Investigation of Dall's Porpoise (Phocoenoides dalli) Responses to Survey Vessels: Progress Report

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Introduction:

In 1982 as part of the United States-Japan cooporative agreement on Dall's porpoise we began investigating the effects of survey vessels on the behavior of porpoise in Prince William Sound, Alaska. The results of the preliminary study were reported at the 1983 INPFC marine mammal Scientific Subcommittee meeting and at the 1983 IWC Small Cetacean Subcommittee meeting (Bouchet et al. 1983a, 1983b). The results from that study encouraged us to repeat the experiment in 1983 with the intention of further quantifying our observations and improving our techniques.

Methods:

The vessel chartered was the M/V NORPAC I, a 26 m (84 ft) former shrimp trawler outfitted for research with a helicopter landing pad and Bell 206 B3 ("Jet Ranger") helicopter. The NORPAC I's cruising speed during the survey was approximately 18 km/hr (10 kts) and that of the helicopter approximately 111 km/hr (60 kts). One hundred fifty two meters (500 ft) was the standard helicopter survey altitude. Aerial surveys were not flown when the wind force was greater than 30/km/hr (Beaufort 4), when visibility was reduced due to rain, or when low clouds prevented the helicopter from flying at sufficient altitude. For each flight, the helicopter was flown: a) directly over the vessel to calibrate position; b) out along the ship's track line for approximately 1-1.5 nm; c) in a 90° turn to either port or starboard; d) perpendicular to the ship's track line for approximately

1 nm; e) again in a 90° turn to fly parallel to the ship until approximately 1 nm ahead of the vessel; f) finally another 90° turn to cross the ship's track (Figure 1). This flight path allowed the helicopter to scan an area 1 nm in front of the ship and 1-1.5 nm to either side of the ship's track line. This distance was chosen to obtain the maximum number of "linked" sightings (groups sighted by both ship and helicopter observers). Initially the helicopter flew up to 2 nm in front of the ship, but it was difficult to link sightings at that distance. The frequency of linked sightings increased significantly after bringing the helicopter survey pattern closer to the ship.

The surveys consisted of a number of these legs determined by the amount of fuel, visibility, sea state, and observer fatigue. During good weather, three surveys per day were flown, each of approximately 2 hr duration. The helicopter crew consisted of the pilot and two observers: the primary observer (and data recorder) was seated next to the pilot and the second observer (video operator) was seated behind the pilot. When a group of animals was sighted, the search pattern was suspended and the species, number, direction of travel, position (latitude-longitude), and behavior of the group were recorded while the helicopter circled the group. Video taping of the porpoises behavior was also conducted from the helicopter. A maximum of 10 min was spent on each encounter (location, direction of travel, and behavior were logged every 2 min), after which the survey track line and altitude were resumed at the approximate point of departure.

