability value near the line.

Density and abundance estimates were calculated for the Shumagin and Kodiak-lower Cook Inlet planning areas (Table 4). The estimated f(0) and mean group size were assumed to be constant among the planning areas since sample sizes were too small to estimate them separately for each planning area. Densities were based on 48 sightings in the Kodiak-lower Cook Inlet planning areas and 6 sightings in Shumagin Planning Area. Humpback abundance was estimated at 220 (±127 SE) for the Shumagin Planning Area and 1,027 (±387 SE) for the Kodiak-1ower Cook Inlet planning areas, a total of 1,247 (±392 SE) animals. These are minimum estimates because they do not account for submerged animals that were missed.

Table 4.–Summary of statistics used to calculate humpback whale density (groups) and abundance (individuals), 1987.

Planning area	Area (nmi^2)	Trackline length (nmi)	Number of groups	f(0)[a]	Group density ($n/nmi^2 \pm$ SE)	Abundance ± SE
Shumagin	21,855	603	6	0.9952	0.005 ± 0.003	220 ± 127
Kodiak[b]	20,584	974	48	0.9952	0.025 ± 0.009	1,027 ± 387
Total	**42,439**	**1,577**	**54**	**0.9952**	**0.014 ± 0.009**	**1,247 ± 392**

[a] Derived from 98 sightings of humpback and finback whale groups.
[b] Includes southern half of Cook Inlet Planning Area.

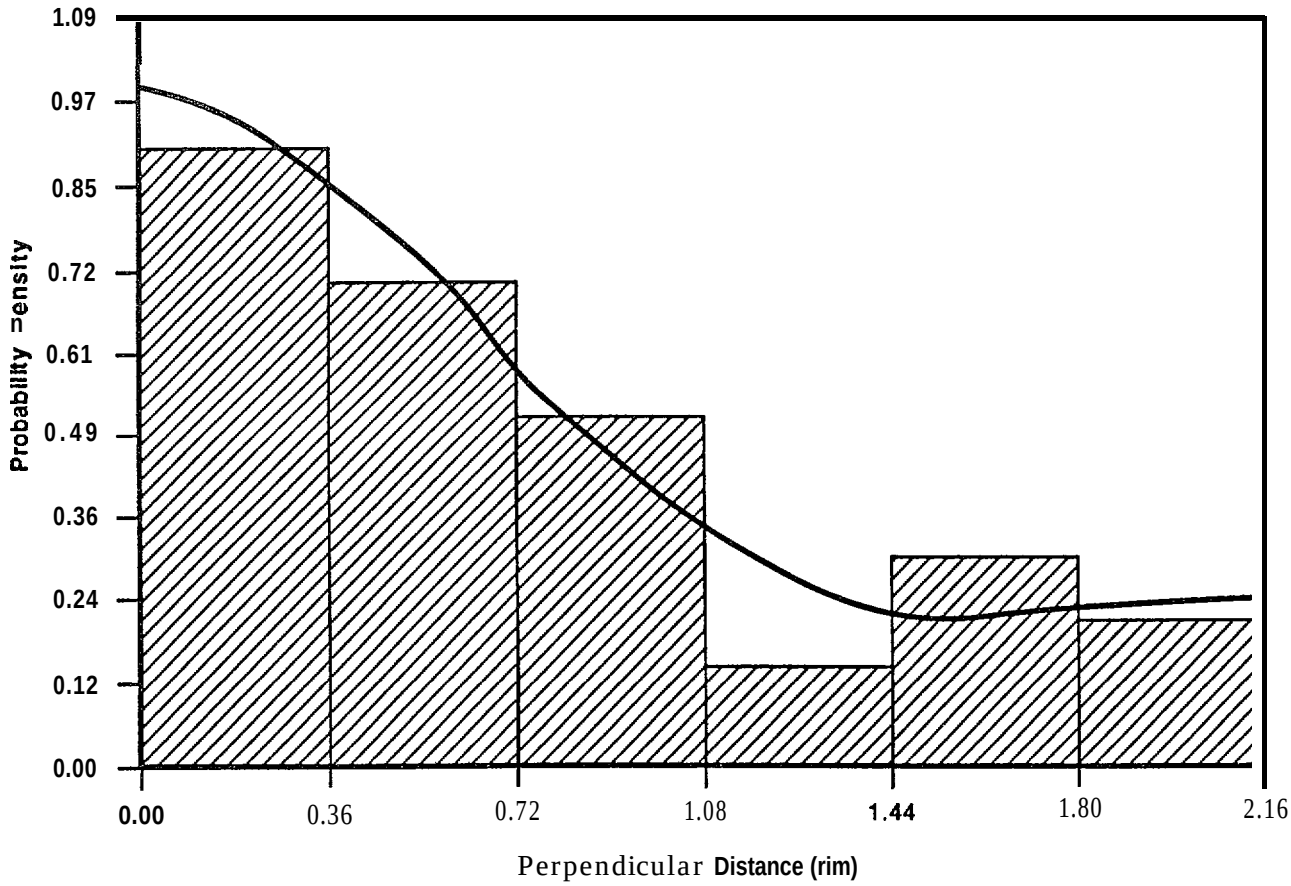


Figure 10.-Probability density function fit of the Fourier series to a frequency histogram of perpendicular distances of 98 sightings of humpback and finback whales, 1987.

Finback Whale

Finback whales were the third most common marine mammal observed, following Dall porpoises and humpback whales. Over the whole study area, 58 groups of 122 finback whales were observed (Table l). During systematic and random surveys, 30 groups of 63 finback whales were observed along 921 nmi of tracklines in the Shumagin Planning Area, and 16 groups of 32 finback whales were observed along 1,113 nmi of tracklines in the Kodiak-lower Cook Inlet planning areas. In addition, five groups of 9 individuals were observed in the Shumagin and seven groups of 18 whales were observed in the Kodiak-lower Cook Inlet planning areas during deadhead surveys. Figure 11 shows the locations of finbacks sighted during this study.

The 45 finback whale groups seen during acceptable sighting conditions were not uniformly distributed in the study area (Figure 12, Table 5) The number of groups observed

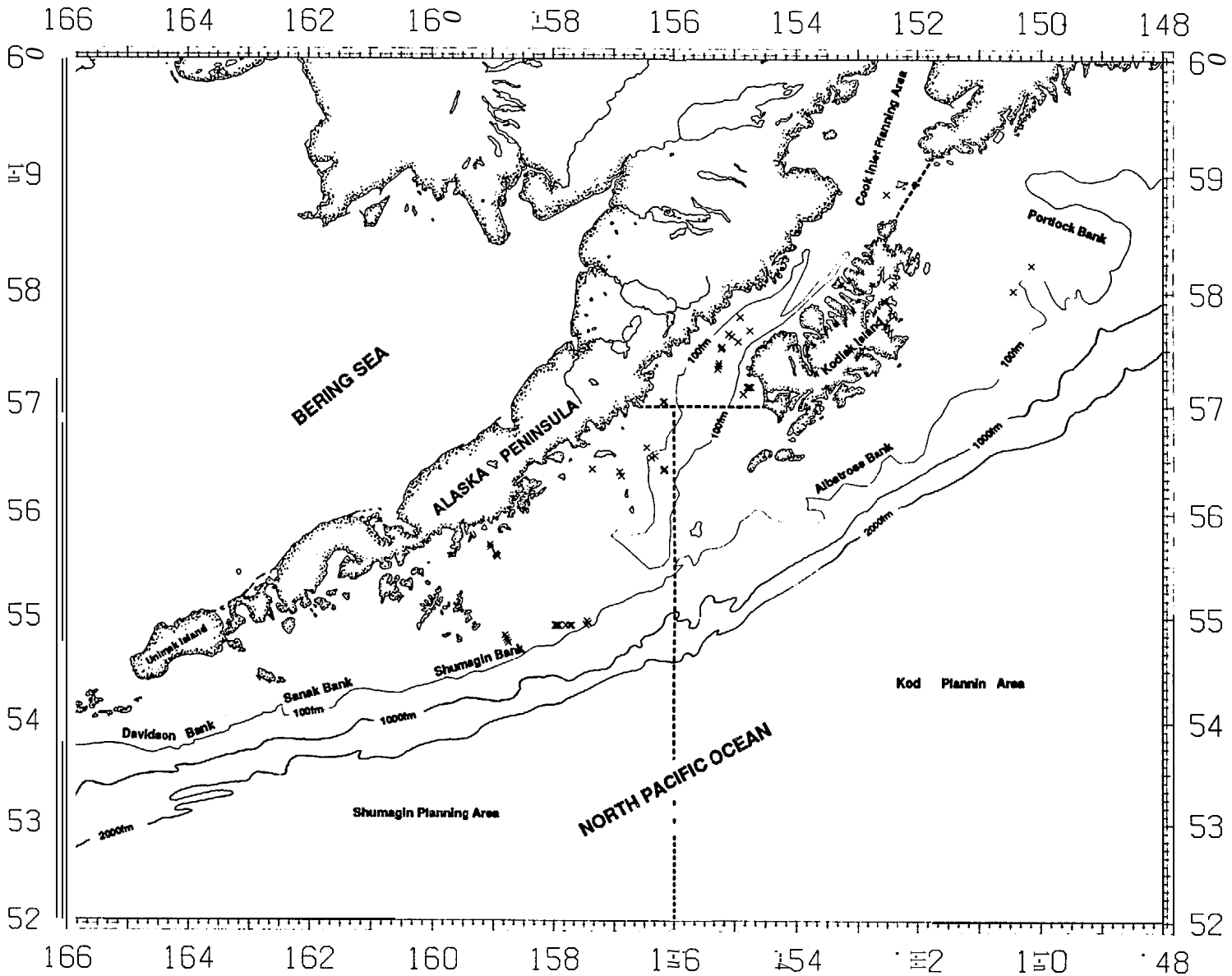
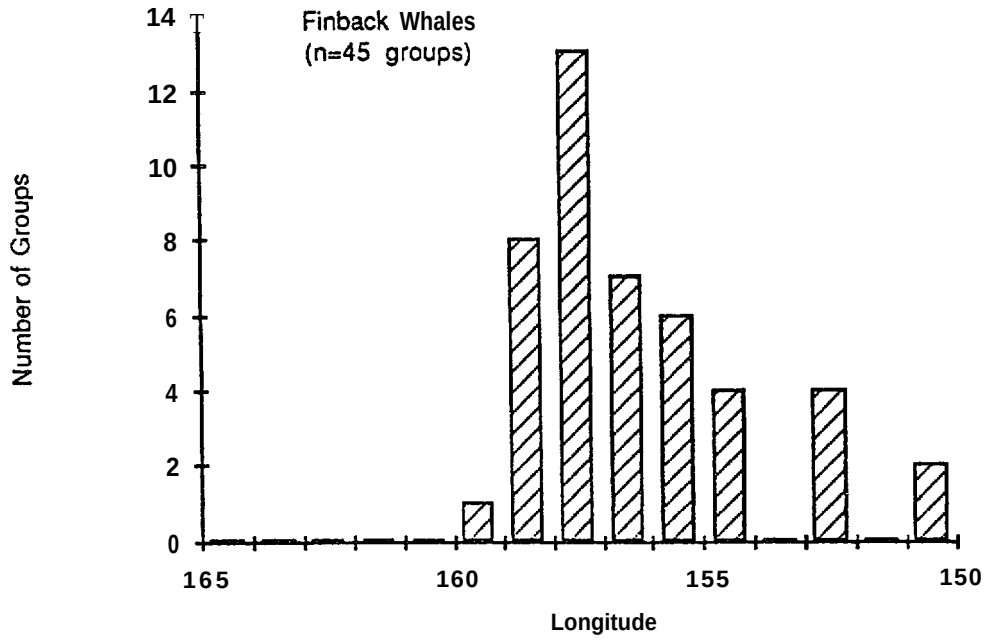


