Exxon Valdez Oil Spill
APEX Project Annual Report

Using Predatory Fish to Sample Forage Fishes, 1998

APEX Project 98163K
Annual Report

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Study History: This project was initiated as part of the *Exxon Valdez* Oil Spill Trustee Council-sponsored Alaska Predator Experiment (APEX) in 1995 (Project 95163K). One annual report and one publication were written at the conclusion of the first year of work (see Roseneau and Byrd 1996, Using predatory fish to sample forage fishes, 1995; and Roseneau and Byrd 1997, Using Pacific halibut to sample the availability of forage fishes to seabirds). Additional data were collected in 1996 and 1997 with support from the Alaska Maritime National Wildlife Refuge and the Trustee Council, respectively, and this information was combined with 1995 data in another annual report (see Roseneau and Byrd 1998, Using predatory fish to sample forage fishes, 1997; Project 97163K). In 1998, the study continued as APEX Project 98163K.

Abstract: Evaluating the influence of fluctuating prey populations (e.g., forage fish) is critical to understanding the recovery of seabirds injured by the T/V *Exxon Valdez* oil spill; however, it is expensive to conduct annual hydroacoustic and trawl surveys to assess forage fish stocks over broad regions. As part of the 1995 *Exxon Valdez* Oil Spill Trustee Council-sponsored Alaska Predator Ecosystem Experiment (APEX), we began to test the feasibility and effectiveness of using stomach contents from sport-caught Pacific halibut *(Hippoglossus stenolepis)* to obtain spatial and temporal data on capelin *(Mallotus villosus)* and Pacific sand lance *(Ammodytes hexapterus)*, two forage fish important to piscivorous seabirds. Because initial efforts provided valuable information on both species of fish in Kachemak Bay - lower Cook Inlet, we collected additional data from this region in 1996-1997 with support from the Alaska Maritime National Wildlife Refuge and Trustee Council, respectively. In 1998, we analyzed another 951 halibut stomachs from the study area. Results from these analyses continued to suggest that this relatively simple sampling technique can supply low-cost relative abundance data on Kachemak Bay - lower Cook Inlet forage fish populations that can be utilized to help monitor seasonal and interannual variations in forage fish stocks and seabird prey bases near nesting colonies.

Key Words: *Ammodytes hexapterus*, Barren Islands, capelin, Cook Inlet, forage fish, halibut, *Hippoglossus stenolepis*, Kachemak Bay, *Mallotus villosus*, Pacific halibut, Pacific sand lance, sand eels, sand lance.

Project Data: (To be addressed in the final report).

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INTRODUCTION

Evaluating the influence of fluctuating prey populations (e.g., forage fish) is critical to understanding the recovery of seabirds injured by the T/V *Exxon Valdez* oil spill; however, it is expensive to conduct annual hydroacoustic and trawl surveys to assess forage fish stocks over broad regions. As part of the 1995 *Exxon Valdez* Oil Spill Trustee Council-sponsored Alaska Predator Ecosystem Experiment (APEX), we began to test the feasibility and effectiveness of using stomach contents from sport-caught Pacific halibut *(Hippoglossus stenolepis)* to obtain spatial and temporal data on capelin *(Mallotus villosus)* and Pacific sand lance *(Ammodytes hexapterus)*, two forage fish important to piscivorous seabirds (APEX Project 95163K; see Roseneau and Byrd 1996, 1997, 1998). Because initial efforts provided valuable information both species of fish in Kachemak Bay - lower Cook Inlet, we collected additional data from this region in 1996-1997 with support from the Alaska Maritime National Wildlife Refuge and Trustee Council, respectively. In 1998, we analyzed another 951 halibut stomachs from the study area for the ongoing APEX ecological processes project. Results from these analyses continued to suggest that this relatively simple sampling technique can supply low-cost relative abundance data on Kachemak Bay - lower Cook Inlet forage fish populations that can be utilized to help monitor seasonal and interannual variations in forage fish stocks and seabird prey bases near nesting colonies.

OBJECTIVES

Objectives were to test the feasibility of using stomach contents from sport-caught halibut to sample forage fish stocks in the Kachemak Bay - lower Cook Inlet region, and evaluate the effectiveness of the technique in obtaining information useful to APEX seabird and forage fish studies in the spill area (e.g., studies of common murres, *Uria aalge*; black-legged kittiwakes, *Rissa tridactyla*; tufted puffins *(Fratercula cirrhata)*, sand lance, capelin).

METHODS

Halibut were chosen as potential samplers of forage fish populations because they opportunistically take a wide range of both fish and invertebrate prey, including sand lance and capelin (see Yang 1990; Roseneau and Byrd 1996, 1997, 1998). They were also selected as sampling tools because a large, 100-150 vessel sport charter boat fleet fishes for them in Kachemak Bay - lower Cook Inlet throughout May-August in several of same areas utilized by foraging seabirds nesting at the Barren Islands and Gull and Chisik islands colonies (see Roseneau and Byrd 1996, 1997).

The Kachemak Bay - lower Cook Inlet study area was set up and divided into 12 sampling subunits in May 1995 (Fig. 1, Appendix 1; see Roseneau and Byrd 1996, 1997, 1998). During late May - early September 1995-1998, we obtained 586, 778, 1,433, and 951 halibut stomachs from 7-8 of these areas, respectively (Appendix 2)[1]. Most stomachs were acquired when charter boat operators filleted fish for customers at public and private fish-cleaning facilities on the Homer Spit. However, Lake Clark National Park and Alaska Department of Fish and Game (ADF&G) biologists collected 173 stomachs from lodge owners and sport fishermen in Areas 1-2 in 1996, and ADF&G fisheries personnel also obtained 324 and 282 stomachs from these areas in 1997 and 1998, respectively.

Catch dates, locations, and fish lengths were usually obtained when stomachs were removed from carcasses; however, in some cases, these data were attached to bagged frozen samples saved for the project by participating fishermen. Stomach contents were identified using taxonomic keys,

[1] During 1995-1998, halibut lengths averaged 99 cm (n = 586, range = 71-213 cm), 111 cm (n = 778, range = 64-160 cm), 87 cm (n = 433, range = 57-141 cm), and 88 cm (n = 280, range =45-147 cm), respectively.

photographs, and voucher specimens (see Roseneau and Byrd 1996, 1997, 1998). Whole and partly digested, but still recognizable fish and invertebrates were sorted into several categories, including capelin, sand lance, flatfish, sculpin, cod, crabs, shrimp, squid, octopus, mollusks, and other fish and invertebrate species. Empty stomachs were weighed to obtain estimates of content weight, and undigested capelin and sand lance were weighed and measured to obtain size data for other investigators (e.g., J. Piatt, Project 98163M). Some whole capelin and sand lance were also frozen, or preserved in 10% buffered formaldehyde and 75% ethanol - 2% glycerin solutions for later analysis by other researchers.