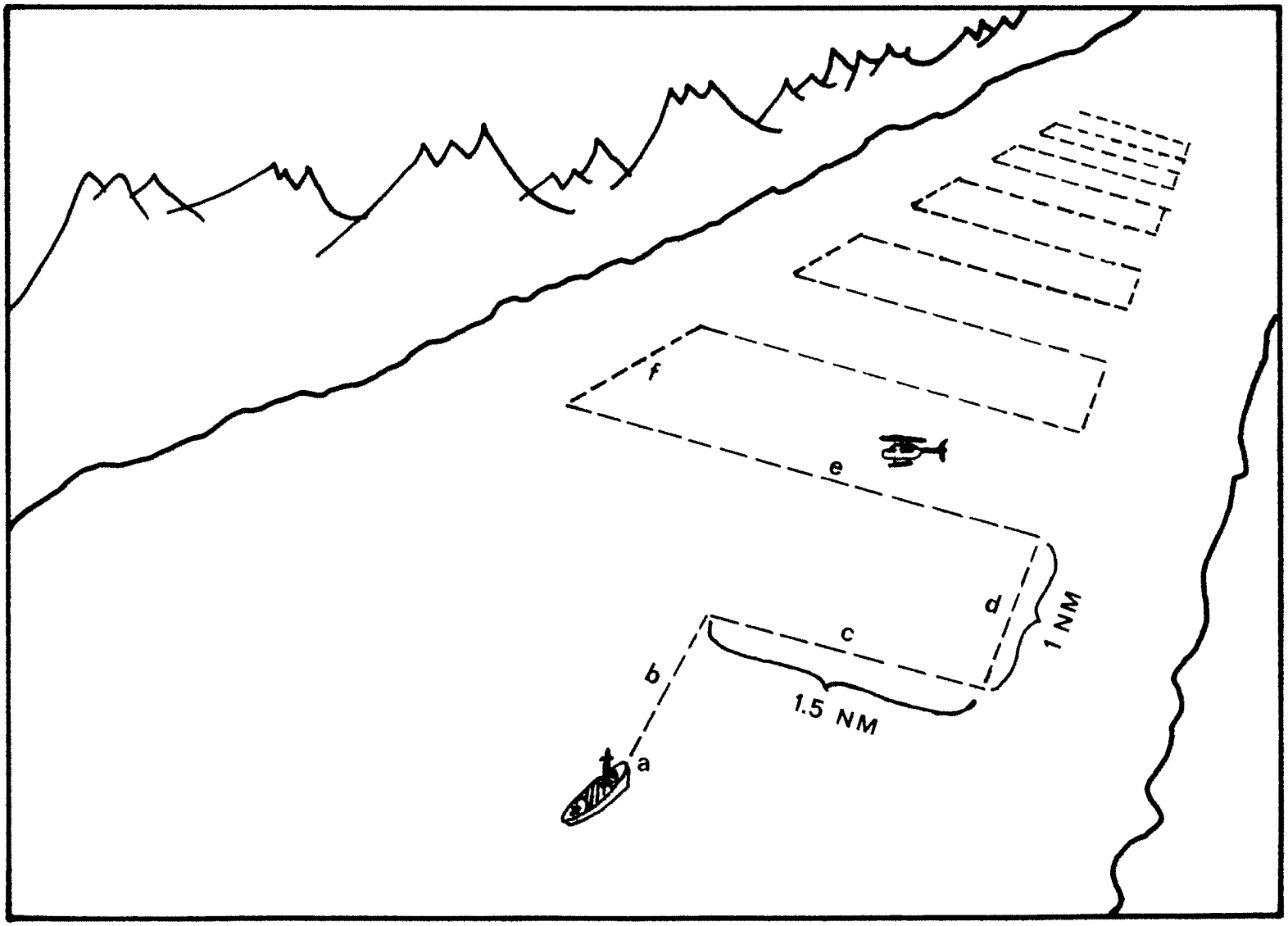

Figure 1. Experimental design, Dall's porpoise behavior study 1983. Dashed line indicates approximate helicopter flight path. See text for details.

Watches were conducted onboard the ship concurrent with the helicopter flights. These watches were conducted by two observers: one on the bridge and the second in the "crow's nest" (a small platform located 10 m (33 ft) above the water level) acting as the primary shipboard observer. The primary ship observer followed our standard POP[1] sighting procedures-- scanning for the presence of animals with the unaided eye; using binoculars to confirm identification. The observations (species, number, distance, angle from the ship and behavior) were then transmitted (via radio) to the bridge observer who recorded them while acting as the communications coordinator between all observers. The bridge observer was also recording ship position (latitude-longitude) and helicopter relative position (range and bearing) at each helicopter change of direction. In addition, positions were taken whenever the helicopter encountered a school of porpoise and each two minutes while circling.

The helicopter observers concentrated on recording behavioral data from each group sighted, particularly noting if animals were observed reacting (or not reacting) to the presence of the vessel. The helicopter data recorder recorded helicopter position (latitude-longitude) along with the sighting data (species, number and behavior). See Appendix Table 1 for a full description of the field data formats.

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1. POP--NOAA's Platforms of Opportunity Program, National Marine Mammal Laboratory, Seattle, Washington.

A portable video cassette recorder (1/2" VHS format) and camera were used to document the research. The video equipment was primarily utilized during the helicopter surveys. While observing porpoise groups, video documentation of different types of behavior and behavioral sequences were obtained. On board ship, other phases of the research were documented.

The coastal waters were surveyed between Homer and Prince William Sound, offshore to Middleton Island, and the southwest portions of Prince William Sound (especially Montague Strait, Knight Island passage and surrounding waters)(Figure 2). When flights could not be made due to rain or low ceiling, vessel surveys were made in adjoining bays to census other marine mammals. The survey dates were 16-27 August 1983.

Results:

A total of 29.5 hours of helicopter surveys were conducted over a 10 day period (Appendix Table 2). Most effort was concentrated in a 4 day interval of excellent weather at the beginning of the cruise. The ship observers sighted 90 groups of porpoise during the surveys; 60 groups were sighted from the helicopter. Of these, 29 groups were sighted by both the helicopter and ship (linked). Eight of these were omitted from analysis because the ship observer initially sighted the animals at distances greater than 2.5 km and the reliability of distance estimates at this range is known to be poor. The remaining 21 sightings are listed in Table 1. Sighting distance and angle