Figure 11.–Locations (X) of finback whale sightings recorded during June-July 1987 shipboard survey.



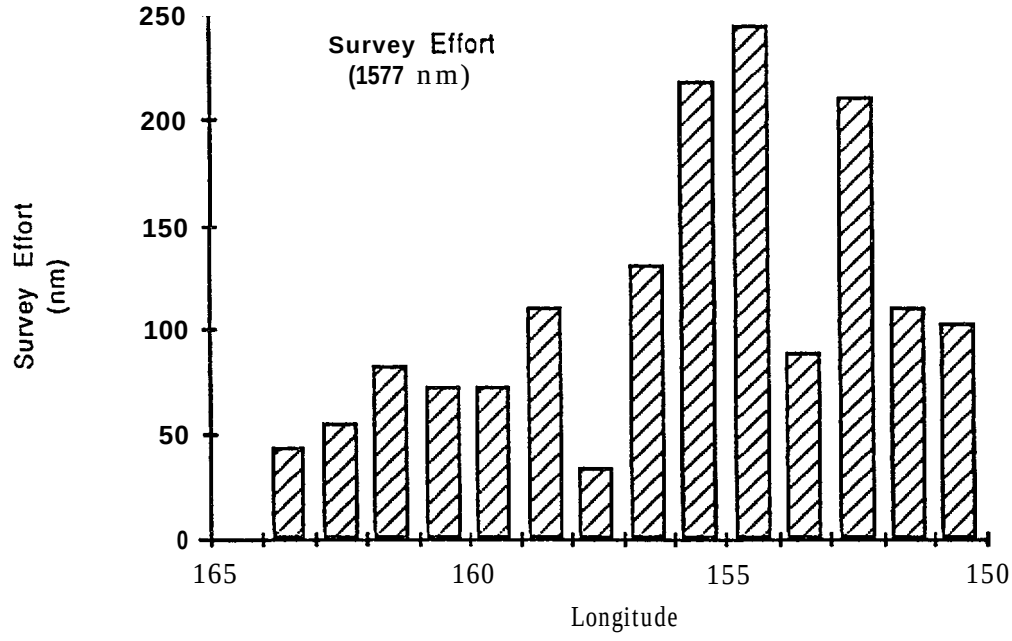


Figure 12.–Survey effort and number of finback whale groups observed by longitude degree during random and systematic surveys.

Table 5.–Relative occurrence of finback whale groups by longitude.

Longitude	Effort[a] (nmi)	Number of groups Observed	Expected[b]	x^2	Preference[c]
150°-152°(W)	214	2	6.1	2.76	0
152°-1540	299	4	8.5	2.38	0
154°-1560	461	10	13.2	0.78	0
156°-1580	164	20	4.7	49.81	+
158°-1600	184	9	5.2	2.78	0
160°-1640	255	0	7.3	7.30	–
Total	1,577	45	45	65.81[d]	

[a] Effort included random and systematic surveys during Beaufort O-4 and fair to excellent visibility.
[b] Expected number of groups based on proportion of effort within each longitudinal zone.
[c] + indicates preference; – indicates avoidance; and O indicates no selection ($p < 0.05$, $X^2_{0.05,1} = 3.841$).
[d] $X^2_{0.05,5} = 11.070$.

at longitudes 156° to 158°W was greater than expected ($p < 0.05$), based on the proportion of the effort that occurred there. This area includes most of the Shumagin Bank and an unnamed bank 60 nmi east of Shumagin Bank, where many of the finbacks were observed. Aggregations of finback or humpback whales over these banks were also observed in 1985 (Brueggeman *et al.* 1987).

Finback whales were most frequently observed in waters between 50 and 150 fathoms deep (Figure 13, Table 6). Over 45% of the observations were in waters 50 to 75 fathoms deep. Observed numbers of finback whales exceeded expected numbers in the 50- to 75-fathom and 100- to 150-fathom water depth categories, whereas the number of whales observed in waters 25-50 fathoms deep and more than 150 fathoms was less than expected ($p < 0.05$). Areas of high topographic relief, where prey productivity may have been high, were associated with the former two depth categories. Similar findings were made in the Shumagin Planning Area by Brueggeman *et al.* (1987) in 1985.

As in 1985, finbacks occupied the summer feeding areas in small groups. The mean group size for finback whales observed during acceptable sighting conditions was 1.87 ± 0.15 SE (n = 45). Over 82% of the groups consisted of one or two animals (Figure 14), while the largest group included five. These values are virtually identical to those obtained in the 1985 surveys (Brueggeman *et al.* 1987), when mean group size was 1.88 (±0. 15 SE), 80% of the groups had one or two animals, and the largest group was also five.

