Exxon Valdez Oil Spill Trustee Council

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ASSESSMENT OF INJURIES TO KILLER WHALES IN PRINCE WILLIAM SOUND, KODIAK ARCHIPELAGO, AND SOUTHEAST ALASKA

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EXECUTIVE SUMMARY

Photographs of individual killer whales occurring in Prince William Sound (PWS) were collected from May to September 1989-91 to assess the impact of the Exxon Valdez oil spill (EVOS) on killer whale abundance and distribution. To account for killer whales potentially displaced from Prince William Sound to other areas, concurrent photo-identification studies were also conducted off Kodiak Island (1989) and southeast Alaska (1989 to 1991).

Research vessels traversed an average of 9,205 nautical miles in PWS each year. In 1989, eight resident (143 whales) and four transient pods (34 whales) were documented, totalling 177 animals in 89 encounters. In 1990, nine resident pods (148 whales) and four transient pods (30 whales) were identified, representing 80 encounters. During 1991, seven resident pods (105 whales) and two transient pods (14 whales) were identified from Prince William Sound, representing 54 encounters. Despite increased effort in Prince William Sound over the last three years (1989 to 1991), the number of encounters with killer whales appears to be decreasing. The missing animals were not seen near Kodiak Island or southeast Alaska.

Photographic analysis of resident pods revealed 14 animals missing from AB pod over the three-year period (1989-1991). The mortality rates for AB pod ranged from 3.1% in 1988 to 19.4% in 1989, 20.7% in 1990, 4.3% in 1991, and zero in 1992. Killer whale annual mortality rates are usually less than 2%. Annual pod mortality rates on the order of 20% are unprecedented for North Pacific killer whales.

No new calves were born into AB pod in 1989 or 1990. There was one calf born in 1991 and two born in 1992 in AB pod. AB pod size in 1988 was 36; in late 1992 the pod had 25 members.

The cause(s) of the disappearance of 14 killer whales from AB pod is unknown. We are confident that 1) whales have not been mis-identified, 2) adequate effort was made to locate missing whales, and 3) the number of encounters was sufficient to evaluate the presence or absence of an individual whale. The current life history information available on killer whales does not support the possibility that the whales moved elsewhere. Therefore, we assume, that the whales are dead from natural causes, a result of interactions with fisheries, from the EVOS, or a combination of these causes.

INTRODUCTION

Killer whales, Orcinus orca, occur in all oceans of the world (Dahlheim and Heynig, in press). Population estimates, based on photo-identification studies, are available for three North Pacific regions, Washington State, inland waterways of British Columbia, and Prince William Sound (Balcomb et al. 1982; Bigg 1982; Bigg et al. 1987; Leatherwood et al. 1984, 1990; Matkin et al. 1987). Counts for Prince William Sound include 11 resident pods (representing 245 whales) and eight transient pods (representing 52 whales) totalling 297 whales (Heise et al. 1991). The purpose of this study was to determine the possible impact of the Exxon Valdez oil spill (EVOS) on killer whales in Prince William Sound (PWS) since on four separate occasions, five different killer whale pods were observed swimming directly through oil. There were no apparent attempts made by the whales to avoid the oil. We determined impact by obtaining photographs of individual killer whales in Prince William Sound from mid May to September 1989, 1990 and 1991. These photographs were compared to an existing photographic database from 1984 to 1988 (Heise et al 1991; Matkin unpub. data) to determine if changes occurred in whale abundance, seasonal distribution, birth and mortality rates, and continuity of habitat usage. Results of the research allowed determination of the loss (reduction in numbers; change in vital rates) to killer whale populations or extent of injury (displacement) resulting from the EVOS.

OBJECTIVES

1. To count the number of killer whales in Prince William Sound.
2. To test the hypothesis that killer whale distribution within Prince William Sound and adjacent waters is similar to that reported for previous years.
3. To test the hypothesis that pre- and post-oil spill killer whale pod structure and integrity have remained the same.
4. To test the hypothesis that killer whale natality has not changed since the EVOS.
5. To test the hypothesis that killer whale mortality rates have not changed since the EVOS.

METHODS

Count and Identify Killer Whales:

Field Procedures - Prince William Sound

Field seasons occurred from May to September each year. In 1989, small skiffs (< 6 m) operated from camps located on Squire Island, Hinchinbrook Island, and Perry Island (Fig. 1). The Perry Island camp was moved to Point Nowell (14 miles south of Perry Island) in mid-season. In 1990 and 1991, only one field camp was established in the southwestern region at Squire Island (off the southwest side of Knight Island). The Squire Island camp was staffed by two biologists using one small boat. In 1990 and 1991 two biologists used a live-aboard vessel for locating killer whales.

Weather permitting, an average of 8 to 10 hours per day were spent conducting boat surveys searching for or photographing whales. Specific areas known for whale concentrations were emphasized. If whales were not located in known areas and opportunistic sighting reports were not available, a general search pattern was developed and implemented. Travel routes (based on information acquired on the whales prior to the EVOS) used by whales were surveyed.

Killer whales were photographed when sighted and a survey form completed for each encounter (Fig. 2). When whales were encountered, the vessel was guided onto the whale's course and speed to approach within 30-60 meters of the whales left side. The whale's dorsal fin and saddle patch were then photographed with 35 mm camera systems (i.e., Nikon, Canon, Pentax) with motor drives and 300 mm lens set at 1/1000th sec shutter speed, or the highest speed possible. Black and white Ilford HP5 film (ASA 400) was used and developed at ASA 1600. Exposed film was developed by the same photographic laboratory and processed throughout the season to allow field personnel to obtain necessary feedback. Exposed film was labeled with date, roll number, photographer's initials, location, species code, and ASA setting. A new roll of film was used for each encounter.

All exposed film was analyzed for individual identification (Fig. 3). Each negative (or prints as needed) was placed under a dissection microscope for identification purposes and notes and sketches made of the dorsal fin and saddle-patch. Sub-standard

photographs (not showing enough detail or improper angle/side) were not used. Photographs were then grouped by individual and each identified whale was visually compared to the historical photographic database available through the National Marine Mammal Laboratory and the Pacific Biological Station Nanaimo, British Columbia, Canada. Once an individual whale was identified, it was relatively easy to identify the pod to which it belonged. Once all photographs were examined, it was then possible to determine 1) if all members of the pod were present, 2) if pod structure/integrity was similar to previous years, and (3) if whales were recruited (born) into the pod. Any missing animals were noted.

The stability of resident pods over time is such that if an individual is listed as missing for at least one year, that missing whale is considered dead. No animal consistently missing from a resident group has ever returned to its pod or appeared in another pod in 24 years of research in the United States and Canada. Unfortunately, due to the highly variable nature of transient pods, pod structure and mortality rates cannot be conclusively documented for transient groups to assess damage.

