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Results of a Pilot Program to Document Interactions Between Sperm Whales and Longline Vessels in Alaska Waters

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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

Interactions between sperm whales (Physeter macrocephalus) and longline fisheries have been well-documented in the Southern Ocean, but in Alaska waters only anecdotal reports of sperm whales interacting with longline operations have been available. In 1996, NMFS received reports from observers on commercial fishing vessels that sperm whales were preying on sablefish (Anoplopoma fimbria) targeted by longline vessels in the Gulf of Alaska. As a result, a pilot project was initiated to characterize the nature and extent of the interactions between sperm whales and the commercial longline fishery in Alaska. Between 17 May and 14 December 1997, fishery observers aboard 16 different vessels monitored 557 longline sets and recorded observations and behavior of sperm whales and any damage to fish brought aboard. Likewise, between 31 March and 14 November 1998, fishery observers aboard 41 different vessels monitored 1,060 longline sets. Sperm whales were not present during any of the 1,075 sets in the Bering Sea. Whereas, sperm whales were present in 28.5% of the 562 sets in the Gulf of Alaska and observers recorded fish damage in 46.2% of the sets in which sperm whales were present. However, few damaged fish (n = 65, $\bar{x}$ = 3.45, SE = 0.28) were landed during sets in which depredation was reported. There was no evidence that mortality or serious injury to sperm whales was occurring as a result of this interaction. An initial exploration of the catch data suggested that average standardized catch (metric tons/1,000 hooks) depended on the fish species caught, the North Pacific Fishery Management Council (NPFMC) statistical area fished, and the bottom depth. The presence of sperm whales appeared to be related to bottom depth and NPFMC statistical area. To control for these factors, we computed the average standardized catch for trips that had at least three sets when both sperm whales were absent and present and which met the following criteria: 1) predominant fish species was sablefish; 2) sets were conducted within NPFMC statistical areas 630 through 680; and, 3) bottom depth was greater than 200 fm. This data selection provided 12 trips with 285 sets (113 without sperm whales present and 72 with sperm whales present) for the comparison. The Wilcoxson signed rank test of a difference in catch associated with sperm whale presence (V = 62, n = 12) was not significant (P = 0.08). The average difference in catch between sets with sperm whales present and absent was -0.095 t (SE =

0.057). At an average weight of 3.5 kg , 27 fish per set were lost to account for the 0.095 t estimated difference in catch between sets in which sperm whales were present and absent. Our finding of no significant difference does not mean that there was no loss. Sperm whale interactions clearly reduced the catch because some fish were damaged (and were therefore worthless) and other fish were presumably removed from the line. However, at present, the difference in catch was too small to estimate precisely with the current sample size and high variability in catch per set.

CONTENTS

INTRODUCTION

Sperm whales (Physeter macrocephalus) are widely distributed in the North Pacific, where in the winter they are typically encountered south of latitude 40/N (Gosho et al. 1984). Females and young sperm whales usually remain in tropical and temperate waters year-round (Rice 1978), while males are thought to move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands. However, movement patterns of sperm whales into Alaska waters are unclear because commercial whaling data (i.e., Discovery Tags) revealed substantial east-west movement between Alaska waters and the western North Pacific (Japan and the Bonin Islands), with little evidence of north-south movement into Alaska waters (B. Taylor, pers. comm., Southwest Fisheries Science Center, P.O. Box 271, La Jolla CA 92038)

Due to the residual impacts of commercial whaling, sperm whales are listed as "endangered" under the Endangered Species Act of 1973. There are no reliable estimates for the number of sperm whales inhabiting the North Pacific (Hill and DeMaster 1998). Though believed to be upwardly biased, preliminary abundance estimates indicate that 102,112 (CV=0.155) sperm whales inhabit the western North Pacific (Kato and Miyashita 1998). Barlow and Taylor (1998) estimate that there are 39,200 (CV=0.60) sperm whales in the eastern temperate North Pacific. There is no abundance estimate for sperm whales in Alaska waters (Hill and DeMaster 1998).

Interactions between sperm whales and longline fisheries have been well-documented in the Southern Ocean; in particular off South Georgia, the Kerguelen Islands, and Southern Chile. Such interactions include entanglement in gear (Anonymous 1994, Ashford et al. 1996), following vessels for periods of days (Ashford et al. 1996, Capdeville 1997), and observed feeding off gear (Crespo et al. 1997, Anonymous 1994). This evidence, combined with anecdotal reports, suggests that interactions between sperm whales and longline operations may be widespread in Southern Ocean waters. In Alaska waters, aside from scattered anecdotal reports (Dahlheim 1988, Rice 1989, NMML unpubl. data), few data are available regarding sperm whale behavior in relation to commercial longline operations.

The National Marine Fisheries Service (NMFS) is charged with monitoring groundfish fisheries in the U.S. Exclusive Economic Zone (EEZ) off Alaska. Commercial fishing for sablefish occurs annually from 15 March to 15 November on the upper continental slope at depths

averaging 250-350 fm. An individual fishing quota (IFQ) for sablefish was implemented in 1995, with over 1,000 individuals receiving quota shares. In 1996, 639 longline vessels targeting sablefish landed over 17,000 metric tons (t) in Alaska waters worth an estimated $73.1 million.[3,4] Vessels targeting sablefish tend to be small (78% less than 18 m; 21% between 18-38 m in length) and usually fish two or three sets of gear concurrently, alternating between sets (i.e., hauling in the gear, deploying the gear and then moving on to the next set). It is estimated that these vessels fished 48.2 million hooks in 1996.[4] Each set of the longline gear averaged 9 km in length with circle hooks spaced at approximately 1.2 m intervals.

In 1996, NMFS received reports from observers on commercial fishing vessels that sperm whales were preying on sablefish (Anoplopoma fimbria) targeted by longline vessels in the Gulf of Alaska. Some observers suggested the whales were removing fish directly from the longline gear while others believed the whales were feeding on the discarded offal. Anecdotal reports from commercial fishers on vessels without observers corroborated this information.[5] As a result, a pilot project was initiated to characterize the nature and extent of the interactions between sperm whales and the commercial longline fishery in Alaska. This paper reports on the results of the pilot study for 1997 and 1998.

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[3]Includes the value of the fish and the value of dressing the fish at sea, but not the value of any further processing at-sea or ashore.

[4]The 1996 fishery statistics were compiled from vessel, landings, and fishery Observer Program data provided by the Alaska Fisheries Science Center, Alaska Region Office, and the Pacific States Marine Fisheries Commission.

[5]Observer coverage in Alaska groundfish fisheries is assigned according to vessel length; where vessels greater then 38 m have 100% coverage, vessels 18-38 m have 30% coverage, and vessels less than 18 m are not required to carry observers.

METHODS

Fishery observers aboard longline vessels fishing in Alaska waters are required to collect data used to manage the fishery (e.g., species targeted, tons landed, area fished), assess the resource (e.g., measure fish lengths and weights), record the level of bycatch (e.g., number of non-target or prohibited species landed), and record interactions between the fishery and protected species (e.g., mortalities and deterrences of marine mammals and seabirds). Observers are also asked to record opportunistic sightings of marine mammals using a standard sighting form.

In addition to their regular duties, fishery observers participating in the pilot program were asked to collect detailed sighting and behavioral information on sperm whales. During each longline set in which sperm whales were present, observers were instructed to complete a sperm whale interaction form along with the standard sighting form. Prior to departing on an assignment each observer was briefed via phone or in person about proper form completion, the types of interactions and behaviors that might be encountered, and the importance of detailed observations to ensure there was ample evidence to support any interaction that could occur. Assignments occurred when observer positions on longline vessels became available.

Upon completion of an assignment, observers were debriefed through the NMFS Groundfish Observer Program managed by the Resource Ecology and Fisheries Management (REFM) Division (Alaska Fisheries Science Center, Seattle, WA). All pilot project participants who observed sperm whale interactions (depredation of longline-caught fish) met with the Principal Investigator (S. Hill) to discuss what was observed and to address any data ambiguities. All data collected during pilot project cruises were then provided either as original data or in an edited format from the NORPAC database (which is managed by REFM and contains data related to each observed longline set).

We examined both direct and indirect measures of sperm whale depredation on standardized fish catch (t/1,000 hooks) from the longline. The only direct measure of depredation by sperm whales was the number of damaged fish per set. However, that ignores the possibility that the entire fish was removed from the hook. Therefore, we also examined indirect measures

of depredation by comparing standardized catches when sperm whales were present and absent. We used the Mann-Whitney test (Zar 1996) to compare the distributions of catches. However, in doing so, we assumed that the only difference between the sets was the presence and absence of sperm whales. The possibility existed that the factors affecting sperm whale presence also affected longline catch and any association with sperm whale presence was largely spurious. Therefore, we explored various factors that might affect catch and for a series of trips with comparable conditions we used the paired Wilcoxson signed rank test to compare the average catch when sperm whales were absent to the average catch when sperm whales were present during the same trip.

RESULTS

During 1997, 12 fishery observers participated in the sperm whale/longline interaction pilot project aboard 16 different vessels. Observers monitored 557 longline sets (Fig. 1) between 17 May and 14 December 1997. Longline fishing effort was not uniformly distributed over time on the fishing grounds. Vessels conducted more sets (n = 462) in the Bering Sea than the Gulf of Alaska (n = 115). Most sets in the Gulf of Alaska occurred prior to September, with none occurring after October (Fig. 2). Fishing effort was concentrated in the Bering Sea during the latter part of the year (Sept.-Dec.). Sperm whales were not seen during any of the 462 longline sets conducted during 1997 in the Bering Sea.

During 1998, 22 fishery observers participated in the sperm whale/longline interaction project aboard 41 different vessels. Observers monitored 1,060 longline sets (Fig. 3) between 31 March and 14 November 1998. Vessels conducted more sets (n = 613) in the Bering Sea than the Gulf of Alaska (n = 447). Monitored sets were more evenly distributed within the Bering Sea and Gulf of Alaska than in 1997, with sets occurring in both regions from April through November (Fig. 4). A majority of the sets in the Bering Sea occurred during April and May where as a majority of sets in the Gulf of Alaska occurred from May through July. As in 1997, sperm whales were not observed during any of the longline sets conducted during 1998 in the Bering Sea.

In 1997, sperm whale sightings were recorded during 50 of the 115 (43.5%) longline sets within the Gulf of Alaska. Interactions (incidents where observers believed sperm whales were feeding on longline-caught fish) were reported during 34 sets, or 68.0% of the sets in which sperm whales were sighted. Interactions occurred within 110 nautical miles (nmi) of Middleton Island in the northern Gulf of Alaska, either slightly to the southwest (referred to hereafter as SW of Middleton) or almost due east of the Island near a bathymetric feature called Pamplona Spur (southwest of Icy Bay; Fig. 5). The only exception was a single interaction which occurred approximately 10 nmi off Kruzof Island in southeastern Alaska. All interactions during May (n = 19) and August (n = 6) occurred SW of Middleton while all interactions during July (n = 8) occurred near Pamplona Spur. The remaining three interactions were recorded SW of Middleton, near Pamplona Spur, and off Kruzof Island, respectively, within a 6-day period during a September trip. Few sightings and no interactions were recorded in North Pacific Fishery Management Council (NPFMC) statistical areas 610 and 620, to the southwest of Kodiak Island (Fig. 5).

