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Ecosystem Considerations for 2003

Reviewed by
The Plan Teams for the Groundfish Fisheries
of the Bering Sea, Aleutian Islands, and Gulf of Alaska

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Seabirds

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Seabirds spend the majority of their life at sea rather than on land. The group includes the albatrosses, shearwaters, and petrels (*Procellariiformes*), cormorants (*Pelecaniformes*), and two families of the *Charadriiformes*: gulls (*Laridae*), and auks, such as puffins, murres, auklets, and murrelets (*Alcidae*). Several species of sea ducks (*Merganini*) also spend much of there life in marine waters. Other bird groups contain pelagic members such as swimming shorebirds (*Phalaropodidae*), but they seldom interact with groundfish fisheries and, therefore, will not be discussed further. For detailed descriptions of seabird life histories, population biology, and foraging ecology, see section 3.5.1 of the draft Programmatic SEIS on Alaska Groundfish Fisheries (DPSEIS, NMFS 2001a).

This current section is limited to minimal background material plus new information such as: updated seabird population and diet information; maps with updated fishing effort relative to seabird colony locations, short-tailed albatross (*Phoebastria albatrus*), Laysan albatross and black-footed albatross observation locations, movement of satellite-tagged short-tailed albatross and northern fulmars (*Fulmarus glacialis*); and updated seabird bycatch estimates.

Thirty-eight species of seabirds breed in Alaska. More than 1600 colonies have been documented, ranging in size from a few pairs to 3.5 million birds (Figure 1). The U.S. Fish & Wildlife Service (USFWS) is the lead Federal agency for managing and conserving seabirds and is responsible for monitoring populations, both distribution and abundance. Breeding populations are estimated to contain 36 million individuals in the Bering Sea (BS) and 12 million individuals in the GOA (Table 1); total population size (including subadults and nonbreeders) is estimated to be approximately 30 percent higher. Five additional species occur in Alaskan waters during the summer months and contribute another 30 million birds (Table 2).

The sizes of seabird colonies and their species composition differ among geographic regions of Alaska, due to differences in marine habitats and shoreline features. In the southeastern GOA, there are about 135 colonies, and they tend to be small (<60,000 birds, and often < 5,000). These colonies are concentrated near the outer waters of southeast Alaska, or near large inland straits and fjords, such as Glacier Bay, and Icy and Sumner straits. Exceptions are two colonies with 250,000-500,000 birds at Forrester and St. Lazaria Islands (Figure 2). Along the coast of northcentral GOA, colonies are generally small but number over 850 locations, with larger colonies at the Barren and Semidi island groups. Moving west along the Alaska Peninsula (with 261 colonies) and throughout the Aleutians (144 colonies), colonies increase in size, and include several with over 1 million birds and two with over 3 million birds. Large colonies are also found on the large islands of the BS, where each may have over 3 million birds. Relatively few colonies are located along the mainland of the BS coast, and colonies along the Chukchi and Beaufort seas are small and dispersed.

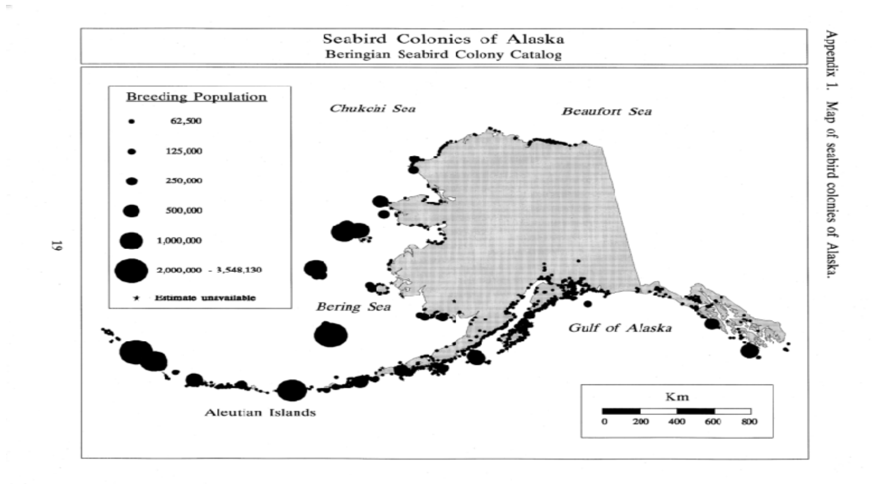


Figure 1. Seabird Colonies of Alaska. Beringian Seabird Colony Catalog, 2000. USFWS.

Table 1. Estimated populations and principal diets of seabirds that breed in the Bering Sea and Aleutian Islands and Gulf of Alaska regions.

Species	**Population** [1,2]		**Diet** [3,4]
	BSAI	**GOA**	
Northern Fulmar (*Fulmarus glacialis*)	1.500,000	600,000	Q,M,P, S,F,Z,I,C
Fork-tailed Storm-Petrel (*Oceanodroma furcata*)	4,500,000	1,200,000	Q,I,Z,C,P,F
Leach's Storm-Petrel (*Oceanodroma lucorrhoa*)	4,500,000	1,500,000	Z,Q,F,I
Double-crested Cormorant(*Phalacrocorax auritis*)5	9,000	8,000	F,I
Pelagic Cormorant (*Phalacrocorax pelagicus*)	80,000	70,000	S,C,P,H,F,I
Red-faced Cormorant (*Phalacrocorax urile*)	90,000	40,000	C,S,H,F,I
Brandt's Cormorant (*Phalacrocorax penicillatus*)	0	Rare	H,F,G,I
Pomarine Jaeger (*Stercorarius pomarinus*)	Uncommon-Rare	Uncommon	C,S,F
Parasitic Jaeger (*Stercorarius parasiticus*)	Uncommon	Uncommon	C,S,F
Long-tailed Jaeger (*Stercorarius longicaudus*)	Uncommon	Rare	C,S,F
Bonaparte's Gull (*Larus philadelphia*)	Rare	Uncommon	Z,I,F
Mew Gull (*Larus canus*) [5]	700	40,000	C,S,I,D,Z
Herring Gull (*Larus argentatus*) [5]	50	300	C,S,H,F,I,D
Glaucous-winged Gull (*Larus glaucescens*)	150,000	300,000	C,S,H,F,I,D
Glaucous Gull (*Larus hyperboreus*)[5]	30,000	2,000	C,S,H,I,D
Black-legged Kittiwake (*Rissa tridactyla*)	800,000	1,000,000	C,S,H,P,F,M,Z
Red-legged Kittiwake (*Rissa brevirostris*)	150,000	0	M,C,S,Z,P,F
Sabine's Gull (*Xema sabini*)	Uncommon	Uncommon	F,Q,Z
Arctic Tern (*Sterna paradisaea*) [5]	7,000	20,000	C,S,Z,F,H
Aleutian Tern (*Sterna aleutica*)	9,000	25,000	C,S,Z,F
Common Murre (*Uria aalge*)	3,000,000	2,000,000	C,S,H,G,F,Z

Thick-billed Murre (*Uria lomvia*)	5,000,000	200,000	C,S,P,Q,Z,M,F,I
Pigeon Guillemot (*Cepphus columba*)	100,000	100,000	S,C,F,H,P,I,G,Q
Black Guillemot (*Cepphus grylle)*	Rare	0	S,F,I
Marbled Murrelet (*Brachyramphus marmoratus*)	Uncommon	Common	C,S,H,P,F,G,Z,I
Kittlitz's Murrelet (*Brachyramphus brevirostris*)	Uncommon	Uncommon	S,C,H,Z,I,P,F
Ancient Murrelet (*Synthliboramphus antiquus*)	200,000	600,000	Z,F,C,S,P,I
Cassin's Auklet (*Ptychoramphus aleuticus*)	250,000	750,000	Z,Q,I,S,F
Least Auklet (*Aethia pusilla*)	9,000,000	50	Z
Parakeet Auklet (*Cyclorrhynchus psittacula*)	800,000	150,000	F,I,S,P,Z,C,H
Whiskered Auklet (*Aethia pygmaea*)	30,000	0	Z
Crested Auklet (*Aethia cristatella*)	3,000,000	50,000	Z,I
Rhinoceros Auklet (*Cerorhinca monocerata*)	50	200,000	C,S,H,A,F
Tufted Puffin (*Fratercula cirrhata*)	2,500,000	1,500,000	C,S,P,H,F,Q,Z,I
Horned Puffin (*Fratercula corniculata*)	500,000	1,500,000	C,S,P,H, F,Q,Z,I
Total	36,000,000	12,000,000	

Notes; 1 = Source of population data for colonial seabirds that breed in coastal colonies: modified from USFWS 1998. Estimates are minima, especially for storm-petrels, auklets, and puffins.

2 = Numerical estimates are not available for species that do not breed in coastal colonies. Approximate numbers: abundant $\geq 10^6$; common = 10^5-10^6; uncommon = 10^3-10^5; rare $\leq 10^3$.

3 = Abbreviations of diet components: M, Myctophid; P, walleye pollock; G, other gadids; C, capelin; S, sandlance; H, herring; A, Pacific saury; F, other fish; Q, squid; Z, zooplankton; I, other invertebrates; D, detritus; ?: no information for Alaska. Diet components are listed in approximate order of importance. However, diets depend on availability and usually are dominated by one or a few items (see NPFMC 2000).

4 = Sources of diet data: see species accounts in seabird section of NPFMC 2000.

5 = Species breeds both coastally and inland; population estimate is only for coastal colonies.

Table 2. Comparative population estimates and diets of nonbreeding seabirds that frequent the Bering Sea and Aleutian Islands and Gulf of Alaska regions.

Species	Population [1,2]			Diet [3,4]
	BSAI	GOA	World[5]	
Short-tailed Albatross (*Phoebastria albatrus*)	Rare	Rare	1,600	Q,F,I
Black-footed Albatross (*Phoebastria nigripes*)	Uncommon	Common	250,000	Q,M,F,I,D
Laysan Albatross (*Phoebastria immutabilis*)	Common	Common	2.5 million	Q,M,F,I
Sooty Shearwater (*Puffinus griseus*)	Common	Abundant	>30 million	M,C,S,A,Q,S,F,Z,I
Short-tailed Shearwater (*Puffinus tenuirostris*)	Abundant	Common	23 million	Z,I, C,Q, F,S
Ivory Gull (*Pagophila eburnea*)	Uncommon	0	~35,000	M,P,R,I,F,Q

1. Source of population data for colonial seabirds that breed in coastal colonies: modified from USFWS 1998. Estimates are minima, especially for storm-petrels, auklets, and puffins.
2. Numerical estimates are not available for species that do not breed in coastal colonies. Approximate numbers: abundant $\geq 10^6$, common = 10^5-10^6, uncommon = 10^3-10^5; rare $\leq 10^3$.
3. Abbreviations of diet components: M, Myctophid; P, walleye pollock; G, other gadids; C, capelin; S, sandlance; H, herring; A, Pacific saury; F, other fish; Q, squid; Z, zooplankton; I, other invertebrates; D, detritus; ?, no information for Alaska. Diet components are listed in approximate order of importance. However, diets depend on availability and are usually dominated by one or a few items (see text seabird section of NPFMC 2000).
4. Sources of diet data: see species accounts in text.
5. World population estimates are provided solely to provide a relative scale. In populations where multiple breeding colonies exist, any analysis of effects on populations must be considered at the colony level, not at the global level. These estimates provided by: Hasegawa, pers. comm.; Whittow, 1993; Whittow, 1993; C. Baduini, pers. comm.; Oka et al 1987; USFWS.
6. Species breeds both coastally and inland; population estimate is only for coastal colonies.

Seabird Demographic Trends

Population trends and reproductive success are monitored at 3 to 14 colonies per species (Figure 2). There have been considerable changes in the numbers of seabirds breeding in Alaskan colonies since the original counts made in the mid-1970s. Trends are reasonably well known for species that nest on cliffs or flat ground such as cormorants, glaucous-winged gulls, kittiwakes, murres, and tufted puffins (Table 3). Trends are known for a few small areas of the state for pigeon guillemots, murrelets, storm-petrels, and terns (Tables 3, 4). In some cases, the trend information is sparse and only covers up to the early 1990s, such as for horned puffins (Piatt and Kitaysky 2002). Trends are unknown at present for other species [jaegers, most auklets; (Byrd and Dragoo 1997, Byrd *et al.* 1998, 1999)]. Population trends differ among species. Trends in many species vary independently among areas of the state, due to differences in food webs and environmental factors.

<u>Trends in Productivity</u>
The most recent, comprehensive summary available for monitored seabird colonies is from the 2000 breeding season (Dragoo, Byrd *et al.* 2001). Overall, seabird breeding chronology in 2000 was earlier than average or unchanged (Table 5). Most species in the SE Bering Sea began nesting earlier than average. Seabirds also nested earlier on Buldir Island in the Aleutians, and sites in the GOA and Southeast Alaska. The one exception was the black-legged kittiwake colony on Middleton Island. This is in sharp contrast to the 1999 season (Dragoo, Byrd *et al.* 2000), when most colonies began nesting later or were unchanged compared to the averages for previous years.

Seabird productivity was generally better than average or equal throughout Alaska in 2000 (Table 6). Exceptions were the murres at Kasatochi Island in the central Aleutians, where both murre species had lower than average productivity. Nearly all piscivorous seabirds had better productivity than past years, whereas the more planktivorous species tended to show no change from previous year's performances (Dragoo, Byrd *et al.* 2001). For the piscivorous birds at least, the higher productivity in 2000 was nearly opposite their relative performance in 1999, when most piscivorous birds had lower than average productivity (Dragoo, Byrd *et al.* 2000). Again, the planktivorous birds showed little change between 1999 and 2000 trends. The 'earlier' nesting in 2000 by many seabirds in various locations of Alaska, might be indicative of a large-scale oceanographic condition resulting in changes in the prey base. Presumably because of favorable oceanograhic effects on the seabirds' prey, 'early' nesting is often associated with cooler water temperatures and higher breeding success (Ainley and Boekelheide 1990). In 2000, there were reports of capelin in the GOA (D. Roseneau, USFWS, Homer, AK), and capelin appeared to be abundant in Prince William Sound in 2001 (K. Kuletz, pers. comm.). Capelin are a high-lipid fish (Anthony, Roby *et al.* 2000, Roby, Jodice *et al.* 2000), and availability of high-lipid prey is often associated with good productivity in seabirds. High lipid and high energetic content is critical to chick growth and fledging mass (Harris and Hislop 1978), and several studies in the GOA have demonstrated the importance of high-lipid fish to seabird growth rates, reproductive success, and population trends (Anthony and Roby 1997, Golet 1998, Piatt, Abookire *et al.* 1998, Roby, Turco *et al.* 1998, Golet, Kuletz *et al.* 2000, Suryan, Irons *et al.* 2000, 2002). The generally higher productivity (compared to previous years at the same site) of piscivorous birds in particular, suggest that availability of forage fish was improved in 2000. Reproductive success of seabirds also depends on synchronization of breeding with prey availability (Gaston and Nettleship 1981, Furness and Monaghan 1987, Ainley and Boekelheide 1990), although the mechanisms responsible for synchronization are unclear.

Figure 2. Location of seabird colony sites in Alaska monitored by the U.S. Fish and Wildlife Service and the USGS Biological Research Division. Some sites are monitored annually (circles), while others are monitored on three-year rotation (triangles).

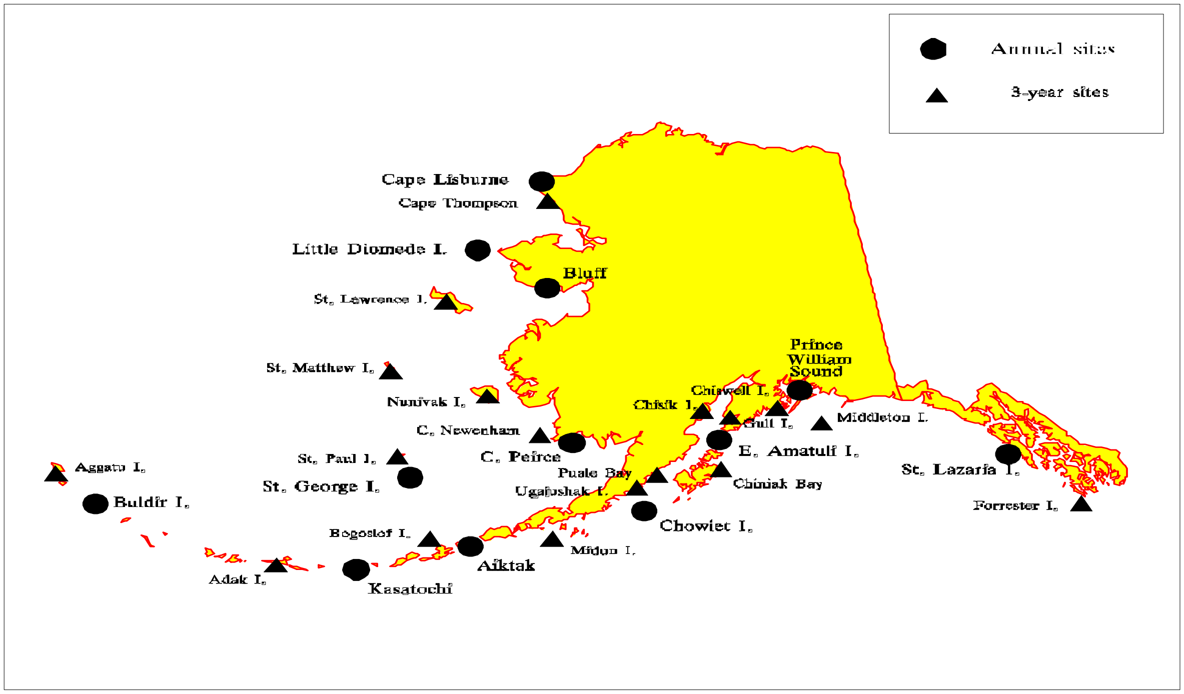


Table 3. Seabird population trends compared within regions[a]. Only sites which were counted in 2000 are included.
This table is printed with permission of the Alaska Maritime National Wildlife Refuge, from their report: Breeding Status and Population Trends of Seabirds in Alaska in 2000.

Region	*Site*	*STPE*	*PECO*	*UNCO*	*GWGU*	*BLKI*	*RLKI*	*COMU*	*UNMU*	*LEAU*	*CRAU*	*RHAU*	*TUPU*
N. Bering/ Chukchi	*Bluff*					+		+					
SE Bering	C. Peirce		=			–		–					
	Bogoslof I.												+
	Aiktak I.	+			=				=				+
SW Bering	Kasatochi I.			=	=					=	=		
	Koniuji I.						=						
Gulf of Alaska	Chiniak Bay					+							
	Gull I.		–			+		+					
	P. William Snd					+							
	Middleton I.		–			–			–				
Southeast	St. Lazaria I.	+	+		=				–			=	

[a]Codes:
"–" indicates negative population trend for this site or region,
"=" indicates no discernable trend
"+" indicates positive population trend for this site or region.
Species' codes: FTSP = fork-tailed storm petrel; LHSP = Leach's storm petrel; RFCO = red-faced cormorant; PECO = pelagic cormorant; GWGU = glaucous-winged gull; BLKI = black-legged kittiwake; RLKI = red-legged kittiwake; COMU = common murre; TBMU = thick-billed murre; PAAU = parakeet auklet; LEAU = least auklet; WHAU = whiskered auklet; CRAU = crested auklet; RHAU = rhinoceros auklet; TUPU = tufted puffin.