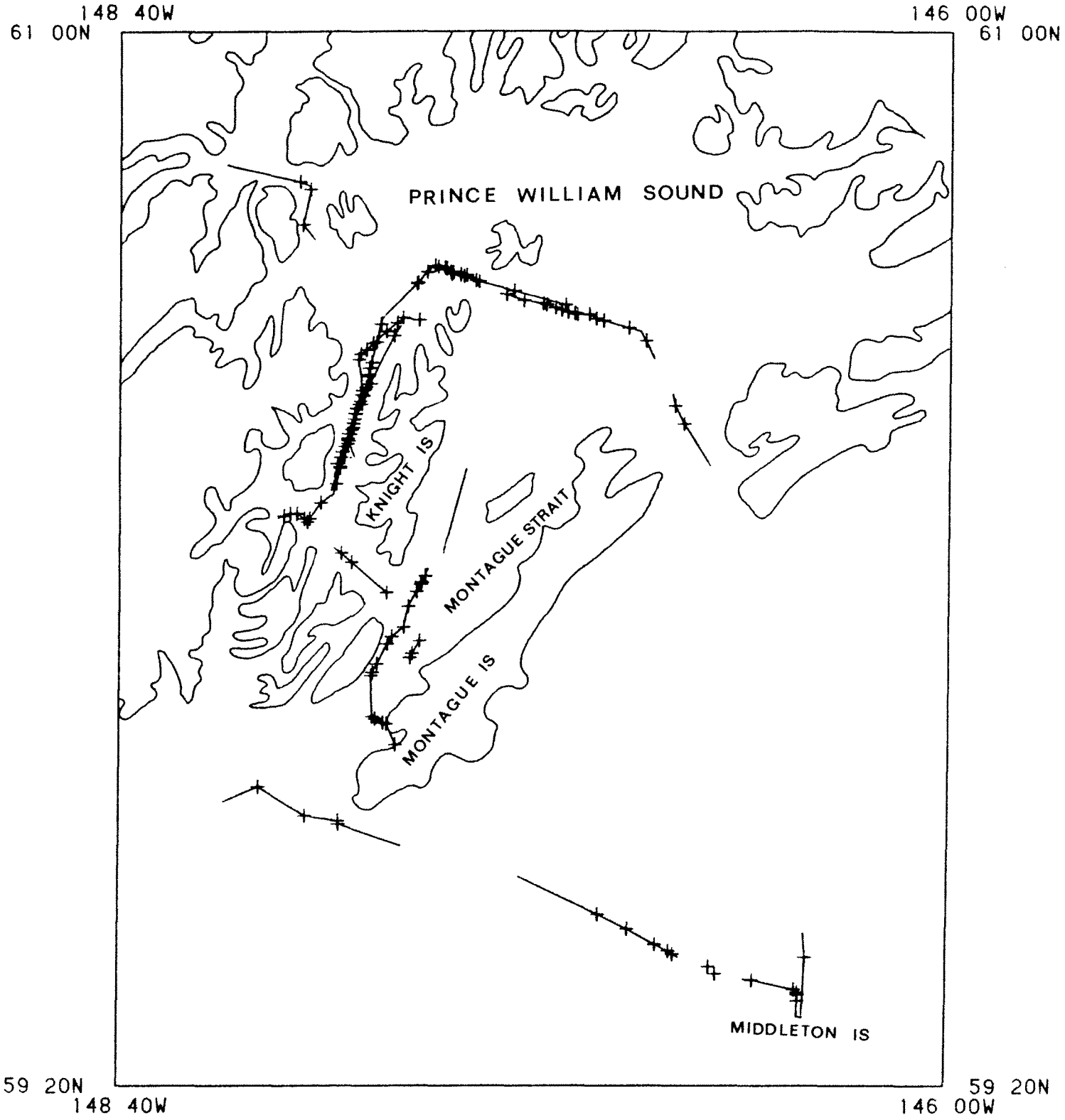

Figure 2. Dall's Porpoise behavior study site. Prince William Sound, Alaska, August 16-27 1983. Lines indicates survey effort; + indicates sightings.

measurements were transformed into perpendicular distances from the ship's track line prior to analysis. Net changes in perpendicular distance are illustrated in Figure 3. Vessel attraction was defined as a decrease in perpendicular distance over the period of observation. If the perpendicular distance increased, this was termed avoidance. We observed, from the linked sightings, 13 occurrences of vessel attraction (61.9%) and 6 cases of avoidance (28.6%). Two net changes (9.5%) were less than 100 meters and were treated as no reaction--neither avoidance nor attraction. The mean net change in perpendicular distance was -90.0 meters (ie. toward the vessel). Withrow[2,3] reported that the majority of Dall's porpoise sighted from the Oshoro Maru in 1982 and 1983 approached the vessel. Table 2 illustrates the reactions of Dall's porpoise to vessels during four studies. The two Prince William Sound studies represent porpoise in near shore (inland) waters responding to a small vessel, whereas the two studies from the Oshoro Maru occured in the north Pacific Ocean and Bering Sea (offshore) with a much larger vessel. The variation between studies was great and the only statistically similar results were between this study (Prince William Sound, 1983) and the Oshoro Maru in 1982 (X^2 = 1.53; d.f. = 2; P = 0.47). However, if you consider only those animals exhibiting an obvious reaction to the vessel, in all cases more porpoise were attracted to the vessels (N=112; 70%) than avoided them (N=48; 30%).

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2. Withrow, D.E. 1982. Report on the marine mammal studies aboard the Japanese research vessel Oshoro Maru 5 June - 10 July 1982. National Marine Mammal Laboratory, Seattle, Washington. 23 July, 1982. 21p.

3. Withrow, D.E. 1983. Cruise report for the Oshoro Maru 5-25 June 1983. National Marine Mammal Laboratory, Seattle, Washington. 11 July, 1983. 16p.