Data were entered stomach-by-stomach into computer spreadsheets. Analysis consisted of eliminating all potential bait items from the data base (e.g., cod and salmon heads; Pacific herring, *Clupea harengus pallasi*); sorting remaining information by dates, areas, and species; and calculating numbers and frequencies of occurrence of fish and invertebrates in different geographic areas and time periods (see Roseneau and Byrd 1996, 1997, 1998).

RESULTS

We limited preliminary multiyear analyses to Areas 2, 4, 6, 8, and 10 (see Fig 1). Data from Areas 1 and 12 will be incorporated into the final FY 99 report. *[Samples were not obtained from Areas 3, 5, 7, 9, and 11 during 1995-1998, because these areas are rarely fished by the sport charter fleet].*

In 1998, fish were present in 39% of the stomachs, compared to 49% in 1995, 55% in 1996, and 32% in 1997 (Fig. 2). Occurrence of fish also varied in stomachs containing prey over the 4-year interval (Fig. 3). The percentage of stomachs containing sand lance tended to increase from 1995 to 1998 (11%, 6%, 17%, and 20%, respectively). In contrast, the percentage containing capelin declined during 1995-1997 and then rebounded to a point between 1995 and 1996 levels in 1998 (33%, 11%, 8%, and 20%, respectively). The proportion of other forage fish (17%, 30%, 28%, and 5%) and non-forage fish (24%, 31%, 34%, and 24%) species was lowest in 1995 and 1998, years when percentages of capelin were highest.

Numbers of fish in stomachs containing prey followed a pattern similar to occurrence of capelin: they declined markedly during 1995-1997 (79%, 45%, and 36%, respectively) and then rebounded in 1998 (50%; Fig 4). Although capelin and sand lance dominated the fish component by number every year (83%, 56%, 68%, and 87 in 1995-1998, respectively), combined percentages of these fish were lowest in 1996-1997, when non-forage fish numbers were highest (22% and 25%, respectively). Capelin and sand lance also clearly switched roles between 1995 and 1997 (60% and 23% in 1995 *vs* 19% and 49% in 1997, respectively; see Fig. 4).

When fish numbers were compared among areas and years, numbers of capelin were consistently lowest in Area 2 (Fig. 5a; mean 3%, range 0-7%) and highest in Areas 6 (Fig. 5b; mean 62%, range 47-74%) and 10 (Fig. 5c; mean 60%, range 28-82%). Data from these areas and Areas 4 and 8 also provided evidence that capelin stocks declined and sand lance populations increased between 1995 and 1997; for the five areas combined, capelin averaged 45% (range 0-82%) and 18% (range 2-47%), and sand lance averaged 23% (range 0-57%) and 47% (range 33-74%), respectively (see Figs. 5a, 5b, and 5c). Combined data from the five areas also suggested that sand lance and capelin stocks were both high in 1998; sand lance averaged 41%, a value only 6% below the 1997 level, and capelin averaged 44%, a figure 26% higher than the 1997 value and identical to the 1995-1996 levels (45% and 44%, respectively; see Figs. 5a, 5b, and 5c).

DISCUSSION

The consistently small number of capelin found in halibut stomachs from Area 2 was probably related to the less saline, more turbid water conditions typically found north of Anchor Point, and the consistently high percentage of these forage fish in Area 6 and 10 stomachs was probably associated with cold water upwellings that occur in the Point Adam and Barren Islands vicinities (J. Piatt, pers. comm.).

Study results indicated that forage fish stocks were higher in 1995 and 1998 than during 1996-1997. They also suggested that sand lance populations increased while capelin stocks declined and rebounded during this 4-year period. These changes were consistent with observations from other studies and charter boat skippers. For example, in 1993-1995, tens of thousands seabirds, including sooty shearwaters *(Puffinus griseus)*, black-legged kittiwakes, tufted puffins, murres, and cormorants *(Phalacrocorax* spp.*)*, and up to 200 humpback whales *(Megaptera novaeangliae)* were regularly observed feeding on large post-spawning schools of capelin in the Barren Islands area during late June - late August (see Roseneau *et al.* 1995, 1996; Roseneau and Byrd 1996, 1997). Capelin schools and associated concentrations of feeding seabirds and whales were scarce in this area during mid-July - mid-August 1996, and almost entirely absent from it during the same interval in 1997 (seabirds primarily consisted of tufted puffins and kittiwakes in groups of fewer than 500 individuals in 1996, and fewer than 100 birds the following year, and the highest daily whale counts in these years were 12 and 4 individuals, respectively; D.G. Roseneau, pers. obs., Projects 96144 and 97144). In 1998, large schools of capelin that attracted as many as 40-100 humpback whales, 20-45 killer whales *(Orcinus orca)*, and thousands of seabirds were common in the Barren Islands, Kennedy Entrance, and Point Adam areas after mid-July (Capt. R. Swenson, Homer Ocean Charters, pers. comm.).

The apparent shift from a capelin dominated food web in 1995 to one containing large numbers of sand lance in 1997 that was suggested by the multiyear halibut stomach data paralleled 1995-1997 changes in Barren Islands kittiwake chick diets. During these three years, kittiwake chicks reared at the East Amatuli Island - Light Rock colony were fed about 64%, 28%, and 14% capelin, and 13%, 53%, and 63% sand lance by weight, respectively (see Roseneau *et al.* 1998). In 1998, when halibut stomachs contained high percentages of both forage fish species, chick diets reflected the change: regurgitation's from nestlings contained about 32% capelin and 50% sand lance, and regurgitation's from adult kittiwakes delivering food to chicks consisted of about 29% capelin and 38% sand lance (Roseneau *et al.*, unpubl. data). *Note: 1998 chick and adult regurgitation s also contained about 5% and 33% unidentified smelt, respectively; most of these fish were probably capelin.*

Preliminary analyses of beach seine data collected by APEX Projects 96163J, 97163J, 96163M, and 97163M also indicated that sand lance were more numerous than capelin in the Kachemak Bay - lower Cook Inlet region in 1997 (M. Robards, pers. comm.). More comprehensive analyses that incorporate halibut stomach information from Areas 1 and 2, and beach seine, trawl, and seabird chick diet data from the Barren Islands and Gull and Chisik islands colonies will be included in the FY 99 final report.

CONCLUSIONS

1. Results from the third year of study helped confirm that analyzing stomach contents from sport-caught halibut can supply low-cost relative abundance data on forage fish populations in Kachemak Bay - lower Cook Inlet that are needed to help monitor and assess seasonal and interannual variations in forage fish stocks and seabird prey bases.