Table 4. Population trends of seabirds that nest non-colonially or in small, dispersed colonies, for areas where trend data is available. Trends ('-',decreasing; '0' no clear trend; '+', increasing) incorporate surveys in the early 1990s to 2000-2002. (Data from Shawn Stephensen or Kathy Kuletz, USFWS, Anchorage, and John Piatt, USGS/BRD, Anchorage, unpublished data).

Site	Arctic Tern & Aleutian Tern	Pigeon Guillemot	Marbled Murrelet	Kittlitz's Murrelet
Prince William Sound	-	-	-	-
eastern Kodiak Island	-	0	?	?
Kenai Fjords	?	?	-	-
Malaspina / Icy Bay	0	0	-	-
Glacier Bay, SEAK	+	0	-	-

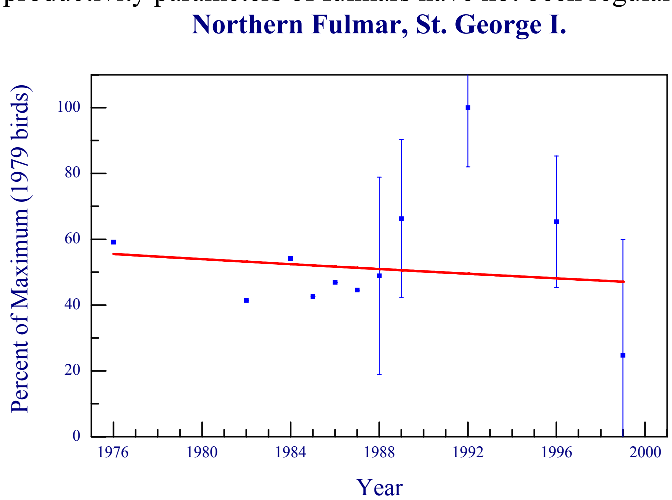
Population Trends

Population trends (Table 3) were more mixed among birds and sites than were the productivity trends. Although population trends are affected by changes in seabird productivity (see review NPFMC 2000), seabirds are long-lived, and changes in the sub-adult and adult population would not be expected on an annual basis (Russell 1999). As of the 2000 censuses, 12 populations (species-site combinations) showed an increase from previous averages, 7 showed no change and 8 showed decreases. Black-legged kittiwakes increased at most sites in the GOA, although the Middleton Island colony continued to decline. Red-legged kittiwakes continued to decline at Koniuji Island, as they had at the Pribilofs in 1999 (Dragoo, Byrd *et al.* 2000). Tufted puffins and storm petrels were more abundant than average in the southeast Bering Sea, but kittiwakes and murres declined.

Between the 1980s and 2002, several nearshore-feeding seabirds have shown declines in coastal breeding areas (Table 4). These species are usually monitored by their numbers at-sea, because it is difficult to monitor their small, dispersed colonies (guillemots), or their colonies are impermanent (terns), or they do not nest in colonies (murrelets). Data are available for Prince William Sound (Stephensen et al. 2001), Glacier Bay (Robards, Drew *et al.* 2002), Kodiak Island (Stephensen, Zwiefelhofer *et al.* 2001), Kenai Fjords (data on terns and guillmots still pending), and the Malaspina Forelands/Icy Bay (USFWS, Anchorage, unpubl. data). During this period, arctic terns have declined by 60% in Prince William Sound and eastern Kodiak Island, but have increased in Glacier Bay. Pigeon guillemots have declined by 55% in Prince William Sound and 20% in Glacier Bay (although this decline was not statistically significant), but have remained relatively stable in Kodiak Island and Icy Bay. Marbled and Kittlitz's murrelets combined have declined by 55% in Prince William Sound and about 60% in Glacier Bay, with similar declines along the Malaspina Forelands and the Kenai Fjords. The apparent declines in many areas for some nearshore seabirds may be indicative of widespread changes in the nearshore prey base or other aspects of nearshore waters.

Northern fulmar populations. – Population trends of northern fulmars are of particular interest because fulmars comprise the largest proportion of seabird bycatch in the BSAI and GOA groundfish fisheries, and they are the only procellarid ('tubenose' family) with high bycatch rates that also breeds in Alaska. Over 95% of northern fulmars in Alaska nest at four locations: the Semidi Islands (monitored at Chowiet Island) in the GOA has an estimated 440,000 birds, Chagulak Island in the Aleutians with 500,000 birds, the Pribilofs (monitored at St. George Island) in the central BS with 80,000 birds, and St. Matthew/Hall Islands in the northern BS with 450,000 birds (Hatch and Nettleship 1998).

In the Pribilof Islands (Figure 3), the smaller population on St. Paul Island shows an increase in numbers of fulmars since 1990, although data is only available to 1996. On nearby St. George Island, fulmar numbers have been more erratic, with an unusually high number in 1992, and sharply decreasing numbers between 1992 and 1999. (The Pribilofs are being censused by Alaska Maritime National Wildlife Refuge biologists in 2002, but because the breeding season continues through September, results are not ready for this draft report). On Chowiet Island in the Semidi Island group (Figure 4), the study plots monitored by S. Hatch (U.S. Geologic Survey/Biological Resources Division, USGS/BRD, Anchorage, unpublished data) indicate that fulmar numbers remained relatively steady prior to a spike between 1993 - 1995, followed by a steep decline in 1998 and 2001. No trend data exist for the fulmar colonies at St. Matthew/Hall or Chagulak Islands. Data on reproductive success of fulmars is difficult to obtain and productivity parameters of fulmars have not been regularly monitored at any site in Alaska.



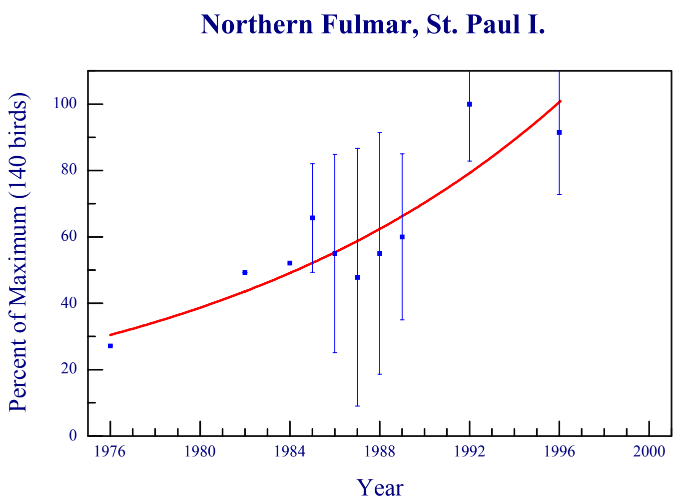


Fig. 3. Population trends of northern fulmars in the Pribilof Islands, based on plot counts on St. George I., 1976 - 1999 (Top) and St. Paul I., 1976 - 1996 (Bottom). Percent of Maximum is based on the number of birds on the study plots only. The majority of the estimated 80,000 fulmars on the Pribilof Islands nest on St. George I. (Data reprinted with permission from Dragoo et al. 2000).

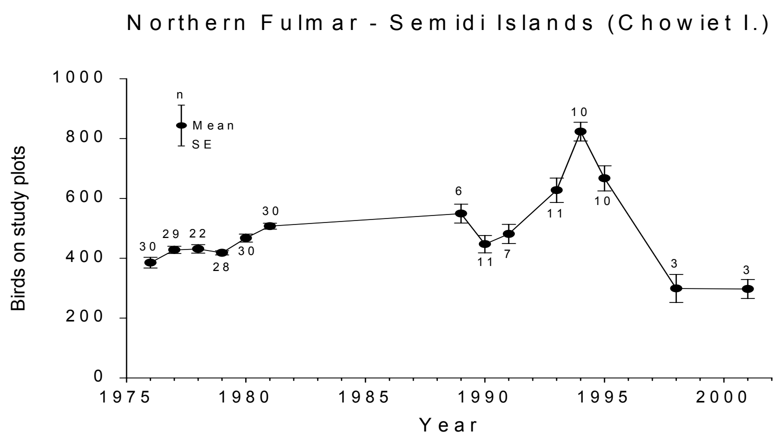


Figure 4. Population trends of northern fulmar on Chowiet Island, based on plot counts taken during summer, 1975 - 2001. (Unpublished data and graphic provided by Scott Hatch, USGS/BRD, Anchorage).

The breeding populations of fulmars in Alaska are fairly well localized and their main colonies are distributed over a large geographic area. For this reason, the fulmar colonies might experience different impacts from environmental as well as fishery-related influences. Fulmars may benefit by obtaining food during fishery operations, but the effects of bycatch mortality might offset such potential gains. To assist in building population models to examine trends and the effects of mortality or food supplementation, affected populations need to be identified and monitored. An effort to identify the colony of origin for fulmars caught in BSAI and GOA groundfish fisheries was begun in 2001 and continues in 2002, through a USFWS funding initiative to the USGS/BRD, in cooperation with the NMFS North Pacific Groundfish Observer Program (see Research Initiatives, below). This project will use genetic markers to compare bycaught fulmars with those at specific colonies. Additional information could be obtained by insuring that observers record the color phase of bycaught fulmars, which range from light to dark in plumage. Light-phase fulmars nest at the large colonies in the central and north Bering Sea, whereas dark-phase fulmars predominate along the Aleutians and in the Semidis (Hatch and Nettleship 1998).

Seabird Diets and Biomass Consumption

A review of seabird foraging ecology, historical records of seabird diet in Alaska, and evidence of impacts on seabirds from changes in their prey base, were provided in NMFS 2001a. Dragoo, Byrd *et al.* (2001) has summarized seabird diets by location, species, and age-class, for those colony sites and species monitored by the U.S. Fish and Wildlife Service. Here, we provide a broad, geographically oriented synthesis of the use of fishes (omitting most invertebrates) during the breeding season from the late 1990s to 2000, which can be examined in detail in the Dragoo, Byrd *et al.* 2001 report. We give a brief review of the prey species most commonly used by seabirds in Alaska. We also provide a review of the estimated biomass consumed by seabirds in Alaska, taken from Hunt, Kato *et al.* 2000, with suggested implications to ecosystem management.

Seabird prey species. – Seabird diets consist mainly of fish or squid less than 15 cm long, large zooplankton, or a combination of both. The fish and invertebrates taken by seabirds varies by season, location and bird species, and can vary between adults and juveniles of the same species in the same location. Most of our information on seabird diet has been obtained during the breeding season, often from the prey that adults bring to their chicks.

Seabirds use the juvenile age-classes (age-class 0-1) of a variety of commercial fish, including Pacific herring (*Clupea pallasi*), walleye pollock (*Theragra chalcogramma*), Pacific tomcod *(Microgadus proximus*), salmon (*Oncorhynchus* spp.), rockfish (*Sebastes* spp.), lingcod (*Ophiodon elongatus*), smelts (Osmeridae spp.), and flatfish (Pleuronectiformes spp.). Squid are also a favored prey of many seabird species. Bottom-feeding birds such as scoters, cormorants, and guillemots may also consume juvenile stages of commercial shrimp and crab species. Non-commercial forage fish include juveniles and adults of Pacific sand lance (*Ammodytes hexapterus*), capelin *(Mallotus villosus*) Pacific sandfish (*Trichodon trichodon*), greenlings (Hexagrammidae spp.), and several species of lanternfish, or myctophids (Myctophidae spp). Birds that feed near the coast and near the sea floor may also take sculpins, blennies, octopus, molluscs and small crustacea.

Most of the fish used by seabirds are caught in shallow waters (< 100 m; usually < 50 m) or in the upper portions of the water column. Deep-water fish like the myctophids are usually taken at night, when they make their vertical migration to surface waters. Fish that in general have high energetic value to seabirds include the myctophids, herring, sand lance, and capelin, whereas the fish with lower energetic value include pollock and most other bottom-dwelling fish (Anthony, Roby *et al.* 2000, Roby, Jodice *et al.* 2000).

Seabird diet at monitored sites. – In the northern-most colonies bordering the Chukchi Sea, birds at Cape Lisburne were feeding primarily on gadids, most likely pollock. Thick-billed murres, common murres, and black-legged kittiwakes also took sand lance, capelin, herring, and squid. In the central Bering Sea, at the St. Matthew/Hall islands, northern fulmars were taking primarily pollock, or other gadids (S. Hatch, USGS, Anchorage, pers. comm.). Birds at the Pribilofs took a wide variety of fish, squid, and smaller invertebrates. The most frequently used fish at the Pribilofs were myctophids, which comprised the primary prey for northern fulmars and red-legged kittiwakes, but were also prominent in the diet of black-legged kittiwakes. Pollock were also taken frequently in the Pribilofs, and they were the primary prey for black-legged kittiwakes and common murres. Northern fulmars also took sand lance, and black-legged kittiwakes included sand lance and greenling in their diet. The thick-billed murres in this region relied solely on squid and euphausiids, although between 1975 and 1985, pollock had been an important part of their diet as well (Dragoo, Byrd *et al.* 2001).

Myctophid fish were also the primary prey for most seabirds in the western Aleutians, at the Buldir Island colonies. These fatty fish were the main food item for fork-tailed storm petrels, red-legged kittiwakes and black-legged kittiwakes. These birds also consumed euphausiids and greenling. Squid was the main prey for both common and thick-billed murres, with the common murre also taking pollock and herring and the thick-billed murre taking some myctophids. The Leach's storm petrel also used myctophids, but relied more on euphausiids and other large plankton.

In the central Aleutians, at Koniuji Island, black-legged kittiwakes fed on myctophids. Further east, on Aiktak Island, thick-billed murres fed primarily on pollock, and glacous-winged gulls took primarily herring, but both species also utilized sand lance. To the east, in the Semidi islands, three species of seabirds, rhinocerous auklets, common murres, and northern fulmars, used sand lance as the primary prey (fulmar data from S. Hatch, USGS). Secondary prey for murres was pollock, and capelin was also used by murres and fulmars. In the northern GOA, on the Barren Islands, capelin was in all diets, and was the main prey for common murres. Black-legged kittiwakes took mainly sand lance and tufted puffins took mainly pollock.

In Prince William Sound, black-legged kittiwakes took a variety of prey over the years, including sand lance, herring, salmon, capelin, and some pollock. These same fish were also taken by other birds in the area, including marbled and Kittlitz's murrelets, tufted and horned puffins, glaucous-winged gulls and arctic terns (Kuletz, pers. obs.). In Southeast Alaska, on St. Lazaria Island, myctophids were the main prey of fork-tailed storm petrels and Leach's storm petrels.

To summarize the regional breakdown of seabird diet since the late 1990s, and based on a limited number of sample sites and seabird species, most of the more frequently used forage fish species appeared througout Alaska waters, although some patterns emerge. In the Chukchi and north-central Bering Sea, pollock predominated, and in the western and northern GOA, pollock was present, but usually secondary to other species. Pollock were rare in Prince William Sound and absent at St. Lazaria Island. Myctophids predominated in the Pribilofs and the western and central Aleutians, and on St. Lazaria, but were absent from western and northern GOA. Sand lance was found from the Pribilofs to the eastern Aleutians and along the northern GOA to Prince William Sound. The use of capelin was more restricted, and appeared in seabird diets from the Semidi Islands and Shelikof Strait up to Prince William Sound. Herring comprised small proportions of overall diet in the Aleutians, and was common in Prince William Sound, but elsewhere it was not observed in seabird diets. However, herring are an important food for the same species of seabirds in British Columbia (Vermeer, Sealy *et al.* 1987, Vermeer and Ydenberg 1989), are therefore probably used by seabirds in Southeast Alaska. The storm petrels that are monitored at St. Lazaria would not be good indicators of the availabiltiy or use of herring, since they feed primarily on myctophids and large plankton (Dragoo, Byrd *et al.* 2001).

Biomass consumption by seabirds. – Estimates of the biomass consumed by seabirds have been made for certain areas and specific groups of birds, and the results were reviewed and summarized in Hunt, Kato *et al.*(2000). Using these results, and extrapolating from what was estimated for bird abundance and known about marine bird energy requirements, Hunt, Kato *et al.* (2000) modeled the biomass taken by seabirds in the North Pacific during summer (92 days, June - August/September, depending on species). The Hunt, Kato *et al.* report also provides regional summaries of seabird abundance and diet (including pre-1990s data), and estimates of metric tons of prey consumed by selected seabird species within each region. For our purposes, we summarized total prey consumption for four of the eight sub-regions defined in their model (Table 7a). Three of the sub-regions correspond to waters within the Alaska fishing regions (the Bering Sea Continental Shelf, the GOA Continental Shelf, and the Eastern Subarctic), and a large portion of the fourth overlaps with Alaskan waters (the Bering Sea Pelagic). The latter, however, also includes the western BS and shelf regions, which do not directly pertain to Alaska fisheries.

Among the four sub-regions defined by the PICES report (Hunt, Kato *et* al. 2000), we focus on the eastern BS and GOA shelf regions. The former has the greatest number of birds, but the latter, with its smaller surface area, has the highest biomass of birds, and the highest daily energy consumption (Table 7a). The Eastern Subarctic, which includes waters between the GOA shelf break and the Eastern Tropical Zone, has a relatively low biomass of birds and very low daily energy consumption. The Bering Sea Pelagic has fairly high daily energy consuption rates, but includes waters beyond the EEZ.

The PICES model examined prey consumption in two ways, total metric tons consumed (mt), and as metric tons consumed per square kilometer (mt/km$^{2)}$. Because the energy density of prey can affect the amount of fish that seabirds will need to survive and reproduce, the model also derived the estimates using two assumptions, being that, either all prey were high energy density fish (7 kj/g; such as myctophids or herring) or all prey were of low energy density (3 kj/g; such as cod or pollock). The results (Table 7a), indicate that total prey consumption in the Eastern BS could range from 656,000 mt (with high energy fish) to 1,530,000 mt (with low energy fish), and in the GOA shelf, could range from 316,000 mt to 738,000 mt. Prey consumption per km^2 was actually higher in the GOA. Partly because low energy fish such as pollock are more commonly taken by seabirds in the BS, the total mt of low energy fish consumed in the Eastern BS was nearly 50x greater than the amount taken in the GOA shelf waters. Medium energy density fish, such as capelin and sand lance, were taken in roughly equal amounts between the two regions, and comprised the bulk of prey taken by birds in the GOA. High energy fish, such as myctophids, had greater consumption in the Eastern BS, but in either region the total biomass was dwarfed by low and medium energy density fish.

Zooplankton and other invertebrates comprised a slightly greater proportion of seabird diet in the Eastern BS than in the GOA, and as a result, fish accounted for 47 % of the total biomass consumed by birds in the former, and 51% in the latter. The importance to seabirds of zooplankton, cephalopods and other invertebrates (Hunt, Kato, *et al.* 2000), highlights the need to better understand the physical and biological factors that may control abundance and availability of these prey as well.