Table 1. Calculated perpendicular distances and net change in perpendicular distances for ship and helicopter observations of Dall's porpoise.

	SIGHTED BY SHIP					SIGHTED BY HELO					
Date (Aug. 1983)	Time	Number	Distance (m)	Angle	Calculated Perpendicular Distance m	Time	Number	Bearing	Range (m)	Calculated Perpendicular Distance m	Net Change Perpendicular Distance m
17	1339	5	150	320	96	1333	6	010	2408	418	-322
18	0815	3	315	340	108	0808	4	250	1111	1044	-936
18	0836	3	150	350	26	0827	4	019	926	302	-276
18	1500	4	130	040	84	1503	3	085	1482	1476	1392
18	1528	6	500	330	250	1529	6	316	2037	1415	1165
18	1559	1	1000	030	500	1605	2	030	2778	1389	889
18	1610	2	500	000	500	1611	4	059	1852	1588	1088
19	0855	2	1000	090	1000	0843	4	034	3704	2071	-1071
19	0912	4	1000	030	500	0909	3	027	2408	1093	-593
19	1110	5	500	320	321	1110	5	322	1482	912	-591
19	1233	1	1200	340	410	1235	5	321	741	466	56
19	1249	5	1000	010	174	1246	6	028	1852	865	-691
19	1251	4	1200	300	1039	1251	4	317	926	632	407
19	1309	5	1200	340	410	1310	4	012	370	77	-333
19	1510	4	500	040	321	1513	5+2	046	1111	799	478
20	0834	2	200	290	188	0829	$\overline{1}$	019	926	302	-114
20	1203	3	020	020	7	1154	2	315	1667	1179	-1172
20	1228	4	250	030	125	1213	3	002	1296	45	80
20	1228	3	300	340	103	1219	2	323	741	446	-343
20	1238	2	800	080	788	1235	3	070	1296	1218	-430
20	1248	3	600	030	300	1243	1	028	1852	870	-570