An "encounter" was defined as the successful detection, approach and taking of identification photographs. A "sighting" was the detection and observation of whales when no photographs were obtained. Reliable and specific accounts of whales from other vessels were termed "reports". Although sightings and reports were used to select areas to be searched, all

identifications used in analysis were made from photographs taken during encounters.

Daily effort logs were maintained. These logs permitted 1) quantification of the amount of time searching for whales versus photographing whales, 2) quantification of search effort under different weather conditions; 3) daily vessel trackline, and 4) an estimation of number of vessels/aircraft encountered in the study area.

Vital Rates:

Calves of the year were identified by size, their mothers identified, and pod birth rates calculated. No dead killer whales were located during the study; mortality was assumed based on the absence of an identified animal after missing for more than one year. Mortality rates were calculated for resident pods only because the data base is more reliable. Finite annual birth rates (BR) and mortality rates (MR) for each pod were calculated as follows:

$$MR = \frac{NM}{NP}$$

where: NM = number of whales missing from the pod in given year.

NR = number of new calves in a pod in a given year.

NP = number whales present at end of previous year.

$$BR = \frac{NR}{NP}$$

Mean weighted mortality and birth rates for each pod for all

years was determined by pooling the data for all years (including years before and after EVOS) for each pod. For comparison with AB pod mortality rates, a mean weighted mortality and birth rate for all pods for all years was determined by pooling the data for all pods (except AB) for all years.

We used the logistic regression to examine correlations between observed mortality rates and factors such as pod and year. If mortality (m) is the expected mortality rate, the logistic regression model assumes that the logit of m, i.e. the natural logarithm of m/(1-m), can be expressed as a linear combination of the factors. The regression coefficients in the linear combination were estimated by maximum likelihood (McCullagh and Nelder 1983). The estimation technique assumes that mortality rates can be estimated more precisely for large than small pods.

Displacement:

Aerial surveys were conducted in PWS during 1989 to locate whales on the eastern side of Prince William Sound. The thought was that if killer whales were displaced due to the spill or clean-up activities, they may have moved into the eastern sector of Prince William Sound rather than moving out of the area and not be available for counting or identification. Surveys were flown in a Cessna 180 with two observers and the pilot. Airspeed averaged 115 kts at about 300 m elevation. The survey route consisted of 23 transects connecting 24 waypoints. The waypoints were either obvious landmarks or locations preset into the Loran

c. Sighting locations were obtained off the Loran C. Each survey covered approximately 328 nautical miles averaging 3.8 hrs in duration. Transect grid width was 4 miles. Survey schedules were weather dependent making sighting conditions comparable between surveys.

Killer whales may have been displaced out of PWS to southeastern Alaska or the Kodiak Archipelago. In 1989, two shore-based camps and one floating camp were established in southeastern Alaska from 1 June through 30 September 1989 (Fig. 4). One shore-based camp was located at Glacier Bay National Park and the other at The Brothers (a group of islands off the southeast corner of Admiralty Island in Frederick Sound). Glacier Bay personnel surveyed the waters of Glacier Bay, Pt. Adolphus, Cross Sound and then east and south into Icy Strait. The camp at Frederick Sound was responsible for surveying Stephens Passage and Frederick Sound and included at least four researchers operating two vessels. The floating camp provided coverage in Upper Stephens Passage, Lynn Canal, Chatham Strait and the eastern side of Icy Strait. In 1990 and 1991, only one field camp was established at Glacier Bay National Park, operating each year from April to November. Similar field methods apply in southeastern Alaska as those described for PWS except that no aerial surveys were done.

Between 8 September and 18 October 1989, marine mammal surveys were conducted off Kodiak, Alaska. Out of 399 available daylight hours, 155.5 hours were spent conducting sighting

surveys. Approximately 30.7% (122.5 hrs) were lost to survey effort due to inclement weather (Beaufort 5 conditions or greater). Cetaceans composed the majority of observations. Four killer whale groups were seen, totalling 65 individuals. Bad weather precluded collection of killer whale photographs.

RESULTS

Count and Identify Killer Whales in PWS:

Between May and September 1989-91, the mean number of nautical miles surveyed in Prince William Sound was 9,205 (sd = 1,695) (Table 1). In 1989, eight resident (143 whales) and four transient pods (34 whales) were identified, totalling 177 animals in 89 encounters. In 1990, nine resident pods (148 whales) and four transient pods (30 whales) were identified totalling 178 animals, representing 80 encounters. During the 1991 season, seven resident pods (105 whales) and two transient pods (14 whales) were identified totalling 119 animals, representing 54 encounters. Despite increased effort in PWS during 1989-91, the number of sightings per effort has declined (Fig. 5).

In 1989, 47 hours of aerial survey were flown covering 3,504 nautical miles. Survey effort was comparable between June and August (average 12.5 hrs/month) but declined in September (5.7 hrs). Killer whales were the most abundant cetacean seen with 90 individuals observed in 12 encounters. Most sightings occurred in July (8 encounters). It is not known if the 90 individuals were subsequently photographed by the field camp crews.

Vital rates:

Birth rates

Two calves were observed in AE pod and one in AJ pod in 1989. In 1990, four calves were observed in AN pod, one in AE, one in AJ, and one in AK pod. Calves were not observed in AB pod during 1989 or 1990. One calf was born in AB pod in 1991 and two were born in 1992 (Table 2). Calculated birth rates for 1988/89 were: 15.4% for AE; 3.7% for AJ; and 5.1% for AN. Table 2 lists birth rates for the years 1989/90 through 1991/92.

An annual birth rate of Prince William Sound killer whales was 3.8% combined for the period of 1984 to 1989 (excluding AB pod). A rise in the birth rate of AB pod was documented for the years 1985-86 at 6.3%, 1986-87 at 6.4%, and 1987-88 at 15.6%. Increased natality followed an increase in mortality rates documented for this particular pod.

Mortality rates

In 1989, seven whales were missing from AB pod and two were missing from AE pod resulting in an overall observed mortality rate of 20%. The two whales missing from AE were first missing in 1987 and 1988 (one each year) and not related to EVOS. Twenty two whales were missing from AN pod but were subsequently sighted 1990. Of the seven missing whales from AB pod, two were reproductively active adult females which had calves of two and three years old, respectively. The other missing AB pod members were three juveniles of unknown sex and two adult females that had not reproduced since 1984.

In 1990, the seven whales were still missing from AB pod, plus an additional six animals. Of these six whales, two were adult females, one was an adult male, and three were juveniles (two were born in 1988 and one was born in 1986). In 1991 one additional animal was missing from AB pod. The missing 1991 whale was a subadult male. No other resident whales were reported missing for 1991.

Ten or 11 whales may be missing from AT pod (a transient pod). This pod was encountered ten times during the 1991 season. Three of these missing animals (AT 5, AT 7 and AT 8) were photographed behind the Exxon Valdez on 27 March 1989.