Implications of seabird diet to ecosystem management. – The PICES model relied on many generalizations and assumptions, and its authors acknowledge that the parameters and values will need to be changed as new infomation is obtained. Nonetheless, it provides a quantitative starting point by which to integrate seabirds into ecosystem mangement. The model also provides for continued fine-tuning of prey requirements by using sub-regions in the analyses, which could be updated with changes in the diet of seabirds or their population trends, by species or region. A cautionary factor, however, is that the estimate of prey consumption indicates a minimum amount required by birds during the breeding season, but it does not estimate the biomass of fish needed for efficient food-finding and capture of prey, which likely requires a much greater biomass (Hunt, Mehlum *et al.* 1999). As stated earlier (NMFS 2001a), we need a better understanding of the factors limiting seabird prey availability. Further, the model does not attempt to incorporate the seasonal changes that are known to occur in prey use, energy density of fish, or in the bird's energetic requirements (Hunt, Kato *et al.* 2000).

Pollock appear to be an important and widespread prey for seabirds, despite their low energy denstiy, and are likely the most abundant or most available prey for seabirds during the breeding season in the BS. Pollock were used by seabirds throughout the BSAI and GOA, although for most seabirds they were the primary prey only in the Chukchi Sea and at the large islands of the BS. (Exceptions were the tufted puffins and murres, which used pollock in the GOA). The cannibalism of juvenile pollock by adult pollock has been hypothesized as a regulating factor in pollock abundance. Additionally, adult pollock eat other species of small forage fish used by seabirds. Hunt and Stabeno (2002) suggested that the negative correlation between adult pollock biomass in the eastern BS and reproductive success of black-legged kittiwakes in the Pribilofs is evidence of indirect effects of abundant adult pollock consuming and thus reducing availability of forage fish to seabirds. This suggests that seabird productivity could be affected by fishery management decisions, and that the indirect effect of pollock harvest on seabirds could be incorporated into ecosystem-based models.

The general survey of diet data available in Dragoo, Byrd *et al.*(2001) suggests other areas where research efforts or management considerations could focus. For example, capelin and sand lance are important prey for the birds in the northern GOA, but little is known about the fishes' spawning grounds, or to what degree those areas overlap with the relatively nearshore bottom trawling in that region. Fishing activities can also directly interfere with foraging of seabirds. For example, myctophids are an important prey for many birds in the southern BS and Aleutian islands, and for petrels in southeast Alaska. Because birds likely feed on these deep water fish at night when myctophids migrate to surface waters, interference with seabird foraging would most likely occur in these regions, especially when bright lights are used by fishing vessels. Incidents of vessel strikes may be one indication of such interference (see 'Vessel Strikes', below).

Seabirds Interfacing with Fisheries

For detailed descriptions of ecological interactions affecting seabirds and factors that influence the availability of food to seabirds, see the seabird section in the "Ecosystem Considerations in 2001" appendix (NPFMC 2000) and section 3.5.2 in the DPSEIS, respectively (NMFS 2001a).

Seabird Colony Distribution and Groundfish Fisheries

A major constraint on breeding for seabirds is the distance between the breeding grounds on land and the feeding zones at sea (Weimerskirch and Cherel 1998). Seabirds must have access to prey within efficient foraging range of the breeding colony in order to raise their chicks successfully (Piatt and Roseneau 1998, Suryan, Irons *et al.* 1998a, Suryan, Irons *et al.* 2000, Golet, Kuletz *et al.* 2000). If food supplies are reduced below the amount needed to generate and incubate eggs, or the specific species and size of prey needed to feed chicks is unavailable, local reproduction by seabirds will fail (Hunt et al. 1996, Croxall and Rothery 1991).

Most of the groundfish fisheries have occurred between September and April (Appendix E, NMFS 2001a), and do not overlap temporally with the main seabird breeding period that occurs from May through August (DeGange and Sanger 1987, Hatch and Hatch1990, Dragoo, Byrd *et al.* 2000, 2001). However, some species, such as larids, pigeon guillemots, and murrelets, may arrive at breeding sites in April, and others, including fulmars, puffins, and murres, are still rearing young in September. Among the 'latest' breeding species are the fulmars, which have a long incubation and chick-rearing periods and generally fledge chicks in September or early October. Both fork-tailed and Leach's storm-petrels do not fledge young until October (DeGange and Sanger 1987, Hatch and Hatch 1990, Dragoo, Byrd *et al.* 2000). Seabird attachment to the colony is thus most likely to overlap with fisheries effort during the early (pre and early egg-laying) and during the late (late chick-rearing and fledging) portion of their breeding season. Juvenile birds, generally on their own and not experienced foragers, would also be most abundant at sea during the fall fisheries. Fishery seasons have shifted and could do so in the future. For example, since 2000, the Pacific cod longline fishery in the BSAI has begun in August, and in the GOA, a large portion of the catcher-vessel trawl pollock fishery occurs in June and September (Appendix E, NMFS 2001b).

Indirect effects of groundfish fisheries might affect prey availability around seabird colonies even though they do not overlap with the seabird's breeding season. These potential effects include boat disturbance, alteration of predator-prey relations among fish species, habitat disturbance, or direct take of fish species whose juveniles are consumed by seabirds (see seabird section in Ecosystem Considerations chapter, NPFMC 2000, for review). Competition for prey may also be involved, as suggested by the negative relationship between age-3+ pollock biomass in the eastern Bering Sea and the reproductive success of black-legged kittiwakes in the Pribilof Islands (Livingston, Low *et al.* 1999, Hunt and Stabeno 2002). The interpretation of this relationship is that adult pollock consume the small fish (mainly, age-1 pollock and adult capelin) required by kittiwakes to successfully raise young (Hunt and Stabeno 2002). Thus, higher catch levels of some top-level species such as pollock might indirectly benefit piscivorous birds. This scenario is complicated, however, by the effects of warm vs cold-water regimes, which can directly affect some forage species such as capelin, and indirectly drive the system by altering top-down or bottom-up regulatory processes (Hunt, Stabeno *et al.* 2002). Additionally, the benefit of reducing the biomass of key predators such as pollock might be lost if populations of other large predatory fish increase due to reduced competition with pollock (Hunt and Stabeno 2002).

If seabirds are in competition with other upper-trophic level consumers, it suggests that the seabirds might, at a local scale, also impact fish populations. Overall consumption of fish biomass by seabirds is generally low, estimated at < 4 % (Livingston 1993), however, seabirds may impact fish stocks within foraging range of seabird colonies during summer (Springer, Roseneau *et al.* 1986, Birt, Birt *et al.* 1987). Fifteen to eighty percent of the biomass of juvenile forage fish may be removed by birds each year near breeding colonies (Wiens and Scott 1975, Furness 1978, Springer, Roseneau *et al.* 1986, Logerwell and Hargreaves 1997). Consequently, seabirds may therefore be vulnerable to factors that reduce forage fish stocks in the vicinity of colonies (Monaghan, Walton *et al.* 1994).

To examine the overlap between fisheries effort and seabird colonies, we combined seabird colony data from the Alaska Seabird Colony Database (S. Stephensen, USFWS, Anchorage, AK) with coverage of fisheries effort (NPFMC, Anchorage, AK). The maps illustrate areas of overlap between seabirds and fisheries both in terms of potential risk of seabird bycatch, and potential for indirect interactions with the seabird's prey base. These interactions are primarily relevant during the seabird's breeding season, which for most species extends from late April through September, but varies by region and species, and may not always intersect with fishery effort in every region.

For the colony maps, we included only piscivorous seabird species (Table 7b), since those species include the groups most susceptible to bycatch, and their prey base may be more subject to influence from the fisheries. Although the fisheries data is current (between 1998-2001), the colony data has been collected since the 1970's, and many of the smaller colonies, in particular, have not recently been surveyed. Colony sizes, therefore, may not be current, although the order of magnitude and distribution of the colonies should be reliable. Larger colonies and regularly monitored sites (Figure 2) include current data.

Table 5. Seabird relative breeding chronology compared to averages for past years within regions[a]. Only sites for which there were data from 2000 are included. This table is printed with permission of the Alaska Maritime National Wildlife Refuge, from their report: Breeding Status and Population Trends of Seabirds in Alaska in 2000.

Region	Site	FTSP	LHSP	PECO	GWGU	BLKI	RLKI	COMU	TBMU	PAAU	LEAU	WHAU	CRAU	RHAU	TUPU
SE Bering	St. Paul I.					–	–	–	=						
	St. George I.					–	–	–	=						
	C. Peirce			=		–		–							
	Aiktak I.	–	=		–										–
SW Bering	Buldir I.					–	=	–	=	–	=	–	=		
	Kasatochi I.										=		=		
	Bogoslof I.						+								
Gulf of Alaska	Gull I.					–		–							
	Chisik/Duck I.					=		–							
	Middleton I.			–	–	+								–	–
Southeast	St. Lazaria I.	–	–		=			=	=						

[a] Codes:
"–" indicates hatching chronology was > 3 days earlier than average for this site or region,
"=" indicates within 3 days of average
"+" indicates hatching chronology was > 3 days later than average for this site or region.

Species' codes: FTSP = fork-tailed storm petrel; LHSP = Leach's storm petrel; RFCO = red-faced cormorant; PECO = pelagic cormorant; GWGU = glaucous-winged gull; BLKI = black-legged kittiwake; RLKI = red-legged kittiwake; COMU = common murre; TBMU = thick-billed murre; PAAU = parakeet auklet; LEAU = least auklet; WHAU = whiskered auklet; CRAU = crested auklet; RHAU = rhinoceros auklet; TUPU = tufted puffin.

Table 6. Seabird relative productivity levels compared to averages for past years within regions[a]. Only sites for which there were data from 2000 are included. This table is printed with permission of the Alaska Maritime National Wildlife Refuge, from their report: Breeding Status and Population Trends of Seabirds in Alaska in 2000.

Region	Site	FTSP	LHSP	RFCO	PECO	GWGU	BLKI	RLKI	COMU	TBMU	PAAU	LEAU	WHAU	CRAU	RHAU	TUPU
N. Bering/ Chukchi	C. Lisburne						=									
	Bluff						+									
SE Bering	St. Paul I.			+			+	+	=	=						
	St. George I.			=			+	+	=	=						
	C. Peirce				=		+		=							
	Bogoslof I.			=	=	=	+	=	+	+						=
	Aiktak/ Ugamak Is.	=	=	=	+	=			+	+						+
SW Bering	Buldir I.						+	=		=	=	=	=	=		
	Ulak I.	=		+	+											
	Kasatochi I.			+	+				–	–		=		=		
	Koniuji I.						=									
Gulf of Alaska	Chiniak Bay						=									
	Gull I.						+		+							
	Duck I.						=		0							
	Pr. Will. Snd.						=									
	Middleton I.				+	+	=								=	=
Southeast	St. Lazaria I.	=	=		+	=			=	=						

[a] Codes: "–" indicates productivity was > 20% below average for this site or region,
"=" indicates within 20% of average
"+" indicates productivity was > 20% above average for this site or region.

Table 7a. Seabird abundance, biomass, and prey consumption in Alaskan waters during 92 summer days (June - August), as estimated in PICES Scientific Report No. 14 (Hunt, Kato *et al.* 2000). Note that the Bering Sea Pelagic sub-region includes the western Bering Sea and shelf along Russia. Na = not available.

Sub-region	**Eastern Bering Sea/ Continental Shelf**	**GOA / Continental Shelf**	**Eastern Subarctic**	**Bering Sea Pelagic (Russia/ Aleutians)**
Number of bird species	37	38	24-30	45
Individuals (No. Of birds)	34,690,000	16,140,000	7,905,000	22,325,000
Density (individual birds km^{-2})	34	38	2	16
Biomass ($kg \bullet km^{-2}$)	18.6	21.5	0.8	7.0
Daily Energy Consumption ($kj \bullet km^{-2} \bullet d^{-1}$)x 10^3	48.8	56.2	2.1	18.7
Assuming all prey with Energy Density of $7 kj \bullet g^{-1}$ Total Prey Consumption (x 1,000 mt)	656	316	99	333
Prey Consumption $mt \bullet km^{-2}$	0.64	0.74	0.03	0.25
Assuming all prey with Energy Density of 3 $kj \bullet g^{-1}$ Total Prey Consumption (x 1,000 mt)	1,530	738	230	777
Prey Consumption $mt \bullet km^{-2}$	1.50	1.72	0.06	0.57
Total Metric tons consumed Low energy density fish	251,053	5,128	na	466
Medium energy density fish	260,920	246,873	na	6,609
High energy density fish	12,094	78	na	12
With all fish & all other food sources	1,109,409	494,046	na	219,334

Table7b List of Piscivorous Seabird Species or Species Groups included in the Piscivorous Seabird Colony Maps (see Figures 3 and 4).

Species Code	Piscivorous Species or Species Group
NOFU	Northern Fulmar (Fulmarus glacialis)
HEGU	Herring Gull (Larus argentatus)
GWGU	Glaucous_winged Gull (Larus glaucescens)
GHGU	Glaucous_winged/Herring Gull hybrid (Larus spp.)
GLGU	Glaucous Gull (Larus hyperboreus)
GGGU	Glaucous_winged/Glaucous gull hybrid (Larus spp.)
MEGU	Mew Gull (Larus canus)
BLKI	Black_legged Kittiwake (Rissa tridactyla)
RLKI	Red_legged Kittiwake (Rissa brevirostris)
UNGU	Unidentified Gull (Larus spp.)
COTE	Common Tern (Sterna hirundo)
ARTE	Arctic Tern (Sterna paradisaea)
ALTE	Aleutian Tern (Sterna aleutica)
UNTE	Unidentified Tern (Sterna spp.)
BLGU	Black Guillemot (Cepphus grylle)
PIGU	Pigeon Guillemot (Cepphus columba)
UNIG	Unidentified Guillemot (Cepphus spp.)
MAMU	Marbled Murrelet (Branchyrampus brevirostris)
ANMU	Ancient Murrelet (Synthilboramphus antiquus)
PAAU	Parakeet Auklet (Aethia psittacula)
RHAU	Rhinoceros Auklet (Cerorhinca monocerata)
TUPU	Tufted Puffin (Fratercula cirrhata)
HOPU	Horned Puffin (Fratercula corniculata)
UNPU	Unidentified Puffin (Fratercula spp.)
TOCO	Total Cormorant (all cormorant species combined)
TOMU	Total Murre (all murre species combined)

Piscivorous Seabird Colonies and Trawl Effort. – In the GOA, seabird colonies are generally small, but are numerous and dispersed along most of the coastline. The main areas of overlap with the trawl fisheries include the east side of the Kodiak Archipelago, and to a lesser extent, the Semidi Islands and Shumagin Islands (Figure 5). Those birds that primarily forage near their colonies, such as cormorants, pigeon guillemots, terns, small larids, and the non-colonial marbled and Kittlitz's murrelets, might be the species most influenced by fisheries in these immediate areas by disturbance or indirect interactions with the prey. Interaction with these 'near shore' foraging species would be most direct during the limited June trawl fishery. Because this fishery extends to the shelf edge, birds from these colonies that may forage >40 km from their colonies, such as fulmars and larger gulls and alcids, have potential for greater interaction and bycatch in these offshore waters. Alcids are, in fact, one of the seabird groups most frequently taken as bycatch in trawl fisheries (see section here, "Bycatch of Seabirds in Fishing Gear"), and trawl fisheries account for most alcid bycatch. Because murres and puffins (the large alcids in this area) are often still raising chicks in September, they would also have the greatest temporal overlap with those fisheries occurring in September. Fulmars nesting on Chowiet Island in the Semidis could likewise interact with trawl fisheries in this region and north along Kodiak and the shelf edge, during both the June and September-October fishery.

In the BSAI, trawl effort is concentrated between Unimak Pass and the Pribilof islands, over a wide area of the shelf waters (Figure 5). The main temporal overlap between trawl fisheries and seabird colonies in BSAI would be late in the bird's breeding season, in August and September. Seabird colonies are sparse along the BS side of the Alaska Peninsula, but the area of Unimak Pass west to Unalaska Island has numerous small colonies (Figure 5). One of the largest colonies, which includes fulmars, is on St. George Island in the Pribilofs, and these birds would have the greatest spatial overlap with the trawl fisheries. Chagulak Island in the Aleutians and St. Matthew/Hall islands in the northern BS support the other two large colonies of piscivorous birds, including fulmars. Trawl effort is absent or at some distance from these colonies. At St. Matthew/Hall islands, birds with greater foraging distances, such as fulmars, could interact with fisheries to the southwest of the islands in late summer or early fall.

Piscivorous Seabird Colonies and Longline Effort.– The longline fisheries have the greatest overlap with seabird colonies in the BSAI, although temporal overlap would be primarily in April and August - September. The hook and line Pacific cod fishery extends farther north along the shelf edge than the trawl fisheries (Figure 6). Again, birds nesting in the Pribilofs, including one of the largest fulmar colonies on St. George Island (~80,000 fulmars), have the greatest potential for interaction with this fishery. Because the St. George Island fulmar breeding population is relatively small compared to the other three primary fulmar sites, they might have the greatest potential to experience colony-level effects from bycatch mortality. However, because of the concentration of the fishery north along the shelf edge, birds in the St. Matthew/Hall islands colonies may interact with this fishery as well, and this colony has a much larger fulmar population (~450,000 birds; Hatch and Nettleship 1998) than the Pribilofs. Birds nesting throughout the Aleutian chain overlap in near shore areas, but there is little longline effort beyond the narrow shelf along the islands. As a result, birds foraging near shore or near their colonies, such as cormorants, pigeon guillemots, terns, small larids, and the non-colonial marbled and Kittlitz's murrelets, might be most influenced by these fisheries, either by disturbance or indirect interactions with the prey. Because of the limited temporal overlap with fisheries, the indirect effects of fishing on the seabird prey base could be more important along the Aleutians, although such indirect effects are not well understood.

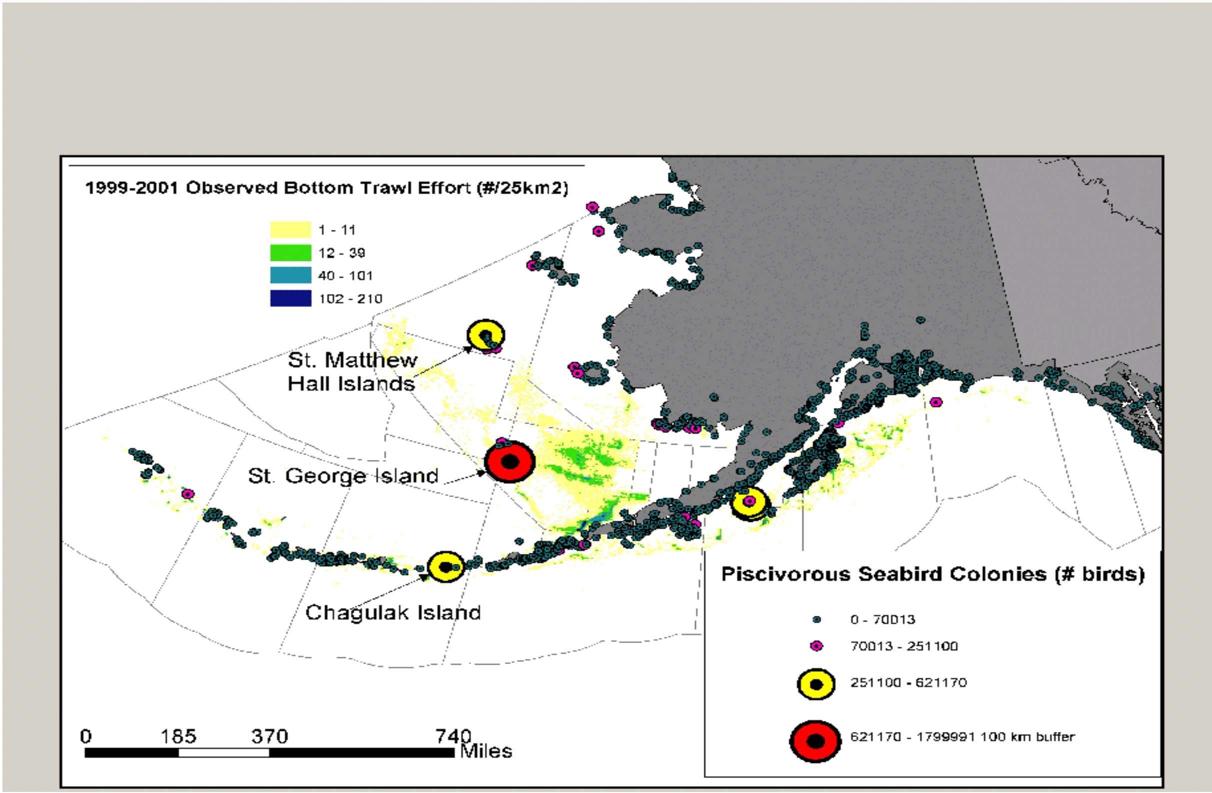


Figure 5: Location and relative size of seabird colonies (counting piscivorous birds only) in Alaska, relative to the 1999-2001 observed trawl effort (hauls/25 km2).