$\bar{x}$ = -90
N = 21

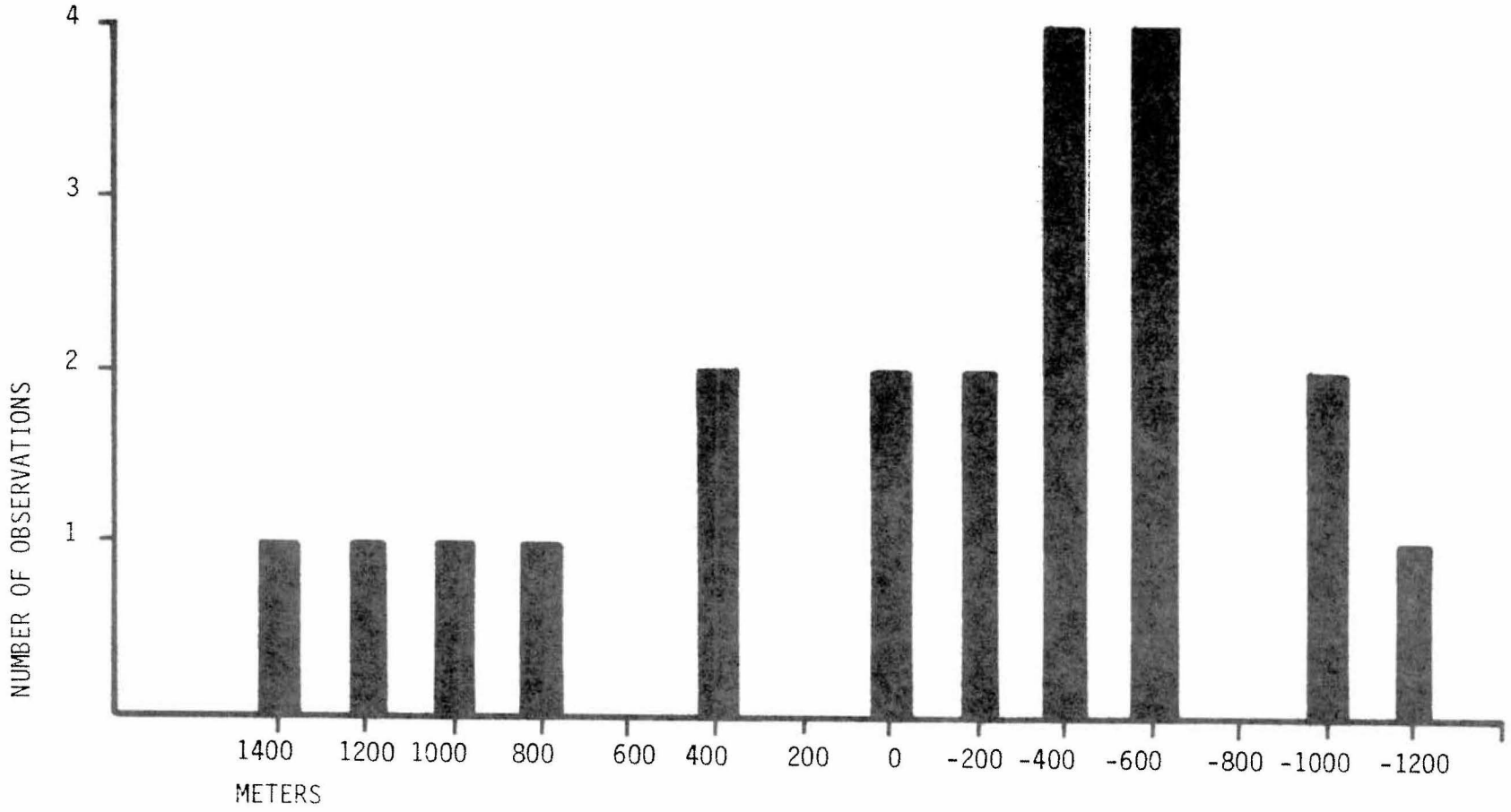

Figure 3. Net change in perpendicular distance from the survey vessel's trackline over the time of observation, Dall's porpoise behavior study, 1983.

Table 2. Comparison of Dall's Porpoise reaction to survey vessels in Prince William Sound and in the North Pacific Ocean.

	Prince William Sound				North Pacific Ocean[a]			
	1982		1983[b]		1982		1983	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Attraction	37	21.9	13	61.9	47	52.2	15	48.4
Avoidance	15	8.9	6	28.6	24	26.7	3	9.7
No Reaction	117	69.2	2	9.5	19	21.1	13	41.9

a. Oshoro Maru
b. Linked sightings only.

Group sizes were recorded from both the vessel and helicopter. There were no significant differences in observed mean group sizes between the ship and helicopter (Table 3)).

Table 3. Frequency of group sizes of Dall's porpoise sighted from the ship and helicopter.

Group Size	Ship	Helo
1	15	8
2	23	13
3	26	13
4	14	13
5	8	9
≥ 6	4	4
N =	90	60
$\bar{X}$ =	2.9	3.2
S.D. =	1.4	1.4

$x^2 = 3.48$ d.f. = 5 P = 0.62

Behavioral observations:

Individual behaviors observed did not differ from those reported by Bouchet et al.(1983b)[4]. The incidence of the three most common behaviors is examined in Table 4. There was no statistical difference between the relative frequencies of the porpoise behaviors sighted from the ship and helicopter (Chi-square goodness of fit test, P=0.8025).

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4. "Five distinct Dall's porpoise behavioral patterns were noted. The first three were observed from both the shipboard and helicopter while the last two were observed only from the helicopter.

a. Slow roll - a portion of the porpoise's upper body surface was visible briefly as the animal quietly broke the water surface, arched its back, and submerged while maintaining forward momentum. The entire sequence created only a slight disturbance at the water surface.

b. Rooster tail - this characteristic V-shaped spray was created on the water surface as fast swimming porpoise rapidly surfaced and submerged. Helicopter observers noted that intermittent "rooster tail" splashes were associated with a normally sustained, fast, subsurface swimming mode ("fast swimming").

c. Surface splash - these "rooster tail" type splashes, generally directed over a short distance, were coupled with sharp changes of direction of travel at and just below the water surface, and subsurface rolls about the body axis (up to 90° left and/or right). This behavioral pattern, believed to be associated with feeding, always occurred in pods of several to many animals (up to 20) in an area seldom exceeding several hundred square meters.

d. Fast swimming - this sustained, rapid rate of swimming just beneath the surface of the water left no visible disturbance at the surface and was observed in Dall's porpoise that were not, in our judgement, reacting to the presence of the survey vessel.

e. Deep dive - the activity was regularly observed as a continuation of the "slow roll" followed by 1.5-3.0 min dive times. When a pod or individual porpoise proceeded from "fast swimming" to the into "deep dive" mode, they arrested their forward momentum by executing a sharp left or right turn ("hockey stop") at the water surface, took several breaths while slowly moving forward just below the surface, and then initiated the dive. Following the "deep dive", porpoise(s) surfaced slowly and took several breaths while slowly moving forward, submerging shallowly between breaths. On occasion, the first and sometimes the second exhalations were plainly visible from the helicopter which was hovering at 152 m (500 ft). "

Table 4. Relative percentage of three most common Dall's porpoise behaviors observed from the ship and helicopter.

	Ship		Helicopter	
	Freq.	Percent	Freq.	Percent
Slow Rolling	43	58.1	55	62.5
Rooster-tailing	26	35.1	27	30.7
Surface splash/Milling	5	6.8	6	6.8
N =	74		88	

$x^2 = 0.37$ d.f. = 2 P = 0.83

Cows with calves:

Calves were sighted frequently from the helicopter (Table 5). From the air, 173 adult porpoise and 21 calves (17 sightings) were seen. Thus, 10.8% of all porpoise sighted from the helicopter were calves. Bouchet et al. (1983b) reported seeing only 12 cow/calf pairs from the ship and helicopter combined which composed only 2% of all porpoise sighted. In the present study, 265 adults and only 2 calves (0.7% of the sample) were seen from the ship. Better sighting conditions in this study may account for the higher proportion of calves seen. In rough water conditions it becomes more difficult to identify calves.