In 1998, sperm whale sightings were recorded during 110 of the 447 (24.6%) longline sets within the Gulf of Alaska. Few sightings and no interactions were recorded in NPFMC statistical areas 610 and 620, to the southwest of Kodiak Island (Fig. 6). Interactions were reported during 40 sets, or 36.4% of the sets in which sperm whales were sighted. Interactions occurred, as in 1997, in the northern Gulf of Alaska, SW of Middleton Island and near Pamplona Spur (southwest of Icy Bay; Fig. 6). The increased coverage in Southeast Alaska during 1998 also documented interactions off Yakutat and along the coast to as far south as the southern tip of Baranof Island. The two interactions during April occurred near Yakutat. Interactions during May (n = 21), June (n = 8), July (n = 6), and August (n = 3) occurred in both the northern Gulf of Alaska (SW of Middleton and Pamplona Spur) and off Southeast Alaska, simultaneously at times. For example, interactions were recorded off the southern tip of Baranof Island and Pamplona Spur on the same day in May, and off Kruzof Island and SW of Middleton one day apart in June.

When whales were present and suspected depredation of hooked fish occurred, observers reported the nature and magnitude of damage to caught fish, sometimes providing photographs (Fig. 7). Damage to fish included lack of tails, only heads or lips left on the hook (some of which

were smashed or flattened), large gashes along the sides, and stomachs torn out. Fish recorded as damaged were primarily sablefish, except during seven cruises in which damaged grenadiers (Coryphaenoides spp.) were also noted. Several observers believed that depredation had occurred while the line was being hauled because severely damaged fish were still alive. Some observers reported incidents where the depth sounder clearly showed whales around the gear; lower catch rates when whales were diving as compared to when they were at the surface; many hooks were clean of bait and straightened (note: this damage could occur if the gear was caught on the bottom); and a whale was seen approaching the gear underwater and pausing in the vicinity of the fishing gear.

Observers recorded fish depredation (interaction) in 74 of the 160 sets (46.2%) in which sperm whales were present during both years. However, few damaged fish (n = 65, $\bar{x}$ = 3.45, SE = 0.28) were landed during sets in which depredation was reported (Fig. 8). Pod sizes ranging from one to twenty-two whales (n = 74, $\bar{x}$ = 4.29, SE = 0.36) were observed during sets where depredation was recorded. Whales would typically remain near the vessel during the entire set, often following the vessel from its previous set or arriving as soon as haul back of the gear was initiated. During several cruises, the same group of whales followed the vessels for consecutive days (individual whales were re-identified by unique characteristics such as scar patterns). Observers noted that the whales did not exhibit any behaviors that would suggest they were disturbed by or aggressive towards the vessel. However, one observer reported tangled gear on every set during which depredation of the catch occurred. Groups of whales typically remained 25-100 m off the stern or starboard quarter of the vessel (gear is hauled on the starboard side) and alternated between resting at the surface and diving. At times individual whales were within 2 m of the vessel.

When we examined the distribution of standardized catch for each set when sperm whales were absent and present (Fig. 9), we found that the catch was lower for sets when sperm whales were present (Wilcoxson rank sum test $Z = 5.29$, $P < 0.0001$). The mean catch was 0.83 t/1,000 hooks (n = 160, SE = 0.04) when sperm whales were present and 0.99 t/1,000 hooks (n = 402, SE=0.03) when they were absent. However, the observed difference was not necessarily the result of depredation by sperm whales.

An initial exploration of the data suggested that many different variables potentially affected both fish catch and sperm whale presence during the set. The average catch was lower ($Z = 6.5$, $P < 0.001$) for sets when the predominant species was sablefish (n = 478 sets, $\bar{x} = 0.94$, SE = 0.02) than for sets catching predominantly non-sablefish (n = 68, $\bar{x} = 1.80$, SE = 0.13), which was primarily halibut (Fig. 10). The average catch for sablefish sets was greater ($Z = 3.5$, $P < 0.001$) in NPFMC statistical areas 610 and 620 (n = 92 sets, $\bar{x} = 1.12$, SE = 0.06) than the average catch in statistical areas 630 through 680 (n = 368 sets, $\bar{x} = 0.90$, SE = 0.02) (Fig. 10). Sets on sablefish occurred primarily where the bottom depth exceeded 200 fm and non-sablefish sets were primarily in shallower water (Fig. 11). The average catch decreased with bottom depth (Fig. 12) which could be partially explained by the target species. Likewise, the presence of sperm whales appeared to be related to bottom depth and fishing region. The observed proportion of sets with sperm whales present increased with bottom depth (Fig. 12), and sperm whales were more often present and more likely to interact with sets (i.e., damage fish) in NPFMC statistical areas 630 through 680 than in statistical areas 610 and 620 (Fig. 13).

We used this initial exploration to restrict the data to a set that would eliminate most of the variables that could create a spurious relationship. We computed the average standardized catch for trips that had at least three sets when both sperm whales were absent and present and which met the following criteria: 1) predominant fish species was sablefish; 2) sets were conducted within NPFMC statistical areas 630 through 680; and, 3) bottom depth was greater than 200 fm. This data selection provided 12 trips (Table 1) with 285 sets (113 without sperm whales present and 72 with sperm whales present) for the comparison. The paired comparison within trip controlled for year, vessel, and target species. It also largely controlled for time of year, fishing region, and bottom depth. When the target catch was sablefish, there was no significant effect of sperm whale presence on catch (Wilcoxson signed rank: $V = 62$, n = 12, $P=0.08$). The average difference in catch between sets with sperm whales present and absent was -0.095 t (SE = 0.057).

Table 1. Number of sets and average catch categorized by sperm whale presence for the 12 trips of the paired analysis. All trips were from different vessels except trips 15 and 40, which were from the same vessel.

	Sets without sperm whales		Sets with sperm whales present		
Trip	n	Mean catch	n	Mean catch	Difference
12	37	21	1.250	0.968	-0.283
13	8	7	0.585	0.569	-0.015
15	9	3	0.799	0.730	-0.069
21	3	4	1.029	0.918	-0.111
24	4	4	0.774	0.736	-0.037
25	14	7	1.212	1.170	-0.042
26	3	4	1.019	0.894	-0.124
29	11	6	0.512	0.462	-0.049
36	5	4	0.722	0.971	0.249
37	4	5	1.145	0.883	-0.262
38	4	4	1.647	1.122	-0.525
40	11	3	0.853	0.977	0.124

DISCUSSION

In general, pilot program coverage (Figs. 1 and 3) gave a reasonable representation of overall observer coverage in the Alaska longline fishery during 1997 and 1998 (Figs. 14 and 15). While effort in the observed segment of the fleet may not precisely reflect effort in the unobserved portion of the fleet (e.g., if observer presence contributed to decisions regarding where and when a vessel fished), the lack of reported interactions in the Bering Sea by the pilot program and ancillary data sources (see Appendix 1) suggests that sperm whale depredation of longline-caught fish is not occurring outside the Gulf of Alaska. This is also supported by: 1) the paucity of sperm whale sightings from observers aboard longline vessels operating in the Bering Sea and along the

Aleutian archipelago; 2) the lack of any indication of sperm whale interactions from ancillary data sources from that region; and, 3) the small number of sperm whale sightings in the Bering Sea dating back to 1958 in the National Marine Mammal Laboratory's Platforms of Opportunity database (Fig. 16).

Due to the opportunistic nature of the ancillary data (i.e., sightings data are provided on a not-to-interfere basis with other duties), those data are not readily comparable with the pilot program data. However, the ancillary data supports certain trends seen in the pilot program data such as interactions tending to occur in predominantly the same locations (Figs. 5, 6, 17 and 18). Although sperm whales were sighted by longline vessels operating to the west of Kodiak Island, longline depredation seems to be restricted to the Gulf of Alaska waters east of Kodiak. Gear depredation off southeastern Alaska may be more widespread than the pilot program and ancillary data indicated because most longline vessels operating in that region are less than 18 m in length and did not have fishery observers on board. Anecdotal reports from these vessels and from the Alaska Department of Fish and Game indicated that longline vessels operating off southeastern Alaska were commonly visited by sperm whales.

Sperm whale depredation on longlines may be a learned behavior that begins when the whales associate fishing operations with a feeding opportunity. Yano and Dahlheim (1995) made a similar assumption when documenting longline depredation by specific killer whale (Orcinus orca) pods in Alaska waters. In the present study, gear depredation was relatively localized spatially and temporally. It is possible that instead of a being a widespread behavioral phenomenon only several groups of sperm whales have learned to exploit longline-caught fish. This theory is supported by: 1) the timing and location of depredation occurrences in the pilot program and ancillary data; 2) the documented reports of groups of whales (believed to be the same whales, as determined by characteristic features) following a particular vessel between sets for a period of days; and, 3) individually identifiable whales photographed across areas and years (see Appendix 2). Anecdotal reports from longline fishermen in the Gulf of Alaska indicate that sperm whale sightings in the past were uncommon while fishing, whereas sperm whales now tend to remain in the vicinity of their vessels while fishing. This suggests the number of whales learning the behavior and the overall impact of this behavior on the fishery may rise in the future.

The changes in the Alaska sablefish longline fishery from derby-style (in which many vessels raced to maximize catch during the short fishery openings) to IFQs (in which fishermen can choose when and where to fish over a 7-8 month season) may have fostered learning the behavior of feeding from the gear and increased the potential for the whales to impact the fishery. The prolonged season allows groups of whales to follow longliners around and prey off the discards, drop-offs, or directly from the gear. Having a pod of whales accompany a vessel during an entire trip could have a significant impact on the catch, thereby causing longer trips and increasing the costs.

Unlike killer whales, which tend to strip nearly all of the fish from large sections of the gear, depredation by sperm whales is much less obvious. Some observers were convinced the whales were not feeding on the gear but were eating discarded fish and drop-offs until they observed severely damaged live fish being landed. The numbers of damaged fish used as evidence for sperm whale depredation on the catch was small. Although no other marine mammals were sighted during instances of depredation, it is impossible with the available evidence to determine if damaged fish were caused by the sperm whales or some other predator. However, observers stated that the types of injuries seen on the fish only occurred when sperm whales were present.

As there are numerous reasons why a hook could be empty (e.g., bait falls off, bait taken without catching the fish, fish falling off, or fish taken off), it is not possible for observers to estimate the number of fish actually taken by the whales by the number of empty hooks. Although average catch was lower when sperm whales were present, the difference was not statistically significant. Our finding of no significant difference does not mean that there was no loss. Sperm whale interactions clearly reduced the catch because some fish were damaged (and were therefore worthless) and other fish were presumably removed from the line. However, our result does mean that the difference in catch is too small to estimate precisely with the current sample size and high variability in catch per set. Factors that may lead to the high variability include spacing between hooks on the longline, time of day, weather, and actual fish density. Therefore, the total take of longline-caught fish by sperm whales is unknown, as is the associated total impact on the fishery.

During recent years the average weight of sablefish caught during NMFS longline cruises in Alaska was 3.5 kg (Sigler et al. 1998). It would take 27 fish of this weight to account for the 0.095 t estimated difference in catch between sets in which sperm whales were present and absent. An average of 3.45 damaged fish per set were reported by observers during depredation events, representing approximately 13% of the estimated loss. It is quite reasonable that the remaining estimated loss of fish (23 per set) were completely removed from the hooks.

CONCLUSION

In 1997 and 1998, sperm whale depredation of longline-caught fish was recorded in the Gulf of Alaska. Within the Gulf of Alaska, the sperm whale/longline interaction pilot program demonstrated a high percentage of sets during which sperm whales were observed. Whales were present during 28.5% of the 562 sets monitored over the two years. Depredation was recorded during 46.2% of the 160 sets in which sperm whales were present over that same period. The whales clearly affect the longline fishery, although at this time it is not possible to assess the level of impact.