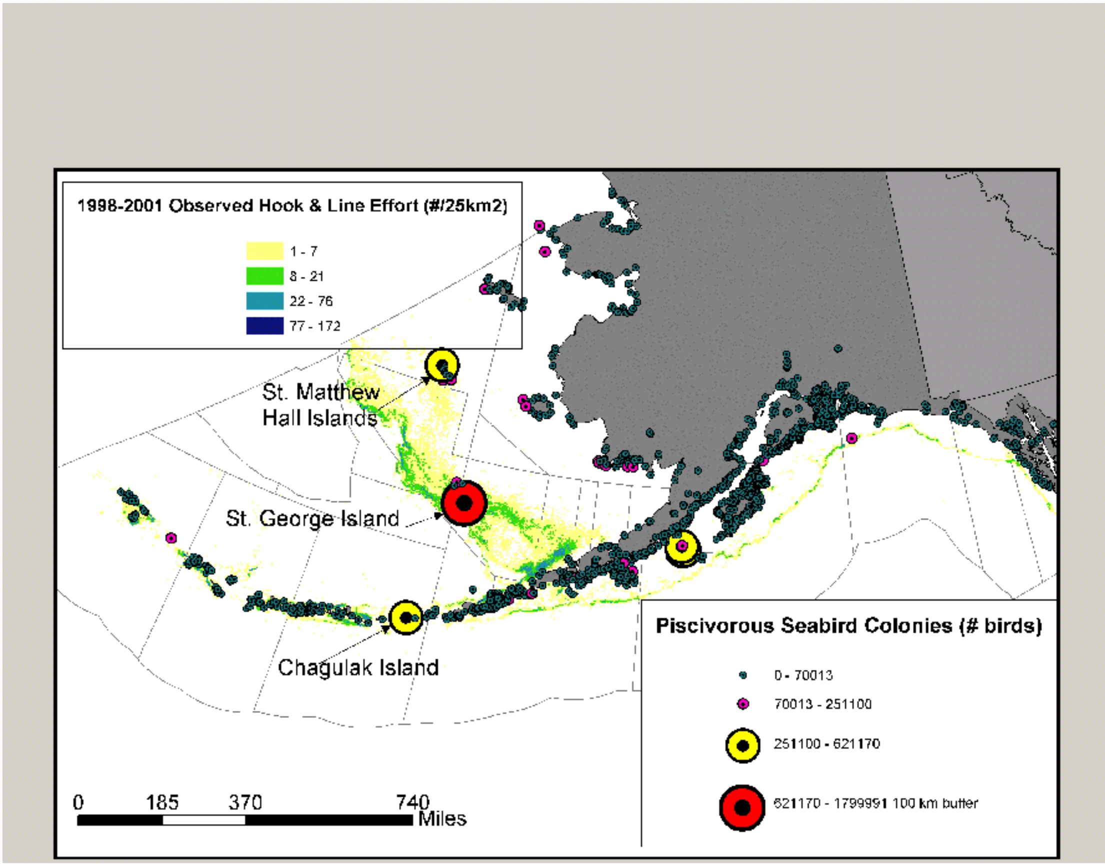


Figure 6: Location and relative size of seabird colonies (counting piscivorous birds only) in Bering Sea/Aleutian Islands region of Alaska, relative to the 1999-2001 observed hook-and-line Pacific cod fishery effort (sets/25 km2).

Satellite Telemetry Tracking of Fulmars. – A more precise and current example of fulmar foraging from a colony was provided by satellite telemetry (Scott Hatch, USGS/BRD, Anchorage, AK, unpublished data). In June 2001, two northern fulmars were captured in the Pribilofs on St. George Island. Both birds had laid eggs but did not complete nesting. One bird, tracked through September, remained in the southern Bering Sea, while the other, tracked through November, crossed into the GOA in early October. Both of the 2001 birds demonstrated a foraging pattern similar to that indicated by the pelagic distribution of fulmars recorded during surveys conducted in the 1970-80s (see below). Both birds ranged along the BS shelf edge, extending from northwest of St. Matthew Island to the Alaska Peninsula. The forage areas overlapped extensively with the 1998-2000 longline fishery effort (Figure 7A).

In 2002, five fulmars fitted with satelite transmitters in June, showed less overlap with longline fisheries (Figure 7B). One bird banded on Chagulak Island in the central Aleutians, abandoned its nest and traveled west along the Aleutians and up to an area about 150 miles northwest of St. Matthew Island. The remaining birds were banded on Hall Island (next to St. Matthew Island). These four birds, three of which are still raising chicks (as of late August), primarily travel between Hall Island and the same specific area northwest of St. Matthew Island where the Chagulak bird was located. This area, where all five tagged fulmars have been foraging, is not heavily fished by U. S. vessels (Figure 7B), however, it is right on the International line where foreign vessels congregate (Anchorage Daily News, 2001). It may be that foreign fishing activity attracts fulmars to this region, which might provide food for birds from the Hall colony, but could also pose an unmonitored bycatch threat. This pilot study demonstrated an ability to obtain precise foraging patterns of individual birds throughout the season, and could further be used to determine the extent that individuals depend on the fishery directly for food in different regions.

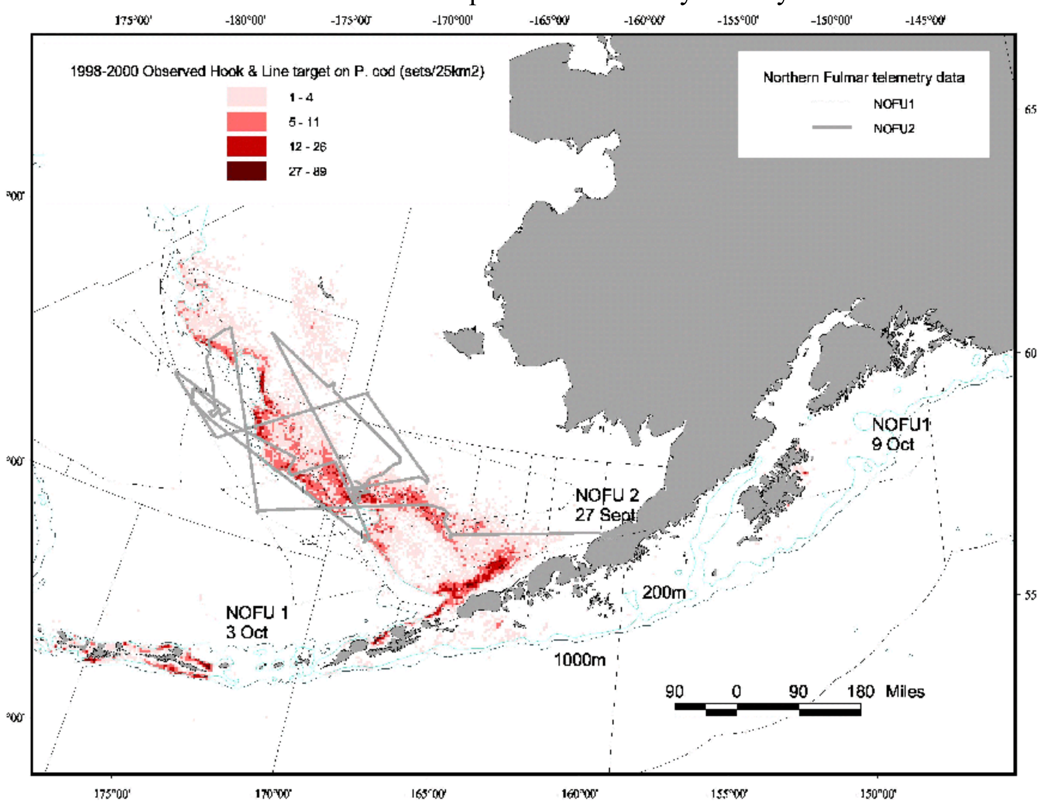


Fig. 7a Locations and track lines of two northern fulmars equipped with satellite telemetry packages. The birds were tagged at St. George Island in the Pribilofs in June 2001, and signals were transmitted every six days. Fulmar No.2 died between 3 - 10 October on the Alaska Peninsula. (Unpublished telemetry data provided by Scott Hatch, USGS/BRD, Anchorage, Alaska)

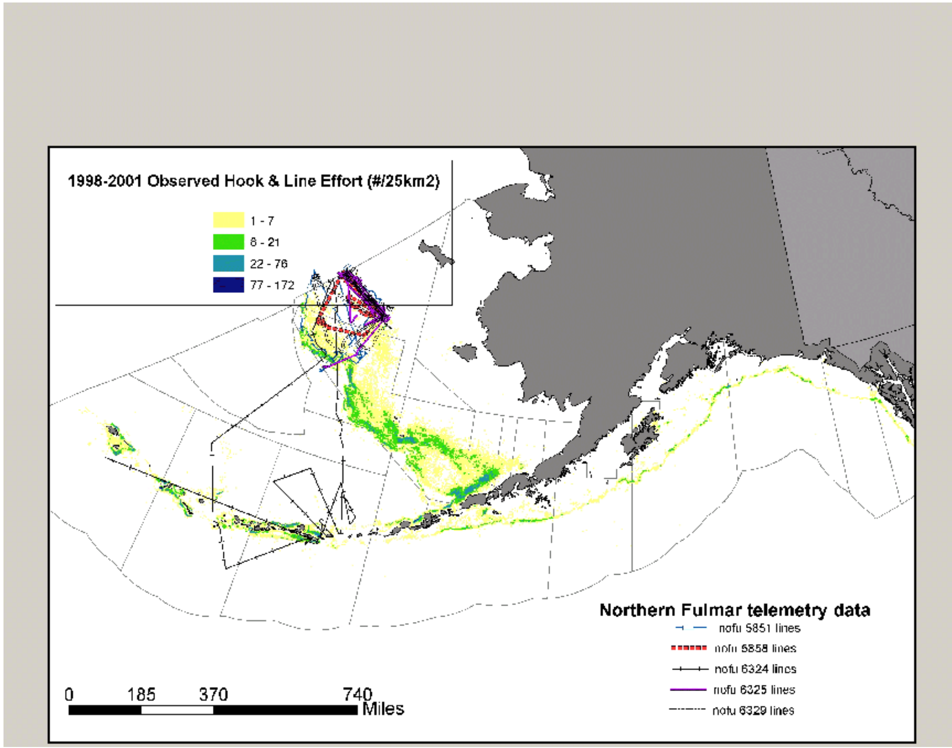


Fig. 7B Locations and track lines of northern fulmars equipped with satellite telemetry packages in June, 2002. Five birds were tagged, one at Chagulak and four at Hall Island, near St. Matthew Island.

Seabird Distribution at Sea and Groundfish Fisheries

All species of seabirds depend on one or more oceanographic processes that concentrate their prey at the necessary time and place, such as upwellings, stratification, ice edges, fronts, gyres, or tidal currents (Schneider 1990, Schneider *et al.* 1987, Coyle *et al.* 1992, Elphick and Hunt 1993, Hunt and Harrison 1990, Hunt 1997, review in Hunt *et al.* 1999, Springer *et al.* 1999). Thus, the distribution of birds at sea might be expected to follow patterns similar to those of the commercial fisheries, which also rely on oceanographic processes that concentrate fish. Although some overlap of fisheries effort and seabird distribution is self-evident from bycatch records and observer sightings, there has been little effort to examine this relationship in Alaska.

We examined the at-sea distribution of selected birds relative to the fishing effort in longline and trawl fisheries in Alaska. The selected species include those that are either abundant in Alaska and comprise a significant portion of the seabird bycatch in the groundfish fisheries, or they are species of concern. The seabird data is a preliminary subset of data currently being incorporated into the North Pacific Pelagic Seabird Database (NPPSD) by the USGS/BRD, USFWS, and Mineral Management Service (MMS). The NPPSD will eventually include all available at-sea survey data for the North Pacific, but the data available to date consists of subsets of data collected during cruises of the Outer Continental Shelf Environmental Assessment Program (OCSEAP). Thus, the seabird data, gathered from 1975-1985, may not reflect current population levels, however, it has the advantage of being independent of fishery observer effort, and thus useful to illustrate general distribution at sea. We assumed that general seabird distribution has not altered appreciably at the scale used for this application. (For a detailed explanation of the database, contact John Piatt, USGS/BRD, Anchorage, AK, or David Irons or Shawn Stephensen, USFWS, Anchorage, AK).

Table 8. Estimated Total Incidental Catch of Seabirds by Species or Species Groups[a] in Bering Sea and Aleutian Islands Longline Fisheries, 1993–2001. Values in Parentheses are 95% Confidence Bounds.

Year	Actual Number Taken[b]	STAL	BFAL	LAAL	NOFU	Gull	SHWR	Unid. Tubenoses	Alcid	Other	Unid. ALB	Unid. Seabird	Total
Bering Sea and Aleutian Islands													
1993	1,942	0	11 (4-21)	617 (458-777)	4,251 (3416-5103)	853 (576-1130)	64 (22-107)	0	15 (4-30)	4 (1-10)	352 (188-517)	1,799 (1399-2200)	7,975 (6981-8968)
1994	2,700	0	37 (7-66)	311 (218-404)	4,826 (4185-5467)	1,734 (1297-2172)	675 (487-864)	350 (226-475)	4 (1-13)	4 (1-11)	76 (43-109)	2,615 (1956-3274)	10,633 (9604-11662)
1995	4,832	0	66 (26-107)	463 (267-660)	9,628 (8613-10643)	3,954 (3274-4634)	330 (225-434)	475 (253-697)	4 (1-11)	45 (16-74)	38 (19-57)	4,211 (3489-4933)	19,214 (17853-20576)
1996	2,002	4 (1-13)	20 (5-48)	234 (156-313)	5,636 (4817-6455)	1,487 (1232-1741)	487 (246-728)	14 (4-26)	46 (9-103)	49 (13-86)	60 (31-90)	442 (326-558)	8,480 (7594-9366)
1997	4,123	0	9 (2-22)	343 (252-433)	13,611 (12109-15122)	2,755 (2276-3234)	300 (154-445)	173 (103-243)	0	7 (2-16)	14 (3-28)	852 (519-1185)	18,063 16491-19634)
1998	5,851	8 (2-15)	9 (2-21)	1,431 (1068-1734)	15,533 (13873-17192)	4,413 (3732-5093)	1,131 (936-1326)	21 (5-38)	53 (24-82)	48 (15-81)	4 (1-11)	1,941 (1584-2297)	24,592 (22769-26415)
1999	3,293	0	18 (4-34)	573 (475-675)	7,843 (6477-9209)	2,208 (1816-2600)	449 (358-540)	409 (144-673)	4 (1-10)	47 (12-85)	0	859 (551-1167)	12,409 (10,940-13,877)
2000	3,868	0	16 (5-33)	441 (320-562)	10,941 (9,503-12,378)	4,504 3,857-5150	556 (414-697)	85 (44-125)	5 (1-14)	16 (4-30)	15 (3-30)	1,576 (1,166-1,985)	18,154 (16,462-19,746)
2001	1,987	0	4 (1-12)	425 (304-547)	5,517 (4,701-6,332)	2,459 (2,044-2,873)	457 (337-578)	94 (49-139)	2 (1-6)	33 (6-61)	5 (1-14)	997 (698-1,295)	9,992 (9,027-10,958)
Average Annual Estimate													
1993-1996	na	1 (0-4)	33 (18-48)	406 (336-477)	6,087 (5667-6508)	2,007 (1784-2230)	389 (307-471)	210 (146-274)	17 (3-33)	26 (13-38)	132 (89-175)	2,267 (2001-2533)	11,576 (11034-12117)
1997-2001	na	2 (0-4)	11 (5-18)	643 (558-728)	10,689 (10,069-11,309)	3,268 (3,028-3,507)	578 (514-643)	156 (100-213)	13 (6-19)	30 (18-43)	7 (2-13)	1,245 (1,091-1,399)	16,642 (15,966-17,318)
1993-2001	na	1 (0-3)	21 (14-29)	538 (481-595)	8,644 (8,252-9,036)	2,707 (2,541-2,874)	494 (443-545)	180 (137-223)	15 (7-23)	28 (19-37)	63 (43-82)	1,699 (1,553-1,845)	14,390 13,944-14,836

Notes: [a]Species or species group codes.
[b]Actual number taken is the total number of seabirds recorded dead in the observed hauls.
STAL – Short-tailed albatross,

LAAL – Laysan's albatross
BFAL – Black-footed albatross
NOFU – Northern fulmar
Gull – Unidentified gulls (herring gulls, glaucous gulls, glaucous-winged gulls)
SHWR – Unidentified shearwaters (unidentified dark shearwaters, sooty shearwaters, short-tailed shearwaters)
Unidentified Tubenose – Unidentified procellariiformes (albatrosses, shearwaters, petrels)
Alcid – Unidentified alcids (guillemots, murres, puffins, murrelets, auklets)
Other – Miscellaneous birds (could include loons, grebes, storm-petrels, cormorants, waterfowl, eiders, shorebirds, phalaropes, jaeger/skuas, red-legged kittiwakes, black-legged kittiwakes, terns)
Unidentified ALB – Unidentified albatrosses (could include short-tailed albatrosses, Layson's albatrosses, black-footed albatrosses)

Source: (NMFS observer data; analyzed by Alaska Fisheries Science Center/National Marine Mammal Laboratory, 2002).

Spectacled eider, Steller's eider, marbled murrelet, red-legged kittiwake, and Kittlitz's murrelet were not reported by observers in any observed sample from 1993 to 2001. Although of these birds only the 2 eider species are listed under ESA in the action area, USFWS identifies the other 3 species as 'species of concern' because of low and/or declining population levels. 'Species of concern' is an informal classification by the USFWS, Office of Migratory Bird Management. Inclusion on the 'species of concern' list has no regulatory implications.

Table 9. Estimated Total Incidental Catch of Seabirds by Species or Species Groups[a] in Gulf of Alaska Longline Fisheries, 1993–2001. Values in Parentheses are 95% Confidence Bounds.