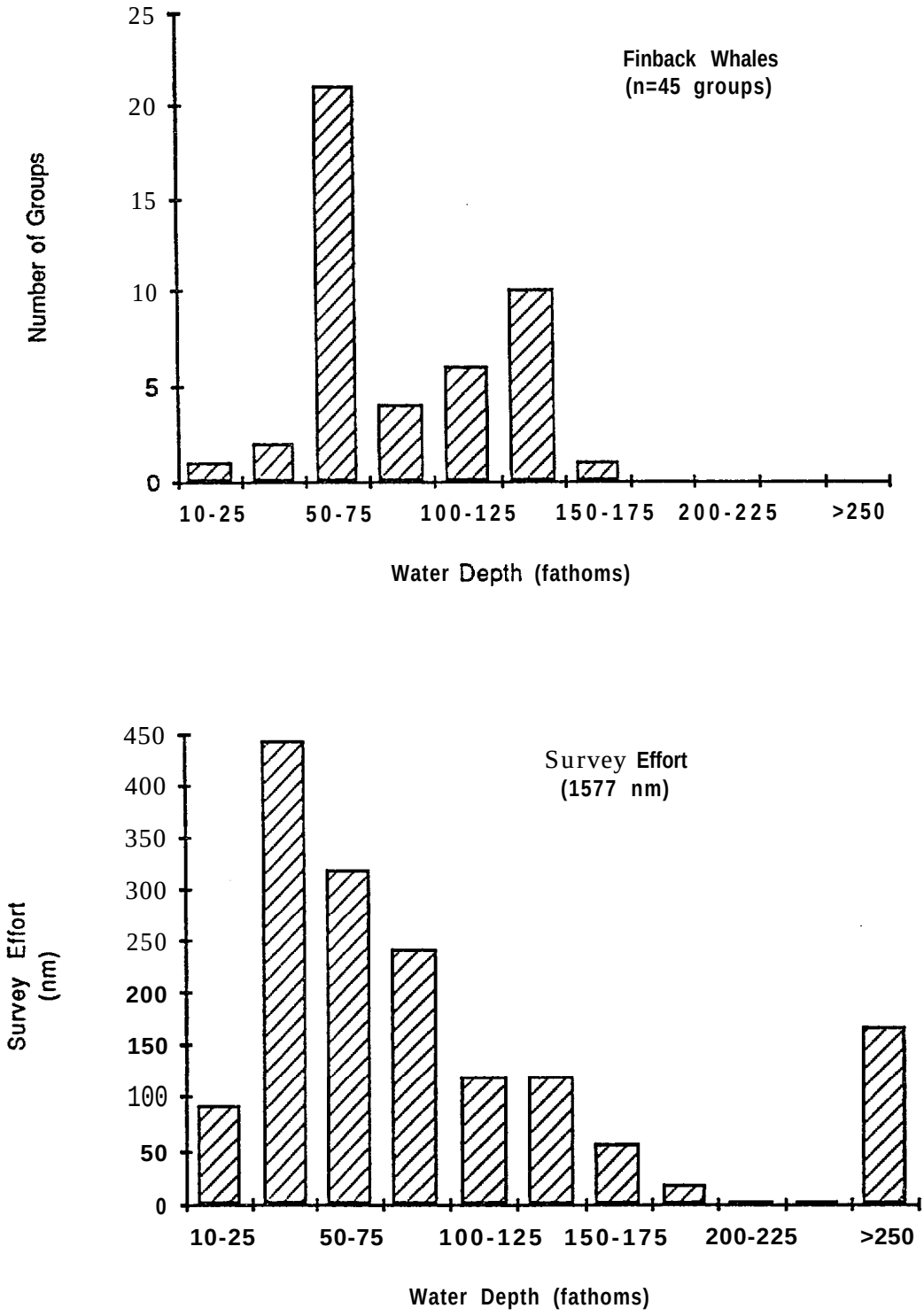


Figure 13.–Survey effort and number of finback whale groups observed by depth class.

Table 6.-Relative occurrence of finback whale groups by water depth.

Water depth (fathoms)	Effort[a] (nmi)	Number of groups Observed	Expected[b]	X'	Preference[c]
10-25	91	1	2.6	0.99	0
25-50	444	2	12.7	9.01	–
50-75	318	21	9.1	15.60	+
75-1oo	242	4	6.9	1.22	0
100-150	239	16	6.8	12.45	+
≥150	2 4 3	1	6.9	5.04	–
Total	1,577	45	45	44.31[d]	

[a] Effort included random and systematic surveys during Beaufort O-4 and fair to excellent visibility.
[b] Expected number of groups based on proportion of effort within each depth class.
[c] + indicates preference; – indicates avoidance; and O indicates no selection ($P < 0.05$, $X^2_{0.05,1} = 3.841$).
[d] $X^2_{0.05,5} = 11.070$.

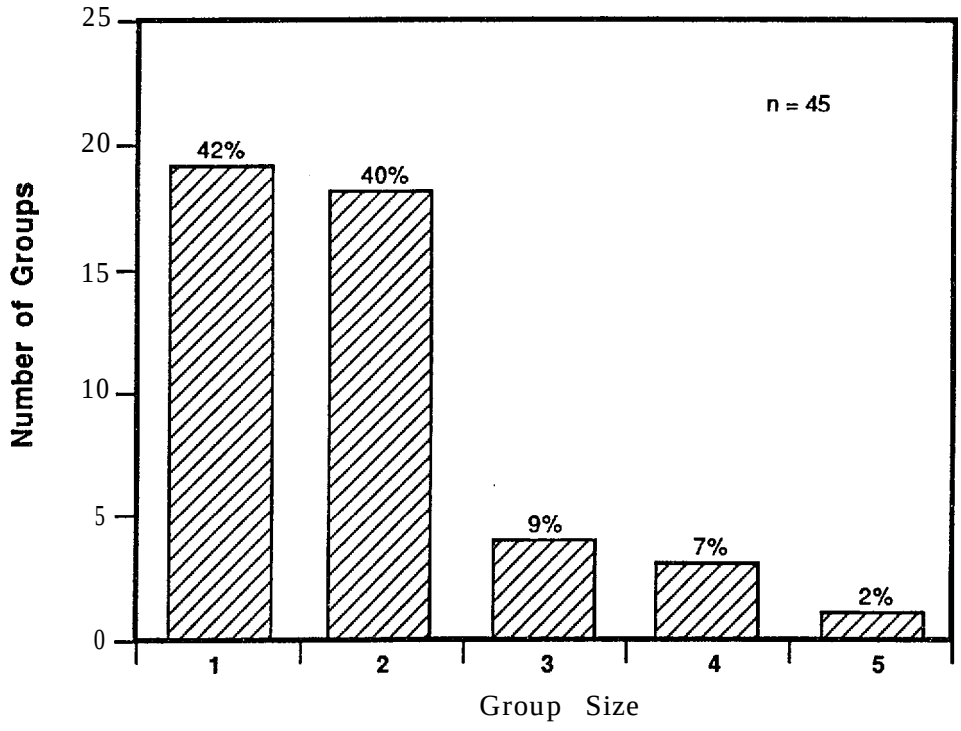


Figure 14.-Group size of finback whales observed, 1987.

The 30 groups of finbacks analyzed for movement patterns showed no consistent directional orientation (Figure 15). This suggests that the majority of the whales were summering in, rather than migrating through, the study area. Although most of the finback whales observed were exhibiting traveling behavior (Figure 16), it was difficult to accurately classify whale behavior from a moving ship.

Density and Abundance

Finback whale density and abundance estimates were derived from random and systematic surveys conducted during acceptable sighting conditions (Table 7). These estimates were calculated from the combined humpback and finback f(0) derived for the entire study area (see the Density and Abundance section for humpback whales).

Finback abundance was estimated at 943 (±536 SE) for the Shumagin Planning Area and 314 (±176 SE) for the Kodiak-lower Cook Inlet planning areas, or 1,257 (±563 SE) total animals. These are minimum estimates since they do not account for missed or submerged animals. The density of finbacks was based on 28 groups in the Shumagin Planning Area and 16 groups in the Kodiak-lower Cook Inlet planning areas. The f(0) and group size were assumed to be constant between areas, since sample sizes were small.

Other Cetaceans

Cetaceans other than humpback or finback whales observed in the project area included minke whales, killer whales, Dan porpoises, and harbor porpoises. The most commonly observed species was the Dan porpoise, of which 101 groups totalling 288 individuals were observed along systematic and random tracklines (Table 1). Over 71% of these sightings occurred in the Kodiak-lower Cook Inlet planning areas. Another 24 groups of 63 porpoises were observed on deadhead surveys. Although Dan porpoise locations were not analyzed by water depth, there was a propensity for sightings to occur approximately on the 100-fathom isobath near the shelf edge and along the Shelikof Strait canyon edge (Figure 17).

The most unusual sighting of the entire survey was a single group of approximately 100 killer whales observed over Portlock Bank on 13 July (Figure 18). The group was strung out in a nearly continuous line of animals for approximately a half-mile. Twenty-four were counted as bulls, based on the dorsal fins. As the ship approached closer, the whales segregated into three groups of approximately 30 animals each, except for a few solitary bulls. The observer counted a minimum of 83 animals. A lone bull was also observed on this date over Portlock Bank, approximately 20 nmi from the large group.

The 11 minke whales observed were spread over all three planning areas (Figure 18). Two groups of three whales were observed in the Shumagin Planning Area and six groups of seven whales were sighted in the Kodiak-lower Cook Inlet planning areas. A single minke whale was observed on deadhead surveys in both the Shumagin and Kodiak

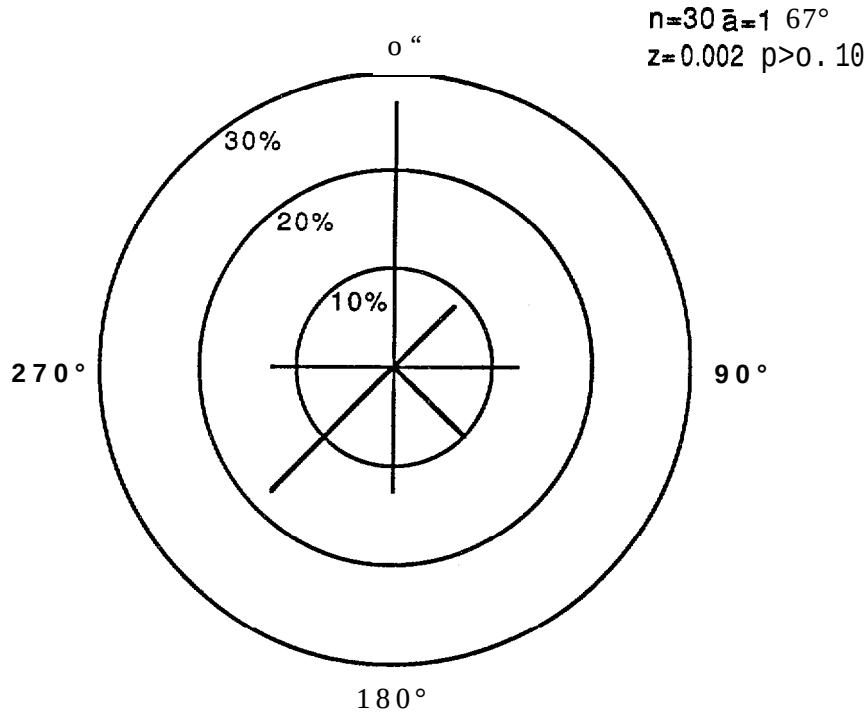


Figure 15.-Directional analysis of finback whales, 1987.