The expected mortality rates (m) and the observed rates are provided in Table 3. The highest expected (15.9%) and observed (20.0%) mortality rates are those of AB pod in 1988-90. Both pod effects and year effects for all other pods and years lead to a reduced value of m. The p-values of the regression coefficients provide a rough indication of the significant of the mortalities (Table 3). These values indicate the likelihood of obtaining similar results by chance if all pods and all the years represented a population with a uniform annual mortality rate.

The significance of the pod effects is exaggerated because we chose the pod with the highest mortality (AB) to contrast to the others. However, the p-values for the year effects are meaningful because they reflect the null hypothesis, namely that the EVOS did not affect subsequent mortality rates. These comparisons indicate that mortality in 1988-90 was significantly

higher than in 1984-86, when whales died from other sources.

A combined annual mortality rate for all Prince William Sound resident killer whale pods was 1.8%, covering the years from 1984 to 1988. Similar mortality has been noted for resident pods off British Columbia, where an annual combine rate of 2.2% (1973-88) has been documented.

A summary of the number of whales in each resident pod from 1984-91 is shown in Fig. 6. AJ pod was not reported in 1984 or 1991. The reduction in AN pod in 1990-91 reflects the absence of ten whales that were subsequently seen and given a different pod designation (AN20).

No reports of dead stranded killer whales occurred in 1989. However, in 1990 three whales stranded. One whale was found each year for 1991 to 1993. Only one whale was identified. None of the stranded whales were from AB pod, and no evidence of Exxon Valdez oil was found in or on the whales.

Displacement:

The study teams in southeastern Alaska did not identify any killer whales originating from PWS during 1989. The teams collectively surveyed 1,011 hours in search of killer whales with a combined effort totalling 230 days of field research between early June and late September 1989. Sixty three killer whales were photographed, principally in the Icy Strait region. Limited photographic studies occurred in 1990 and 1991 in early June to December with no PWS killer whales identified.

No PWS killer whales were identified in the Kodiak

Archipelago or Shelikof Strait in 1989.

Areas of known resident pod concentrations and movement patterns were qualitatively compared between 1989 and 1984-1988. Since 1984, AB pod has been the most frequently encountered resident group for all months from April to September. Historically, AB pod was observed in the area south of Naked Island where herring stage before completing their spawning run in mid-April to early May. The occurrence of AB pod on the western side of PWS in early April is also well documented by blackcod fishermen. AB pod was observed in this area on 31 March 1989 but was not seen again until 27 July 1989. In 1989, AK pod was seen more frequently than AB pod.

In late summer and early fall, multi-pod aggregations typically occur in lower Knight Island Passage and Montague Strait, with AB and AI pod usually present (accompanied by various other pods, e.g., AN and AJ). In 1989, only AB and AI pods remained and aggregations were short-term, lasting for only a day. In contrast with other years, the whales did not use lower Knight Island Passage but remained in Montague Strait. Similar distribution patterns were observed in 1990 and none occurred in 1991. Observations of killer whale pods were of a short-term nature and in contrast with other years the whales did not use lower Knight Island Passage but remained in Montague Strait.

DISCUSSION

The reported loss of 14 individual whales from AB pod (which numbered 36 whales in 1988) for the years 1989 through 1991 is unprecedented. Several possible explanations for the missing whales were examined.

The 14 missing animals could have been an artifact of the survey protocol. This possibility was evaluated by examining the potential for error in the photo-identification process and the bias in survey coverage. The number of animals present in Prince William Sound pods during summer surveys in 1989-91 was obtained through detailed examination of the photographic database of individual animals. Presence or absence of members of each pod were evaluated by comparing photographs taken during the 3-year study period to previous years. Results of the comparisons verified the absence of 14 whales in AB pod.

To evaluate whether or not a mistake was made during the identification process (for example, was a whale present but mis-identified) four independent tests were conducted. Animals were recorded as being present or absent each time the pod was encountered. The results showed that earlier identifications were correct and that 14 whales were missing.

Another possible bias that could have resulted in the 14 whales not being seen and photographed was the amount of effort varied when establishing presence or absence of individuals in the pod. The overall effort (miles surveyed) conducted during 1989-1991 resulted in the greatest amount of effort to date in

Prince William Sound. The number of times each pod was seen in 1989, 1990, and 1991 seasons exceeded that reported for earlier studies. The amount of effort and the number of times each pod was encountered was more than adequate for locating and identifying the presence of individual animals.

We next considered the possibility that individual whales may have moved out of the Prince William Sound area and were not available to be photographed during these studies. Although considerable searching effort took place in southeastern Alaska and the Kodiak Archipelago, the missing whales were not encountered. Unfortunately, minimal effort was expended near Kodiak Island and the waters adjacent to Prince William Sound to locate the missing whales during the 1989, 1990, and 1991 seasons. However, in 1992 photo-identification studies were conducted from Kodiak Island to Seward. AB pod pod members were not seen during these investigations.

An examination of the 20-year killer whale database from British Columbia and Puget Sound, Washington, indicated that no resident killer whale consistently missing during repeated encounters had ever returned to its pod or appeared in another pod. The possibility that the missing whales have moved out of the area is not supported by our knowledge of the social structure and behavior of resident killer whales. Based upon the historical life history information, it is likely that the missing resident whales are dead and have not moved off to other areas. However, a perturbation as severe as the EVOS and its

direct impact on cetaceans has never been investigated. It is therefore possible that a major catastrophe such as the EVOS could have effected killer whales in ways never described before. This possibility, although highly unlikely, should not be disregarded.

The most reasonable explanation for the missing whales is that they are dead. However, the cause(s) of their death remain unclear. Natural mortality is certainly plausible, but unlikely. This species is characterized by a low birth and death rate (less than 2.2% per year or less; Olesiuk et al., 1990). The mortality rate for AB pod calculated for the 1989 season with the loss of seven whales was 19.4%. Six additional whales were reported missing from AB pod resulting in a 20.7% mortality rate for the 1989/90 season. In 1991, one more whale was noted as missing from AB pod (mortality rate of 4.3%). These rates for the 1989 and 1990 season are significantly higher than would be expected from natural causes. It is unlikely that natural mortality would account for more than 1-3 animals, and not the loss of 14 whales over a 3-year period as observed.

Examination of other causes to explain the mortality of the 14 missing whales are complicated by the past history of AB pod. This pod was involved in interactions with the Prince William Sound sablefish longline fishery in the mid 1980's (Dahlheim 1988; Matkin et al. 1986, 1987; Leatherwood et al. 1990). In 1985, the National Marine Mammal Laboratory received reports of killer whales being shot by fishermen. Several of the animals

showed evidence of bullet wounds. In 1985, three whales were reported missing. In 1986, three additional whales were missing. In 1987 and 1988, this pod lost two more individuals. The loss of at least some of these 8 whales was attributed to shooting (although never confirmed). These whales have never been seen again after the year they were first identified as missing. It is possible that the 14 whales reported missing during the 1989 through 1991 season could have been shot. However, this is unlikely because 1) longline fishing was closed between the time when all whales were accounted for (September 1988) and the time when the first seven whales were first determined missing (March 1989), 2) there were no reports of shootings and, 3) no new bullet wounds have been observed on individuals of AB pod since 1986.