Table 5. Frequency of calves sighted by ship and helicopter observers.

	Ship	Helicopter
No. Adults	285	173
No. Calves	2	21
% Calves in Sample	0.7%	10.8%
Number of Sightings with Calves	2	17
Mean Group Size	3.0	3.824
Standard Deviation	--	1.237

The mean distance from the ship to calves sighted by helicopter observers was 2233 meters (Table 6). In contrast, the mean distance from the ship to calves sighted by the ship observers was 35 meters. In only one instance was there a linked sighting of a group of porpoise that included calves. The helicopter reported seeing three cow/calf pairs 2.4 km (1.3 nm) from the ship. Six minutes later the ship observer reported 5 porpoise 150 m away, rooster tailing. This was definitely the same group, however the ship observer missed one animal and could not distinguish calves from adults. Kasuya and Jones (in press) reported that calves could be recognized if within 100 m of ship. Thus it appears that shipboard observers can only identify calves if calves come very close to the ship.

It appears as though porpoise pods with calves tend not to approach ships. In 1982, groups were seen splitting up, with the cow/calf pairs remaining at some distance while the rest of the group was attracted to the vessel. Although this was not observed in 1983, Kasuya and Jones (in press) also reported that cow/calf pairs never came to the ship and rode the bow wave during that cruise. Withrow (op.cit.), however, reported 2 ocurrences of cow/calf pairs bow riding from the Oshoro Maru in 1982.

Table 6. Initial sighting distances (meters) of calves sighted from the ship and helicopter and associated group sizes.

SHIP	Number Adults	Number Calves	HELICOPTER	Number Adults	Number Calves
50	2	1	2408	4	1
20	2	1	2408	3	3
			2222	2	1
			5186	1	1
			1852	1	1
			1852	3	1
			3704	3	1
			2408	2	1
			2963	3	1
			2222	4	1
			1482	3	2
			2222	1	1
			2593	4	1
			741	4	1
			741	2	1
			1667	1	1
			1296	2	1
	$\bar{x}$ = 35			$\bar{x}$ = 2233	
	S.D. = 21.2			S.D. = 1065	
	N = 2			N = 17	

The mean group size of porpoise pods with calves was 3.82. The mean reported during the 1982 study was 3.58. Although higher than the mean group sizes for all sightings reported in Table 3, the difference was not significant (Chi-square goodness of fit test; P =0.8025).

Discussion:

If the porpoises react to the ship over the same distances offshore as they do in Prince William Sound, the implications for population estimation are great. A net movement of 90 m toward the ship will significantly bias abundance surveys resulting in overestimation of population size (Bouchet, 1983).

The frequencies of different types of porpoise behavior observed offshore are quite different from those observed in Prince William Sound. Table 7 lists the number of occurrences of Dall's porpoise exibiting slow rolling, rooster-tailing, surface splash/ milling and riding ship's wave (bow or stern) behaviors in offshore areas (NMML unpublished data). At sea, the most frequently observed of these four behaviors was rooster-tailing (51.2 %) followed by wave riding (32.5%) and slow rolling (14.3 %). In contrast, Prince William Sound animals were observed rooster-tailing only 32.5% of the time and slow rolling 60.1% of the time. There was virtually no wave riding behavior in Prince William Sound in 1983 (0.6%). The differences between the Prince William Sound and pelagic animals were significant (Chi square test $p=<0.0001$, Table 7.).

Table 7. A comparison of the relative frequencies of the four most common Dall's behaviors between pelagic animals (POP 1979-82) and in Prince William Sound (ship and helicopter).

	POP (Pelagic)		Prince William Sound (Ship & Helicopter)	
	Freq.	Percent	Freq.	Percent
Slow Rolling	379	14.3%	98	60.1%
Rooster-tailing	1357	51.2%	53	32.5%
Surface splash/Milling	55	2.0%	11	6.8%
Riding ship's wave	862	32.5%	1	0.6%
N =	2653		163	

$x^2 = 266.37$ d.f. = 3 $P < .0001$

Apparently sighting conditions, particularly wind and sea state, affect both the porpoises behavior and the ability of the observers to categorize behavior. Figure 4 illustrates how the frequency of the four most common behaviors change as the sighting conditions vary (based on the POP data). Rooster-tailing is the predominant behavior observed during pelagic sighting surveys. As visibility conditions deteriorate, the relative frequency of bow (and stern) wave riding increases, until at visibilities 5 and 6 it becomes more common than rooster-tailing. The relative frequency of slow rolling animals decreases as bow riding increases. This could be a result of a change in the frequency of observation of these behaviors, rather than an actual change in the porpoises' behavior(ie. as conditions deteriorate, an observer is more likely to see bow riding animals since they would be close to the vessel).