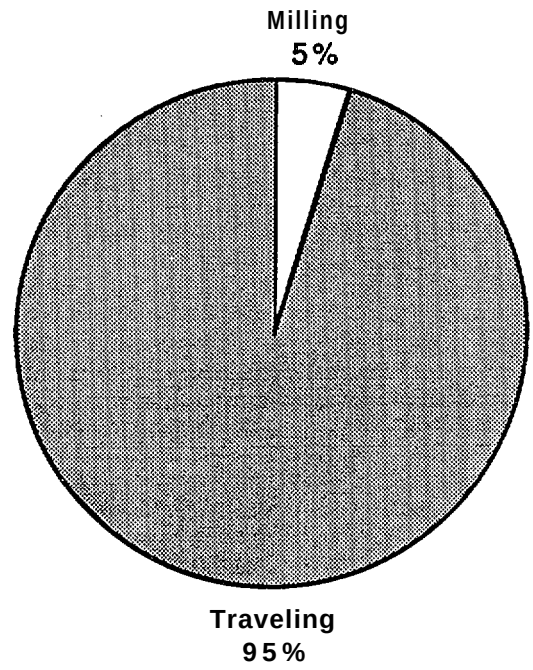


Figure 16.-Observed finback whale behavior, 1987.

Table 7.–Summary of statistics used to calculate finback whale density (groups) and abundance (individuals), 1987.

Planning area	Area (nmi^2)	Trackline length (nmi)	Number of groups	f(0)[a]	Group density ($n/nmi^2 \pm SE$)	Abundance ± SE
Shumagin	21,855	603	28	0.9952	0.023 ± 0.013	943 ± 536
Kodiak[b]	20,584	974	16	0.9952	0.008 ± 0.005	314 ± 176
Total	42,439	1,577	44	0.9952	0.016 ± 0.013	1,257 ± 563

[a] Derived from 98 sightings of humpback and finback whale groups.
[b] Includes southern half of Cook Inlet Planning Area.

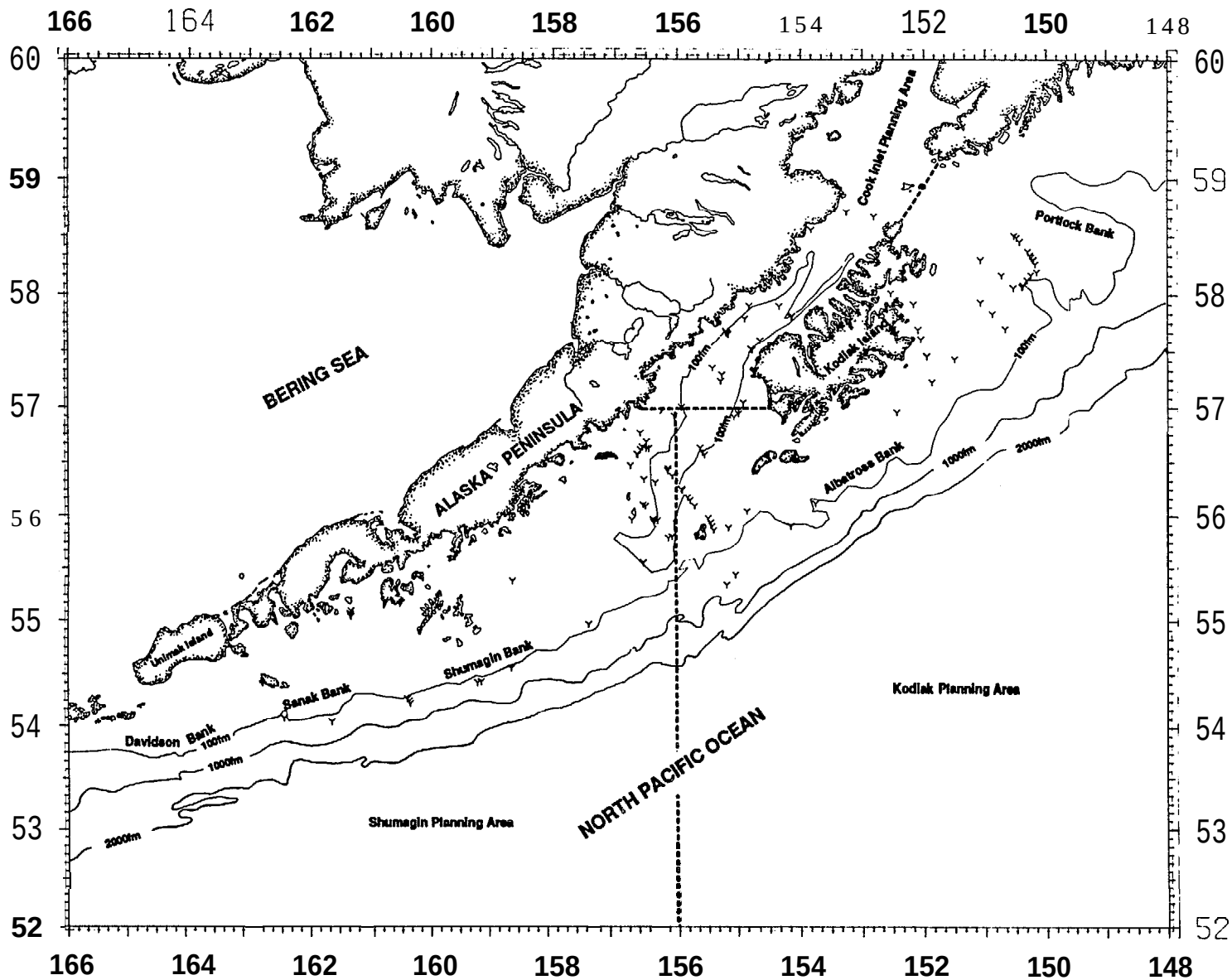


Figure 17.–Locations (Y) of Dan porpoise sightings recorded during June-July 1987 shipboard survey.