Year	Actual Number Taken[b]	STAL	BFAL	LAAL	NOFU	Gull	SHWR	Unid. Tubenoses	Alcid	Other	Unid. ALB	Unid. Seabird	Total
Gulf of Alaska													
1993	318	0	29 (9-50)	125 (62-187)	833 (615-1052)	45 (12-77)	59 (18-99)	0	0	3 (1-7)	3 (1-9)	213 (107-318)	1,309 (1056-1563)
1994	126	0	7 (2-16)	169 (89-250)	258 (165-351)	30 (2-81)	26 (5-54)	0	0	0	8 (2-18)	33 (8-66)	532 (397-668)
1995	374	0	236 (169-304)	67 (35-99)	520 (348-692)	99 (53-145)	39 (9-69)	6 (1-16)	0	3 (2-6)	376 (275-476)	173 (105-240)	1,519 (1302-1736)
1996	250	0	658 (455-860)	154 (90-128)	665 (349-982)	121 6-317)	14 (2-35)	0	0	0	0	19 (3-42)	1,631 (1203-2059)
1997	74	0	99 (32-167)	40 (5-109)	307 (164-451)	46 (14-79)	9 (2-21)	0	0	0	0	12 (2-30)	514 (338-689)
1998	184	0	289 (25-596)	217 (56-378)	919 (308-1530)	53 (14-92)	13 (3-30)	0	0	0	4 (1-12)	0	1,495 (792-2198)
1999	159	0	183 (70-297)	202 (123-280)	277 (156-399)	358 (136-581)	50 (8-93)	0	0	7 (1-21)	0	16 (4-37)	1,093 (812-1375)
2000	72	0	139 (53-225)	93 (25-160)	297 (70-524)	179 (15-415)	0	0	0	0	0	34 (2-102)	742 (392-1,032)
2001	45	0	72 (20-124)	67 (6-128)	230 (115-344)	98 (4-244)	20 (1-58)	0	6 (1-18)	0	15 (1-44)	3 (1-9)	512 (311-713)
Average Annual Estimate													
1993-1996	na	0	233 (179-287)	129 (97-160)	569 461-677)	74 (21-127)	35 (19-50)	1 (0-4)	0	1 (0-3)	97 (71-122)	109 (76-142)	1,248 (1108-1388)
1997-2001	na	0	156 (86-227)	124 (81-167)	406 (268-544)	147 (75-219)	18 (6-31)	0	1 (0-4)	1 (0-5)	4 (0-10)	13 (1-28)	871 (696-1,047)
1993-2001	na	0	190 144-236	126 (98-154)	479 (388-569)	114 (68-161)	26 (16-36)	1 (0-2)	1 (0-2)	1 (0-4)	45 (33-57)	56 (39-73)	1,039 (923-1,154)

Notes: [a]Species or species group codes.
[b]Actual number taken is the total number of seabirds recorded dead in the observed hauls.

STAL – Short-tailed albatross
LAAL – Laysan albatross
BFAL – Black-footed albatross
NOFU – Northern fulmar
Gull – Unidentified gulls (herring gulls, glaucous gulls, glaucous-winged gulls)
SHWR – Unidentified shearwaters (unidentified dark shearwaters, sooty shearwaters, short-tailed shearwaters)
Unidentified Tubenose – Unidentified procellariiformes (albatrosses, shearwaters, petrels)
Alcid – Unidentified alcids (guillemots, murres, puffins, murrelets, auklets)
Other – Miscellaneous birds (could include loons, grebes, storm-petrels, cormorants, waterfowl, eiders, shorebirds, phalaropes, jaeger/skuas, red-legged kittiwakes, black-legged kittiwakes, terns)
Unidentified ALB – Unidentified albatrosses (could include short-tailed albatrosses, Layson’s albatrosses, black-footed albatrosses)

Source: (NMFS Observer data; analyzed by Alaska Fisheries Science Center/National Marine Mammal Laboratory, 2002).

Spectacled eider, Steller’s eider, marbled murrelet, red-legged kittiwake, and Kittlitz’s murrelet were not reported by observers in any observed sample from 1993 to 2001. Although of these birds only the 2 eider species are listed under ESA in the action area, USFWS identifies the other 3 species as ‘species of concern’ because of low and/or declining population levels. ‘Species of concern’ is an informal classification by the USFWS, Office of Migratory Bird Management. Inclusion on the ‘species of concern’ list has no regulatory implications.

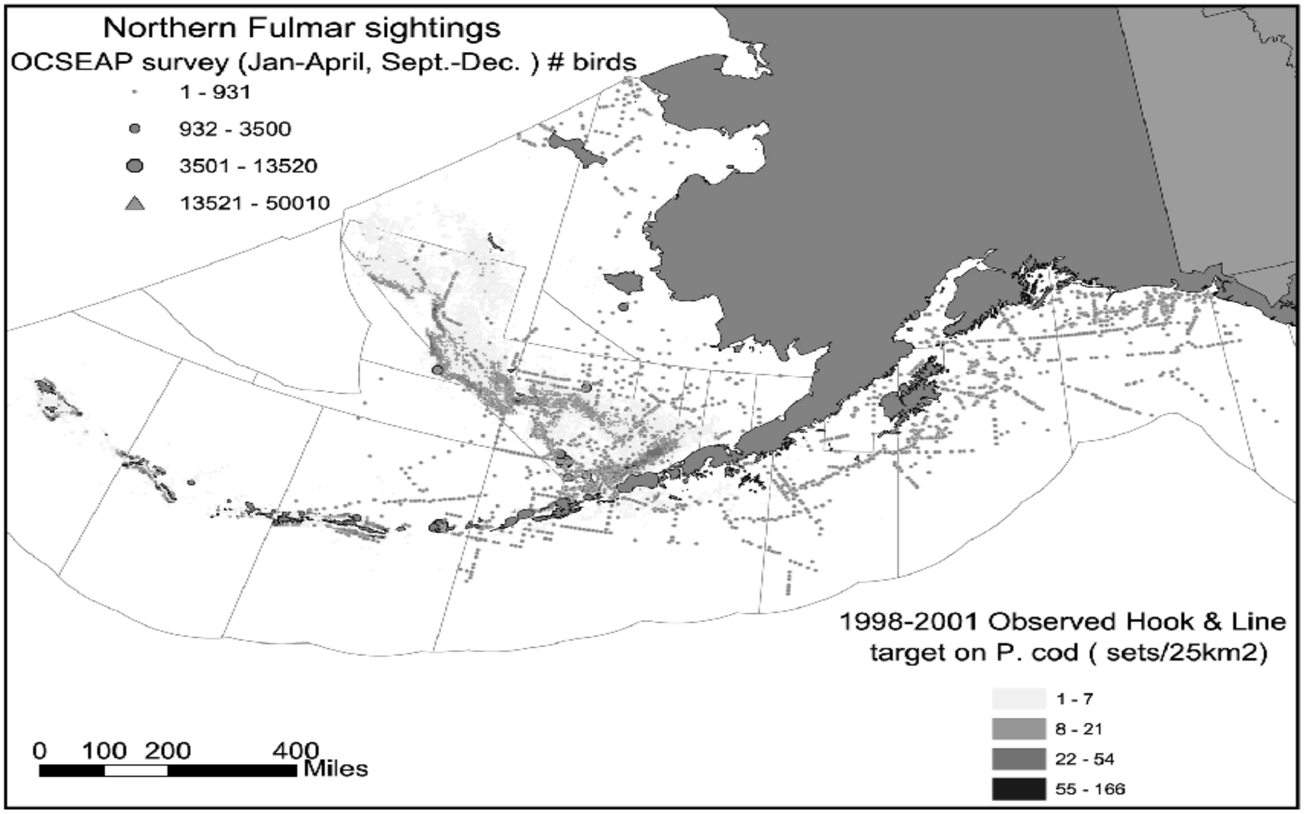


Figure 8: Distribution of northern fulmars at sea in Alaska, as determined from boat-based surveys conducted between 1975-1985. Data are a subset of the North Pelagic Seabird Database, under development by the USGS/BRD and USFWS in Anchorage, AK. Hook-and-line fishery

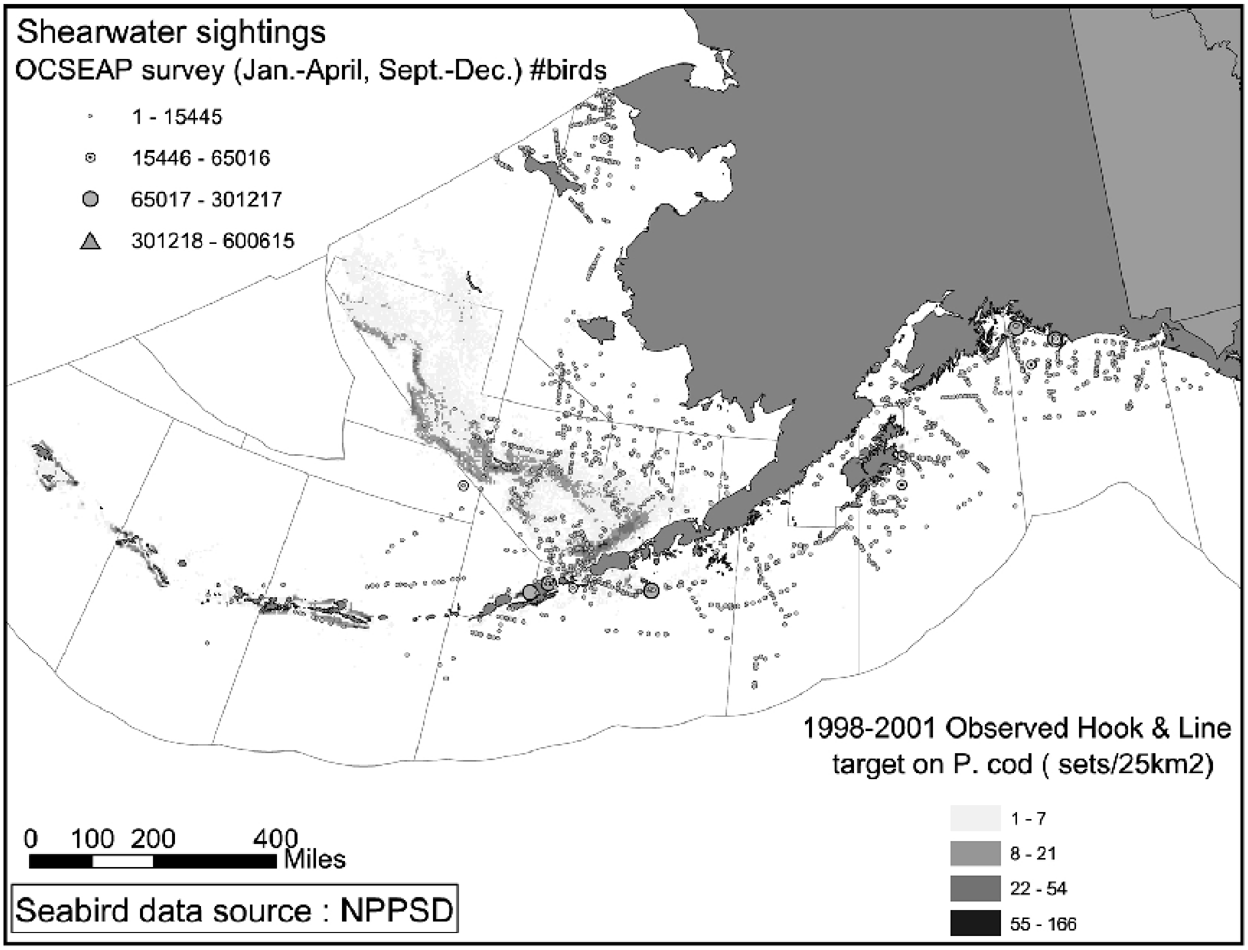


Figure 9: Distribution of shearwaters (primarily sooty and short-tailed spp) at sea in Alaska, as determined from boat-based surveys conducted between 1975-1985. Data are a subset of the North Pelagic Seabird Database, under development by the USGS/BRD and USFWS in Anchorage, AK. Hook-and-line fishery target on Pacific cod (sets/25km2) using observer data from 1998-2001 is also displayed.

At-sea Distribution of Northern Fulmars. – In both the BSAI and GOA, the northern fulmar comprises the majority of seabird bycatch. The fulmars are the only tubenose that is both a significant portion of the seabird bycatch and breeds in Alaska. Over 90% of the fulmars in Alaska nest on four large islands, Chowiet in the GOA, Chagulak in the Aleutians, St. George in the central BS, and St. Matthew/Hall islands in the northern BS (Hatch and Nettleship 1998). The year-round presence of fulmars in Alaska's waters, together with their foraging habits, likely are factors contributing to the large numbers incidentally caught in the BSAI and GOA groundfish fisheries. Additionally, the continued presence and high overlap of fulmars with fisheries effort may partially explain why they are the only species which shows a relationship between fishing effort (number of hooks deployed) and the estimated number of birds taken (NMFS 2001a).

To examine fulmar distribution at-sea during the period of greatest temporal overlap with longline fisheries, we selected only those bird sightings from the months of January through April and September through December, when the vast majority of the hook-and-line Pacific cod harvest occurs. Fulmar distribution shows a strong spatial overlap with the hook-and-line fishery in the BS, primarily in the area between Unimak Pass and the Pribilof Islands, over a wide area of the continental shelf (Figure 8). Fulmars are also scattered northeast toward the mainland side of the shelf edge, and along the central Aleutian chain. In the GOA, longline effort is relatively low, and occurs mainly east of Kodiak. Fulmars appear to be less dense in the GOA, and widely dispersed along the shelf edge. As might be expected, longline bycatch of fulmars in GOA is considerably lower than in the BS (Tables 8 and 9).

At-sea Distribution of Sooty and Short-tailed Shearwaters. – Sooty shearwaters breed in New Zealand and Australia or South America, and short-tailed shearwaters breed in Australia and Tasmania. Both species are trans-equatorial migrants that travel into Alaskan waters where they reside, roughly between May and September (Oka et al. 1987, Harrison et al. 1983). For both species, some non-breeders may remain in Alaska throughout the winter. The increase in shearwater bycatch during late summer/early fall (Figure 16) may reflect a seasonal shift in their distribution just prior to their migration back to their southern breeding grounds.

We examined both species of shearwater together during the months of January through April and September through December (Figure 9), to coincide with the majority of the hook-and-line Pacific cod harvest. In the BS, shearwaters were concentrated at Unimak Pass and to the north, which overlaps with the longline fishery. However, there was a gap in shearwater distribution along the shelf, where the fishery was concentrated, and shearwater abundance is much greater eastward toward the mainland side of the shelf, where fishing effort was low or absent. Few shearwaters were observed along the Aleutian chain. Shearwaters were also distributed along the GOA shelf, particularly near the Semidi Islands, northeastern Kodiak Island, and off the Copper River Delta. There should be little overlap in the GOA between shearwaters and longliners, and shearwaters are not taken in large numbers in that region (Table 9). Trawl fisheries, however, take a large portion of the total shearwater take in bycatch (Table 11), and the distribution of trawl effort (see Figure 5) suggests that shearwaters could overlap in both the BS and the GOA with that fishery.

At-sea Distribution of Black-footed Albatross. – Black-footed albatross breed primarily in the Northwestern Hawaiian Islands and forage in Alaska waters during the summer months, which is reflected in the increased proportion of black-footed albatross of the total seabird bycatch (Figure 16). However, nonbreeders may remain in Alaska, and some breeding birds may travel to Alaska to forage, based on movements of radio-tagged birds.
We pooled observations for all months to examine the distribution of black-footed albatross relative to the hook-and-line Pacific cod fishery. This albatross is found primarily in the GOA, along the shelf edge from the Shumagin Islands area north, particularly the northern portion of the GOA, between Cape Suckling and Yakutat (Figure 10). Low numbers were observed near Nunivak Island in the northern BS, and along the Aleutian Islands. The distribution of black-footed albatrosses is reflected in the much larger numbers of them taken in the GOA longline fishery compared to the BS longline fishery (Tables 9 and 8), despite the lower fishing effort in the GOA. Although the trawl fishery effort is relatively greater in the GOA, black-footed albatross have not been reported by observers as taken in that fishery.

At-sea Distribution of Laysan Albatross. – Laysan albatross, which also breed primarily in the Northwestern Hawaiian Islands, are the most abundant of the three albatross species that visit Alaska in the summer. This species is found in both the BS and the GOA (Figure 11), which is evident in the similar bycatch rates for those regions in the longline fishery (Tables 8 and 9). In the BS, low numbers of

Laysan albatross are found south and west of the shelf break, with little overlap with the hook-and-line Pacific cod fishery, which is concentrated along the shelf edge (Figure 11). Larger numbers of Laysan albatross occurred along the central and western Aleutian chain, where the nearshore longline fishery is also concentrated in that region. In the GOA, Laysan albatross are found along the shelf edge, primarily between the Shumagin Islands and eastern Kodiak Island.

Most of the bycatch of Laysan albatross occurs in the longline fishery, and this interaction may be important despite low fishing effort in the GOA. The trawl fishery, which has an effort more equally distributed between the GOA and BS, has occasionally shown relatively high bycatch levels of Laysan albatross (i.e., 1998; Table 11). The distribution of Laysan albatross and fishing effort suggest that the trawl bycatch could more likely occur on the shelf edge of the GOA or closer to shore in the western Aleutians.

At-sea Distribution of Short-tailed Albatross. – The short-tailed albatross is listed as endangered under the ESA, and thus its interactions with the groundfish fisheries are of great interest. Ideally, the at-sea distribution of this (primarily) summer visitor would be independent from the fishery itself. A pilot study was implemented in 2001 to equip short-tailed albatross with satelite telemetry packs at their breeding grounds in Japan, with the goal of tracking their movements throughout the year (G. Balogh, USFWS, Anchorage). This effort was continued in 2002. To date, following the breeding season, the short-tailed albatross appear to move north along the coast of Japan to the southern tip of the Kamchatka Peninsula. From there the birds moved east to the western Aleutians (USFWS, unpubl. data). Thus, prior to following the Aleutian Island chain and BS and GOA shelf breaks (Figures 12 and 13), these albaross spend considerable time along the coast of the western Pacific, where they would be exposed to additional fishery encounters.

The most extensive data coverage available for short-tailed albatross is derived from the NMFS Observer database and sightings from commercial fishing vessels, and this was used to illustrate their distribution in Alaskan waters (Figures 12 and 13). In the BS, the hook-and-line Pacific cod fishery overlaps with short-tailed albatross sightings primarily along the Aleutian chain, although some sightings also overlapped with the fishing effort along the shelf edge (Figure 12). A large portion of the sightings were recorded during the short-tailed breeding season (November to May), and thus may represent primarily immature and non-breeding birds. Most of the recorded take of short-tailed albatross occurred in the northern portion of the shelf edge in the BS, despite relatively fewer sightings there, compared to the Aleutians and with one exception, the takes were of juvenile or sub-adult (i.e. non-breeding) individuals (NMFS, 2001c).

In the GOA (Figure 13), the short-tailed albatross was sighted almost exclusively along the shelf edge, although to what extent this represents the bias of the observer's platforms is unknown. A large part of the trawl effort in the GOA extends from the Shumagin Islands to eastern Kodiak and to the north, but there were few sightings of short-tailed albatross inside of the shelf edge. Two recorded takes of the short-tailed albatross occurred in the GOA near Unimak Pass and Middleton Island in the northern GOA.