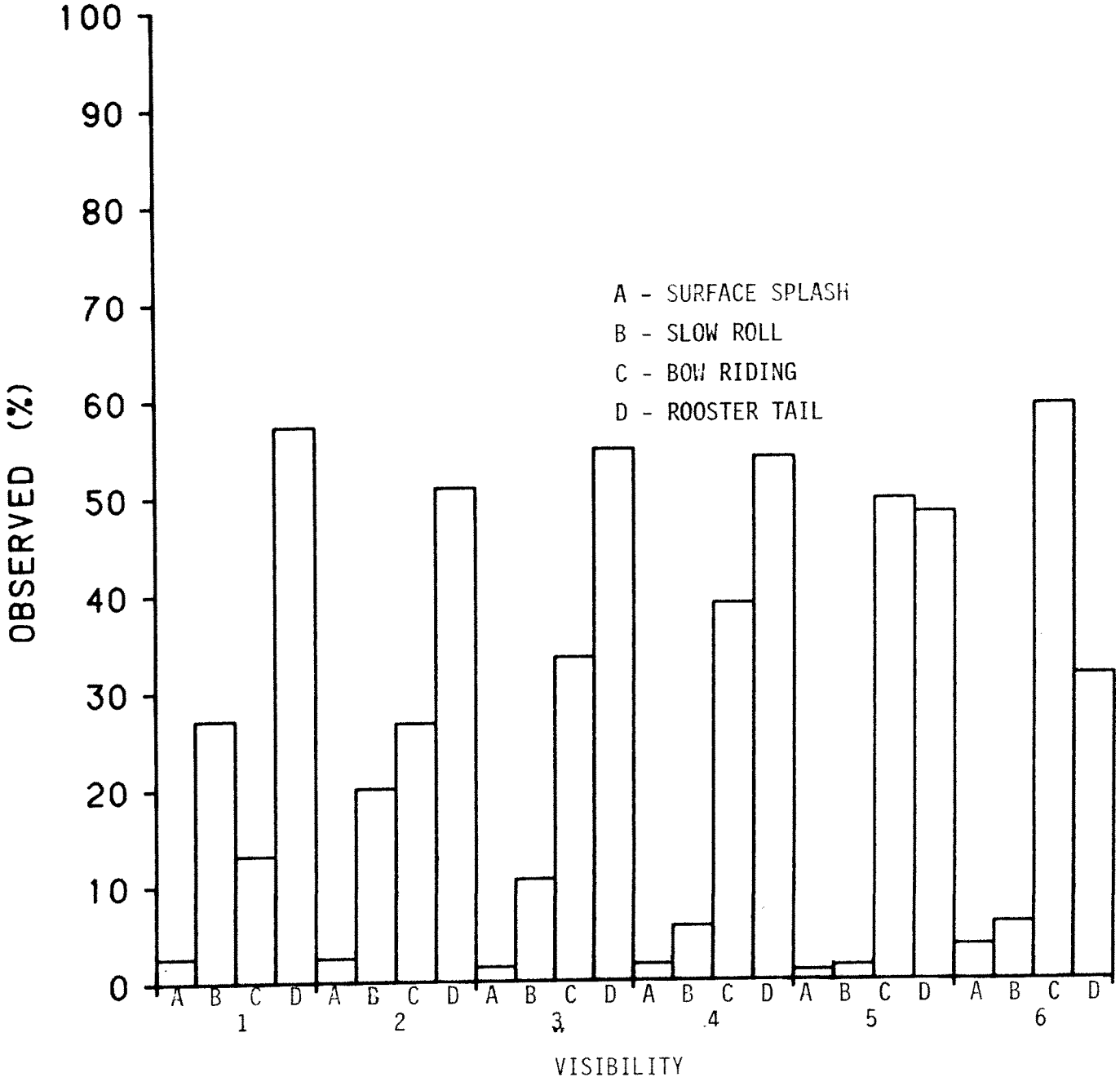

Figure 4. Changes in the relative frequency of four behaviors (A=surface splash, B=slow roll, C=bow or stern wave riding, D= rooster-tailing) over six visibility conditions (1= excellent, 6= unacceptable). POP data base, 1978-1982.

It is clear from the results of this study and from Kasuya and Jones (in press) that Dall's porpoise do not behave in the same way throughout their range. There are differences between areas, time of day, environmental conditions and type of survey vessel. With this in mind, one is reluctant to extrapolate these results to the entire population.

The evidence collected from both the 1982 and 1983 studies indicates that vessel attraction is occurring, at least in one inshore area. We have also shown that it is possible to record the kinds of data necessary to quantify the level of attraction occurring. What remains to be done is to determine how the porpoise behave in the offshore areas currently being censused. We are planning a continuation of this project this summer using the NOAA research vessel Surveyor in offshore waters. The results from that survey may enable us to answer this question.