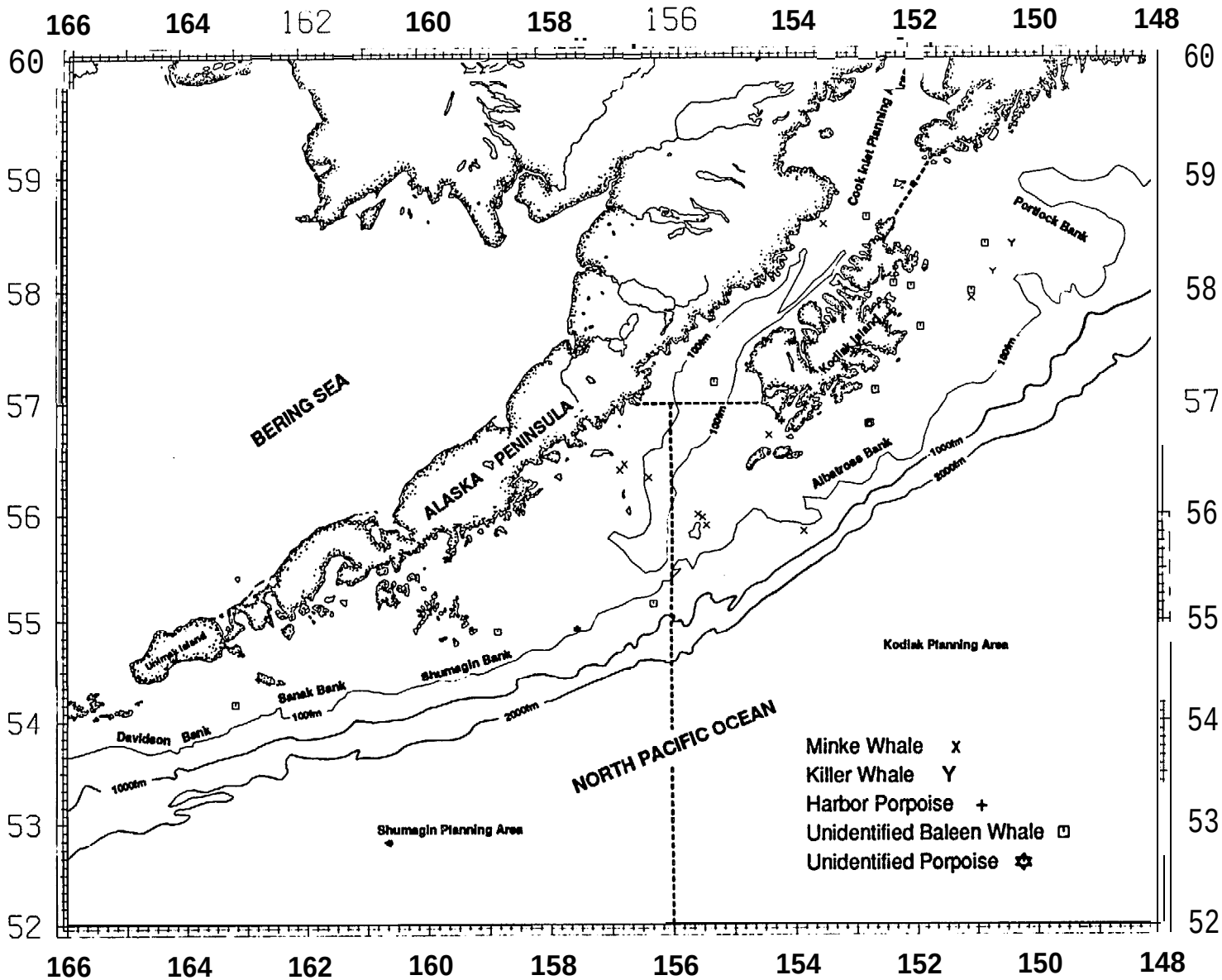


Figure 18.–Locations of nonendangered cetacean sightings recorded during June-July 1987 shipboard survey.

Planning areas. Six of these sightings occurred near Chirikof Island and the Semidi Islands. These results are similar to findings in other studies which show that minke whales are generally solitary animals, widely distributed, and observed in low abundance.

Three harbor porpoises were separately observed in the project area (Figure 18). Two porpoises were observed in Alitak Bay on the southeast end of Kodiak Island and the other one was within Whale Passage between Kodiak and Raspberry Island. Harbor porpoises inhabit nearshore areas which were difficult to survey because of the ship's deep-draft hull.

An additional 14 groups of 19 unidentified large baleen whales were observed in the study area (Table 1, Figure 18). Over 70% (10 groups) of these sightings were made over the Portlock and Albatross banks in the Kodiak Planning Area. These sightings were probably finback or humpback whales that could not be positively identified due to distance of the sighting, poor survey conditions, or inadequate sighting cues. Only one group of two porpoises was not positively identified (Table 1, Figure 18). However, because the animals were approximately 60 nmi from land and at the continental shelf edge, they were most likely Dan porpoises and not harbor porpoises.

Other Marine Mammals

Four other species of marine mammals (northern sea lion, northern fur seal, harbor seal, and sea otter) were observed in the study area (Table 1). Large numbers of these species were not observed, primarily because all but the northern fur seals occur most commonly in shallow nearshore waters which the ship could not reach. Eighty-one percent of the 73 sea otters were observed in the narrow channel of Whale Passage that separates Kodiak Island from Afognak and adjacent smaller islands (Figure 19). Only 54 sea lions were observed in the study area, which included 29 hauled out on one rock in the Shumagin Planning Area. One harbor seal, observed in Whale Passage, was recorded during the entire survey.

The 42 sightings of northern fur seals were equally divided between the Shumagin and Kodiak-lower Cook Inlet planning areas. The fur seals were primarily sighted near the shelf edge or in the deeper (>100 fathoms) waters near Shelikof Strait (Figure 19). The fur seal distribution was very similar to that of the Dan porpoise (Figure 17).

Marine Mammals Not Sighted

We did not observe various other cetaceans that inhabit these waters (Consiglieri and Braham 1982; Leatherwood *et al.* 1983; Brueggeman *et* al. 1985, 1986, 1987). Endangered species include the blue, sperm, gray, sei, and right whales. Blue and sperm whales normally use deep water habitats beyond the boundary of the study area. Gray whales occupy nearshore waters and migrate through the study area during seasons before

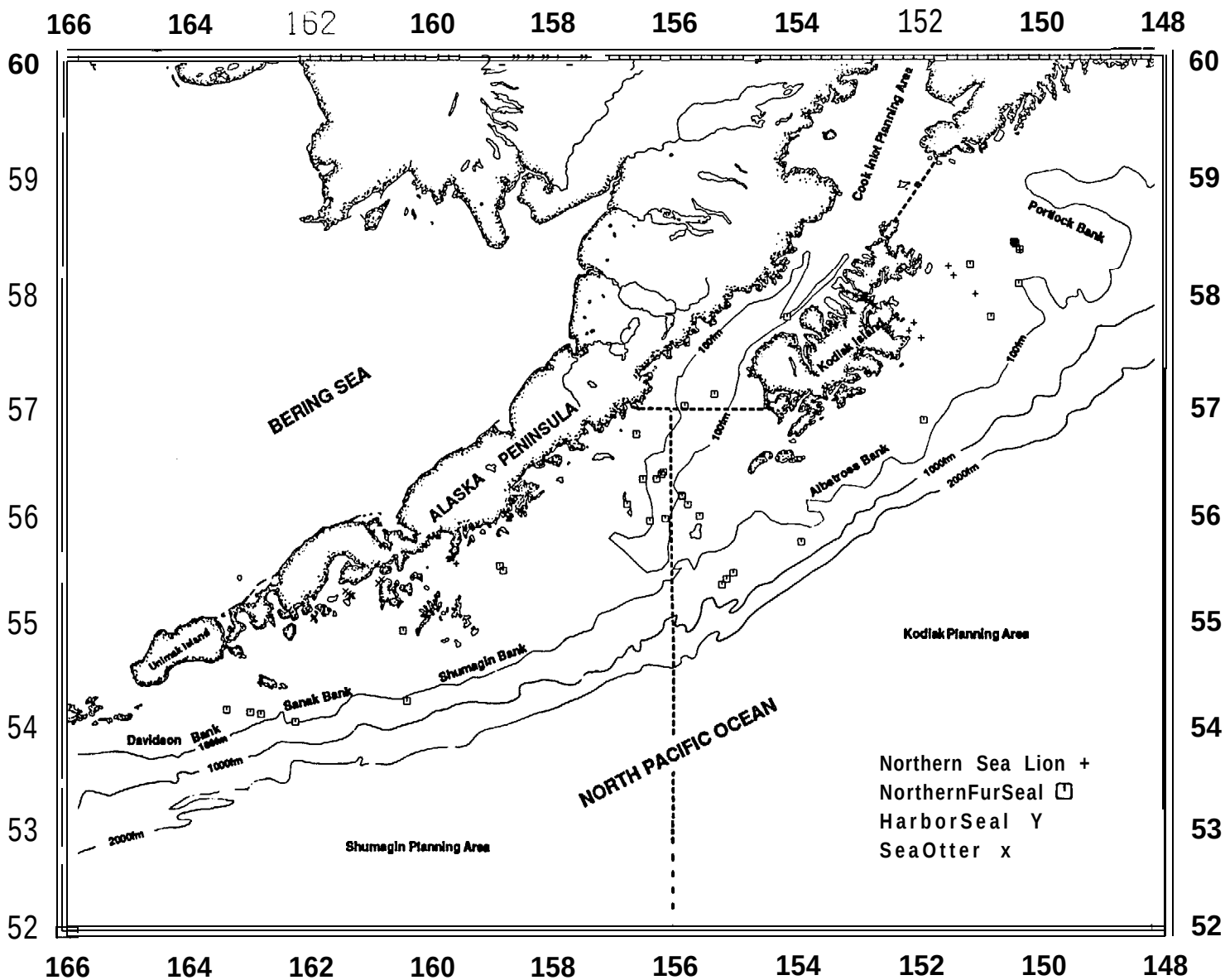


Figure 19.-Locations ofpinniped and sea otter sightings recorded during June-July 1987 shipboard survey.

and after the survey period. Sei whales also occur in the shelf waters, but the infrequency of sightings suggests they are not common. Right whales, while abundant in the 1800s, were reduced in numbers by commercial whalers to the point that fewer than 200 animals are currently estimated to inhabit the North Pacific Ocean. Although right whales historically inhabited the shelf waters in the Gulf of Alaska, the probability of sighting one is extremely low. The last confirmed sighting in the North Pacific and Bering Sea was in 1982 when Brueggeman *et al.* (1984) reported two right whales northeast of St. Matthew Island. Other cetacean species not encountered but known to occur primarily in the Gulf of Alaska include three species of beaked whales which occur in deep waters (Brueggeman *et* al. 1987) beyond the area surveyed from the ship. The lack of sightings of any of these species confirms that they were either not abundant in the study area during the surveys (since they primarily occur outside the survey area or inhabit the study area at times of the year different from the survey period), or are uncommon.

Comparison of 1985 and 1987 Results

This section provides a comparison between marine mammal surveys conducted in 1985 (Brueggeman *et al.* 1987) and 1987. Aerial surveys were conducted in the St. George Basin, North Aleutian Basin, and Shumagin planning areas in 1985 during six 20-day periods between April and December. The comparison between the 1985 and 1987 surveys is limited to the summer feeding period and to marine mammals in the waters south of the Alaska Peninsula. For the 1985 surveys, this included the June to October periods in the Shumagin Planning Area. The 1987 survey, conducted in June-July, overlaps with these previous surveys in the Shumagin area. However, the 1985 surveys extended beyond the shelf break and included nearshore areas that were inaccessible to the ship. Consequently, marine mammals associated with these areas cannot be compared between the two surveys. The shelf-related species, primarily the humpback and finback whales, are discussed below.