The remaining cause of death considered was the effect of the oil spill. Six different killer whale pods were observed swimming through oil (light sheen). The loss of the first seven animals from AB pod could have been through direct contact with the oil, such as from inhalation of toxic volatile gases or ingestion. The loss of the six additional whales one year later is more difficult to explain from oil effects, but might have been associated with residual effects or from indirect effects (e.g., eating contaminated prey).

It is very possible that AB pod was in the Naked Island area when fresh oil was blown down into that area on 27 March 1989. AB pod is known to frequent the Naked Island area in early spring

presumably to feed on herring and become involved with the blackcod fishery that typically opens 1 April. Although killer whale pods are seen in tightly grouped formation when resting and socializing; often when feeding or travelling they are spread out across distances of a mile or greater. It is possible that within a specific pod that some whales and not others could have come in direct contact with oil.

None of the missing whales were found stranded, although killer whales typically sink upon death (Zenkovich 1938). Four carcasses (only one whale could be identified and it was not from AB pod) were found during the 3-year period (1989-1991). This stranding rate is high compared to other geographical areas, and from previous stranding rates from the Prince William Sound region. However, this may simply have been an artifact of increased effort after the spill. Blubber samples and scrapings from the stomach lining from the stranded whales were analyzed for hydrocarbons. There was no indication of oil contamination in these tissues and cause of death could not be determined. Caution, however, must be used when interpreting these results since the carcasses were old when found and decomposition decreases the viability of the tissue samples for hydrocarbon analysis.

CONCLUSIONS

The cause(s) of the deaths of 14 killer whales from AB pod is unknown. We are confident that 1) whales have not been mis-

identified, 2) adequate effort was made in Prince William to locate the missing animals, and 3) the number of encounters was sufficient to evaluate the presence or absence of an individual whale. The current life history information available on killer whales precludes the possibility that the whales moved elsewhere. Therefore, we assume that the whales are dead from either, or a combination of, natural causes; a result of interactions with fisheries; or, for the Exxon Valdez oil spill. The highest mortality rate ever reported in the literature for North Pacific resident killer whales occurred in 1989 and 1990, coinciding with the Exxon Valdez oil spill. There is a strong correlation between the loss of the 14 whales and the Exxon Valdez oil spill, but there is no clear cause and effect relationship.

ACKNOWLEDGEMENTS

Surveys of this magnitude could not have been completed without the help of many people. We thank our field crews for their many hours of effort. D. Matkin (Glacier Bay National Park) conducted the field work in southeast Alaska. T. Loughlin and B. Wright assisted in preparation of this report.

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Table 1. Summary of vessel survey effort in Prince William Sound 1989-91.

	1989	1990	1991
Inclusive dates	5/23-9/15	5/15-9/8	5/29-9/6
Number survey days	260	247	159
Days lost to weather	44	34	20
Naut. miles surveyed	9,623	10,653	7,340
Whale encounters	89	80	54
Miles with whales	1,039	1,320	895
Film frames exposed	6,600	9,300	5,800

Table 2. Identification numbers of killer whales births (b) and deaths (d) in Prince William Sound pods, 1988-92. [] = number of whales in the pod in fall 1988.

	88/89		89/90		90/91		91/92	
Pod	d	b	d	b	d	b	d	b
AB [36]	13		8		29	45		46
	18		19					47
	21		20					
	23		36					
	30		42					
	31		44					
	37							
AK [8]				10		11		
AE [12]	12	16		18				
		17						
AJ [27]		29		30	6			
AN [39]	2			41		45		
				42				
				43				
				44				

Table 3. Expected (m) and observed (obs) mortality rates (%) and number of deaths (y) in each pod for Prince William Sound killer whales, 1984-92.

	1984-86			1986-88			1988-90			1990-92			
Pod ID	m	obs	y	m	obs	y	m	obs	y	m	obs	y	p-value
AB	11.0	9.0	6	4.6	3.2	2	15.9	20.0	13	3.0	2.2	1	0.0210
AI+AK	1.1	3.7	1	0.4	0.0	0	1.7	0.0	0	0.3	0.0	0	0.0210
AE	5.0	7.7	2	2.0	4.2	1	7.4	4.0	1	1.3	0.0	0	0.1275
AJ	1.5	4.0	1	0.6	0.0	0	2.3	0.0	0	0.4	3.4	1	0.0051
AN	0.9	0.0	0	0.3	1.4	1	1.4	1.3	1	0.2	0.0	0	0.0005
1984-86													0.3279
1986-88													0.0173
1990-92													0.0183

Figure Legends.

Figure 1. Map of Prince William Sound showing the approximate range covered by the shore-based field camps.

Figure 2 a, b, c. Data sheets used by shore-based stations to record sighting information and vessel tract line.

Figure 3. Examples of identification photographs of Prince William Sound killer whales.

Figure 4. Map of southeastern Alaska showing the approximate range covered by the shore-based field camps.

Figure 5. The amount of effort expended to located killer whales in Prince William Sound. A resident (AB) and transient pod (AT1) are shown.

Figure 6. Summary of the number of killer whales in each pod in Prince William Sound, 1984-91. Data prior to 1989 are primarily from unpublished data from the North Gulf Oceanographic Society.