2. Results also indicated that the sampling method can be used to monitor seasonal changes in relative abundance of capelin and sand lance in certain circumstances. When data were sufficient to be divided into two-week time blocks, we were able to detect within-season variation in these species (e.g., Area 6 in 1995; see Roseneau and Byrd 1996, 1997, 1998). Based on these data, we believe that this relatively simple cost-effective technique can provide a variety of useful information on forage fish stocks in areas where seabird foraging areas and regular sport fishing activities overlap (e.g., Barren Islands, Gull and Chisik island vicinities).

RECOMMENDATIONS

Based on 1995-1998 results, including similarities between halibut stomach contents and kittiwake chick diets, we recommend continuing this relatively inexpensive forage fish sampling study in Kachemak Bay - lower Cook Inlet during the last field season of the APEX project in FY 99.

ACKNOWLEDGMENTS

We would like to thank our volunteers, Jill Aho (1995-1998), Daniel Boone (1995-1996), and Martin Robards (1996-1998), for their help during the study. Jill and Dan made arrangements to obtain samples from halibut charter boat operators, met returning vessels, recorded catch dates and locations, and processed stomach contents. Martin single-handedly identified contents from over 2,500 stomachs in 1996-1998. We also thank Scott Meyer and Willy Dunn of the Homer office of the Alaska Department of Fish and Game for collecting stomachs from fishermen in the Ninilchik -Deep Creek vicinities in 1996-1998; Alan Bennet, Lake Clark National Park and Preserve, for providing data from stomachs collected by National Park Service staff along the western side of Cook Inlet in 1996; Captain Rick Swenson, Homer Ocean Charters, for letting us sample carcasses at his Homer Spit facilities in 1995-1998, and for contributing valuable observations of forage fish schools and feeding seabirds and whales to the study; and all of the other charter boat operators and vessel captains who provided samples and information to the project. Bruce Wright, National Marine Fisheries Service, and John Piatt, U.S.Geological Survey Biological Resources Division, made helpful suggestions during the work. The study was funded by the *Exxon Valdez* Oil Spill Trustee Council in 1995 and 1997-1998, as part of the ongoing Alaska Predator Ecosystem Experiment (APEX Project 98163); additional support was provided by the Alaska Maritime National Wildlife Refuge and APEX Project 97163M in 1996 (J. Piatt).

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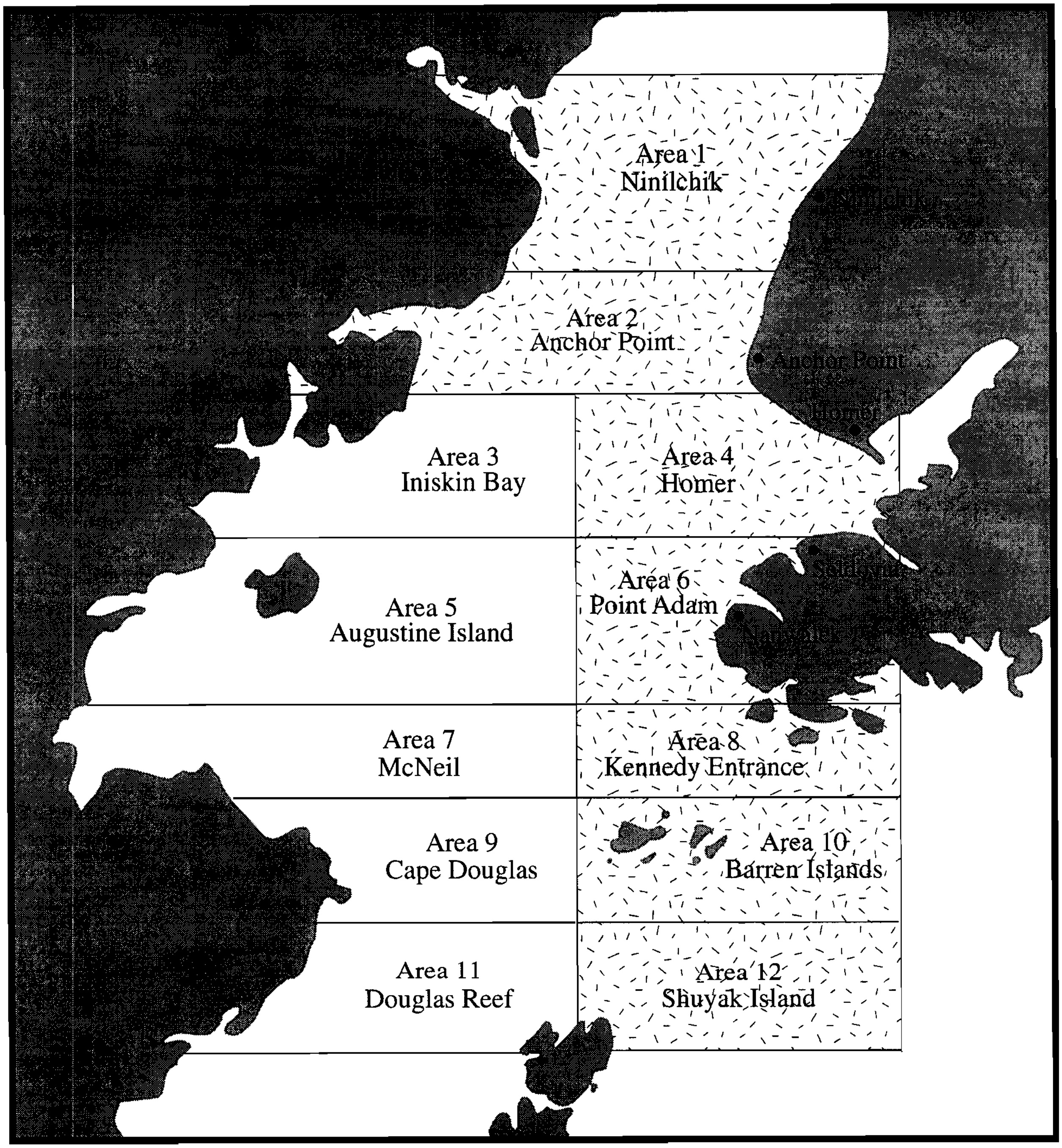

Figure 1. The Kachemak Bay - lower Cook Inlet study area (all samples were obtained from stippled areas).