A total of 14 species of marine mammals were recorded south of the Alaska Peninsula during the 1985 and 1987 surveys: 10 species of cetaceans, 3 species of pinnipeds, and the sea otter (Table 8). Six of the seven endangered species of cetaceans expected in the study area were recorded during the two survey periods, but only the humpback and finback whales were observed in both 1985 and 1987, Totals of 185 humpback and 149 finback whales were recorded in 1985, compared to 150 humpback and 122 finback whales in 1987. Gray whales were observed summering in the study area in 1985 and in 1986 during a sea otter survey (Brueggeman *et al.*, draft report), but not in 1987. Thus it can be concluded that these three species of endangered whales summer in the waters south of the Alaska Peninsula. These species have historically inhabited this area, according to commercial whaling records examined by Reeves *et al.* (1985). In addition, the other eight species of marine mammals recorded during both 1985 and 1987 surveys confirm findings reported by others (Consiglieri and Braham 1982; Leatherwood *et al.* 1983) that these species inhabit waters on or near the shelf.

Table 8.–Number of marine mammal observations recorded during the 1985 aerial surveys and 1987 shipboard surveys conducted south of the Alaska Peninsula.

Species	Habitat	1985 survey (25,059 nmi)[a]	1987 survey (2,034 nmi)
Minke whale	Shelf	4	12
Finback whale	Shelf/slope	149	122
Humpback whale	Shelf	185	150
Gray whale	Shelf	191[b]	0
Cuvier's beaked whale	Rise	2	0
Baird's beaked whale	Rise	9	0
Sperm whale	Slope/rise	23	0
Killer whale	Shelf	38	101
Harbor porpoise	Shelf	1	3
Dan porpoise	Shelf/slope/rise	103	351
Steller sea lion	Shelf	2,997	54
Northern fur seal	Shelf	4	42
Harbor seal	Shelf	282	1
Sea otter	Shelf	1,880	73

[a] Survey effort.
[b] Two observations were recorded during the summer; the others were recorded during the migration periods in April and November-December.

The results of the two survey periods show that while the distribution of marine mammals was widespread, humpback and finback whales are concentrated in generally separate areas. Humpback whales occurred from approximately Sanak Bank (163°W) to beyond Kodiak Island (150°W) (Figure 20). Numbers of humpbacks generally increased from west to east. Commercial whaling records show that the proportion of humpbacks harvested in the total catch was higher for the Port Hobron whaling station (64%), near Kodiak Island, than for the Akutan station (24%), further west near Unimak Pass (Reeves *et al.* 1985). Most whales we observed in the study area were near the 50-fathom isobath, often on a bank. Banks used by the whales included Sanak, Shumagin, Portlock, and Albatross, and an unnamed bank between 157 and 158°W. Humpbacks were observed on Sanak Bank during 1985 and 1987 where commercial whalers harvested humpbacks between 1912 and 1939. Surveys were also conducted over Davidson Bank in 1985 and 1987 but no whales were observed. These results show that humpbacks were largely associated with the 50-fathom isobath, particularly near oceanic banks which may be repeatedly occupied each year. Oceanographic conditions associated with the high relief of these banks provide abundant prey for marine mammals. Studies reported by Payne *et* al. (1986) show a similar association of humpback whales to banks on the East Coast, such as Georges Bank in the Gulf of Maine.

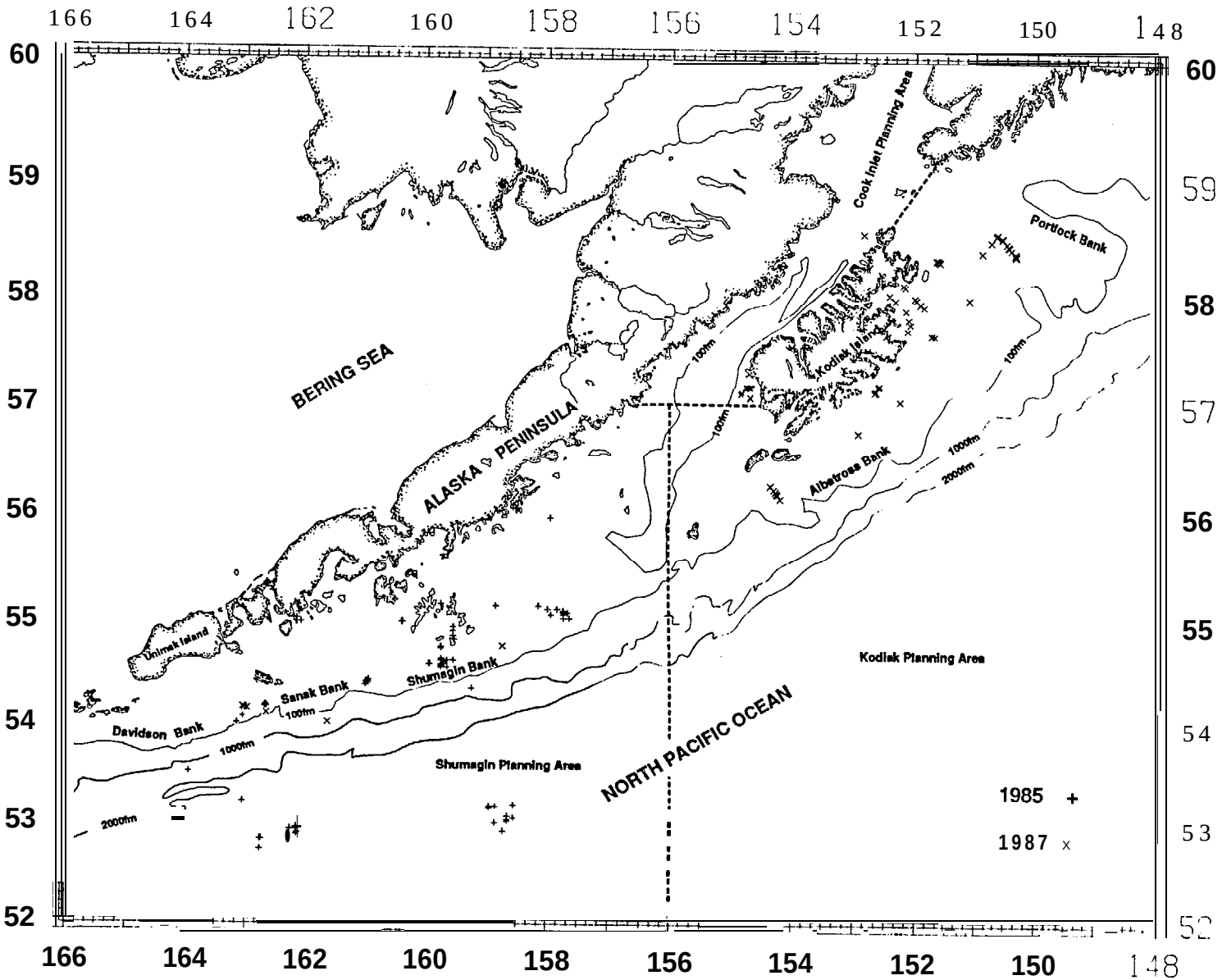


Figure 20.-Humpback whale locations recorded during the 1985 aerial surveys (Brueggeman *et al.* 1987) and 1987 shipboard surveys.

No humpback whale calves were observed in either the 1985 or 1987 study. Correspondingly, there were no calves with the 191 humpbacks recorded in the Gulf of Alaska by Rice and Wolman (1982). Calves have been reported to compose 0-18% of the population summering in Alaska (Jurasz and Palmer 1981; Perry *et al.* 1985) and 9-10% of the population wintering in Hawaii (Herman and Antinoja 1977; Herman *et al.* 1980). Using a conservative estimate that calves make up 5% of the population, 26 calves should have been observed during the three western Gulf of Alaska studies (Rice and Wolman 1982; Brueggeman *et al.* 1987; this study). Possible explanations for this discrepancy include: survey platforms were not suitable for observing calves, calves were subadult size by the time of surveys (D. Rice, pers. commun.), or cow-calf pairs do not use the less protected waters of the western Gulf of Alaska. Nearly all of the humpbacks observed in the three western Gulf of Alaska studies (except for Rice and Wolman's Prince William Sound observations) were in open water habitats. Calves, however, have been commonly observed in protected inland bays of Alaska (C. S. Baker, pers. commun.); therefore, cow-calf pairs may separate from the rest of the population. Inland bays were not surveyed during this study, and bay complexes are not as common in the Shumagin Planning Area as around Kodiak and southeastern Alaska. Furthermore, whalers based out of Akutan and Port Hobron occasionally took or reported finback and blue whale calves, but not humpback calves (Reeves *et al.* 1985). Consequently, humpback calves are either scarce or indistinguishable from adults when summering in Gulf of Alaska waters.