There was no evidence that mortality or serious injury to sperm whales was occurring as a result of this interaction. However, in longline fisheries off South America, entanglements of sperm whales in longline gear has been recorded. The first and only documented sperm whale entanglement in Alaska's longline fishery occurred in 1997 (the animal was not considered seriously injured according to the NMFS definition; Angliss and DeMaster, 1998), providing further impetus to continue research on the nature and magnitude of this interaction.

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APPENDIX 1

Ancillary data

During 1997 and 1998 there were several other sources of data concerning sperm whale/longline interactions in Alaska waters. The largest source in both years was the opportunistic sighting data collected by fishery observers aboard commercial fishing vessels. In 1997 and 1998, fishery observers monitored 15,186 and 16,265 longline sets in Alaska waters, respectively (Figs. 13 and 14). This data set includes data from all observers aboard longliners other than those who participated in the pilot program. Observers aboard longline vessels in Alaska waters recorded 65 sightings of sperm whales between 21 March and 4 October 1997, including 13 instances of depredation (Fig. 19). Between 12 March and 4 November 1998, fishery observers recorded 66 sightings of sperm whales, including 12 instances of depredation (Fig. 19).

Aside from fishery observer information, data were collected during an International Halibut Commission longline survey (1997), National Marine Fisheries Service sablefish longline surveys (1997-98), and interested commercial fishermen (1997-98). These other sources provided 15 sightings with 8 interactions in 1997 and 24 sightings with 14 interactions in 1998 (Fig. 19).

The positions of the sightings and interactions from all ancillary data sources for 1997 and 1998 are shown in Figures 17 and 18, respectively. In both years, there were several sightings (with no interactions) in the Bering Sea. However, most sperm whale sightings occurred in the Gulf of Alaska to the east of Kodiak Island even though there was substantial longline effort in waters to the west. Descriptions of whale behavior were consistent with behaviors noted in the pilot program data (i.e., position of whales in relation to the vessel, number of whales present, reports of damaged fish, and whale groups following the vessel from set to set). Of note in the ancillary data were the following observations: 1) one set in which damaged skates (Raja spp.) were landed; 2) one set in which damaged Greenland turbot (Reinhardtius hippoglossoides) were landed; 3) one set in which damaged halibut were landed; and, 4) the suggestion that the whales are feeding at 40-80 fm by being able pick up and follow whales' echo returns on the echo-sounder.

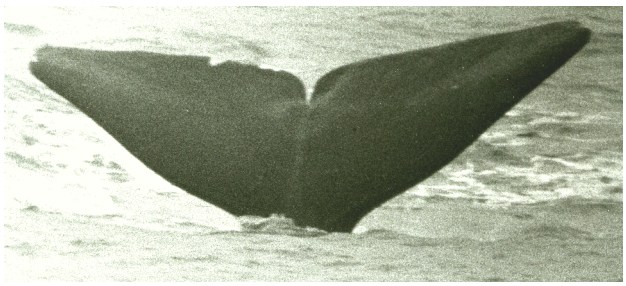
APPENDIX 2

Photo-identification data

Another aspect of the pilot program included taking photographs of sperm whales which were associated with the longline vessels while fishing. Individuals can be identified by unique markings on the flukes or dorsal area. During 1997 and 1998, 46 photos were taken by observers and fishermen. An additional 18 photos were provided by E. Mitchell, which were taken while participating as a fishery observer during 1995. From these 64 photos, twenty-six individuals have been identified. Five individuals have been photographed during different years and three individuals have been photographed in different areas (i.e., off Southeast Alaska during one year and near Middleton Island during another year). Increasing the sample size will enable a better estimate of the minimum number of whales involved in predation events and the frequency of individual whales' predatory behavior. A sample of the interesting matches follows:

1a. Dorsal Fluke

12 June 1995 59° 8.3NN 147° 27.0NW



1b. Dorsal Fluke

6 May 1998 59° 4.2NN 141° 27.0NW

2a. Right Dorsal

11 June 1995 59° 8.3NN 147° 27.0NW

2b. Right Dorsal

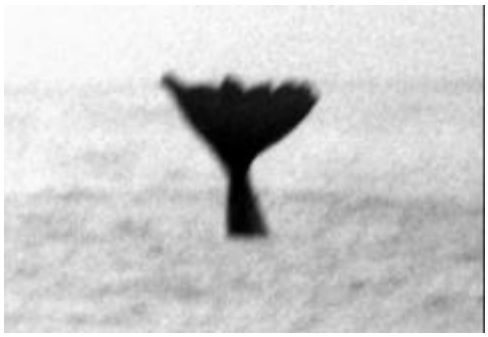
4 June 1998 58° 39.0NN 148° 22.0NW

2c. Right Dorsal

12 June 1995 59° 8.0NN 147° 27.0NW

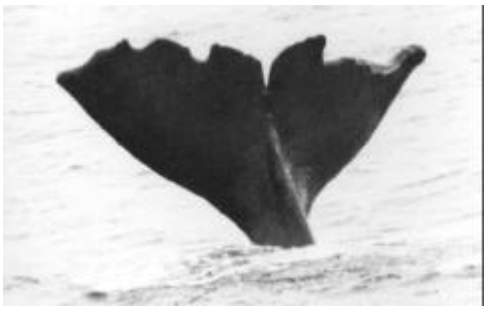
2d. Dorsal Fluke

11 June 1995 59° 8.5NN 147° 29.6NW



3a. Dorsal Fluke

11 June 1995 59° 8.5'N 147°29.6'W

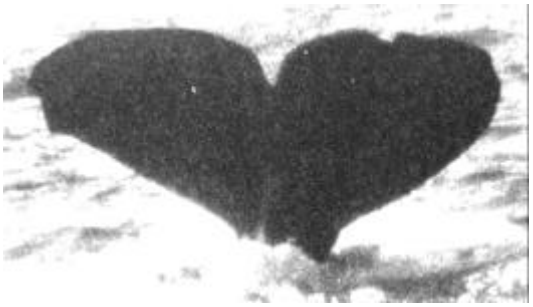


3b. Ventral Fluke

3 July 1997 58°55.0'N 148° 4.0'W

4a. Ventral Fluke

3 July 1997 58°55.0NN 148° 4.0NW



4b. Ventral Fluke

27 May 1998 59°16.4NN 142° 5.5NW

5a. Head scars

3 July 1997 58°55.0NN 148° 4.0NW

5b. Head scars

10 May 1998 56°18.4NN 135°36.6NW

5c. Ventral Fluke

3 July 1997 58°55.0NN 148° 4.0NW

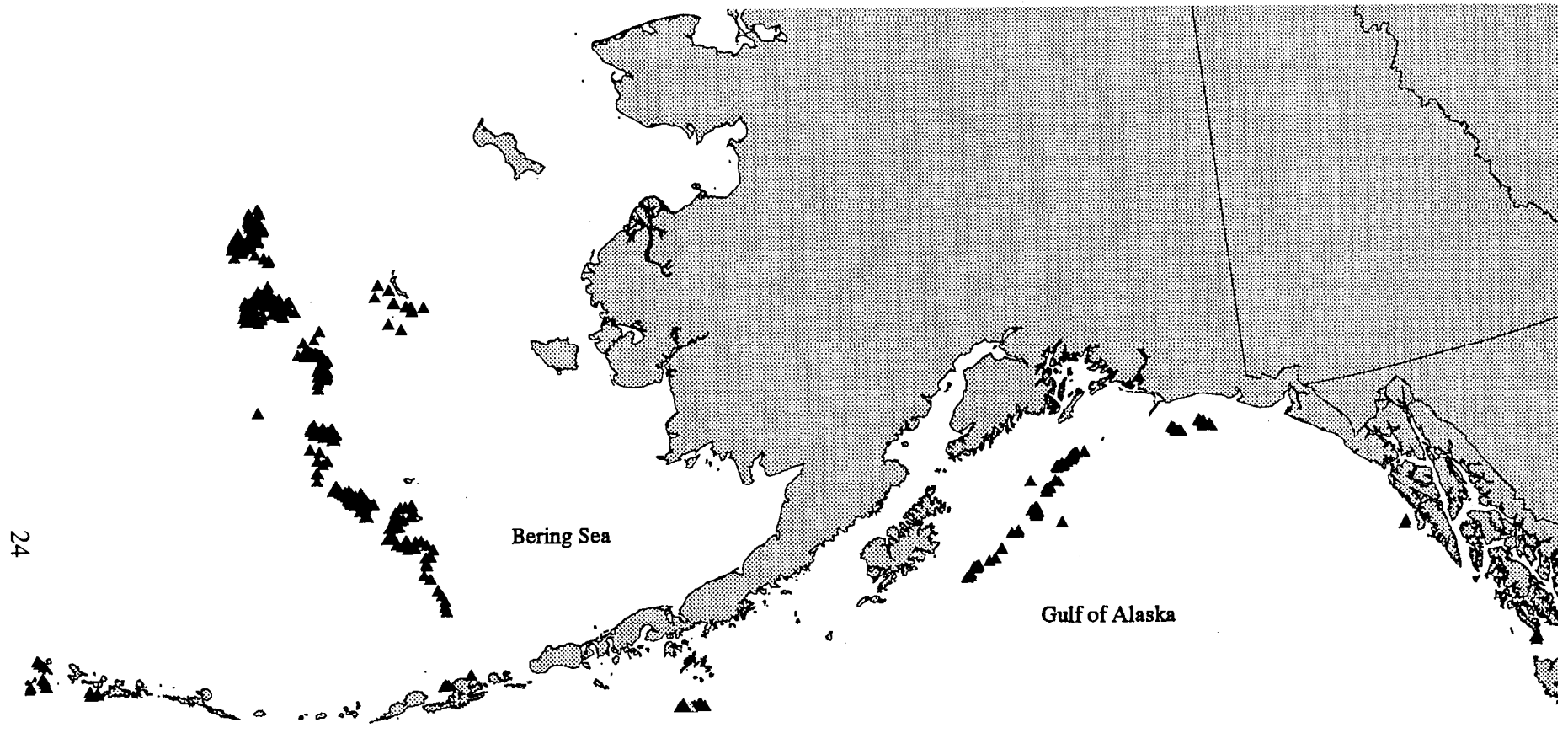


Figure 1. -- Locations (black triangles) of the 557 longline sets conducted during the 1997 sperm whale/longline interaction pilot program. Many triangles overlap because vessels tended to fish relatively small areas during a particular cruise.

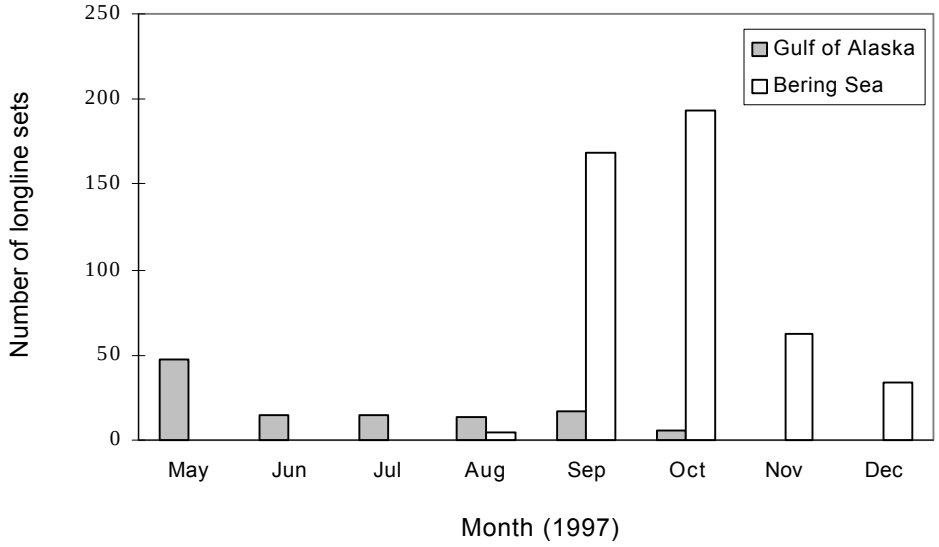


Figure 2. -- 1997 pilot program longline sets by month and region.