Other Marine Mammals:

Additional marine mammal sightings were recorded. Appendix Table 3 illustrates the larger groups of pinnipeds seen. The number of animals present were estimated by experienced observers and not actually counted. All of the sea lion sightings and the first harbor seal sighting were made by observers in the helicopter. The remaining 2 sightings were made from the vessel, since inclement weather prevented an aerial census. A summary table of the total number of marine mammals, by species, appears in Appendix Table 4. These totals are a survey summation of all marine mammals sighted between 16 and 27 August 1983. The most commonly sighted animals were pinnpeds (northern sea lions and harbor seals), followed by small cetaceans (Dall's porpoise, killer whales and harbor porpoise) and finally baleen whales (humpback and minke whales). Sea otters were so numerous that they were not consistently censused since doing so would have significantly decreased the time available for Dall's porpoise work.

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The captain and crew of the NORPAC I, George Rains, Lan Bidon and Mike Fell, and Don Fell, pilot and owner of Maritime Helicopters are to be commended for their generous cooperation, safety consciousness and enthusiastic assistance. We wish to thank Richard Rowlett for his expertise in data collection and tabulation; Vicki Menshouse and Betty Lander for providing valuable support in completing drafts of this paper; the reviewers Linda Jones, Howard Braham and R.V. Miller; and Ethel Zweifel for her assistance in duplicating the final product.

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Appendix Table 1. The field format used in the study of Dall's porpoise behavior.

A. Shipboard Observation Format

Variable Name	Definition and Remarks
RID	The record identifier (or cruise identifier) is a unique seven digit descriptor identifying each cruise.
Date (Yr, Mo, Day)	A six digit descriptor identifying the year, month, and day of the cruise.
Time (Hr, Min)	The time of observation by the 24-hour clock.
Latitude	The latitude in degrees, minutes, and tenths of a minute and hemisphere.
Longitude	The longitude in degrees, minutes, and tenths of a minute and hemisphere.
Species	A two character species code. (See Consiglieri and Bouchet, 1981 Appendix Table 21 for species codes.)
Confidence Interval	A single digit code for the confidence interval applied to the number of animals observed. (See Consiglieri and Bouchet, 1981 Appendix Table 20 for C.I. codes.)
Number	The number of animals observed.
Behavior	A two character code for observed behavior. (See Consiglieri and Bouchet, 1981 Appendix Table 22 for behavior codes.)
Distance	The initial distance from observer to animal(s); recorded in tens of meters.
Angle	The initial sighting angle relative to the ship; recorded in tens of degrees
Visibility	A single digit code which takes into account factors that affect visibility. (See Consiglieri and Bouchet, 1981 Appendix Table 24.)
TFLAG	A transit flag code designating the beginning or end of a transit.
Text	This space assigned to comments to add to existing coded data or to describe in detail behavior observed.

Appendix Table 1. The field formats used in the study of Dall's porpoise behavior (cont'd).

B. Position of the ship and relative position of the helicopter.

RID	See Table 1.A.
Date	See Table 1.A.
Time (Hr, Min, Sec)	The time of record by the 24-hour clock (including seconds).
Latitude	See Table 1.A.
Longitude	See Table 1.A.
Range	The helicopter's range in nautical miles from the ship.
Bearing	The helicopter's bearing in degrees relative to the ship.

C. Helicopter sightings data was recorded using the same format as in Table 1.A except time was recorded to seconds and distance and angle from the ship were not collected.

Appendix Table 2. Dates, hours, and visibility codes of helicopter flights.

Flight No.	Date	No. Hours	Visibility Code
1	16 August	1	1-2
2	16 August	1	3
3	17 August	2	2-3
4	17 August	2	3
5	17 August	2	2-3
6	18 August	2	1-3
7	18 August	2	1-3
8	18 August	2	1-2
9	19 August	2	1
10	19 August	2	1
11	19 August	1-1/2	1
12	20 August	1	4
13	20 August	1-1/2	3
14	20 August	1-1/2	3
15	23 August	1	3
16	24 August	2	1-2
17	24 August	1/2	2-5
18	26 August	1-1/2	2-3
19	27 August	1	2
		29-1/2	

Appendix Table 3. Large groups of other marine mammals sighted during surveys (estimates).

Species	Date	Number	Location
Northern Sea Lion (Eumetopias jubatus)	16 August	4705	Sugar Loaf Is. (58.53N 152.02W)
	17 August	425	Middleton Is. (59.25N 146.20W)
	19 August	1500	Seal Rocks (60.10N 146.50W)
Harbor Seal (Phoca vitulina)	18 August	250	Green Is. (60.18N 147.24W)
	22 August	650	Columbia Glacier (61.00N 147.05W)
	26 August	2500	Chenega Glacier (60.16N 148.22W)

Appendix Table 4. Summary table of marine mammals sighted between 16 and 27 August 1983. Prince William Sound,Ak.

Species	Number
Northern Sea Lion (EJ)	6,865
Harbor Seal (PV)	3,581
Dall's Porpoise (PD)	489
Killer Whale (OO)	35
Harbor Porpoise (PP)	17
Humpback Whale (MN)	11
Minke Whale (BA)	8
Sea Otters (EL)	numerous (not consistently censused).