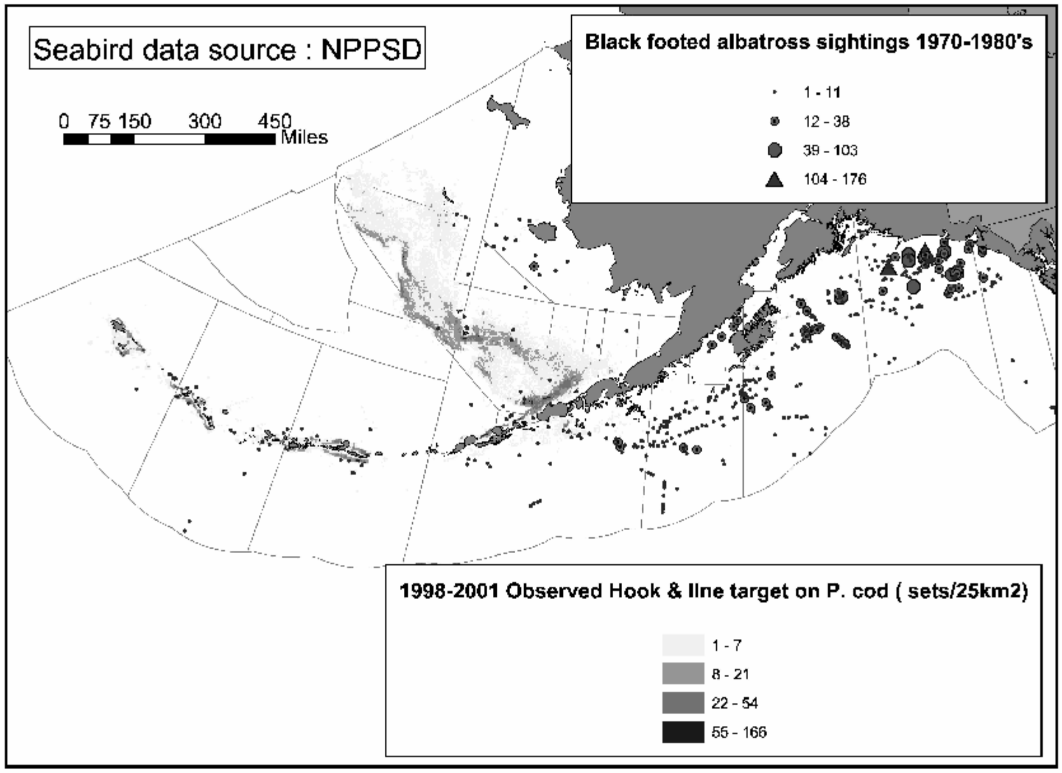


Figure 10: Distribution of black-footed albatross in Alaska, as determined from boat-based surveys conducted between 1975-1985. Data are a subset of the North Pacific Pelagic Seabird Database, under development by the USGS/BRD and USFWS in Anchorage, AK. Hook-and -line fishery target on Pacific cod using observer data from 1998-2001 is also displayed.

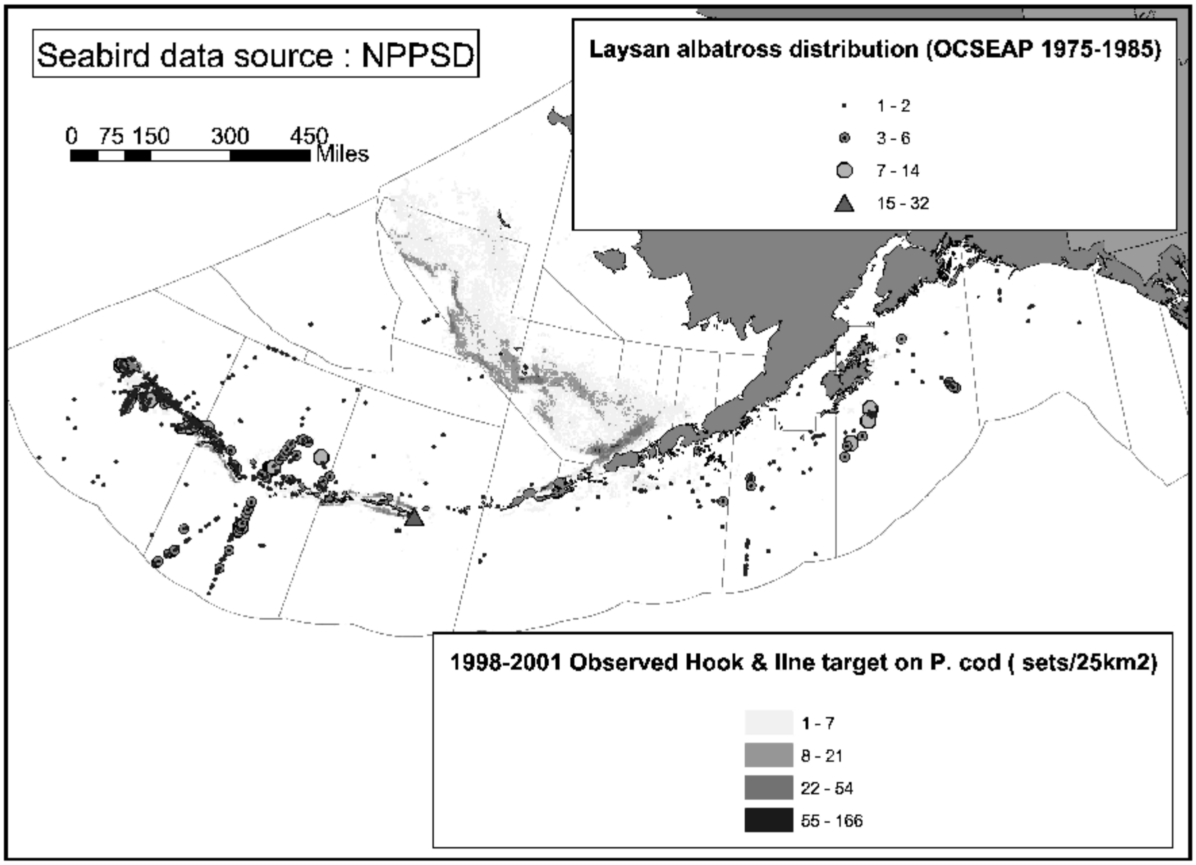


Figure 11: Distribution of Laysan albatross in Alaska, as determined from boat-based surveys conducted between 1975-1985. Data are a subset of the North Pacific Pelagic Seabird Database, under development by the USGS/BRD and USFWS in Anchorage, AK. Hook-and -line fishery target on Pacific cod using observer data from 1998-2001 is also displayed.

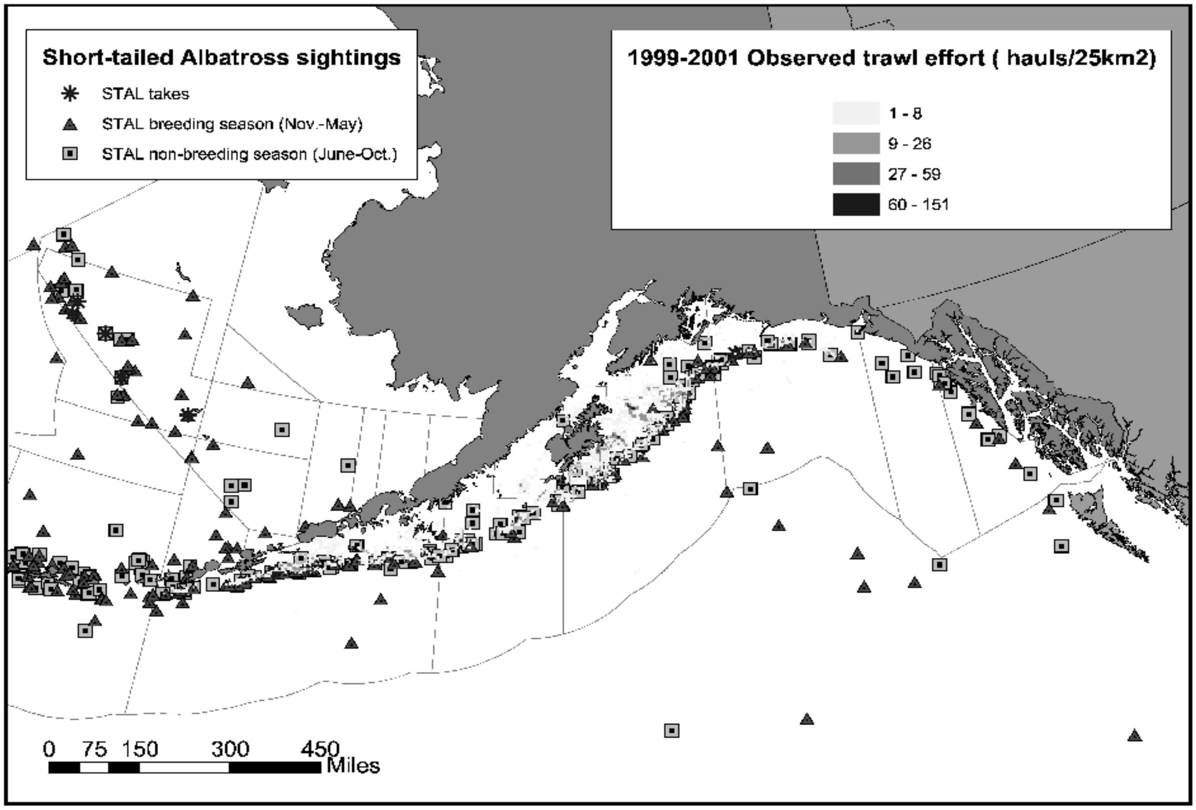


Figure 12: Short-tailed albatross (STAL) sightings (by breeding season and take locations) in the BSAI in relationship to the 1998-2001 observed hook and line Pacific cod fishery effort (sets/25 km^2).

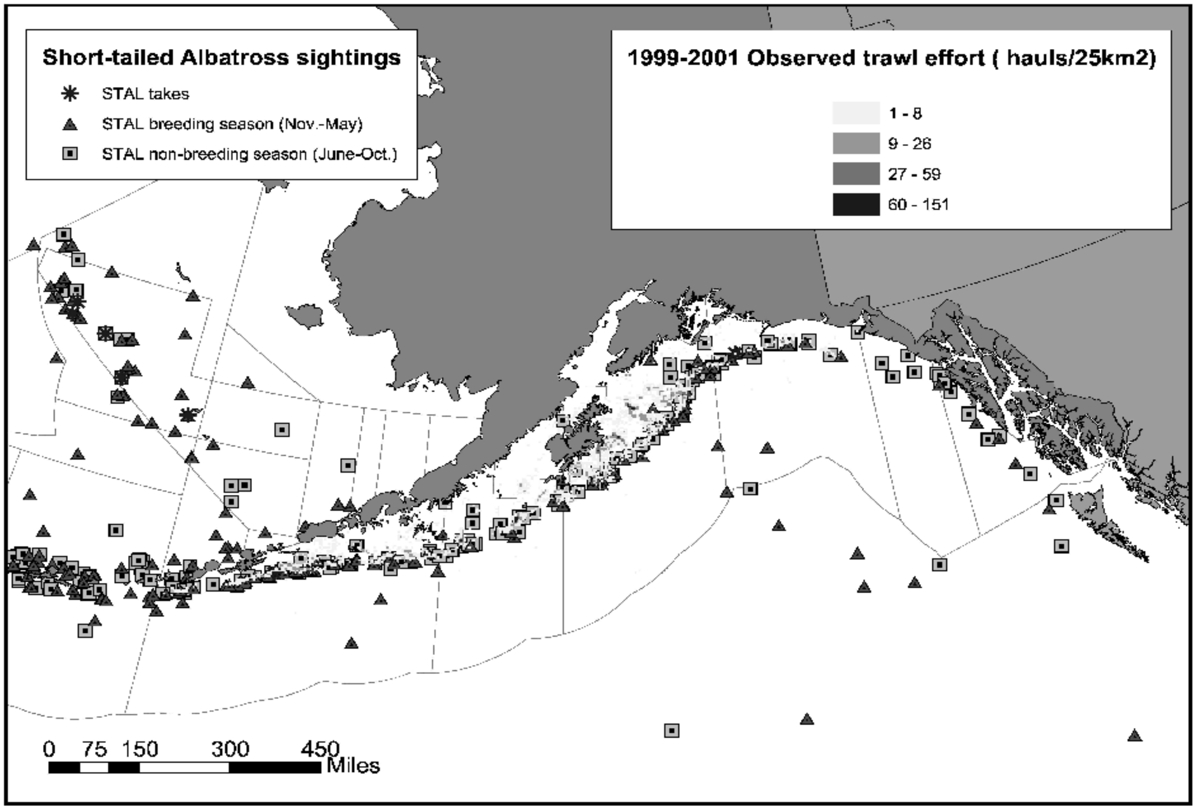


Figure 13: Short-tailed albatross (STAL) sightings (by breeding season and take locations) in the GOA in relationship to the 1998-2001 observed trawl fishery effort (hauls/25 km^2).

Incidental Catch of Seabirds in Fishing Gear

Seabirds are caught incidentally in all types of fishing operations (Jones and DeGange 1988). In a coastal drift gillnet fishery in Washington state, sea state and time of day were significant predictors of seabird bycatch rates, indicating that visibility or maneuverability, as well as feeding behaviors, may affect susceptibility of birds (Melvin, Parrish *et al.* 1999). In a demersal trawl fishery for hake off of southern Africa, the distribution of some seabird species was affected by trawling activity (Ryan and Moloney, 1988). This effect would depend on the species foraging behaviors and patterns. Generally, species with large radii of attraction were influenced by trawling activity and trawler offal comprised a large part of the diet. Species with small radii of attraction were less influenced and trawler offal comprised a minimal part of their diet. In Southern Ocean longline fisheries, the incidental catch of wandering albatrosses is likely to depend on the space and time overlap of the albatross population and fishing effort (Tuck, Polacheck *et al* 2001). This will be a function of the sex of the birds, age, breeding status, and the particular population under consideration. In groundfish fisheries off Alaska, longlines account for most of the seabird incidental catch. Trawls also take some seabirds, primarily those that feed beneath the surface on prey in the water column. Pots occasionally take diving seabirds. Some birds also are injured or killed by striking the vessel superstructure or gear while flying in the vicinity. In a two-year study on the effectiveness of seabird avoidance measures on the incidental take of seabirds in demersal longline fisheries off Alaska, results indicated that “year” (ie inter-annual differences) significantly affected both seabird attack and incidental catch rates (Melvin *et al* 2001). Spatial factors (“region”) explained a large amount of deviation in attack rate and was the most significant variable explaining the incidental catch rate.

Monitoring Seabird Incidental Catch and Seabird/Fishery Interactions and Incidental Catch Estimation Procedures

Data collection regarding seabird/fishery interactions by NMFS in the groundfish fisheries began in 1990 and was expanded during the 1993, 1997, 1999 and 2000 seasons.

A report using 1993-1997 data from the longline fishery describes seabird incidental catch estimation methods and procedures developed by USFWS, in consultation with NMFS (Stehn, Rivera *et al.* 2001). Similar methods and procedures were developed by NMFS and used to calculate preliminary estimates using 1993-1999 data for all groundfish fisheries (NMFS 2001a). Standard statistical procedures ("separate ratio estimators" of stratified random sampling; Cochran 1977) for estimating a population total from a sample were used. NMFS calculated rates and estimates for all seabird species or species groups in each stratum of all gears, statistical fishing areas, regions (BSAI or GOA), vessel types (processors, motherships, and catcher_only vessels), time periods (annual or each of 13 four-week periods in a year) for each year from 1993 to 1999. As requested by USFWS, the following eleven groups of seabirds were chosen for analysis: short-tailed albatross, black-footed albatross, Laysan albatross, unidentified albatross, fulmars, gulls, shearwaters, unidentified tubenoses (procellarids), alcids, other bird species, and unidentified seabirds (those not identified to one of the other ten groups).

Incidental catch estimates were based on the number of seabirds by species in samples from observed hauls and the total commercial fish catch as estimated by the NMFS blend program. The NMFS method utilized two measures of fishing effort: total tons of groundfish catch per haul or set for the trawl fishery (NMFS blend program), and the number of hooks or pots per set for both the longline and pot fisheries (estimated for the unobserved fishery in the NMFS blend program using the average number of hooks or pots, respectively, in the observed fishery). The NMFS Observer Program NORPAC database records the weight of the catch by species in the species composition samples and the estimated weight of the entire catch (all species combined) in the whole haul or set. NORPAC also records the number of hooks or pots in the sample and the estimated number of total hooks or pots in the whole set. The number of observed birds in a species composition sample per effort (tons or hooks or pots) of that sample was used to extrapolate the number of seabirds to the whole haul or set, and similarly upwards to the whole fishery, including the unobserved effort.

On trawl vessels only, observers may use any one of three different sample sizes of groundfish catch to monitor bycatch of birds in a haul. Observers are currently advised to use the largest of the three sample sizes whenever possible However, observers do not record the sample size choice for monitored hauls which have no observable seabird bycatch. Thus, it has been necessary to calculate two alternative sets of estimates of seabird bycatch for trawlers based on the smallest (ALT1) and largest (ALT2) sizes of sampling effort recorded for fish species (see “low” and “high” estimates in Table 11). In each of these two alternative calculation methods, a "separate ratio estimator" was used to bind the results of the catch ratios and variances of data from the three different sample sizes into arbitrary equal samples which were then inflated upwards to the total catch effort of the NMFS blend program. Although, it is not known with certainty which of the 2 sets of estimates is more accurate, the probable level of seabird bycatch on trawl vessels during the 1990s lies somewhere between the 2 sets of estimates.

The unobserved weight of fish was calculated by subtracting the known weight of sampled fish on observed hauls from the estimated total weight of fish (all hauls). The estimated total number of birds caught was the sum of observed birds in the catch and the estimated unobserved birds. For each species or species group in a stratum, the number of unobserved birds was estimated by multiplying the ratio of the number of observed birds of that species or species group caught per unit of effort of sampled groundfish from observed hauls times the total estimated effort of groundfish caught in unobserved hauls. Incidental catch estimates from each stratum were summed to yield total estimates for statistical fishing areas and regions. No estimates were made for those few strata in the NMFS blend program which consisted only of data from unobserved vessels; in this regard the estimates are conservative.

Both the catch rate of birds (number of birds per weight of fish, or birds per 1,000 hooks) and the catch rate of fish (total weight of all fish species per hook/pot/net) were assumed to be equal for observed and unobserved hauls of the same gear, area, and time period. These assumptions may not hold, not necessarily because the presence of the observer may change the fishing practices of the skipper or crew, but rather because, for some other operational reason, the smaller (unobserved) vessels may have different catch rates than the large or mid-sized vessels. The constant catch rates for birds and/or fish among vessel size categories are untested and critical assumptions. If different catch rates do exist for different vessel size categories, then the average area catch rates and the estimates of the total seabird incidental catch number may be overestimated or underestimated.

In the NMFS analysis of 1993 to 2001 observer data, only three of the albatross taken were identified as a short-tailed albatross (and all from the BSAI region). Of the albatross taken, not all were identified. This analysis of 1993 to 2001 data resulted in an average estimate of one short-tailed albatross being taken annually in the BSAI groundfish hook-and-line fishery and zero short-tailed albatross being estimated taken annually in the GOA groundfish hook-and-line fishery. The incidental take limit established in the USFWS biological opinions on the effects of the hook-and-line fisheries on the short-tailed albatross is based on the actual reported takes and not on extrapolated estimated takes.