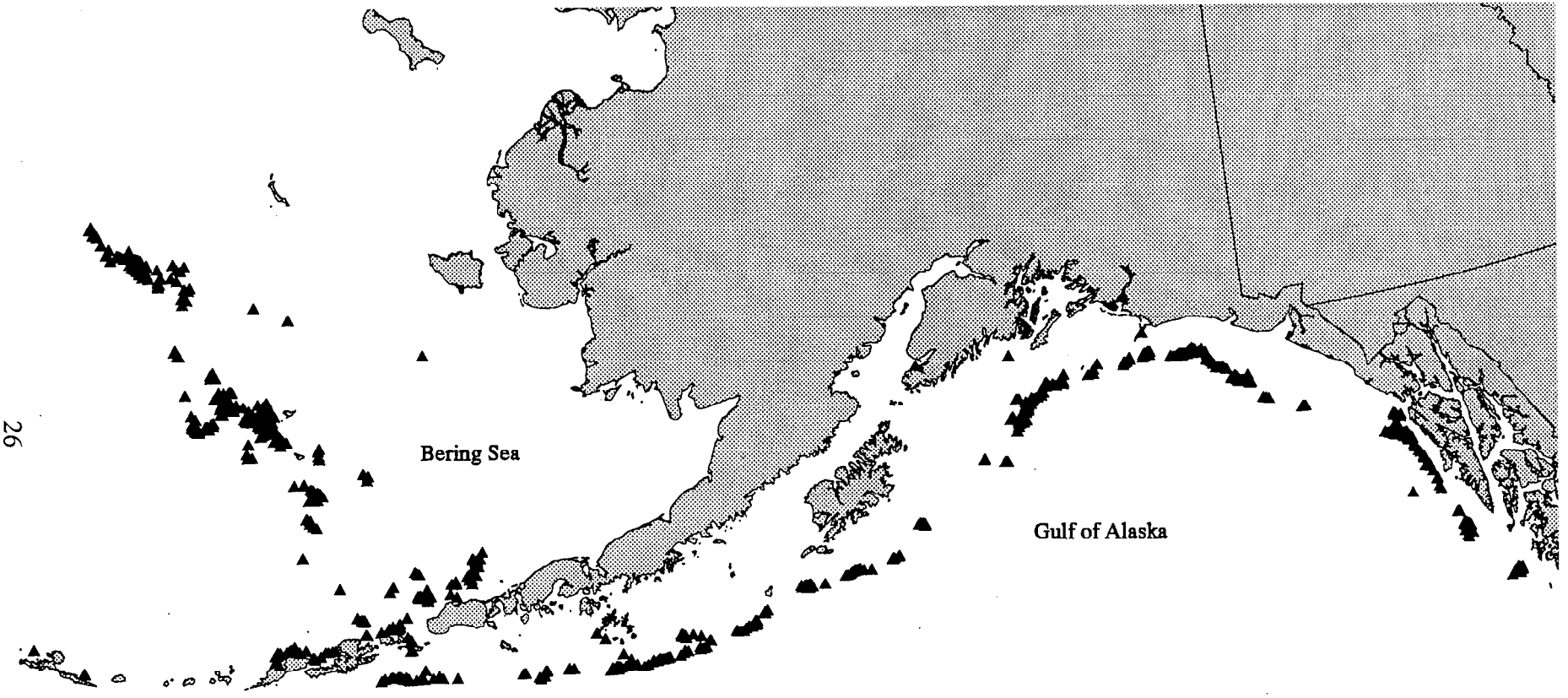


Figure 3. -- Locations (black triangles) of the 1,060 longline sets conducted during the 1998 sperm whale/longline interaction pilot program. Many triangles overlap because vessels tended to fish relatively small areas during a particular cruise.

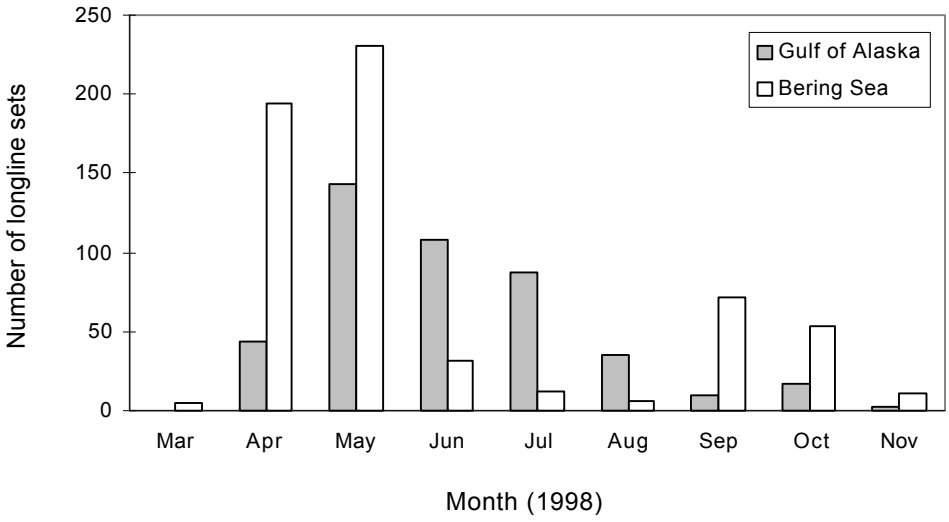


Figure 4. -- 1998 pilot program longline sets by month and region.

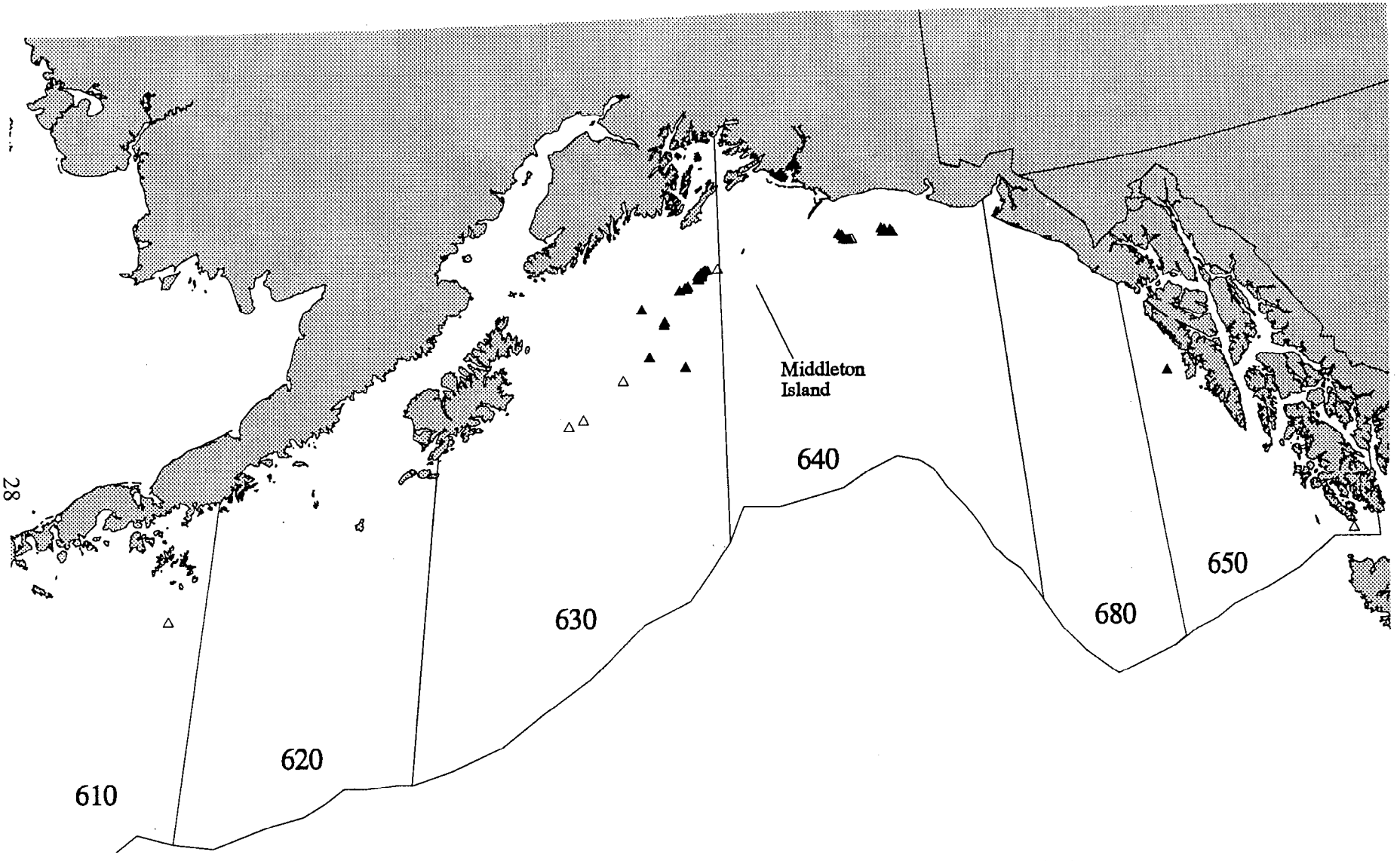


Figure 5. -- Locations of the 50 sperm whale sightings recorded during longline operations in the Gulf of Alaska during 1997. Positions of sightings (open triangles) and interactions (black triangles) are shown for North Pacific Fishery Management Council Statistical Areas.