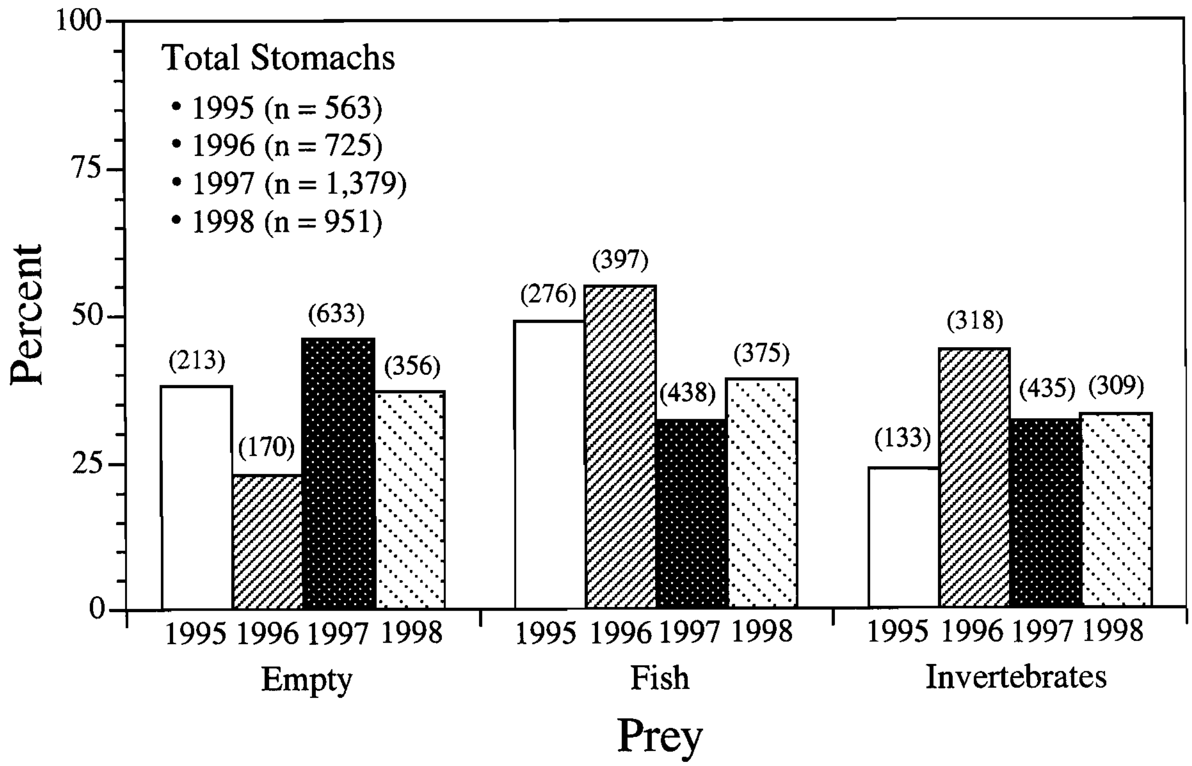

Figure 2. Frequency of occurrence of fish and invertebrates in halibut stomachs from Areas 2, 4, 6, 8, and 10 in Kachemak Bay - lower Cook Inlet, 1995-1998 (numbers of stomachs shown in parentheses).

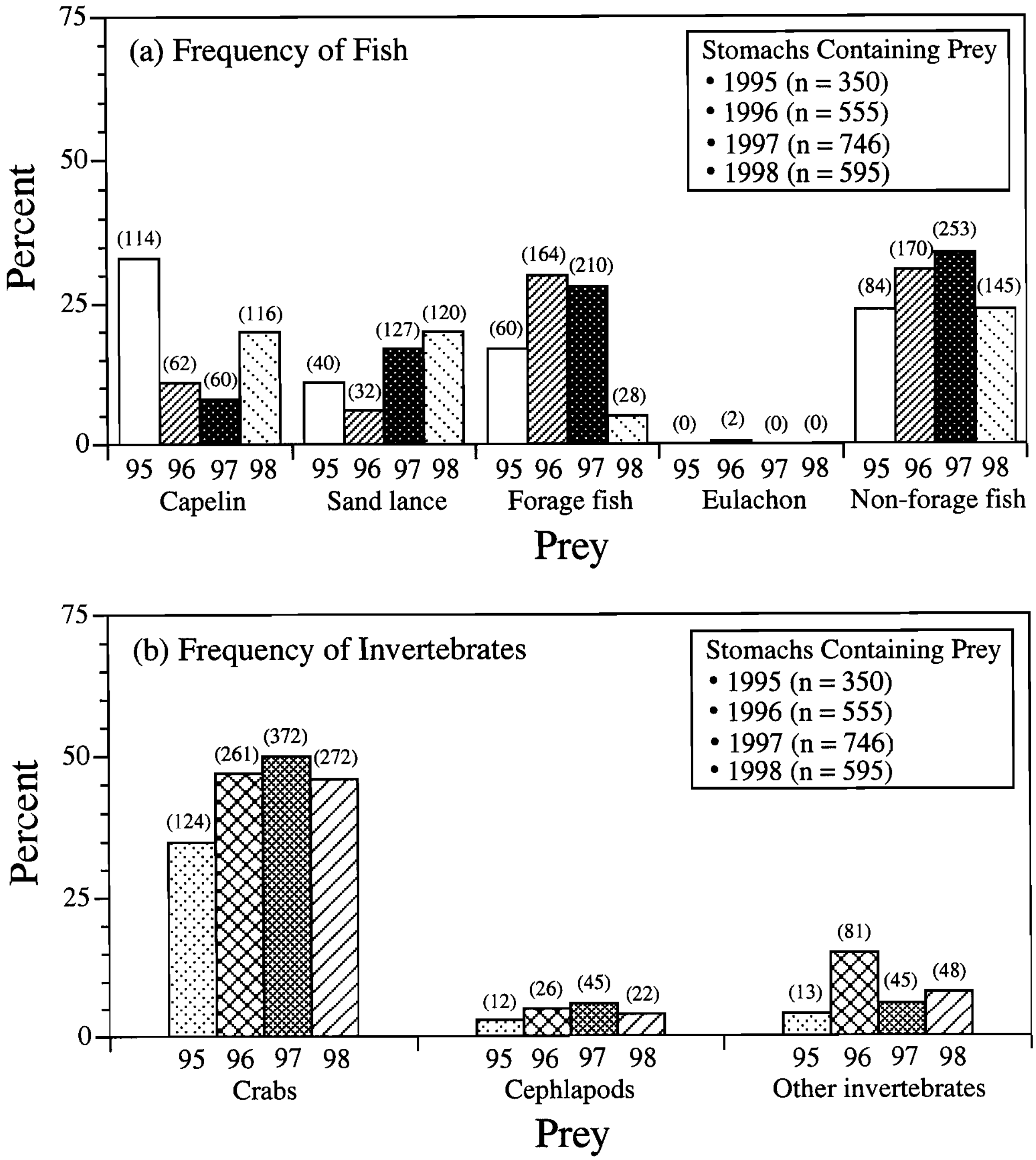

Figure 3. Frequencies of occurrence of (a) fishes and (b) invertebrates in halibut stomachs from Areas 2, 4, 6, 8, and 10 in Kachemak Bay - lower Cook Inlet that contained prey, 1995-1998 (numbers of stomachs shown in parentheses).