Based on estimates of seabirds observed taken in groundfish fisheries from 1989 to 1993, 85 percent of the total seabird bycatch was caught in the BSAI, and 15 percent in the GOA. Longline gear accounted for 90 percent of the total seabird bycatch, trawls for 9 percent, and pots 1 percent. (Wohl *et al.* 1995). NMFS analysis of 1997 to 2001 observer data indicates similar patterns as those seen in the 1989 to 1993 data (Figure 14). Depending on which trawl estimate is used, longline gear accounted for 94 (or 65) percent of the total average annual seabird incidental catch, trawl gear for 6 (or 35) percent and pot gear for less than 1 percent. The higher percentage of trawl incidental catch coincides with the higher trawl estimate displayed in Table 11. Based on the average annual estimates of seabirds observed taken in groundfish longline fisheries from 1993 to 2001, 93 percent of the longline seabird bycatch was caught in the BSAI, and 7 percent in the GOA (Table 10). Also of note, the bycatch rates in the BSAI are approximately 4 times higher than in the GOA (Table 10).

Incidental Catch in Longlines

Longlines catch surface-feeding seabirds that consume invertebrate prey which resemble bait. During setting of the line seabirds are hooked as they attempt to capture the bait. Birds that habitually scavenge floating material from the sea surface are also susceptible to being hooked on longlines (Brothers 1991, Alexander *et al.* 1997, Brothers, Cooper *et al.* 1999). Recent studies have implicated longline fishing in these population declines of albatross species. A model was developed for assessing the effects of longlining on wandering albatross populations at South Georgia and Crozet Islands in the Southern Ocean. The model results suggest that the marked decline in both populations, and subsequent recovery of the Crozet Islands population, can be explained by the tuna longline incidental catch (Tuck, Polacheck et al 2001). Longline fishing is considered the most recent and potentially most serious global threat faced by albatrosses and other procellariiforme taxa (Brothers *et al.* 1999a). Effects of the incidental catch in longline fisheries off Alaska of albatross and other seabirds at the population level are uncertain (Melvin et al 2001). With the exception of the short-tailed albatross, data on the number, size and geographic extent and mixing of seabird populations are poorly understood. Seabird mortality in Alaska longline fisheries represents only a portion of the fishing mortality that occurs, particularly with the albatrosses. The endangered short-tailed albatross population is currently increasing, the total population estimated at about 1600 to 1700. Mortality of black-footed and Laysan albatrosses occurs in both Alaskan and Hawaiian longline fisheries and may be assumed to occur in other North Pacific longline fisheries conducted by Japan, Taiwan, Korea, Russia, and China (Brothers *et al.* 1999b). See section 4.7.1 for a discussion of the potential cumulative impacts of North Pacific longline fisheries on the black-footed albatross (NMFS 2001b).

Estimates of the annual seabird incidental catch for the Alaska groundfish fisheries, based on 1993 to 2001 data, indicate that approximately 15,400 seabirds are taken annually in the combined BSAI and GOA groundfish fisheries (14,400 in the BSAI; 1,000 in the GOA) at the average annual rates of 0.09 and 0.01 birds per 1,000 hooks in the BSAI and in the GOA, respectively (Table 10).

Of the estimated 14,400 seabirds that are incidentally caught in the BSAI, the species composition is: 60 percent fulmars, 19 percent gull species, 12 percent unidentified seabirds, 4 percent albatross species, 3 percent shearwater species, and 2 percent ‘all other’ species (Table 8).

Of the estimated 1,000 seabirds that are incidentally caught in the GOA, the species composition is: 46 percent fulmars, 35 percent albatrosses, 11 percent gull species, 4 percent unidentified seabirds, 3 percent shearwater species, and less than 1 percent ‘all other’ species (Table 9, Figure 15). Five endangered short-tailed albatrosses were reported caught in the longline fishery since reliable observer reports began in 1990: two in 1995, one in 1996, and two in 1998, and all in the BSAI. Both of the birds caught in 1995 were in the vicinity of Unimak Pass and were taken outside the observers' statistical samples; the bird caught in 1996 was near the Pribilof Islands in an observer's sample; the two short-tails taken in 1998 were in observers’ samples.

It is difficult at this time to make valid comparisons of bird bycatch rates between regions. We cannot discern if the differences between the BSAI and GOA estimated bycatch rates are due to the vastly different levels of fishing effort in each region, the different types of vessels used in each region (‘small’ catcher vessel in GOA, ‘large’ catcher-processor in BSAI), different distribution and abundance of birds, etc. An analysis of covariance would allow for a valid statistical comparison of the regional bycatch rates.

Table 10. Annual Estimates, by Area, of Total Fishery Effort, Total Numbers and Bycatch Rates of Seabirds Taken in Longline Fisheries. Values in Parentheses are 95% Confidence Bounds.

Year	Effort (No. of Hooks in 1,000s)	No. of Birds	Bycatch Rate No. of Birds per 1,000 Hooks	Percent of Hooks Observed
Bering Sea and Aleutian Islands				
1993	123,232	7,975 (6981-8968)	0.06	24.5
1994	134,954	10,633 (9604-11662)	0.08	24.5
1995	141,779	19,214 (17853-20576)	0.14	24.2
1996	141,810	8,480 (7594-9366)	0.06	23.8
1997	176,534	18,063 (16491-19634)	0.10	22.6
1998	175,530	24,592 (22769-26415)	0.14	23.5
1999	157,319	12,409 (10940-13877)	0.08	25.0
2000	192,994	18,154 (16,562-19,746)	0.09	22.8
2001	226,186	9,992 (9,027-10,958)	0.04	21.0
Average Annual Estimates				
1993–1996	135,444	11,576 (11034-12117)	0.09	24.5
1997-2001	185,725	16,642 (15,966-17,318)	0.09	22.8
1993-2001	163,377	14,390 (13,344-14,836)	0.09	23.3
Gulf of Alaska				
1993	56,300	1,309 (1056-1563)	0.02	10.2
1994	49,452	532 (397-668)	0.01	4.9
1995	42,357	1,519 (1302-1736)	0.04	12.7
1996	33,195	1,631 (1203-2059)	0.05	10.8
1997	28,047	514 (338-689)	0.02	10.0
1998	29,399	1,495 (792-2198)	0.05	8.1
1999	31,895	1,093 (812-1375)	0.03	8.6
2000	35,345	742 (392-1,032)	0.02	6.5
2001	34,216	512 (311-713)	0.01	7.8
Average Annual Estimates				
1993–1996	45,326	1,248 (1108-1388)	0.03	9.5
1997-2001	31,780	871 (696-1,047)	0.03	8.1
1993-2001	37,801	1,039 (923-1,154)	0.03	8.8

Table 11. Range of Estimates of Total Incidental Catch of Seabirds by Species or Species Groups[a] in the Combined Bering Sea and Aleutian Islands and Gulf of Alaska Trawl Fisheries, 1997–2001

Year	Actual Number Taken [b]	Estimate Range[c]	STAL	BFAL	LAAL	NOFU	Gull	SHWR	Unid. Tubenoses	Alcid	Other	Unid. ALB	Unid. Seabird	Total
1997	55	low	0	0	80	75	0	77	0	115	0	0	181	528
		high	0	0	149	343	0	662	0	115	0	0	1074	2343
1998	45	low	0	0	134	93	1590	856	1	110	3	0	8	2794
		high	0	0	341	2617	708	1238	163	543	2494	0	1035	9138
1999	154	low	0	0	8	446	0	82	0	664	0	0	17	1218
		high	0	0	27	7810	0	812	0	730	85	0	663	10,187
2000	101	low	0	0	0	298	37	10	2	1	0	0	60	407
		high	0	0	0	9,432	114	3,034	155	182	0	0	480	13,397
2001	141	low	0	0	8	323	4	329	9	1	3	0	65	741
		high	0	0	150	9,255	288	887	863	68	297	0	681	12,488
Average Annual Estimate														
1997-2001	na	low	0	0	46	274	326	271	2	178	1	0	66	1,138
		high	0	0	133	5,891	222	1,327	236	340	575	0	787	9,511

Notes: [a]See the species and species groups footnoted in Table 8.
[b]Actual number taken is the total number of seabirds recorded dead in the observed hauls.

[c]The high and low estimates result from different methodologies used by observers to sample the haul. "Low" from effort data of observed hauls based on largest sample unit actually used by observers for fish species monitoring ("whole sample approach"). "High" from effort data of observed hauls based on smallest sample unit actually used by observers for fish species monitoring ("basket sample approach").

Table 12. Estimated Total Incidental Catch of Seabirds by Species or Species Groups[a] in the Combined Bering Sea and Aleutian Islands and Gulf of Alaska Pot Fisheries, 1993–2001. Values in parentheses are 95% confidence bounds.

Year	Actual Number Taken[b]	STAL	BFAL	LAAL	NOFU	Gull	SHWR	Unid. Tubenoses	Alcid	Other	Unid. ALB	Unid. Seabird	Total
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	6	0	0	0	9 (2-23)	3 (1-10)	7 (1-20)	0	19 (2-55)	0	0	0	39 (6-79)
1996	9	0	0	0	80 (7-174)	0	0	2 (1-6)	0	0	0	7 (1-19)	89 (9-183)
1997	4	0	0	0	14 (3-29)	0	0	0	9 (1-26)	0	0	0	23 (4-46)
1998	2	0	0	0	19 (1-54)	15 (1-44)	0	0	0	0	0	0	33 (2-79)
1999	47	0	0	0	166 (71-261)	0	9 (1-26)	14 (5-28)	0	0	0	0	189 (91-286)
2000	1	0	0	0	0	0	0	0	0	0	0	42 (1-22)	42 (1-22)
2001	3	0	0	0	13 (2-33)	3 (1-8)	0	0	0	0	0	0	16 (3-36)
Average Annual Estimate													
1993–1996	na	0	0	0	22 (2-46)	1 (0-3)	2 (0-5)	1 (0-2)	5 (0-14)	0	0	2 (0-5)	32 (6-58)
1997-2001	na	0	0	0	42 (21-64)	4 (0-10)	2 (0-6)	3 (1-6)	2 (0-6)	0	0	8 (0-25)	61 (33-88)
1993-2001	na	0	0	0	33 (17-49)	2 (0-6)	2 (0-5)	2 (0-4)	3 (0-8)	0	0	5 (0-15)	48 (28-67)

Notes:
[a]See the species and species groups footnoted in Table 8.
[b]Actual number taken is the total number of seabirds recorded dead in the observed hauls.

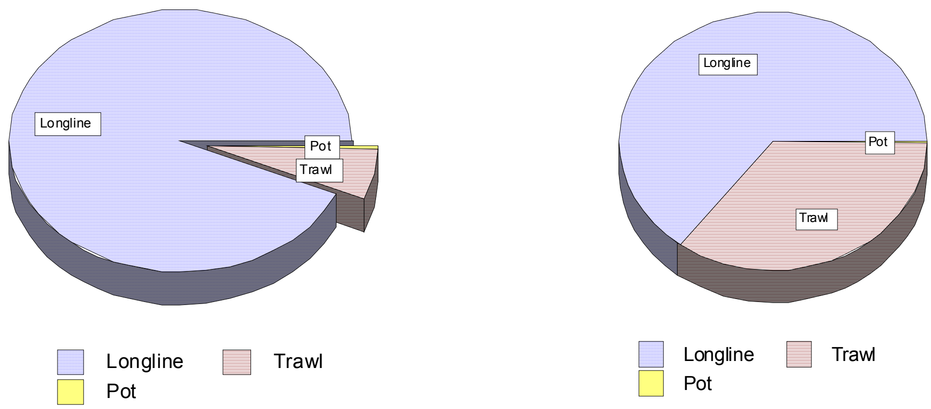


Fig. 14. Average Annual Estimate of Number of Seabirds Taken by Gear Type, 1997-2001. Estimates Differ Based on Trawl Sampling Methodology Used.

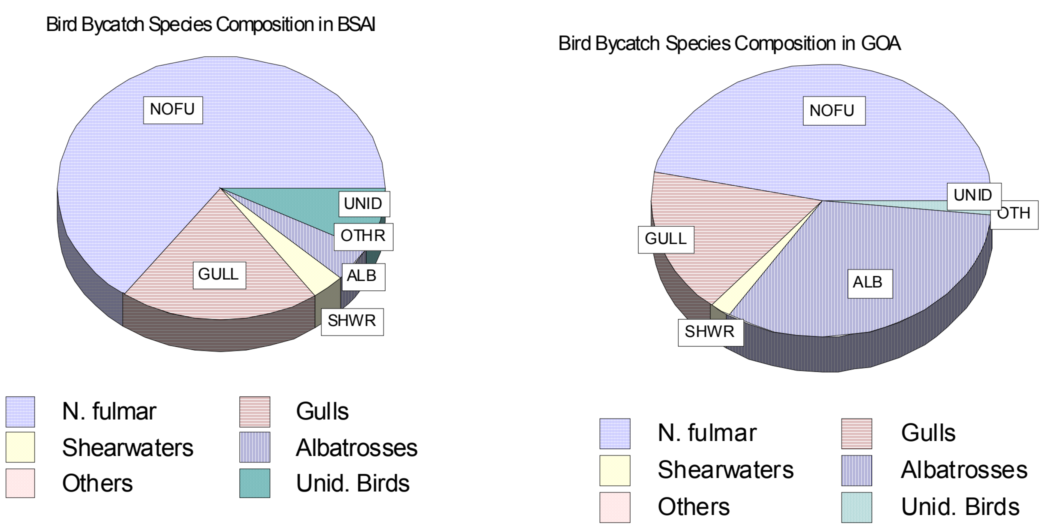


Fig 15. Relative Species Composition of Seabird Incidental Catch in the Longline Fisheries, BSAI (left) and GOA (right). Average annual estimates, 1997-2001.

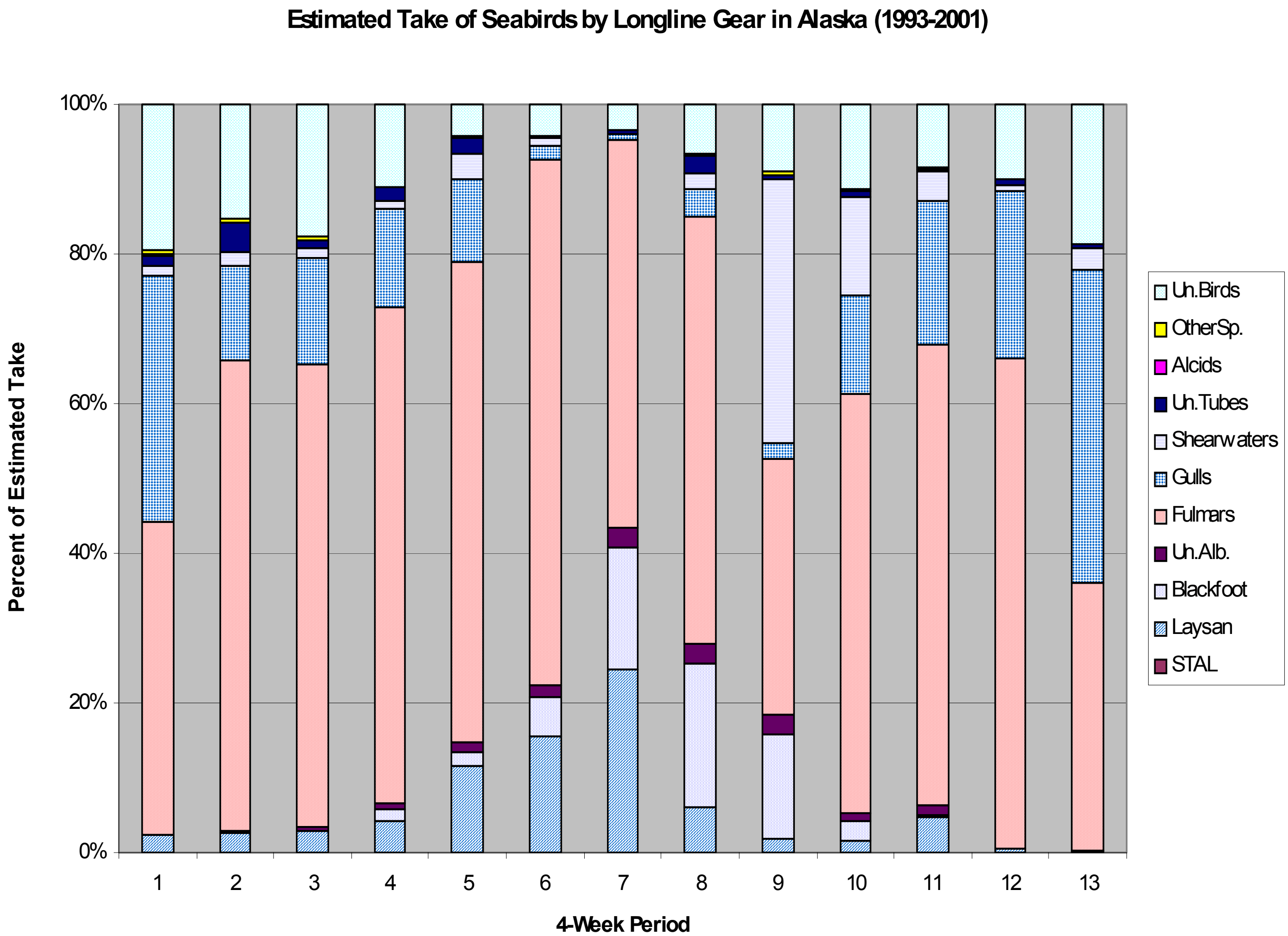


Figure 16: Cumulative Estimated Seabird Incidental Catch in Longline Fisheries in Alaska, by Species Group, by 4-Week Periods, 1993-2001.

Efforts to Reduce Seabird Incidental Catch in Longline Fisheries

The NMFS Alaska Region has been involved with ongoing efforts to reduce seabird bycatch in the longline fisheries off Alaska since the early 1990s. Efforts have included: collection of bycatch data via onboard observers; outreach and education to the fishing fleet and other stakeholders; coordination with the USFWS and full compliance with requirements of biological opinions issued under the ESA; requiring the use of seabird avoidance measures by vessel operators in longline fisheries off Alaska; research on the effectiveness of such measures; implementation of the United States' *National Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries* (NPOA); and international coordination with scientists, fishery managers, and organizations involved with these issues in other parts of the world. Participants from the NMFS Alaska Region, the Council, USFWS, fishermen, and researchers will join others in attending the *Second International Fishers Forum* in November 2002. The primary mission of the forum is to convene an international meeting of fishermen to address possible solutions to incidental catch of sea turtles and seabirds by longline fishing gear. Additional details of these Alaska Region efforts are available in several documents cited here (NMFS 1998, 1999, 2001a, 2001c, 2001d).

The NPOA contains several action elements, one which pertains to reporting. The NPOA states that "NMFS, in collaboration with the appropriate [Regional Fishery Management] Councils and in consultation with USFWS, will prepare an annual report on the status of seabird mortality for each longline fishery, including assessment information, mitigation measures, and research efforts. USFWS will also provide regionally-based seabird population status information that will be included in the annual reports. The reports will be submitted annually as part of the Stock Assessment and Fishery Evaluation (SAFE) Report that is already provided on an annual basis by NMFS and made widely available. Such annual reports will be compiled and incorporated into NMFS' biennial status report to FAO on its implementation of the *Code of Conduct for Responsible Fisheries*." The information contained within this seabird section of the "Ecosystem Considerations for 2003" hereby serves to fulfill the Alaska Region's requirements for annual NPOA reporting.