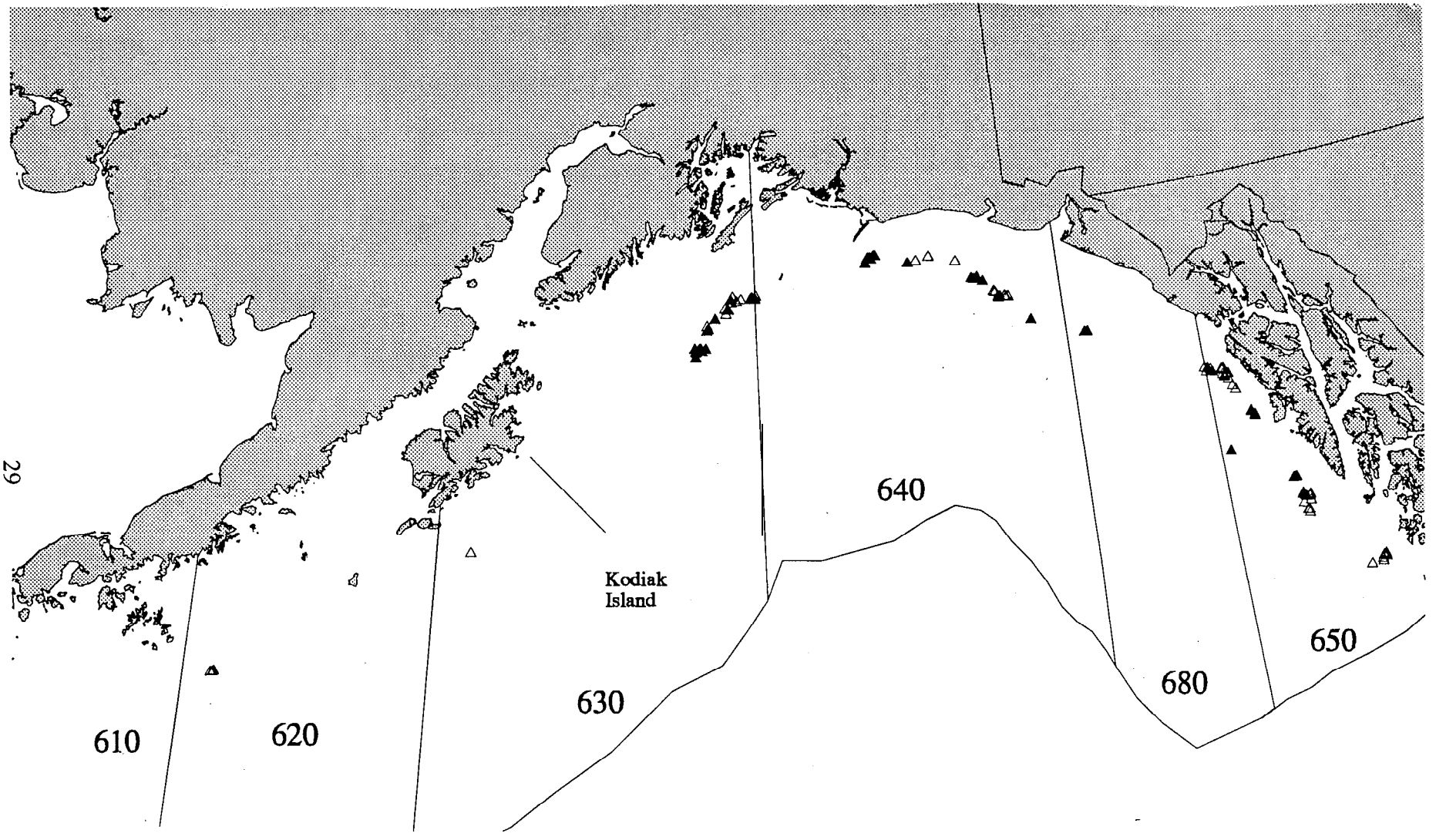


Figure 6. -- Locations of the 110 sperm whale sightings recorded during longline operations in the Gulf of Alaska during 1998. Positions of sightings (open triangles) and interactions (black triangles) are shown for North Pacific Fishery Management Council Statistical Areas.

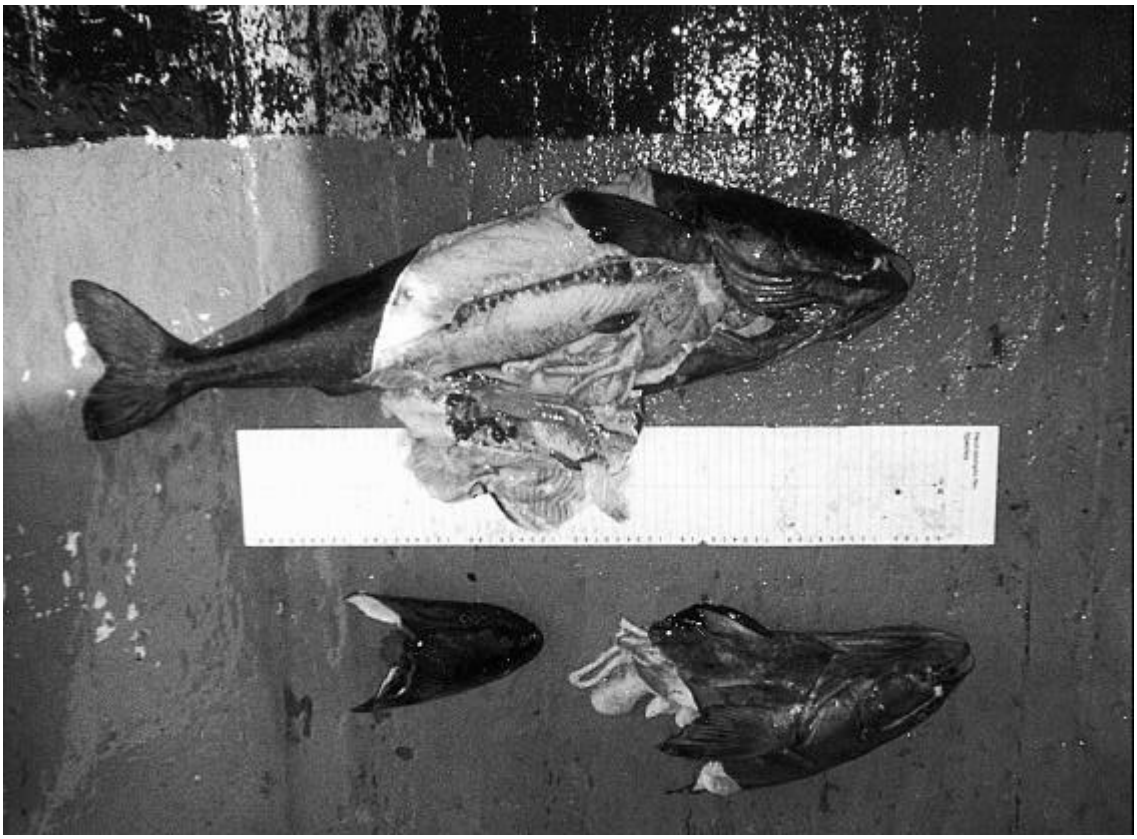


Figure 7.-- Longline-caught sablefish which have been damaged by sperm whales (photo courtesy of T. Mauer, NMFS Observer Program). Scale represents 70 cm.

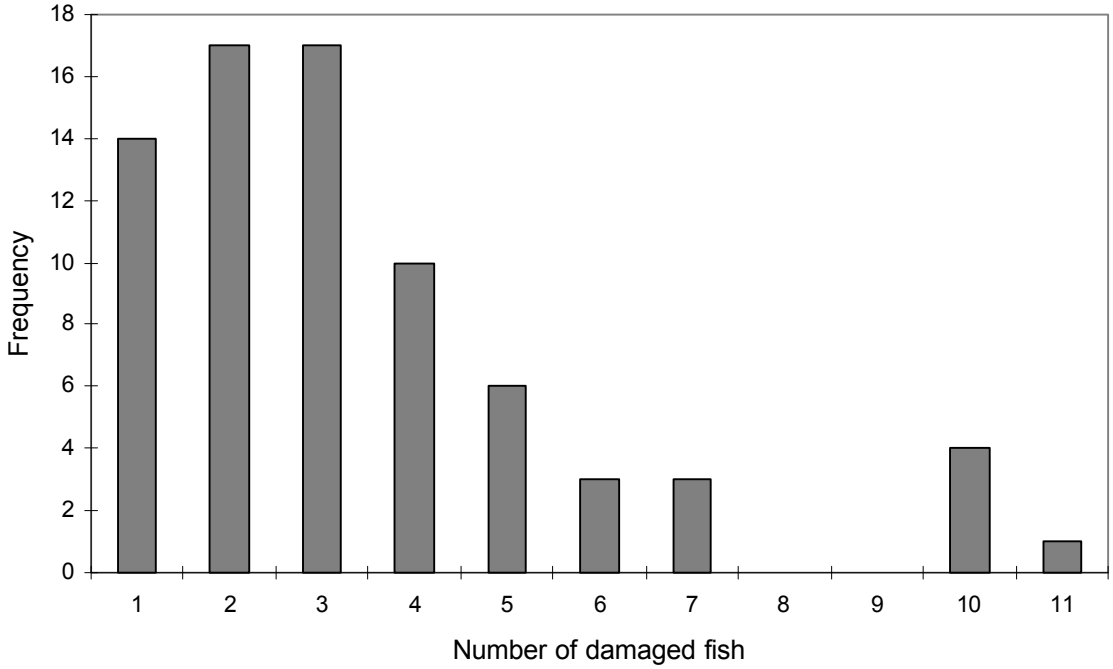


Figure 8. -- Number of damaged fish landed during sets in which depredation on the longline occurred. For 9 of the 74 sets where depredation occurred, the number of damaged fish was not recorded.

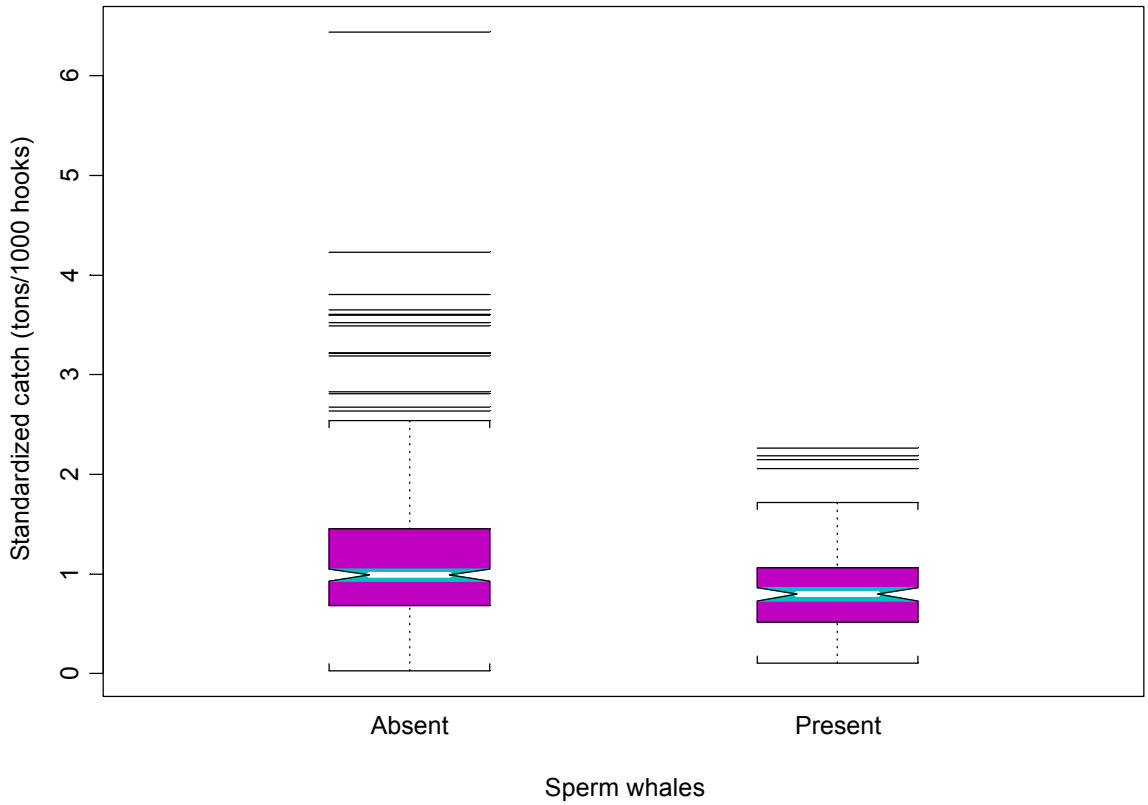


Figure 9. -- Distribution of standardized catch per set (tons per 1,000 hooks) when sperm whales were absent and present. Rectangular shaded box is the inter-quartile range and notched area is the 95% confidence interval for the median. The brackets represent twice the inter-quartile range and values outside are shown as individual lines.