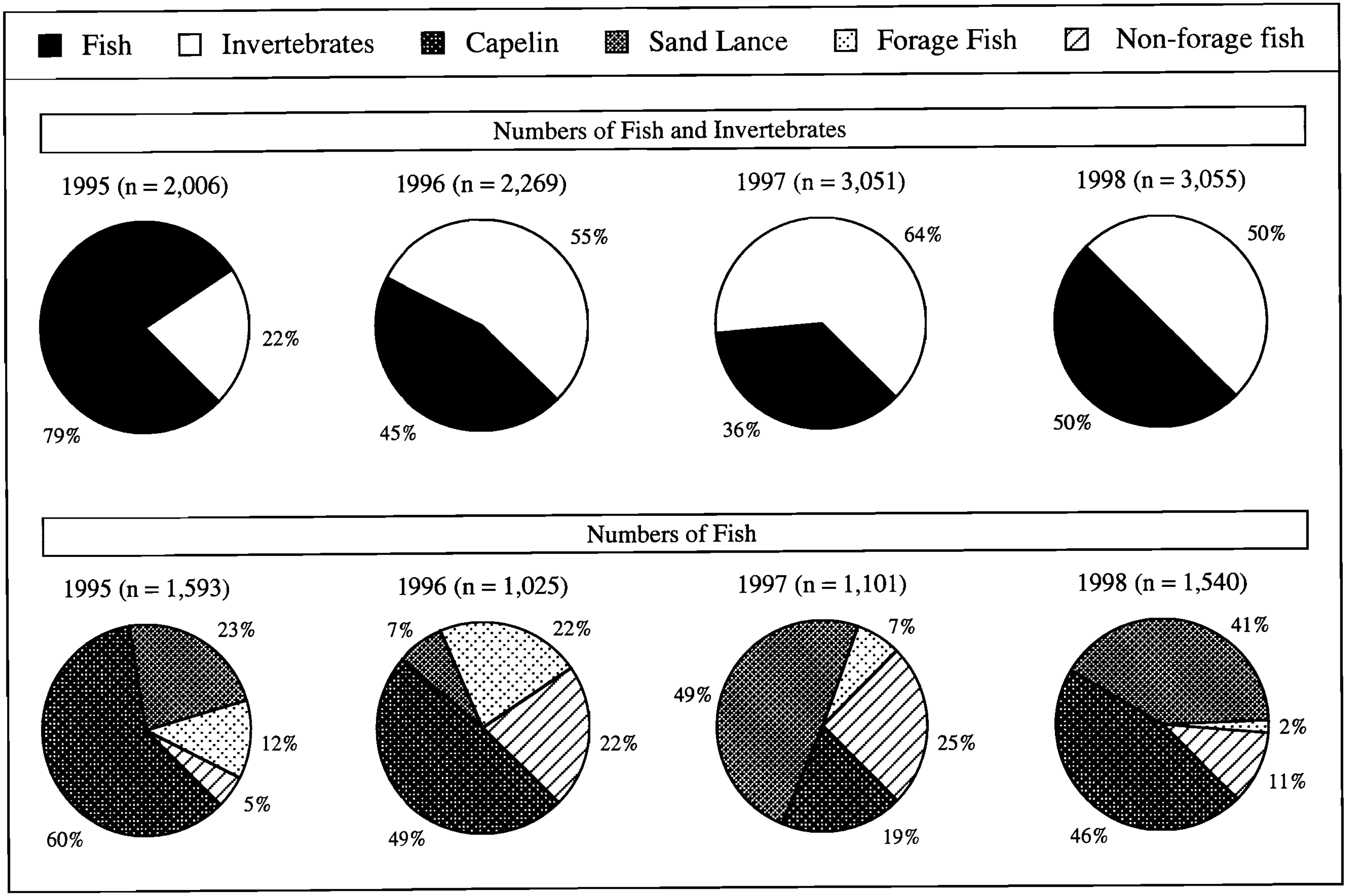

Figure 4. Numbers of fish and invertebrates in halibut stomachs from Areas 2, 4, 6, 8, and 10 in Kachemak Bay - lower Cook Inlet that contained prey, 1995-1998.