Mitigation Measures

NMFS required hook-and-line vessels fishing for groundfish in the BSAI and GOA and federally permitted hook-and-line vessels fishing for groundfish in Alaskan waters adjacent to the BSAI and GOA, to employ specified seabird avoidance measures to reduce seabird incidental catch and incidental seabird mortality in 1997 (62 FR 23176, April 29, 1997). Measures were necessary to mitigate hook-and-line fishery interactions with the short-tailed albatross and other seabird species. Prior to 1997, measures were not required, but anecdotal information suggests that some vessel operators may have used mitigation measures voluntarily. NMFS required seabird avoidance measures to be used by vessels fishing for Pacific halibut in U.S. Exclusive Economic Zone (EEZ) waters off Alaska the following year (63 FR 11161, March 6, 1998).

By regulation, all vessel operators using hook-and-line gear to fish for groundfish and Pacific halibut must conduct fishing operations as follows:

1. Use baited hooks that sink as soon as they are put in the water.
2. Discharge offal in a manner that distracts seabirds from baited hooks (if discharged at all during the setting or hauling of gear).
3. Make every reasonable effort to ensure that birds brought on board alive are released alive. In addition, all applicable hook-and-line vessels at or more than 26-ft length overall, must employ *one or more* of the next four measures.
4. Set gear at night (during hours specified in regulation).
5. Tow a streamer line or lines during deployment of gear to prevent birds from taking hooks.
6. Tow a buoy, board, stick, or other device during deployment of gear at a distance appropriate to prevent birds from taking hooks.
7. Deploy hooks underwater through a lining tube at a depth sufficient to prevent birds from settling on hooks during the deployment of gear.

Fishermen currently are provided some flexibility in choice of options in that they can select the most appropriate and practicable methods for their vessel size, fishery, and fishing operations and conditions.

In October 2001, Washington Sea Grant Program (WSGP) presented research results, recommendations, and its final report "*Solutions to Seabird Bycatch in Alaska's Demersal Longline Fisheries*" (available at http://www.wsg.washington.edu/pubs/seabirds/seabirdpaper.html) to the Council and NMFS. The Council took initial action at this meeting and final action at its December 2001 meeting.

For complete details of the research, results, and recommendations, see the WSGP final report. In summary, the WSGP research program compared seabird incidental take mitigation strategies over 2 years (1999 and 2000) in 2 major Alaska demersal longline fisheries: the Individual Fishing Quota (IFQ) fishery in the GOA and Aleutian Islands for sablefish and halibut and the Bering Sea catcher-processor longline fishery for Pacific cod. A key feature of the program was an industry-agency-academic collaboration to identify possible deterrents and test them on active fishing vessels under typical fishing conditions. The avoidance measures tested were: paired streamer lines, single streamer lines, weighted groundline, line shooter, lining tube, and a combination of paired streamer lines and weighted groundline. Experimentally rigorous tests of seabird avoidance measures on the local abundance, attack rate, and hooking rate of seabirds in both fisheries were conducted on vessels over 60 ft (18.3 m) LOA. On vessels this size (larger vessels), paired streamer lines of specified performance and material standards were found to successfully reduce seabird incidental take in all years, regions, and fleets (88 percent to 100 percent relative to controls with no deterrent). Single streamer lines of specified performance and material standards were slightly less effective than paired streamer lines, reducing seabird incidental take by 96 percent and 71 percent in the sablefish and cod fisheries, respectively. This study represents the largest of its kind in the world with over 1.2 million hooks being set in the sablefish fishery and over 6.3 million hooks being set in the cod fishery component of the 2-year research program.

The Council's recommendations to NMFS for revised seabird avoidance measures are:

- Vessels over 55 ft (16.8 m) LOA using hook-and-line gear in the EEZ would be required to use paired streamer lines of specified performance and materials standards.
- Vessels over 26 ft (7.9 m) LOA to 55 ft (16.8 m) LOA using hook-and-line gear would be required to use less stringent measures such as a buoy bag line or single streamer line—each with its own specified performance and materials standards. The requirement would depend upon fishing location ['Inside' or EEZ, where 'Inside' is Prince William Sound (NMFS Area 649), Southeast Inside District (NMFS Area 659), and state waters of Cook Inlet], vessel type (if masts, poles, or rigging are on vessel), and gear type (if snap gear is used).
- The performance and material standards for measures required on smaller vessels would be guidelines for an interim one-year period, at which time they would become required.
- Directed discharge (through chutes, pipes, or other similar devices suited for purpose of offal discharge) of residual bait or offal from the stern of the vessel while setting gear would be prohibited.
- Prior to offal discharge, embedded hooks would be removed from offal.
- A Seabird Avoidance Plan would be required onboard the vessel.
- Vessels less than or equal to 32 ft (9.8 m) LOA fishing for halibut in IPHC Area 4E within 0 to 3 miles of shore would be exempt from seabird avoidance measures.
- Vessels less than or equal to 26 ft (7.9 m) LOA would continue to be exempt from seabird avoidance measures.

The proposed seabird avoidance measures would apply to the operators of vessels using hook-and-line gear for:

- Pacific halibut in the IFQ and Community Development Quota (CDQ) management programs (0 to 200 nm),
- IFQ sablefish in EEZ waters (3 to 200 nm) and waters of the State of Alaska (0 to 3 nm), except waters of Prince William Sound and areas in which sablefish fishing is managed under a State of Alaska limited entry program (Clarence Strait, Chatham Strait), and
- Groundfish (except IFQ sablefish) with hook-and-line gear in the U.S. EEZ waters off Alaska (3-200 nm).

At its March 2002 meeting, the Alaska Board of Fisheries (Board) approved a Board-generated proposal that will change state groundfish regulations to parallel federal regulations governing seabird avoidance measure requirements for operators in hook-and-line fisheries. NMFS is currently promulgating regulations based on these Council recommendations.

Incidental Catch in Trawls

Trawls primarily catch seabirds that dive for their prey. This probably occurs as the trawl is being retrieved rather than while it is actively fishing. A few birds may also be caught as they are attempting to scavenge fish or detritus at the surface during retrieval. The species composition of seabird incidental catch in observed trawl hauls is currently available for 1993 through 2001. The principal bird species reported in trawl hauls were northern fulmars, gulls, shearwaters, and alcids. Small numbers of other species also were caught. NMFS analysis of 1993 to 2001 observer data indicates that trawl gear accounted for 6 to 35 percent of the total average annual seabird bycatch in the BSAI and GOA groundfish fisheries combined, depending on the trawl sampling methodology used (Figure 14).

Onboard observations of birds (including Laysan albatrosses) colliding with the trawl transducer wires (sometimes called third wire) have been made. These wires are typically deployed from the stern of midwater trawl vessels fishing for pollock and carry the transducer net sounder cable down to the head of the trawl net. Any birds killed by such collisions would most likely not be recorded in the observers' sampling of the trawl haul in that it is unlikely that such dead birds would make their way into the trawl net. NMFS is investigating the extent of use of trawl third wires in the trawl fleet and additional details of the bird/vessel interactions. Solutions may be as simple as hanging streamers from the third wire or trawl gantry (Balogh, USFWS; N. Smith, New Zealand Ministry of Fisheries pers. comm.). See the 'Vessel Strike' section below for additional information about this bird/trawl interaction.

Vessel Strikes

Striking of vessels by birds in flight is reported by observers, and their observations from 1993 - 2000 have recently been put in an Observer Notes Database (USFWS, Anchorage). The bird-strike data are preliminary and have not been analyzed statistically, but some quantitative summaries can be made. Of the over 2600 observation records (which include albatross sightings, vessel strikes, rare seabird observations, effectiveness of mitigation devices, etc.) there are 537 reports of birds found on the vessel, or birds striking the vessel or rigging. The records include 79 species or species groups and involve over 5,300 birds. Of these, 136 records are definitive reports of birds striking the vessel (n = 101), the rigging (n = 19), or specifically striking the 'third wire' on trawl gear (n = 16). The third wire incidents involved 79 birds, mainly fulmars and Laysan albatross, with approximately 90% mortality. The main species involved in vessel strikes were northern fulmars, Laysan albatross, storm petrels, and crested auklets, and for all vessel strikes, almost half of the birds were killed or injured.

Details on the location, time of day, or weather condition are mostly incomplete, pending the merging of observations via their cruise number and haul number to the NORPAC database. For the limited number of records that included such observations, most of the bird-vessel interactions (n= 224) occurred at night (63%) and where weather was recorded (n = 53), it was usually snowing (83%), with some occurring during rain (10%) or fog (7%). Birds are especially prone to strike vessels during storms or foggy conditions when bright deck lights are on, which can disorient them. The proximity of the vessels to seabird colonies during the breeding season is also a factor (USFWS, V. Byrd pers. com).

Incidents of vessel strikes were most frequent for fulmars (564 birds in 38 incidents), Laysan albatross (21 birds in 15 incidents), or petrel species (631 birds in 19 incidents), but the total number of birds involved was greatest for crested auklets (1,305 birds in 7 incidents). Another species with few events but large numbers of birds was the sooty shearwater (526 birds in 6 incidents). Crested auklets appear to be particularly susceptible to collisions; in winter of 1977 an estimated 6,000 crested auklets were attracted to lights and collided with a fishing vessel near Kodiak Island, and in 1964 in the central

Aleutians, approximately 1,100 crested auklets were attracted to deck lights on a processor and collided with structures on the vessel (Dick and Donaldson 1978).

Many trawl vessels deploy a cable ("third wire") from the vessel to the trawl net monitoring device. Seabird mortality resulting from interactions with the third wire has been documented, but is not directly monitored by groundfish observers. Therefore, the temporal and spatial distribution of seabird mortalities or injuries by species is unknown. NMFS's Alaska Fisheries Science Center is currently pursuing contractual arrangements for a study that would use video technology to evaluate the feasibility of detecting and identifying interactions of seabirds with the trawl third wire during trawl fishing operations.

Research Initiatives and Additional Research Needs

In 1999 and 2000, the WSGP compared seabird bycatch mitigation strategies in 2 major Alaska demersal longline fisheries: the GOA and AI IFQ fishery for sablefish and halibut and the BS catcher-processor longline fishery for Pacific cod. Researchers conducted experimentally rigorous tests of seabird bycatch deterrents on the local abundance, attack rate, and hooking rate of seabirds in both fisheries. The goal was to identify mitigation devices that significantly reduced seabird bycatch with no loss of target catch or increase in the bycatch of other organisms. Control sets with no deterrent established a baseline and allowed exploration of seabird interaction with longline gear as a function of temporal and spatial variation, physical factors such as wind and sea state, and fishery practices (Melvin et al 2001). A key feature of this program was an industry-agency-academic collaboration to identify possible deterrents and test them on active fishing vessels under typical fishing conditions. At its December 2001 meeting, the Council made recommendations to NMFS for changes to the existing regulations based on the WSGP research. NMFS is currently promulgating changes to the existing regulations. See the previous section on "mitigation measures" for additional details as well as the WSGP final report (Melvin et al 2001).

Section 4.3.4 of the Alaska Groundfish Fisheries DPSEIS included several research and/or analysis needs identified by scientists currently researching seabirds in the BSAI and GOA ecosystem (NMFS, 2001a). As the information gaps are filled, the view of how seabirds are affected by fisheries may change. Some additional research and analysis needs identified in SSC comments on the DPSEIS, in the *Draft: Bering Sea Ecosystem Research Plan* (AFSC, 1998) and by other seabird scientists are:

- Quantitative models to help evaluate the potential population-level impact of fisheries-related seabird mortality, particularly for those seabirds species that are killed in high numbers (e.g. northern fulmar), for abundant species (e.g. sooty shearwater and short-tailed shearwater, Laysan's albatross), and for less abundant species of concern (black-footed albatross).

- For many species, the potential impact of bycatch mortality needs to be assessed at the colony level. That is, are particular colonies more susceptible to bycatch impacts because of the temporal and spatial distribution of fisheries?

- Quantitative models to help evaluate the potential population-level impacts from the availability of fishery discards and offal, particularly on juvenile birds.

- Research and analysis to ascertain how much benefit seabirds of the North Pacific derive from discards and offal and to then balance that with the adverse impacts associated with the incidental take of seabirds in fishing gear as a result of vessels attracting birds via the processing wastes and offal that are discharged.

- In varying the timing of fishing effort, there may be some effects on the value to seabirds of the discards and offal that result from the fishing activity. Discards in times when the seabirds have high energy demands or when naturally available food is hard to obtain may be more valuable to the seabirds than would be true in times of plentiful prey. A question that should be explored is whether pulsed fishing saturates the ability of the seabirds to take advantage of the waste produced.

- Compilation of pelagic (at-sea) data on distribution of seabirds in Alaska and elsewhere in the North Pacific. Such data on the pelagic distribution and abundance of seabirds is critical for addressing questions such as raised in this analysis on seabirds and could be used to assess the potential interactions between commercial fisheries and seabirds (e.g. longlines and albatrosses).

- Satellite telemetry studies on the short-tailed albatross, a rare and endangered species, to accurately identify spatial and temporal distribution patterns in the BSAI and GOA, particularly as they intersect with commercial fishing activity and the potential for interactions.

- Investigate the extent of use of trawl third wires in the trawl fleet, evaluate the extent to which seabirds interact with this third wire, and if necessary, pursue the development and/or identification of practical and effective methods and devices to reduce seabird interactions with trawl vessels equipped with trawl third wires.

- Conduct a more detailed analysis of multi-year data sets of seabird bycatch to include factors such as: spatial and temporal factors for both fishing effort and seabird distribution, vessel type, effectiveness of seabird deterrent devices.

- Develop and support a minimal program to piggyback marine bird observations on suitable monitoring platforms (e.g. ADF&G, IPHC, and NMFS longline surveys; research cruises).

- Examine the temporal and spatial scale of marine bird aggregations with respect to ephemeral and stable oceanographic features and prey aggregations.

- Use telemetry and standard ship transect methods to define (horizontally and vertically) seabird apex predator feeding areas both in the Being Sea during summer and in areas outside the Bering Sea that may be visited seasonally and to define the relationship of feeding areas to principal fishing areas. Identify and quantify food items used by seabirds in these areas of overlap.

- Expand collection and sysnthesis of data on seabird diet to include fall through spring months, and for all seasons, examine regional patterns of prey use and trends over time.

- Cooperative gear research on commercial fishing vessels to evaluate effective methods for setting longlines underwater to prevent access by seabirds. Methods could include: underwater setting chutes, lining tubes, line-weighting.

In 2001 and 2002, steps were taken to address many of these research gaps by way of a congressional funding initiative. In both years, Congress allocated $575,000 to the USFWS–Office of Migratory Bird Management to reduce the impact of seabird bycatch in Alaska fisheries. Studies and contracts, implemented in FY01 and FY02, addressed the following:

1. *Demographics and Productivity of Albatrosses at Their Breeding Sites*
Recent declines in black-footed albatross, and the high bycatch rate of Laysan albatross, require more sophisticated analyses and modeling of potential population-level effects from incidental catch in groundfish fisheries. Analysis of long-term data from the Northern Hawaiian Islands breeding sites was initiated with this funding. Additionally, a banding database will be completed this year, with the goal of assisting demographics and modeling efforts.

2. Demographics of Albatrosses and Fulmars Caught in Alaska Longline Fisheries
The NMFS North Pacific Groundfish Observer Program began collecting albatross and fulmar carcasses from birds caught in longline fisheries from the BSAI, to be shipped to the University of Alaska, Fairbanks. The UAF Museum has been processing the carcasses to obtain demographic information such as age and sex, as well as body size, condition and other mensural characteristics. Salvaged tissue samples will be sent to USGS/BRD and University of Washington researchers to conduct genetic analyses. Genetic studies may identify colony or region of origin, and together with the demographic information, assist modeling to determine whether population-level effects occur. The project will extend in 2003 to include the GOA region. To date, over 80 carcasses have been processed.

Funds also supported a pilot satellite telemetry project on fulmars (presented in this report). This will eventually determine where fulmars forage throughout the year, to alert fishers of high density fulmar regions and better understand population dynamics.

3. Short-tailed Albatross Satellite Telemetry Tracking and Data Analysis
A joint U.S.-Japan initiative was implemented to determine the occurrence and marine habitat use of the endangered Short-tailed albatross in the Bering Sea and North Pacific. In 2001 and 2002 birds were tagged at Torishima Island, Japan, and a contract was established to fund analysis of albatross distribution and marine habitat use of tagged birds. Information will alert fishers of albatross high-use areas, and will benefit efforts to enhance albatross population recovery and delisting.

4. Pelagic Seabird Database
All agencies identify the need for a comprehensive database on offshore distribution and abundance of waterbirds in Alaska. Over three decades of various types of surveys need to be standardized and synthesized, but could answer basic questions such as where the birds are, when are they present and how many are there. The database will eventually be available to agency and industry groups via a website, to provide fishers with locations of high density seabird areas to promote bycatch avoidance and efficiency in fishing.

Work began on the development of the North Pacific Pelagic Seabird Database, via a contract with the USGS/BRD, in cooperation with USFWS, NMFS, and MMS. Preliminary results from this effort include the at-sea distribution maps of selected seabirds subject to incidental catch in the fisheries, which have been incorporated into this chapter section. As the database is completed and updated, it will assist analysis of additional aspects of seabird distribution, such as long-term temporal and spatial changes.

5. *Educational Video for Fishers*
A contract was established with the Washington Sea Grant Program, University of Washington, to develop a video for fishers, to alert them to the problem of seabird bycatch, methods to reduce bycatch, and instruction on the deployment of bycatch avoidance devices. Footage of fishing operations and streamer deployment have been made, and work has begun on the production of the video.

6. *Fishery Observer Bird Observation Report*
The NMFS North Pacific Groundfish Observer Program contributes incidental information on seabird sightings and seabird-related incidents to the USFWS. The information, while valuable, was not in an easily accessible database. This project entered the observations into a database to make them accessible and quantifiable to all user groups. The main entries of interest include albatross sightings, vessel strikes, rare seabird observations, and notes on effectiveness of mitigation devices. Preliminary results, some of which have been included in this report, assisted in the development of new Seabird Daily Log data sheets. The observer records will be merged with the NORPAC database to complete information such as location and weather for each record.

7. *Test Of A Prototype Weighted Sink Line*
To continue the search for more universally practical, cost effective and efficient methods, this project tests the effectiveness of integrated weight groundlines as a seabird bycatch deterrent in longline fisheries. The Washington Sea Grant Program conducted field tests in Alaska in 2002 on 4 types of lines under different boat sizes and configurations, and will make results available to all parties. Preliminary results indicated that weighted groundlines could be cost-effective and successful at reducing incidental take of birds.

8. *Test Bycatch Reduction Devices On Small Vessels*
Paired streamer lines, properly deployed, are effective in reducing seabird bycatch, but tests conducted between 1999 and 2000 were based on vessels > 55 ft. This project studied the effectiveness of performance and material standards for small vessels to reduce seabird bycatch. In a cooperative study between USFWS and Washington Sea Grant, field work was completed in June 2002 and a final report on the results will be made available in October 2002, to assist NMFS and the Council in defining regulatory actions.

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