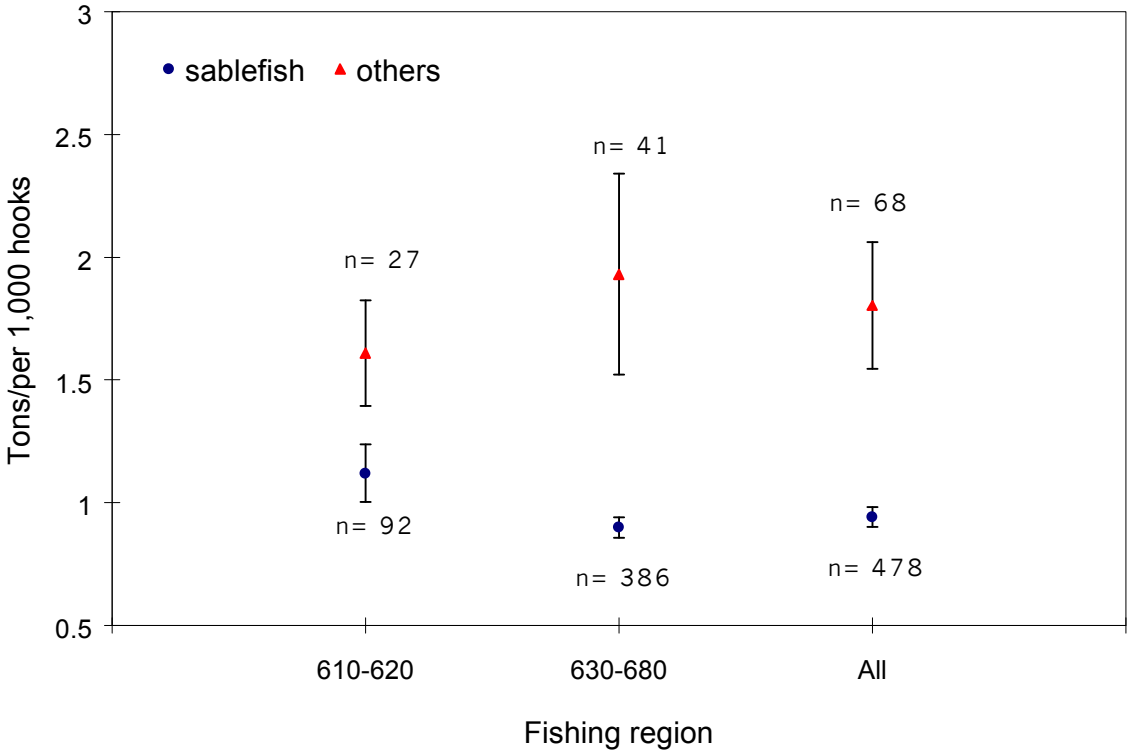


Figure 10. -- Mean catch and 95% confidence interval for sets which predominantly caught sablefish and other species grouped by North pacific Fishery Management Council Statistical Areas. For 16 of the 562 sets, the fish were not sampled so the predominant species was unknown.

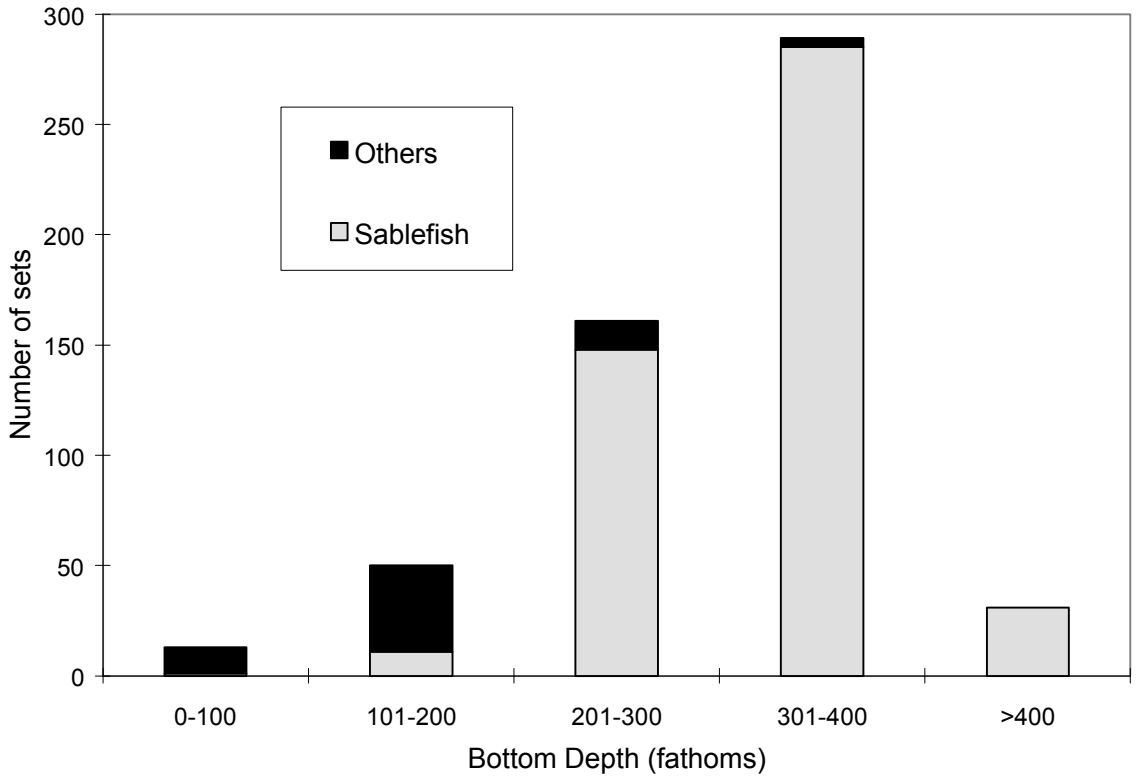


Figure 11. -- Number of longline sets categorized by bottom depth and predominant fish species caught.

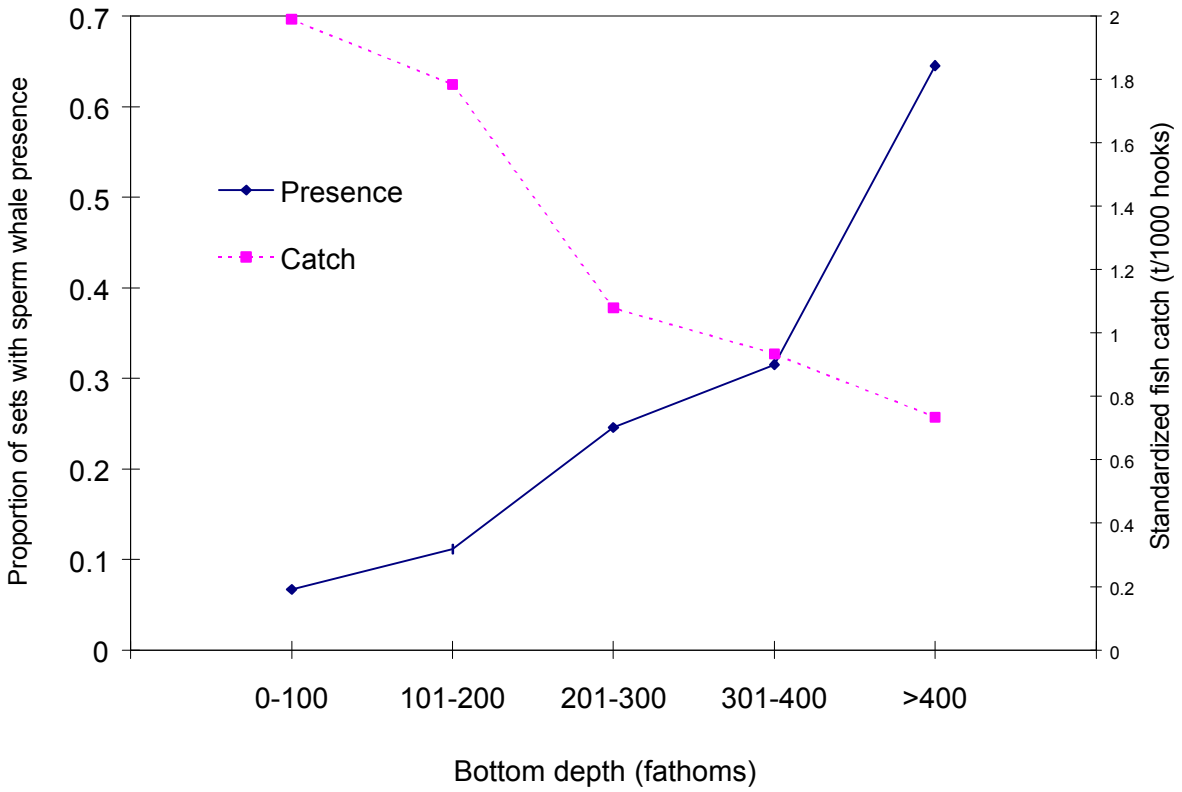


Figure 12. -- Association between bottom depth and sperm whale presence and standardized fish catch.

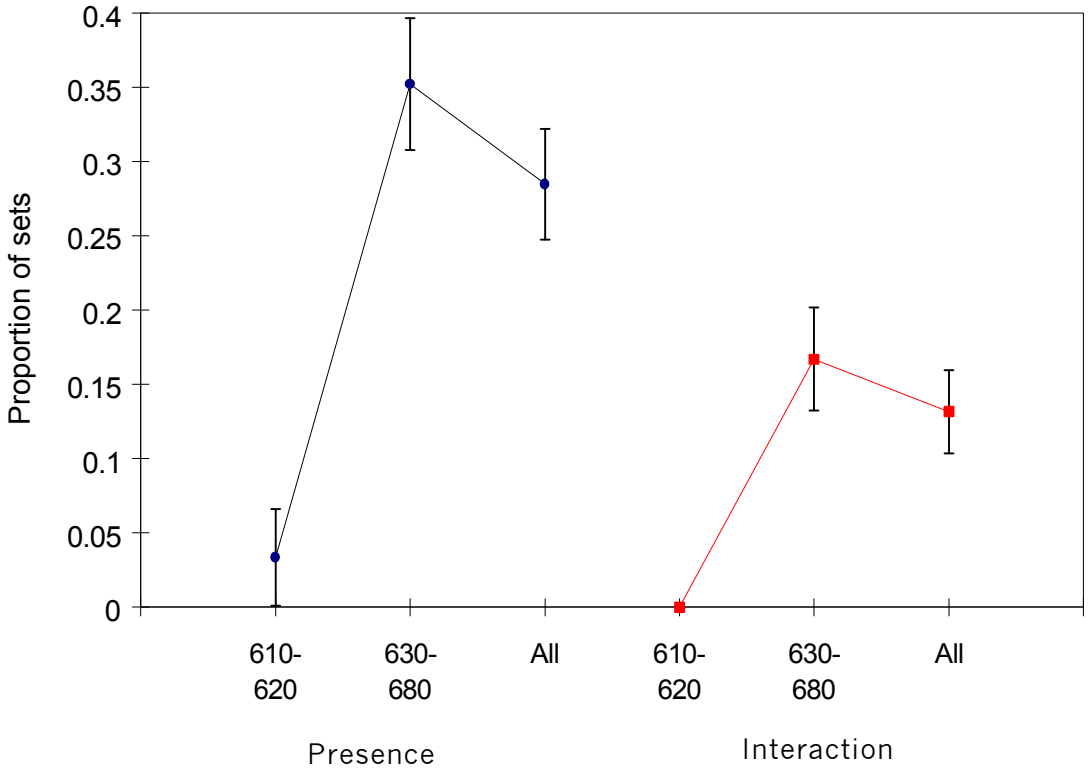


Figure 13. -- Proportion of longline sets with sperm whales present and with a sperm whale interaction (i.e., damaged fish) grouped by North Pacific Fishery Management Statistical Areas. The 95% confidence intervals were constructed based on a normal approximation.