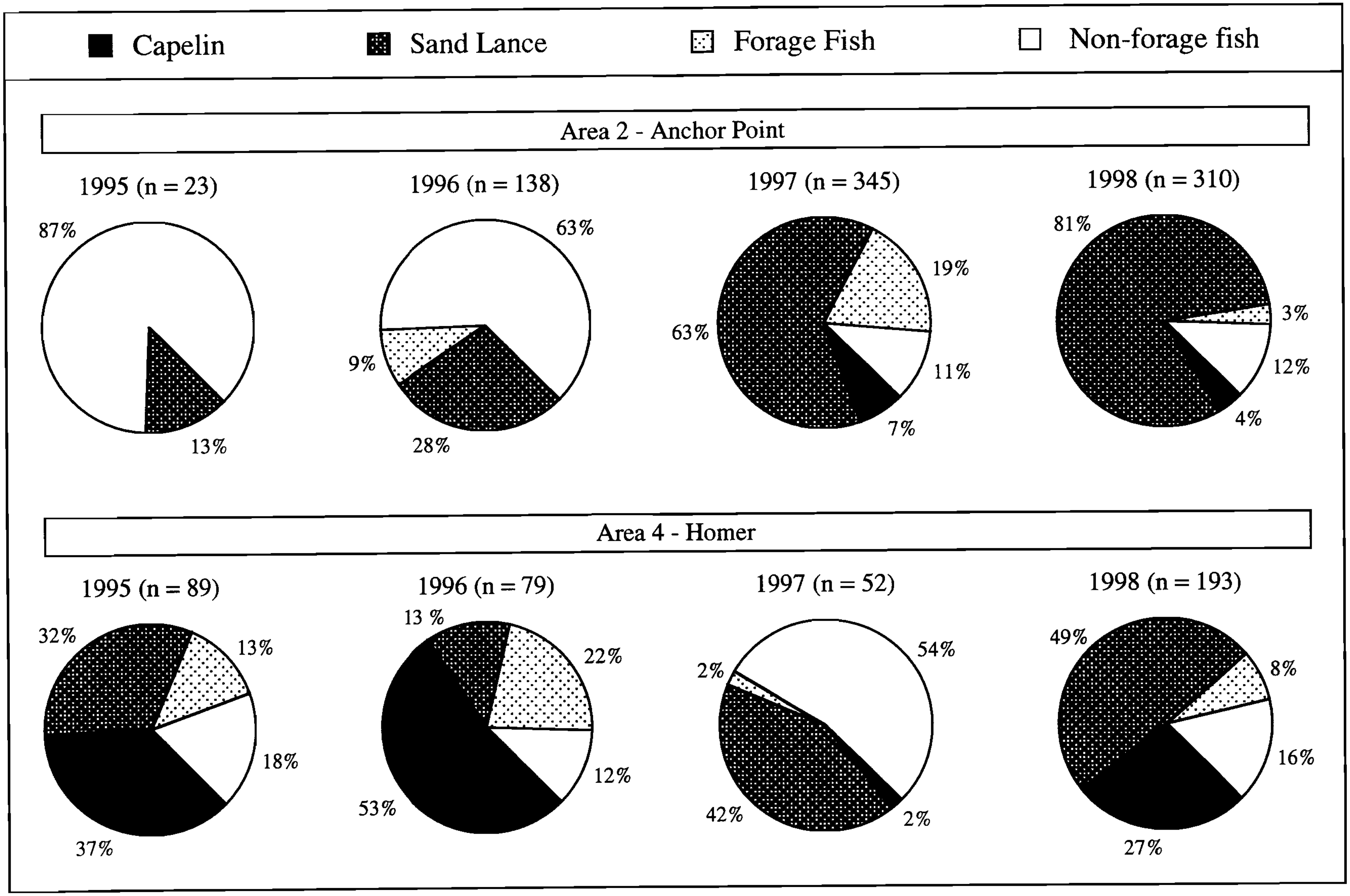

Figure 5a. Numbers of fish in halibut stomachs from Areas 2 and 4 in Kachemak Bay - lower Cook Inlet that contained prey, 1995-1998.

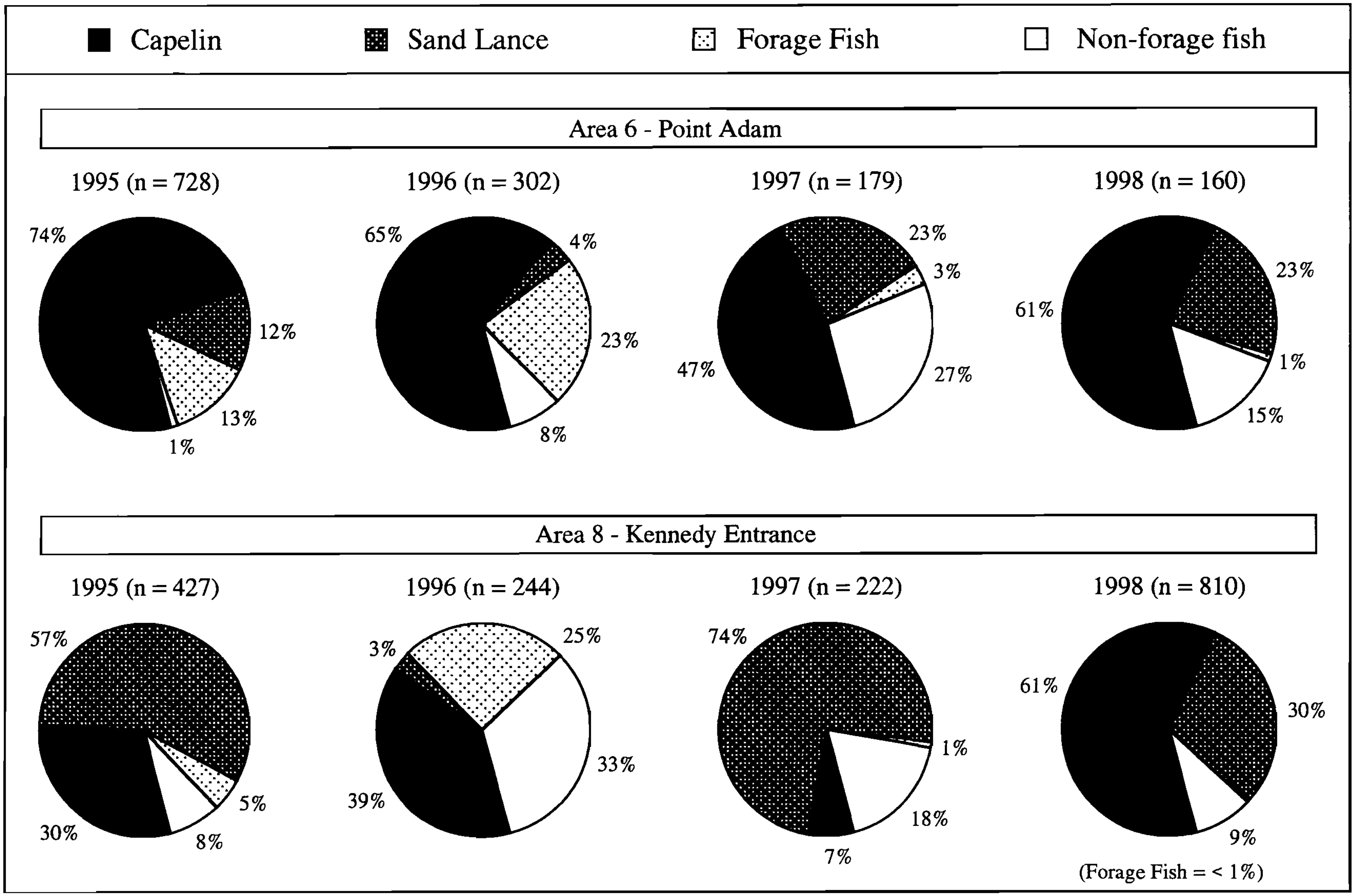

Figure 5b. Numbers of fish in halibut stomachs from Areas 6 and 8 in Kachemak Bay - lower Cook Inlet that contained prey, 1995-1998.