Finback whales were also widely distributed in the study area, but were generally found in areas not occupied by humpback whales (Figure 21). Finback whales were primarily observed between the Shumagin Islands and Semidi Islands in both 1985 and 1987. Most animals were associated with the Shelikof Strait submarine canyon and the nearby unnamed bank. Finback whales occurred on the unnamed bank (where we also saw enormous flocks of shearwaters in 1987) during both survey periods. Finback and humpback whales were found at similar depths, and on occasion were observed feeding together. However, with the exception of Shumagin Bank and the unnamed bank, finbacks were primarily found in the central portion of the study area, particularly along the edges of the Shelikof Strait submarine canyon, while humpbacks typically used the oceanic banks. This trend indicates that, at least to some degree, habitat is partitioned by the two species. On the other hand, these results demonstrate that both finback and humpback whales occur primarily in areas of high bathymetric relief where biological productive ty is probably high.

No finback whale calves were observed during either the 1985 or 1987 surveys. The same explanations provided for the relative absence of humpback whale calves may apply in this instance as well. Fetus records of finbacks from the Akutan and Port Hobron whaling stations (Reeves *et al.* 1985) indicate that calves are 20 feet long when born during late fall and early winter. By the time the 1985 and 1987 surveys began (May-June), these calves were probably indistinguishable from adults.

The only other species having sufficient numbers of observations in both years to show distribution patterns was the Dan porpoise. This species was widespread, but the

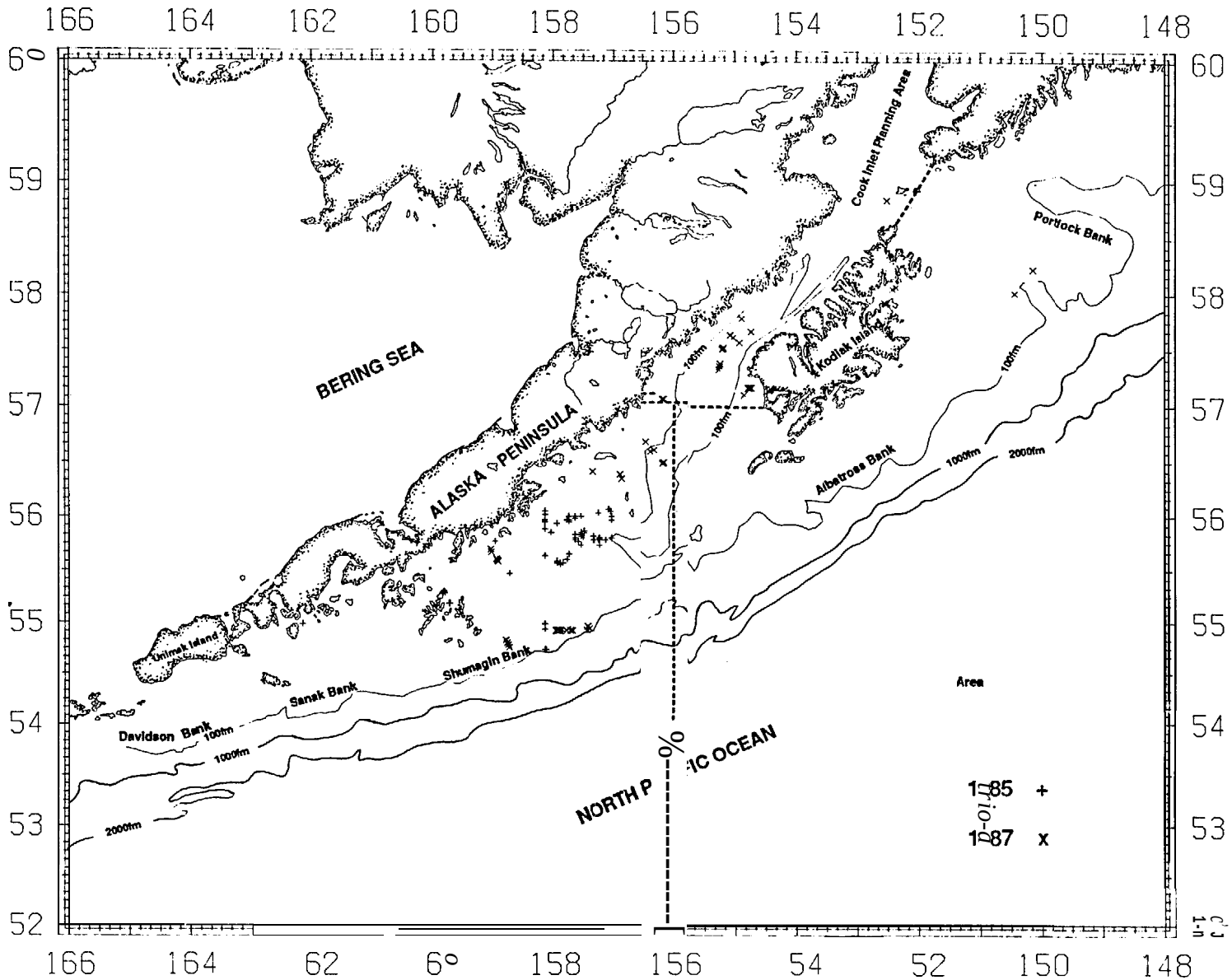


Figure 21.–Finback whale locations recorded during the 1985 aerial surveys (Brueggeman *et al.* 1987) and 1987 shipboard surveys.

animals were particularly associated with high relief areas along the shelf break and the Shelikof Strait submarine canyon. Other studies in Alaska (Consiglieri and Braham 1982; Leatherwood *et al.* 1983; Brueggeman *et* al. 1984) also found this species occurring in or near areas of relatively deep water.

Abundance was estimated for humpback and finback whales in 1985 and 1987. Humpback whale abundance was estimated at 1,247 (±392 SE) for the combined Shumagin and Kodiak-Cook Inlet planning areas in 1987. In the Shumagin Planning Area alone, abundance was estimated at 333 (±217 CI) in 1985 and 220 (±127 SE) animals in 1987. The former estimate is more reliable since it was derived from 34 groups, compared to 6 groups in 1987. Both surveys also made estimates for total humpback whale abundance in Alaskan waters. Brueggeman *et al. (1987)* developed an estimated humpback whale abundance for Alaska of 1,007 animals by adding the 333 animals estimated in the Shumagin Planning Area in 1985, 364 animals estimated in the Gulf of Alaska (Rice and Wolman 1982), and 310 (270-372) animals estimated in southeast Alaska (Baker *et* al. 1985). By comparison, the results of this survey indicate a total of 1,921 animals for Alaska, derived by adding the 1,247 animals we estimated for the combined Shumagin and Kodiak-Cook Inlet planning areas in 1987 to the values provided by Rice and Wolman (1982) and Baker *et* al. (1985).

These total estimates are uncertain, however, since they assume the animal counts were not duplicated among the three estimates. Furthermore, the confidence intervals for the 1985 and 1987 estimates are wide, and Rice and Wolman (1982) did not derive a confidence interval. Their estimate was calculated by expanding the observed density to the total area surveyed.

Despite the limitations, these estimates are the best available for Alaskan waters. Assuming these values are correct, the two total estimates we calculated suggest that the minimum number of humpbacks summering in Alaska is between 1,000 and 1,900 animals, or 45-90% of the estimated 2,100 animals composing the "Hawaiian" humpback whale population in the North Pacific Ocean (Darling and Morowitz 1986). Moreover, these results show that most of the animals summering in Alaska are found in the waters of the Shumagin and Kodiak-Cook Inlet planning areas.

Finback whale abundance in the Shumagin Planning Area was estimated to be much higher in 1987 than it was in 1985. Abundance was estimated at 943 (±536 SE) animals in 1987 compared to 184 (±90 CI) in 1985. Several factors contributed to the difference between the two estimates. In 1987, whales were encountered more frequently per unit of effort than in 1985, and the survey effort (in 1987) was higher in the eastern portion of the Shumagin Planning Area, where finback whales were more common. Other factors, such as survey platform biases, may have also contributed to the difference. The use of correction factors for missed whales could reduce the disparity between the two estimates, but such factors have not been developed by cetacean researchers.

Although the estimates do not closely agree, they suggest that approximately 1,000 finbacks or fewer summer in the Shumagin Planning Area. The 1987 Shumagin estimate combined with the estimate for the Kodiak and Cook Inlet planning areas further suggest that approximately 1,257 (±563 SE) finback whales, less than 10% of the estimated 14,620-18,630 (Braham 1984*b*) in the North Pacific population, summer in these planning areas. Abundance was not estimated for the other species because of small sample sizes, but the 1985 and 1987 results confirm that Dan porpoises were common in the study area.

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APPENDIX A

Visibility and glare criteria.

Table A-1. Criteria used to determine relative visibility.

Visibility	Highest Allowed Beaufort Sea State	Descriptors
Excellent	1	Calm and clear
Very Good	2	Surface ripple, some glare.
Good	4	Light chop, glare, fog
Fair	5	Chop, glare, shadows, fog but all animals on line visible
Poor	5	Same as Fair only some animals on line obscured
Unacceptable	--	Survey tract obscured

Table A-2. Criteria used to classify glare.