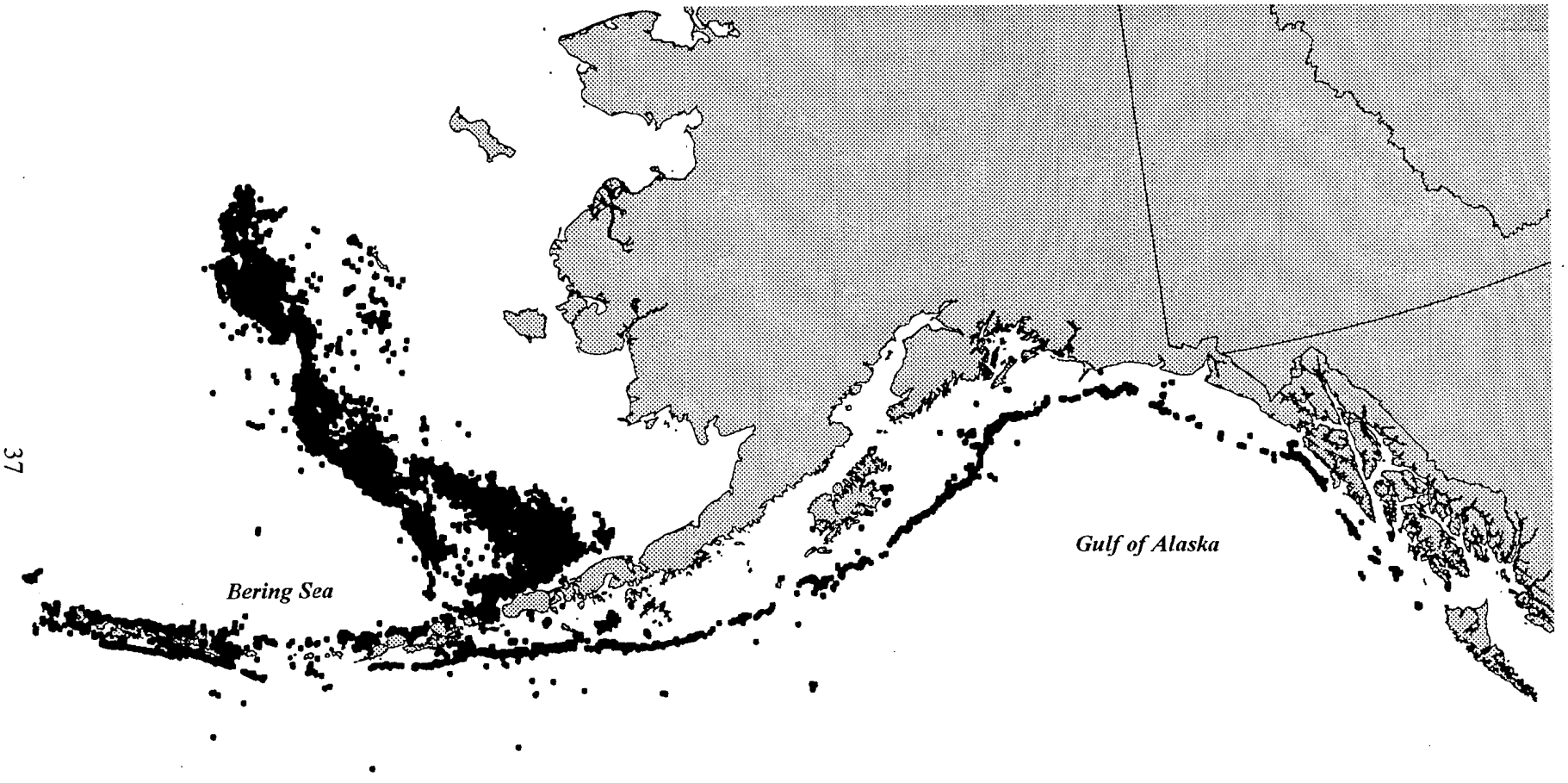


Figure 14. Locations (black circles) of the 15,186 longline sets monitored by fishery observers in Alaska waters during 1997.

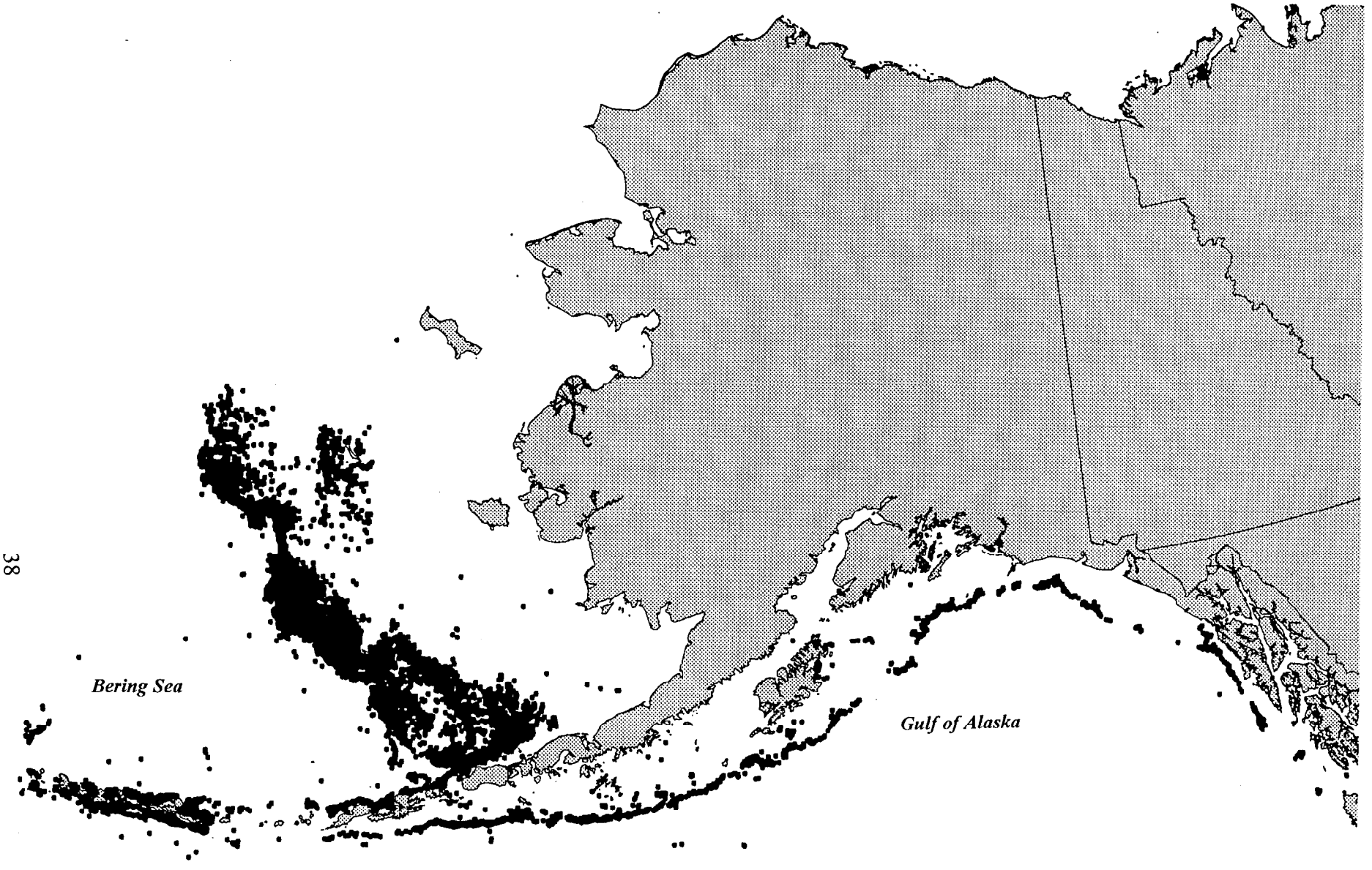


Figure 15. -- Locations (black circles) of the 16,265 longline sets monitored by fishery observers in Alaska waters during 1998.

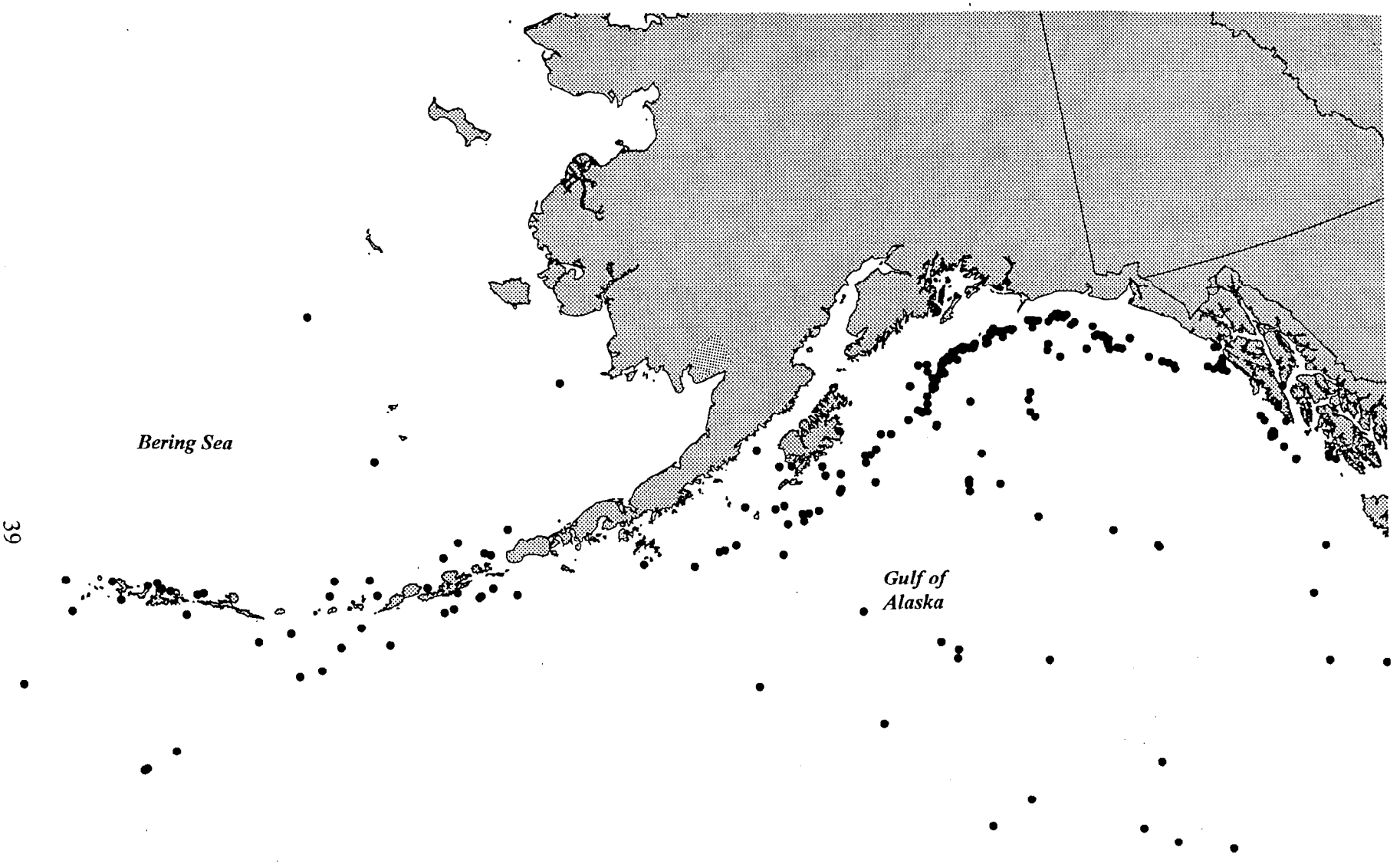


Figure 16. -- Locations of sperm whale sightings (black circles) in Alaska waters during the period from 1958 to 1995. (Unpubl. data from the National Marine Mammal Laboratory's Platforms of Opportunity database).