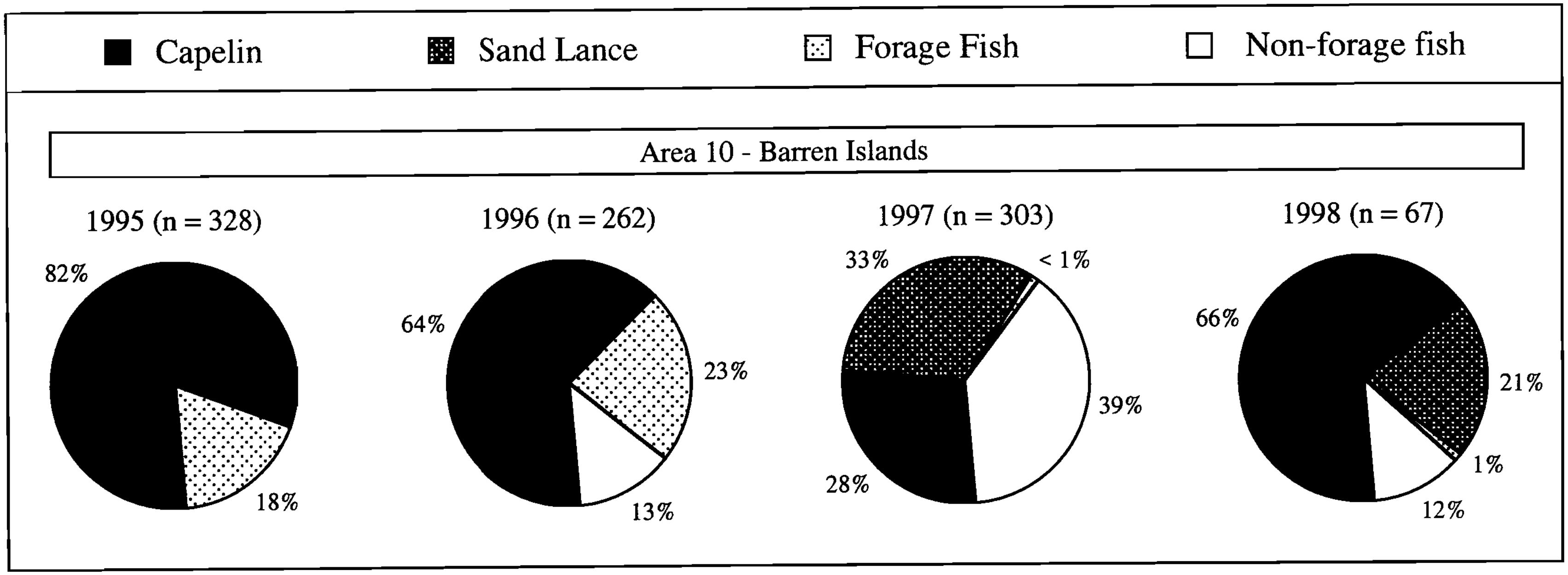

Figure 5c. Numbers of fish in halibut stomachs from Area 10 in Kachemak Bay - lower Cook Inlet that contained prey, 1995-1998.

Appendix 1. Boundaries of the 1995-1998 Kachemak Bay - lower Cook Inlet halibut stomach sampling areas (latitudes and longitudes in hundredths of minutes and degrees and minutes).

Area 1 (Ninilchik): The northern boundary is 60.23 N (60° 14' N), the southern boundary is 59.92 N (59° 55' N), and the western and eastern boundaries are the shorelines of Cook Inlet.

Area 2 (Anchor Point): The northern boundary is 59.92 N (59° 55' N), the southern boundary is 59.72 N (59° 43' N), and the western and eastern boundaries are the shorelines of Cook Inlet.

Area 3 (Iniskin Bay): The northern boundary is 59.72 N (59° 43' N), the southern boundary is 59.45 N (59° 27' N), the western boundary is the shoreline of Cook Inlet, and the eastern boundary is 152.50 W (152° 30' W).

Area 4 (Homer): The northern boundary is 59.72 N (59° 43' N), the southern boundary is 59.45 N (59° 27' N), the western boundary is 152.50 W (152° 30' W), and the eastern boundary is 151.42 W (152° 25' W).

Area 5 (Augustine): The northern boundary is 59.45 N (59° 27' N), the southern boundary is 59.17 N (59° 10' N), the western boundary is the shoreline of Cook Inlet, and the eastern boundary is 152.50 W (152° 30' W).

Area 6 (Point Adam): The northern boundary is 59.45 N (59° 27' N), the southern boundary is 59.17 N (59° 10' N), the western boundary is 152.50 W (152° 30' W), and the eastern boundary is 151.42 W (152° 25' W).

Area 7 (McNeil): The northern boundary is 59.17 N (59° 10' N), the southern boundary is 59.02 N (59° 01' N), the western boundary is the shoreline of Cook Inlet, and the eastern boundary is 152.50 W (152° 30' W).

Area 8 (Kennedy Entrance): The northern boundary is 59.17 N (59° 10' N), the southern boundary is 59.02 N (59° 01' N), the western boundary is 152.50 W (152° 30' W), and the eastern boundary is 151.42 W (152° 25' W).

Area 9 (Cape Douglas): The northern boundary is 59.02 N (59° 01' N), the southern boundary is 58.80 N (58° 48' N), the western boundary is the shoreline of Cook Inlet, and the eastern boundary is 152.50 W (152° 30' W).

Area 10 (Barren Islands): The northern boundary is 59.02 N (59° 01' N), the southern boundary is 58.80 N (58° 48' N), the western boundary is 152.50 W (152° 30' W), and the eastern boundary is 151.58 W (151° 35' W).

Area 11 (Douglas Reef): The northern boundary is 58.80 N (58° 48' N), the southern boundary is 58.58 N (58° 35' N), the western boundary is the shoreline of Cook Inlet, and the eastern boundary is 152.50 W (152° 30' W).

Area 12 (Shuyak Island): The northern boundary is 58.80 N (58° 48' N), the southern boundary is 58.58 N (58° 35' N), the western boundary is 152.50 W (152° 30' W), and the eastern boundary is 151.58 W (151° 35' W).

Appendix 2. Summary of 1995-1998 Kachemak Bay - lower Cook Inlet halibut stomach collections by sample area (samples were not obtained from Areas 3, 5, 7, 9, and 11; see Fig. 1 and Appendix 1).

Area 1 (Ninilchik)

Total stomachs sampled: (1995) n = 10, number empty = 5 (50%), number with prey = 5 (50%); (1996) n = 52, number empty = 7 (13%), number with prey = 45 (87%); (1997) n = 53, number empty = 18 (34%), number with prey = 35 (66%); (1998) n = 70, number empty = 18, number with prey = 52.

Sample dates: (1995) 1 Jul; (1996) 1 Jun, 4 Jun, 5 Jun, 6 Jun, 8 Jun, 10 Jun, 18 Jun, 19 Jun, 20 Jun, 24 Jun, 26 Jun, 25 Jul, & 28 Jul; (1997) 12 Jun, 20 Jun, 21 Jun, 29 Jun, 2 Jul, 16 Jul, 27 Jul, & 28 Jul; (1998) 5 Jun, 8 Jun, 15 Jun, 19 Jun, 20 Jun, 22 Jun, 30 Jun, 8 Jul, 11 Jul, 19 Jul, 28 Jul, & 1 Aug.

Area 2 (Anchor Point)

Total stomachs sampled: (1995) n = 45, number empty = 10 (22%), number with prey = 35 (78%); (1996) n = 130, number empty = 29 (22%), number with prey = 101 (78%); (1997) n = 270, number empty = 67 (25%), number with prey = 203 (75%); (1998) n = 212, number empty = 45, number with prey = 167.