Glare Number	Percent area obscured by sun reflection, fog, or moisture on window surface
1	1 - 10 percent
2	11 - 25 percent
3	26 - 50 percent
4	51 - 75 percent
5	76 - 100 percent

APPENDIX B

Record of whales encountered in the Shumagin and Kodiak-lower Cook Inlet planning areas during June-July 1987.

SPEC I ES[a/]	DATE	NUMBER	LATITUDE (N)	LONGITUDE (W)
BA	708	2	56270	156470
	708	1	56239	156518
	708	1	56200	156230
	709	2	56000	155352
	709	1	55584	155308
	709	1	55540	155270
	709	1	55507	153513
	710	1	56429	154250
	712	1	58352	153316
	713	1	57557	151046
BP	621	2	54453	158444
	621	4	54453	158444
	621	2	54468	158454
	621	1	54496	158476
	622	5	55415	159025
	622	1	55362	158570
	622	1	55353	158561
	622	2	55353	158561
	622	2	55346	158553
	622	3	54552	157582
	622	3	54552	157582
	622	1	54552	157572
	622	2	54552	157563
	622	1	54553	157477
	622	2	54553	157477
	622	2	54553	157477
	622	1	54553	157439
	622	5	54553	157420
	622	1	54556	157275
	622	2	54556	157275
	622	2	54564	157252
	622	2	54577	157267
	625	2	56248	157216
	628	3	56321	156193
	628	3	56311	156229
	628	2	56368	156276
	630	2	56232	156547
	706	3	57552	152319
	707	1	57313	155114
	707	1	57310	155120
	707	1	57303	155125
	707	2	57228	155146
	707	2	57214	155151
	707	1	57021	156098
	707	2	57021	156097
	707	1	57019	156110

SPECIES	DATE	NUMBER	LATITUDE (N)	LONGITUDE (W)
BP	708	2	56210	156530
	708	2	56241	156107
	708	2	56244	156104
	709	2	56248	156099
	709	1	56250	156099
	710	5	57100	154440
	710	2	57100	154450
	710	3	57100	154450
	710	2	57100	154460
	710	3	57100	154470
	710	2	57099	154475
	710	2	57062	154514
	711	2	57381	155050
	711	1	57369	155021
	711	2	57341	154560
	711	1	57400	154447
	711	1	57471	154540
	712	2	58507	152307
	713	4	58140	150092
	713	4	58010	150270
	714	1	58043	152218
	714	3	58033	152252
MN	618	3	54096	163027
	618	1	54089	163014
	618	1	54087	162586
	618	4	54060	162392
	618	5	54006	161378
	621	1	54453	158444
	709	3	56081	154125
	709	2	56109	154163
	709	3	56119	154173
	709	1	56152	154222
	710	2	57041	154420
	710	4	57041	154420
	710	2	57046	154423
	710	3	57096	154416
	710	2	57100	154420
	710	3	57100	154420
	710	3	57100	154430
	710	2	57100	154430
	710	3	57100	154440
	710	2	57100	154460
	710	2	57100	154470
	710	3	57069	154506
	710	1	57060	154516

SPECIES	DATE	NUMBER	LATITUDE (N)	LONGITUDE (W)
MN	712	3	58335	152511
	713	3	58201	151397
	713	3	58201	151397
	713	5	58201	151397
	713	1	58200	151380
	713	2	58196	151371
	713	2	58195	151370
	713	1	58191	151360
	713	1	58191	151360
	713	2	58243	150533
	713	1	58299	150443
	713	2	58333	150392
	713	2	58339	150381
	713	2	58321	150337
	713	2	58318	150333
	713	1	58291	150295
	713	1	58279	150278
	713	1	58274	150270
	713	4	58259	150251
	713	3	58227	150204
	713	1	58230	150204
	713	1	58240	150207
	713	2	57592	151059
	714	1	57554	151516
	714	2	57570	151550
	714	2	57570	151555
	714	2	57593	151592
	714	2	58001	152006
	714	2	58059	152102
	714	1	58069	152117
	714	5	58014	152257
	714	1	57588	152196
	714	2	57588	152196
	714	1	57534	152093
	714	2	57484	152064
	714	4	57458	152049
	714	5	57113	152356
	714	2	57107	152364
	714	2	57079	152388
	714	2	57075	152396
	714	2	57075	152396
	714	2	57073	152402
	715	1	56447	152560
	715	2	57026	152148
	715	2	57391	151412
	715	1	57422	152075

SPECIES	DATE	NUMBER	LATITUDE (N)	LONGITUDE (W)
00	713	100	58250	150238
	713	1	58098	150436
PD	618	1	54043	162272
	618	3	54043	162272
	618	7	54043	162272
	618	8	54022	161400
	619	2	55053	161209
	619	2	55030	161215
	619	3	55020	161210
	619	1	55040	161218
	619	2	54158	160245
	619	6	54146	160227
	619	10	54132	160216
	621	3	54254	159120
	621	2	54250	159157
	621	3	54333	158423
	621	2	54333	158423
	622	11	55226	158413
	622	2	54577	157267
	625	3	55329	156336
	626	2	56053	156317
	626	1	55569	156234
	626	2	55559	156233
	626	6	55473	156094
	626	2	55576	156448
	628	2	56372	156282
	628	10	56373	156307
	628	1	56456	156364
	630	5	56060	156338
	630	5	55578	156242
	701	2	55571	156200
	701	3	55480	156060
	702	5	55205	155127
	702	6	55259	155038
	702	12	55540	154102
	702	4	56069	153461
	707	1	57174	155166
	707	3	57140	155178
	707	2	57210	155257
	707	7	57000	155558
	707	2	56552	156030
	708	2	56408	156304
	708	3	56380	156343
	708	5	56366	156362
	708	3	56341	156396

SPECIES	DATE	NUMBER	LATITUDE (N)	LONGITUDE (W)
PD	712	2	58402	152487
	713	3	58176	151045
	713	3	58301	150320
	713	1	58291	150295
	713	2	58291	150295
	713	1	58269	150264
	713	2	58219	150183
	713	1	58200	150160
	713	2	58200	150160
	713	2	58191	150150
	713	1	58177	150132
	713	2	58177	150132
	713	2	58176	150128
	713	2	58155	150108
	713	6	58114	150094
	713	1	58099	150153
	713	2	58099	150153
	713	1	58073	150190
	713	2	58073	150190
	713	2	58045	150230
	713	3	58038	150239
	713	1	58033	150326
	713	1	58098	150440
	713	2	57557	151046
	713	1	57497	150529
	713	2	57419	150405
	714	2	58005	152319
	714	2	57547	152100
	714	4	57413	152056
	714	3	57363	152028
	714	2	57273	151569
	714	1	57270	151570
	714	6	57270	151570
	715	2	56573	152264
	715	4	57135	151520
	715	1	57256	151298
PP	706	1	58006	153100
	710	1	56499	154127
	710	1	56508	154126
UD	622	2	54554	157343
UW	618	1	54100	163113
	621	1	54537	158522
	625	1	55101	156191
	707	1	57112	155188
	712	1	58390	152490
	713	1	58250	150500

SPECIES	DATE	NUMBER	LATITUDE (N)	LONGJUDE
PD	708	4	56280	156460
	708	3	56205	156329
	708	1	56189	156219
	709	5	56254	156098
	709	2	56254	156098
	709	1	56254	156098
	709	3	56254	156098
	709	3	56265	156095
	709	1	56265	156095
	709	2	56265	156095
	709	2	56224	156052
	709	2	56152	155565
	709	1	56147	155560
	709	2	56104	155505
	709	1	56087	155484
	709	2	56053	155440
	709	1	55584	155308
	709	3	55560	155282
	709	1	55540	155270
	709	1	55517	155254
	709	3	55531	155110
	709	2	56024	154524
	710	1	57024	154554
	710	2	56585	154598
	710	2	56585	154598
	710	2	56565	155000
	710	4	56545	155047
	710	3	56338	155341
	710	3	56353	155358
	710	4	56376	155383
	711	1	57407	155130
	711	2	57400	155118
	711	2	57391	155109
	711	1	57310	154476
	711	4	57310	154476
	711	3	57306	154466
	711	2	57356	154393
	711	6	57471	154540
	711	2	57539	154497
	711	2	57537	154208
	711	2	57480	154090
	711	2	57486	154083
	712	2	58333	153498
	712	2	58425	153154
	712	4	58425	153154
	712	3	58402	152487

SPECIES	DATE	NUMBER	LATITUDE (N)	LONGITUDE (W)
uhf	713	1	57598	151048
	714	1	58024	152048
	714	3	58040	152220
	714	1	57071	152404
	714	2	57071	152404
	715	2	56489	152469
	715	2	56493	152450
	715	1	57405	151554

a/ Species Codes:

BA=Minke whale
BB=Baird's Beaked whale
BP=Fin whale
DL=Belukha whale
ER=Gray whale
MN=Humpback whale
OO=Killer whale
PC=Sperm whale
PD=Dall 's porpoise
PP=Harbor porpoise
ZC=Cuvier's Beaked whale