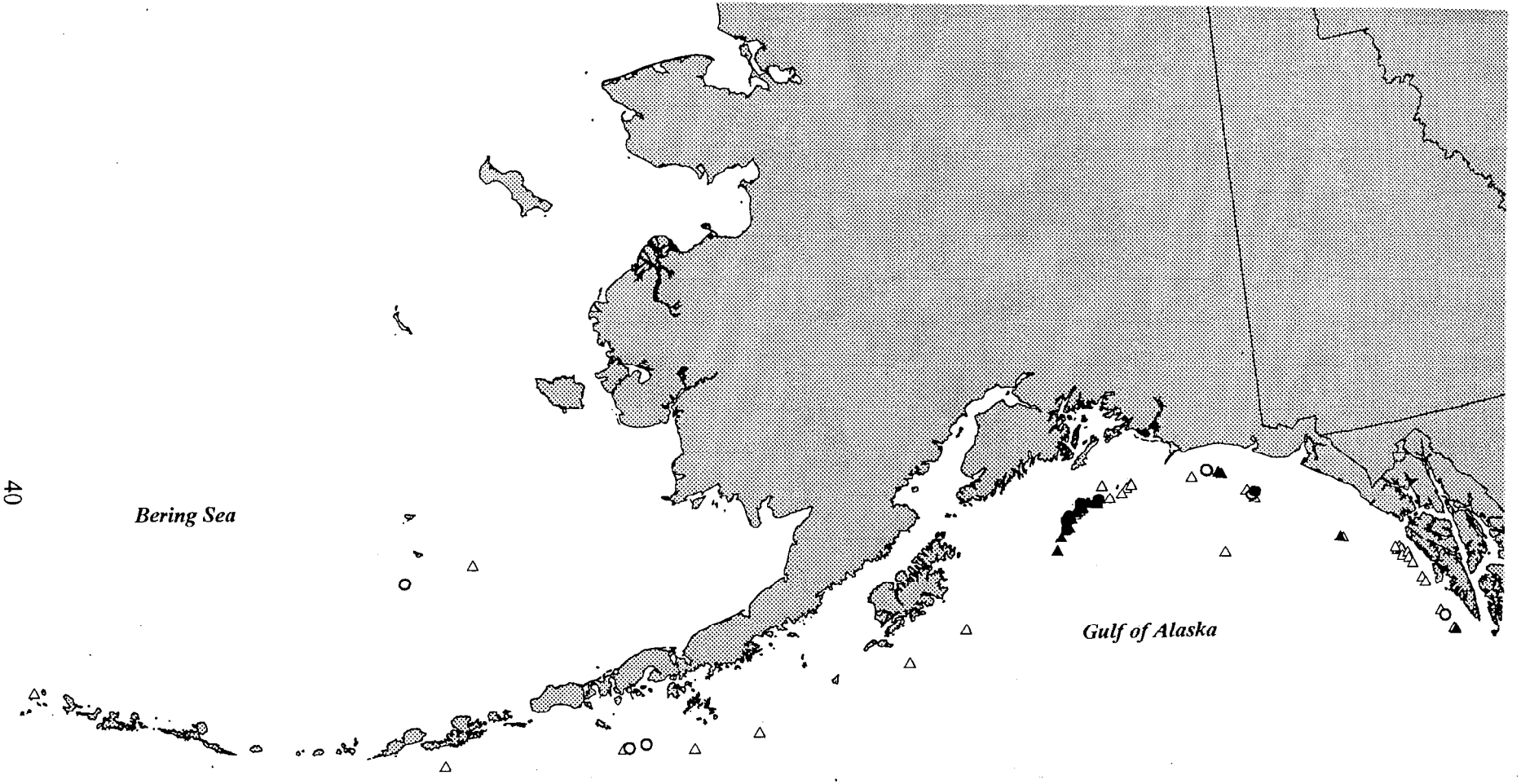


Figure 17. -- Locations of the 80 sperm whale sightings recorded by ancillary data sources operating in Alaska waters during 1997 (see Appendix 1). Positions of fishey observer sightings (open triangles), fishery observer interactions (black triangles), other data source sightings (open dots), and other data source interactions (black dots) are shown.

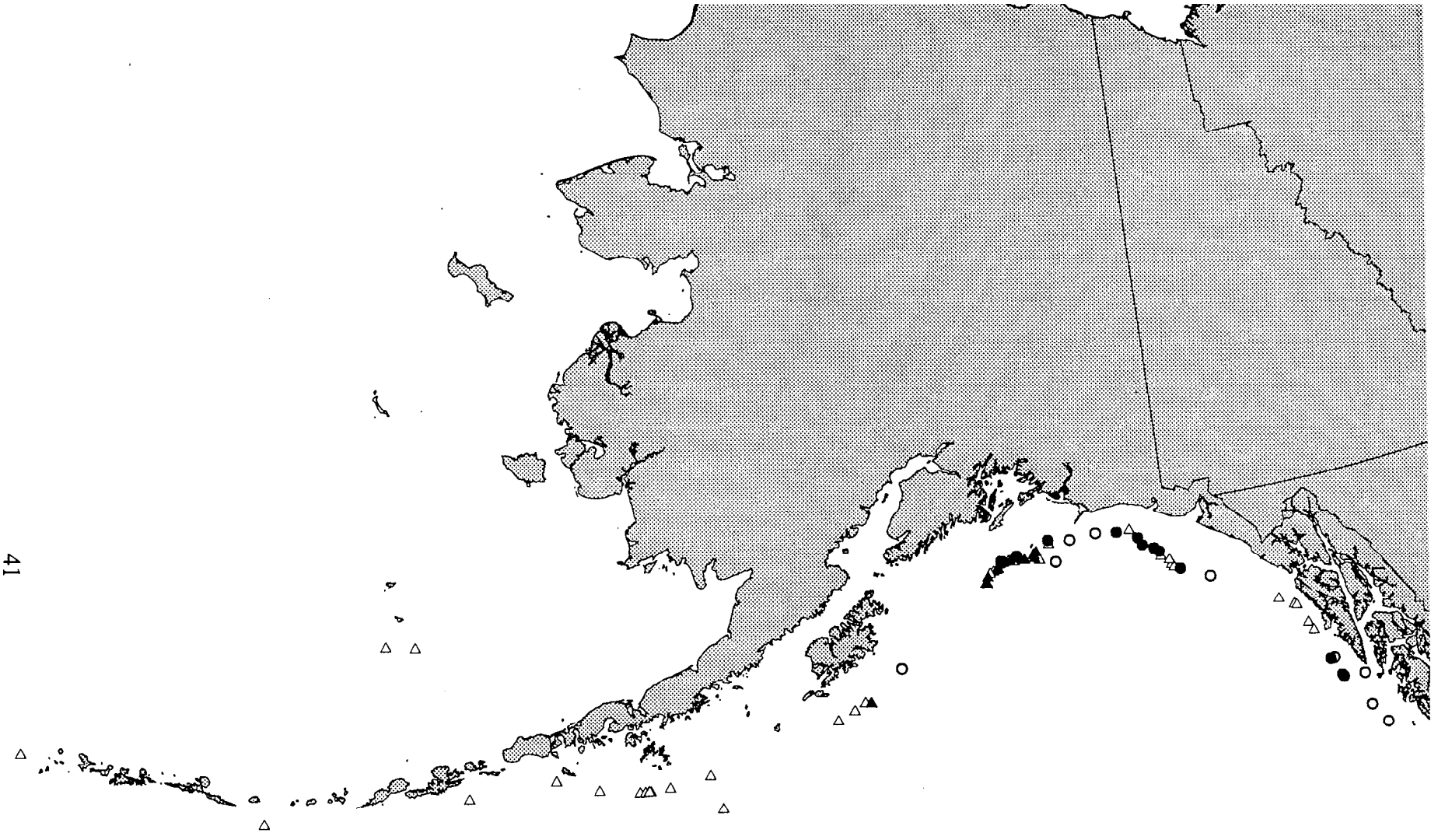


Figure 18.-- Locations of the 90 sperm whale sightings recorded by ancillary data sources operating in Alaska waters during 1998 (see Appendix 1). Positions of fishey observer sightings (open triangles), fishery observer iuteractions (black triangles), other data source sightings (open dots), and other data source interactions (black dots) are shown.

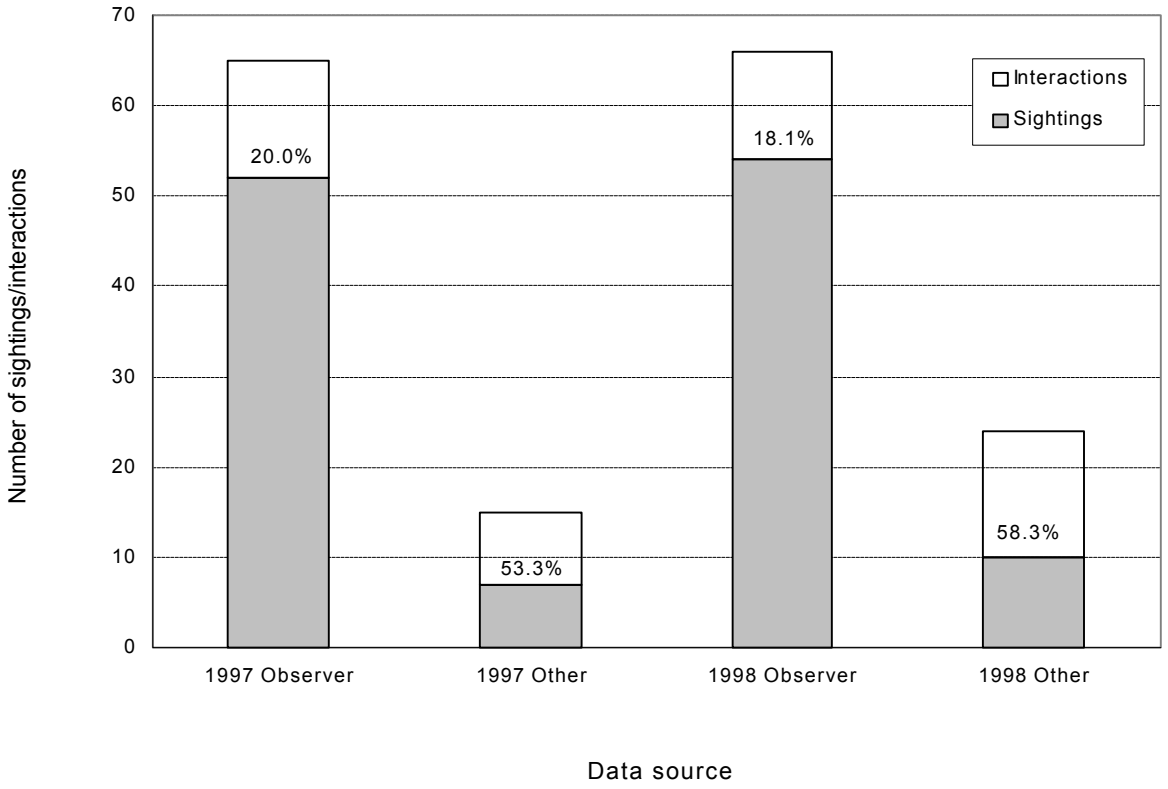


Figure 19. -- Number of sightings and interactions from ancillary data sources during 1997 and 1998. Percentages shown refer to the percentage interactions related to the number of sightings provided by a given data source.

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