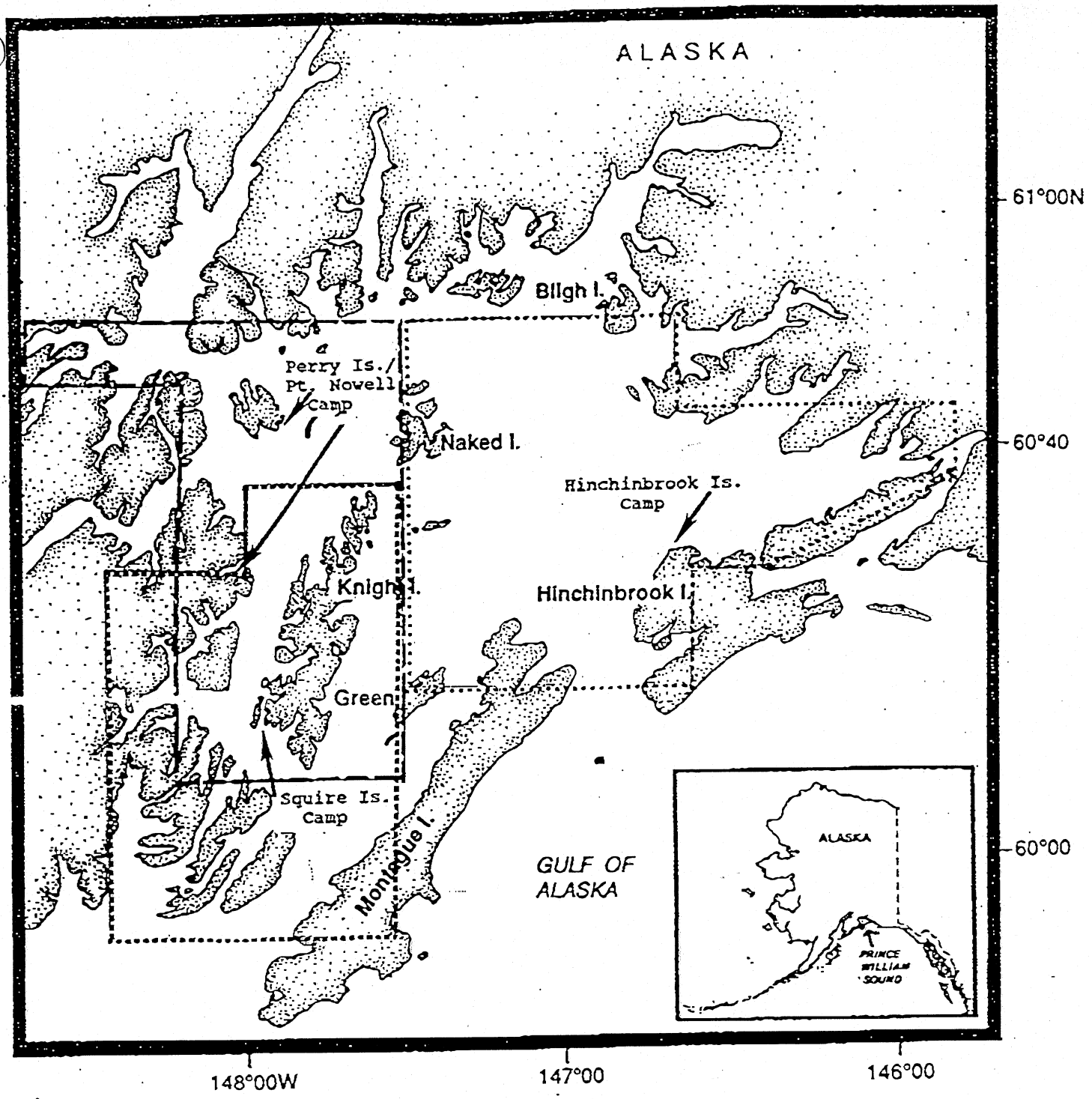


Figure 1. Approximate range covered by shore-based field stations in Prince William Sound; Perry Is./Pt. Nowell Camp (— —), Squire Is. Camp (·····), and Hinchinbrook Is. Camp (·····).

Fig. 7a

DAILY RESEARCH LOG

DATE_____ PLATFORM_____

BEGIN LOCATION_____ END LOCATION_____

_____ _____

_____ _____

BEGIN TIME_____ END TIME_____

SEARCH TIME_____ TIME WITH WHALES_____(Hrs)

TOTAL MILES SURVEYED (trackline) _____

PERSONEL_____

_____

WEATHER & SEA STATE /TIME _____

_____

_____

WHALE
SIGHTINGS/TIME_____

_____

ACTIVITIES/COMMENTS _____

_____

_____

_____

_____

_____

_____

_____

VESSEL TRACK ON REVERSE

Fig. 2b

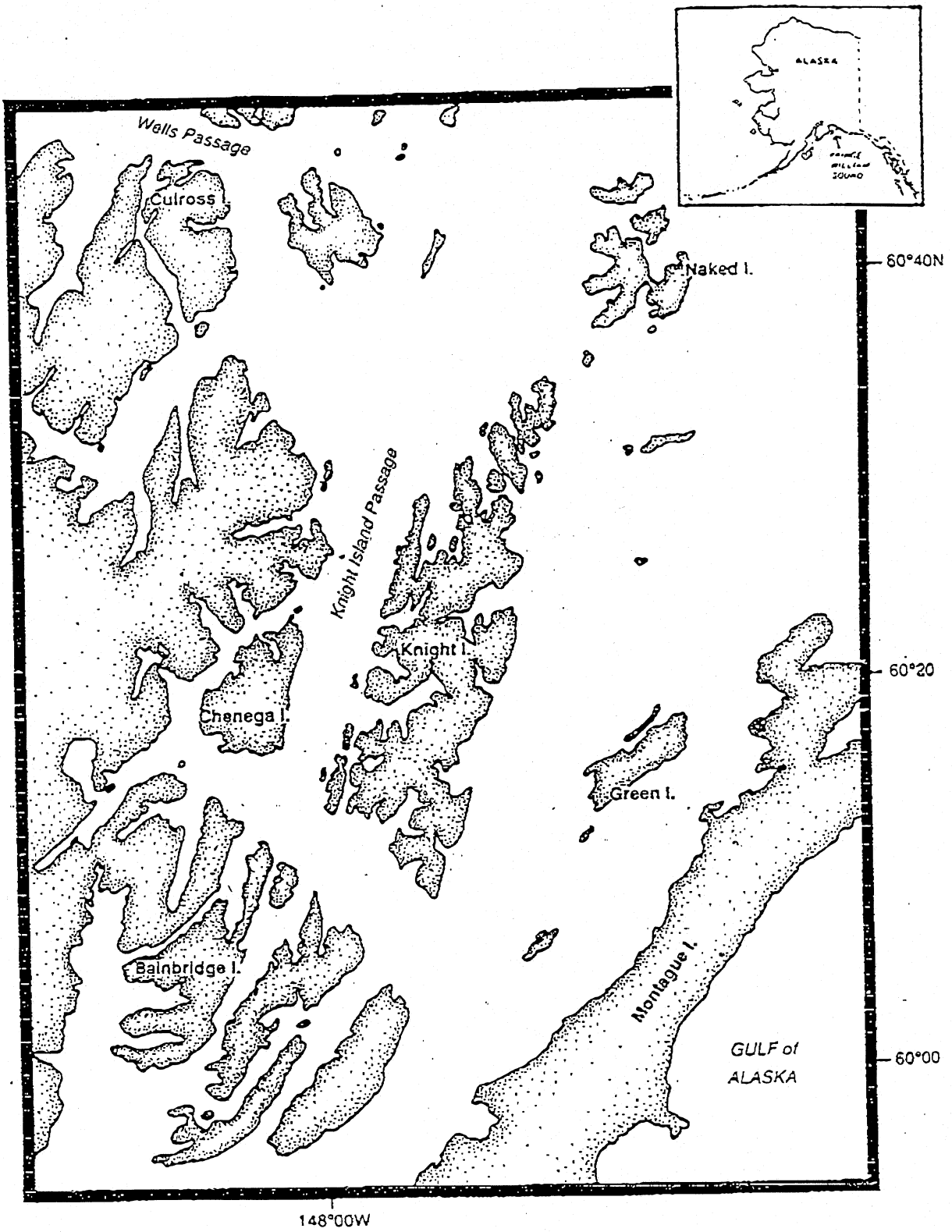

ALASKA
Wells Passage
Culross
Naked I.
60°40N
Knight Island Passage
Knight I.
60°20
Chenega I.
Green I.
Bainbridge I.
Montague I.
GULF of ALASKA
60°00
148°00W