Sample dates: (1995) 27 May, 31 May, 28 Jun, 29 Jun, & 8 Jul; (1996) 1 Jun, 5 Jun,8 Jun, 9 Jun, 10 Jun, 11 Jun, 13 Jun, 20 Jun, 24 Jun, 27 Jun, 9 Jul, 15 Jul, 16 Jul, 21 Jul, 2 Jul, 14 Jul, 25 Jul, & 27 Jul; (1997) 5 Jun, 12 Jun, 14 Jun, 20 Jun, 21 Jun, 29 Jun, 2 Jul, 6 Jul, 8 Jul, 15 Jul, 16 Jul, 17 Jul, 19 Jul, 24 Jul, 28 Jul, 29 Jul, 2 Aug, 5 Aug, 6 Aug, 10 Aug, 17 Aug, 18 Aug, & 22 Aug; (1998) 5 Jun, 15 Jun, 20 Jun, 22 Jun, 28 Jun, 29 Jun, 30 Jun, 4 Jul, 8 Jul, 10 Jul, 11 Jul, 16 Jul, 18 Jul, 19 Jul, 25 Jul, 28 Jul, 1 Aug, & 9 Aug.

Area 4 (Homer)

Total stomachs sampled: (1995) n = 96, number empty = 41 (43%), number with prey = 55 (57%); (1996) n = 60, number empty = 11 (18%), number with prey = 49 (82%); (1997) n = 92, number empty = 42 (46%), number with prey = 50 (54%); (1998) n =153, number empty = 55, number with prey = 98.

Sample dates: (1995) 27 May, 9 Jun, 28 Jun, 7 Jul, 10 Jul, 17 Jul, 18 Jul, 12 Aug, 18 Aug, & 19 Aug; (1996) 24 Jun, 27 Jul, 19 Aug, & 20 Aug; (1997) 5 Jun, 13 Jun, 15 Jun, 14 Jul, 16 Jul, 2 Aug, 14 Aug, & 16 Aug; (1998) 17 Jun, 18 Jun, 19 Jun, 22 Jun, 23 Jun, 18 Jul, 31 Jul, & 14 Aug.

Area 6 (Point Adam)

Total stomachs sampled: (1995) n = 199, number empty = 54 (27%), number with prey = 145 (73%); (1996) n = 177, number empty = 30 (17%), number with prey = 147 (83%); (1997) n = 246, number empty = 93 (38%), number with prey = 153 (62%); (1998) n 136, number empty = 50, number with prey = 86.

Sample dates: (1995) 1 Jun, 3 Jun, 8 Jun, 14 Jun, 16 Jun, 26 Jun, 27 Jun, 8 Jul, 11 Jul, 15 Jul, 21 Jul, 23 Jul, 27 Jul, 31 Jul, 5 Aug, 6 Aug, 9 Aug, & 14 Aug; (1996) 8 Jun, 13 Jun, 14 Jun, 15 Jun, 18 Jun, 19 Jun, 26 Jun, 30 Jun, 5 Jul, 6 Jul, 8 Jul, 9 Jul, 12 Jul, 22 Jul, 23 Jul, 10 Aug, &

Appendix 2 (Continued)

Area 6 (Point Adam)

11 Aug; (1997) 26 May, 5 Jun, 6 Jun, 14 Jun, 18 Jun, 1 Jul, 7 Jul, 16 Jul, 31 Jul, 10 Aug, 18 Aug, & 23 Aug; (1998) 20 Jun, 25 Jun, 3 Jul, 7 Jul, 20 Jul, 29 Jul, 7 Aug, & 14 Aug.

Area 8 (Kennedy Entrance)

Total stomachs sampled: (1995) n = 145, number empty = 61 (42%), number with prey = 84 (58%); (1996) n = 175, number empty = 50 (29%), number with prey = 125 (71%); (1997) n = 288, number empty = 173 (60%), number with prey = 115 (40%); (1998) n =374, number empty = 164, number with prey = 210.

Sample dates: (1995) 1 Jun, 2 Jun, 10 Jun, 14 Jun, 21 Jun, 22 Jun, 3 Jul, 5 Jul, 16 Jul, 20 Jul, 24 Jul, 3 Aug, 21 Aug, 1 Sep, & 3 Sep; (1996) 21 Jun, 22 Jun, 27 Jun, 7 Jul, 8 Jul, 16 Jul, 18 Jul, 23 Jul, 7 Aug, 8 Aug, 9 Aug, 13 Aug, 14 Aug, & 18 Aug; (1997) 1 Jun, 8 Jun, 15 Jun, 20 Jun, 21 Jun, 22 Jun, 28 Jun, 4 Jul, 5 Jul, 14 Jul, 21 Jul, 21 Jul, 26 Jul, 28 Jul, 12 Aug, 16 Aug, & 27 Aug; (1998) 17 Jun, 22 Jun, 4 Jul, 6 Jul, 8 Jul, 12 Jul, 17 Jul, 19 Jul, 22 Jul, 23 Jul, 25 Jul, 27 Jul, 30 Jul, 1 Aug, 3 Aug, 4 Aug, 10 Aug, 12 Aug, 17 Aug, 19 Aug, & 21 Aug.

Area 10 (Barren Islands)

Total stomachs sampled: (1995) n = 80, number empty = 33 (41%), number with prey = 47 (59%); (1996) n = 184, number empty = 49 (27%), number with prey = 135 (73%); (1997) n = 483, number empty =258 (53%), number with prey = 225 (47%); (1998) n = 76, number empty = 42, number with prey = 34.

Sample dates: (1995) 17 Jun, 18 Jun, 23 Jun, 24 Jun, 25 Jun, 2 Jul, 26 Aug, & 30 Aug; (1996) 6 Jun, 7 Jun, 16 Jun, 21 Jun, 28 Jun, 29 Jun, 7 Jul, 14 Jul, 19 Jul, 22 Jul, 24 Jul, 26 Jul, 28 Jul, 3 3 Aug, & 8 Aug; (1997) 4 Jun, 8 Jun, 11 Jun, 15 Jun, 16 Jun, 20 Jun, 21 Jun, 26 Jun, 27 Jun, 28 Jun, 29 Jun, 7 Jul, 10 Jul, 12 Jul, 19 Jul, 27 Jul, 3 Aug, 4 Aug, 6 Aug, 7 Aug, 14 Aug, & 25 Aug; (1998) 26 Jun, 6 Jul, 9 Jul, & 10 Jul.

Area 12 (Shuyak Island)

Total stomachs sampled: (1995) n = 11, number empty = 2 (18%), number with prey = 9 (82%); (1996) n = 0, no data; (1997) n = 0, no data; (1998) n = 29, number empty = 6, number with prey = 23.

Sample dates: (1995) 20 Jun; (1996) none; (1997) none; (1998) 20 Jul & 25 Jul.