Fig. 2c

Date/Enc.#_____ N.G.O.S. KILLER WHALE SURVEY

Platform_____

Observers_____ Time (Beg/End)_____

Location (Beg/End) _____

_____

Pods_____ naut. miles traveled w/whales_____

Total whales_____ ad ♂ ____ ad ♀/imm ♂____ juv/calve____

Recognized Individuals _____

_____

_____# whales photographed_____

Film (Date/Enc#/Roll#/Initials) _____

Recordings Yes/No Tape#/Side Beg/End _____

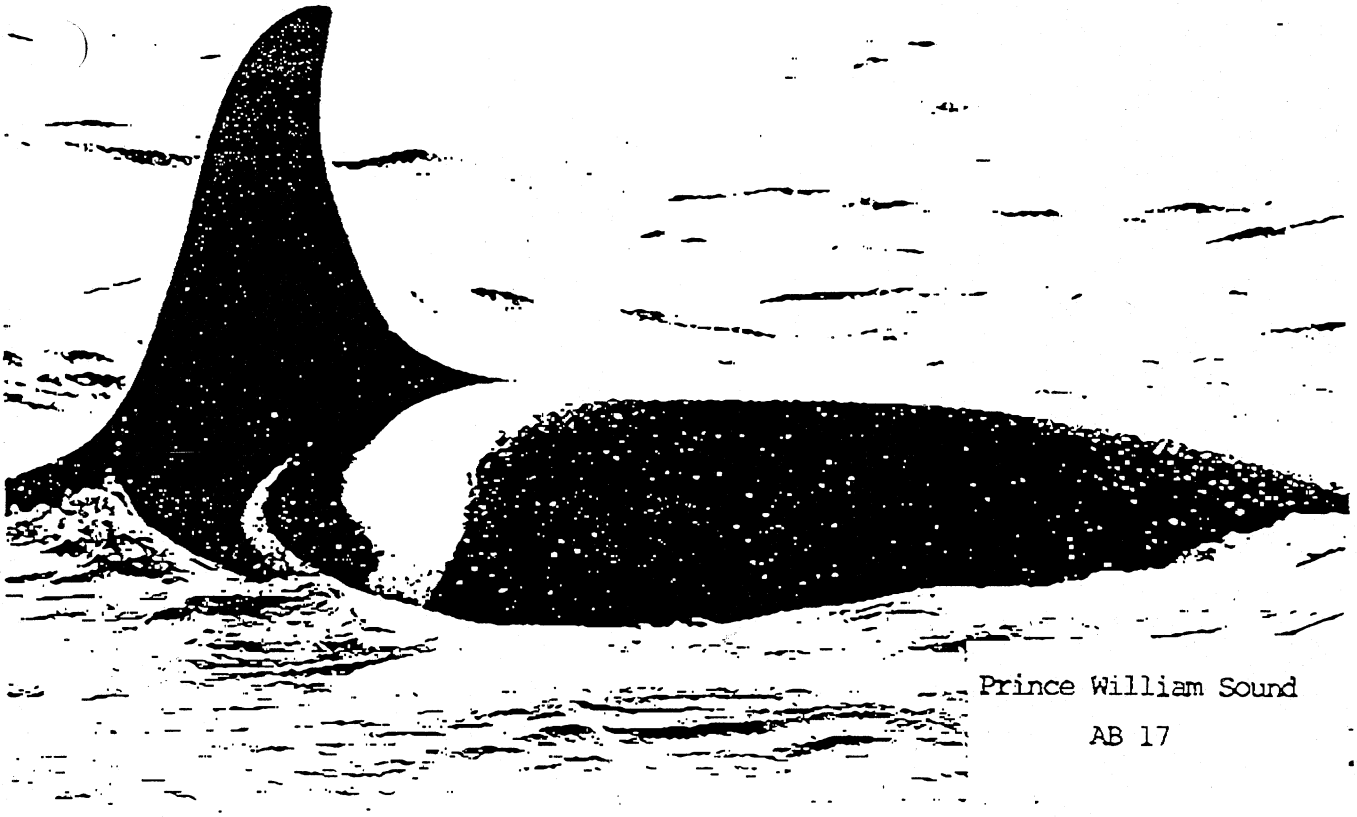
_____

Observations:

Oil present Yes/No Type_____
Harassment of whales by resarchers Yes/No #harassed_____

Note: Behavior (Feeding, Resting, Traveling, Social/Sexual, Milling)
Note: Vessel traffic and interaction w/ whales

Time	Observation



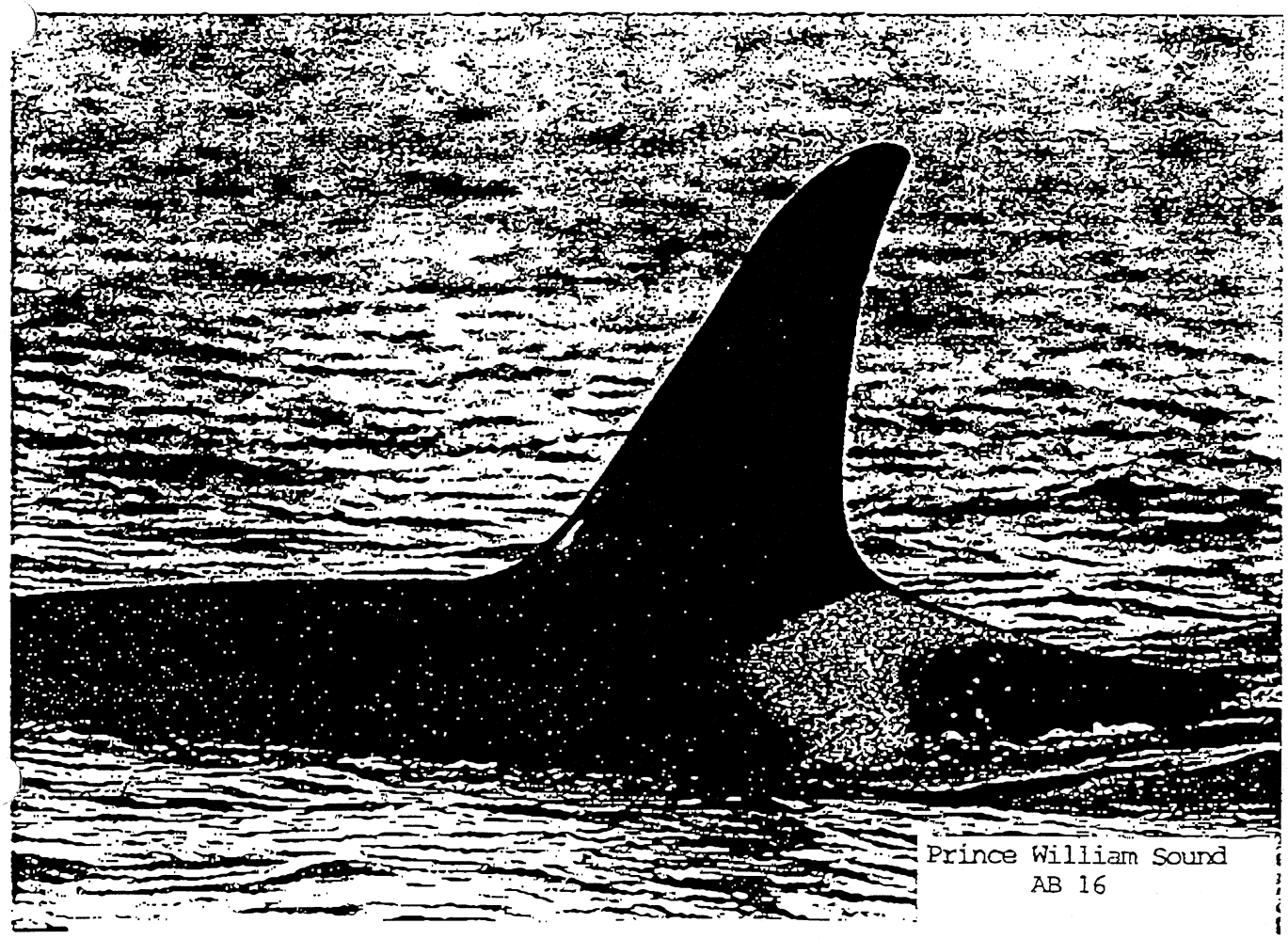


Figure 3. Examples of identification photographs of Prince

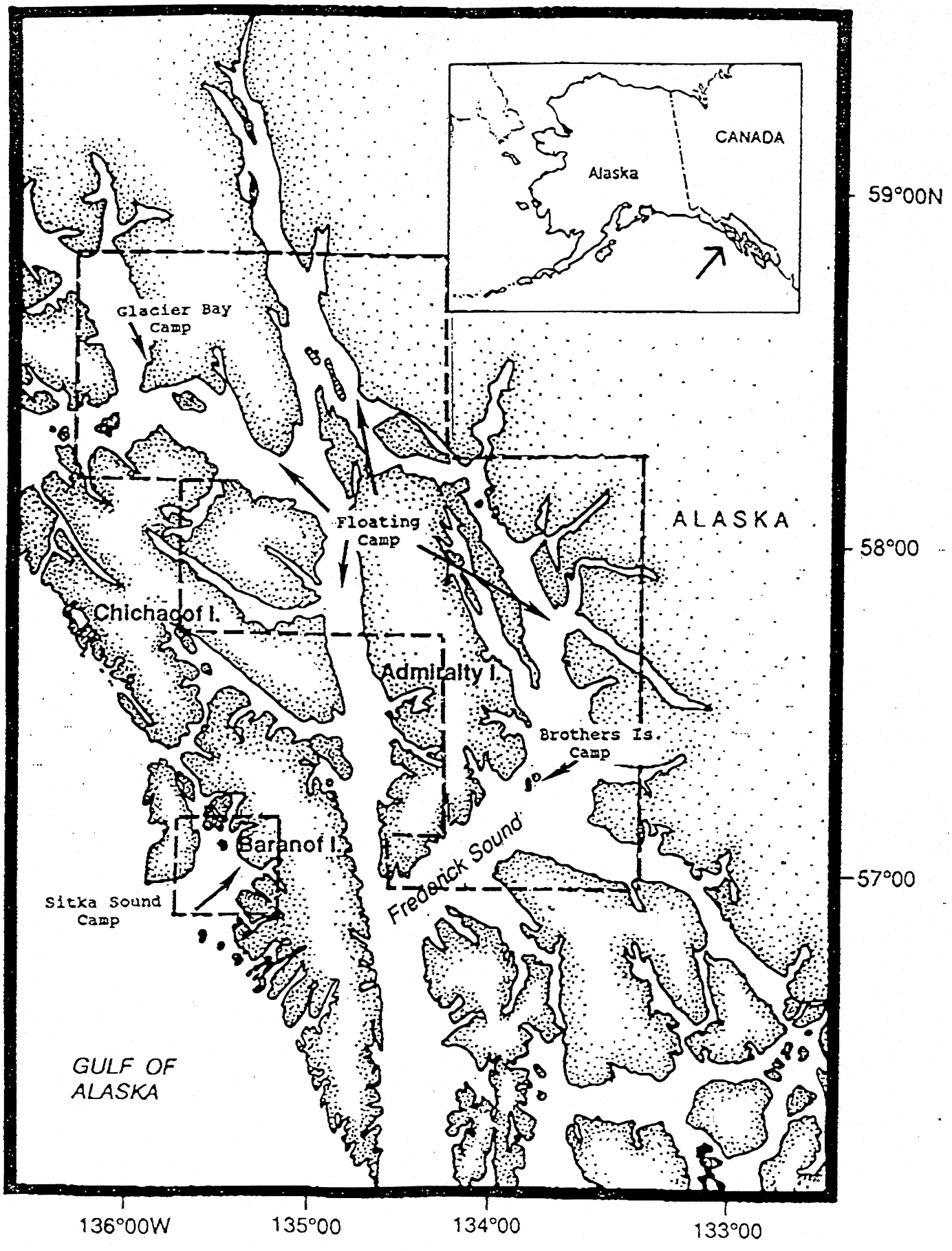


Figure 4. Approximate range covered by the four field research stations in Southeast Alaska

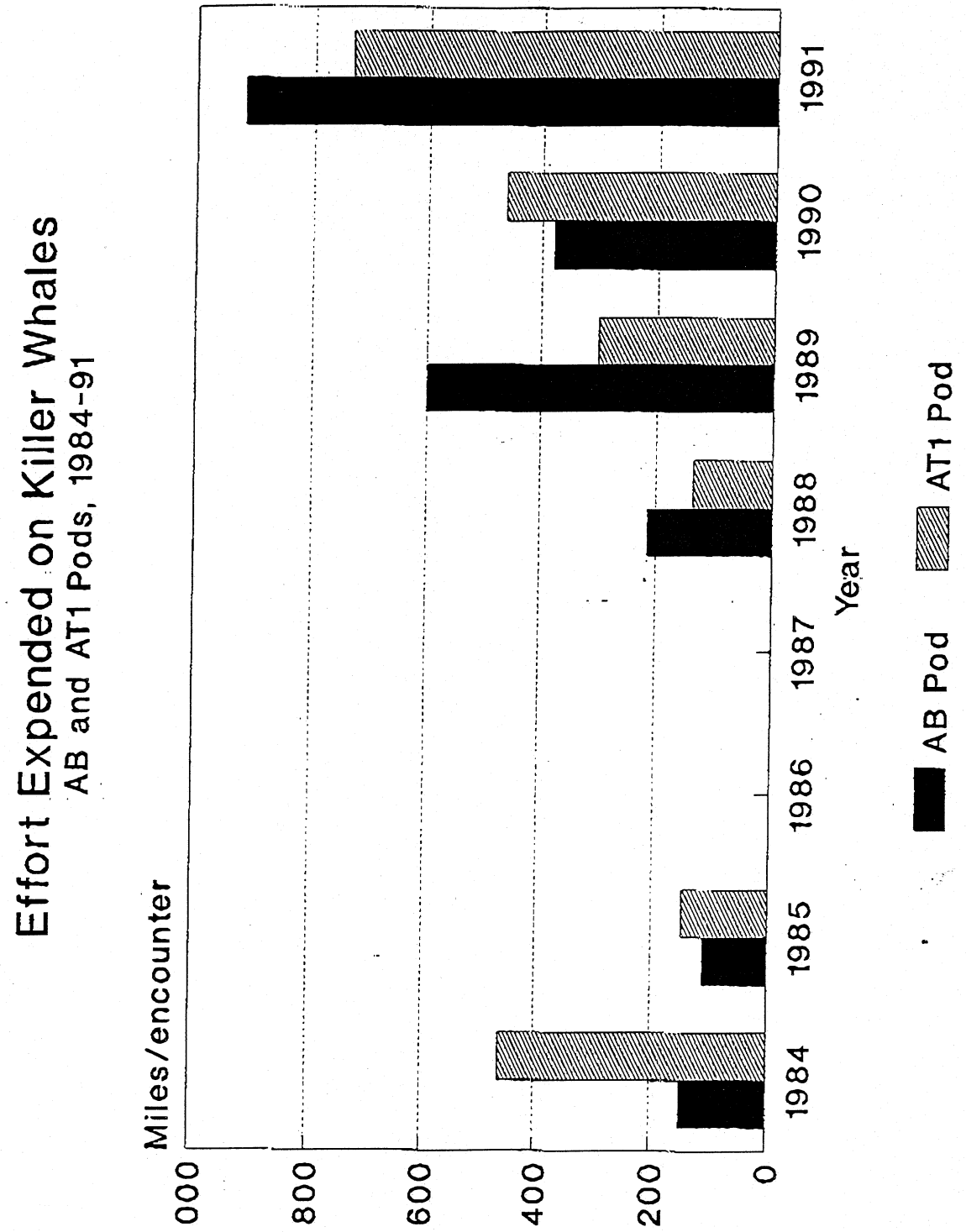

Effort Expended on Killer Whales
AB and AT1 Pods, 1984-91
Miles/encounter
1000
800
600
400
200
0
1984
1985
1986
1987
1988
1989
1990
1991
Year
AB Pod
AT1 Pod

FIG. 5

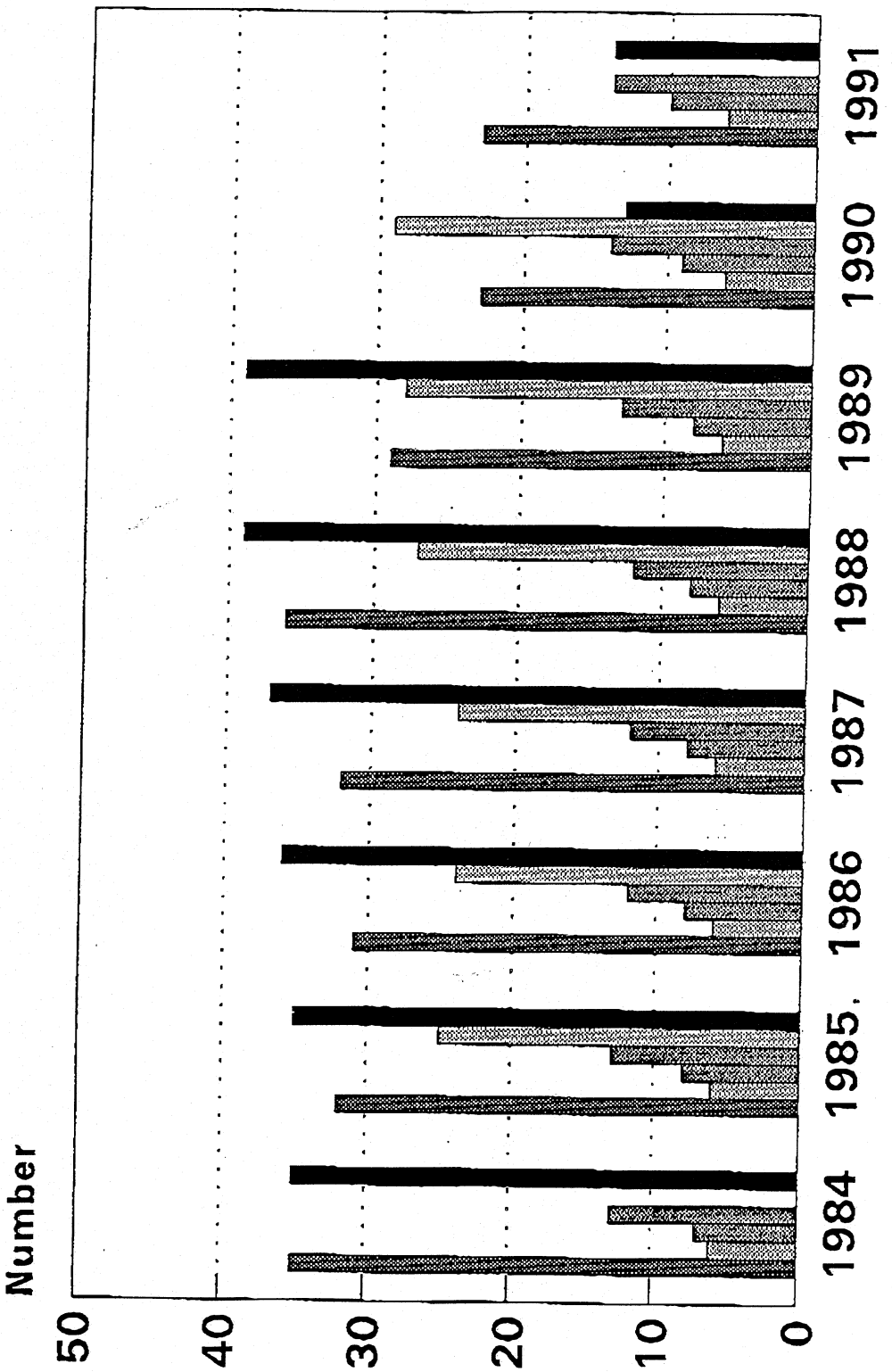

Number of Killer Whales per Pod
Resident pods, 1984-91
Number
50
40
30
20
10
0
1984
1985
1986
1987
1988
1989
1990
1991
Year
AB
AI
AK
AE
AJ
AN

FIG. 6