Cook Inlet Seabird and Forage Fish Studies (CISeaFFS)

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It is difficult to assess the potential for recovery of seabirds from the Exxon Valdez oil spill (EVOS) and other human impacts (e.g., gill-nets, harvest, commercial fisheries, etc.) because long-term changes in the marine environment were apparently also affecting seabirds at the time of the spill, and during subsequent years. Since the late 1970's, seabirds in the Gulf of Alaska have shown signs of food stress: population declines, decreased productivity, changes in diet, and large-scale die-offs. Small-mesh fishing trawls conducted during the past 30 years reveal that a major shift in fish community composition occurred in the late 1970's: some forage species (e.g., capelin) virtually disappeared, while predatory fish (e.g., pollock) populations increased markedly. These changes correlate with long-term cycles in seawater temperature. It is not known whether fish communities will return to their previous composition and population levels.

CISeaFFS ("Sisyphus") was initiated in 1995 as a long-term research project to characterize relationships between seabird population dynamics, foraging behavior, and forage fish densities in lower Cook Inlet— the area in which most seabirds were killed by the EVOS. CISeaFFS is a multidisciplinary research project of the Alaska Science Center and the Alaska Maritime National Wildlife Refuge, which has management responsibility for most seabird colonies in Alaska.

METHODS

In 1995 and 1996, populations, productivity, diets and foraging behavior of seven seabird species (Common Murre, Black-legged Kittiwake, Pigeon Guillemot, Tufted Puffin, Horned Puffin, Pelagic Cormorant, Glaucous-winged Gull) were studied at three seabird colonies in lower Cook Inlet (Chisik, Gull and Barren islands). Oceanographic measurements (SST's, CTD's), seabird transects and hydroacoustic surveys for fish, mid-water and benthic trawls, and beach seines were conducted in core study areas around (<40 km) each colony (Figure 1, next page). In 1996, surveys extended throughout lower Cook Inlet, as far south as Shuyak Island. Also in 1996, coastal transects were added to the survey of core areas to increase sampling of the productive nearshore zone.

OCEANOGRAPHY

The Alaska Coastal Current flows west and north into Cook Inlet (Figure 2), and upwelling of cold, nutrient-rich water occurs around islands and on shallow coastal shelves (Figure 3). Satellite imagery shows this cold water extending well north into Cook Inlet and Kachemak Bay (Figure 3). Vertical CTD salinity and temperature profiles of the water column (Figure 4), and continuously recording temperature probes (Figure 5), reveal that water around the Barrens is completely mixed, cold, and highly saline. Water in Kachemak Bay has a shallow layer of warm, low-salinity water overlaying cold, saline water like that observed at the Barrens. Water near Chisik Island, on the west side of Cook Inlet, is much warmer and less saline, because south-flowing currents carry warm, fresh water from the head of Cook Inlet. The difference in oceanographic regimes between the east and west side of Cook Inlet has important implications for the forage fish and seabirds residing in each area.

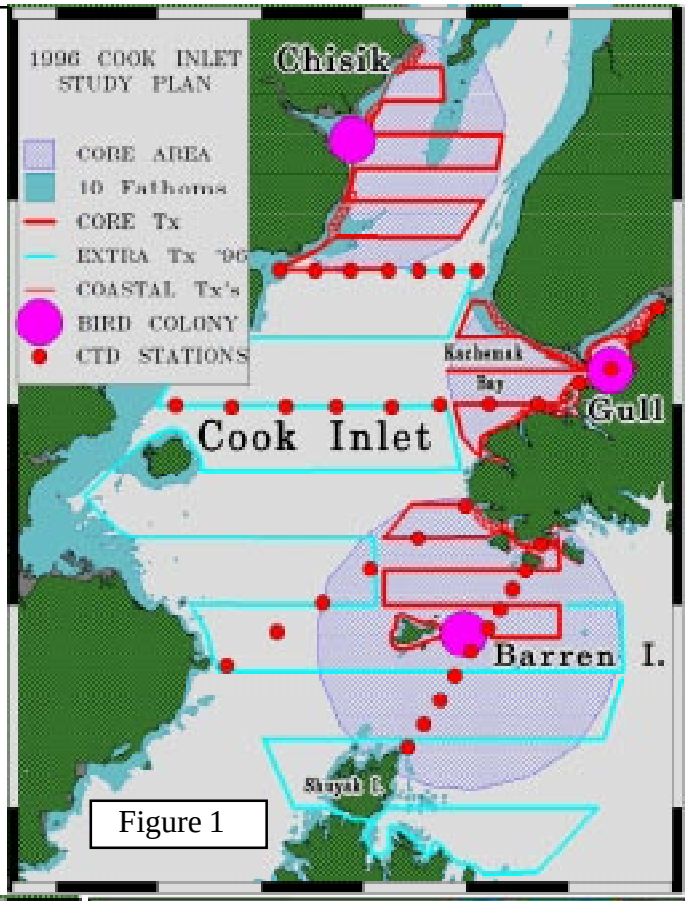


Figure 1

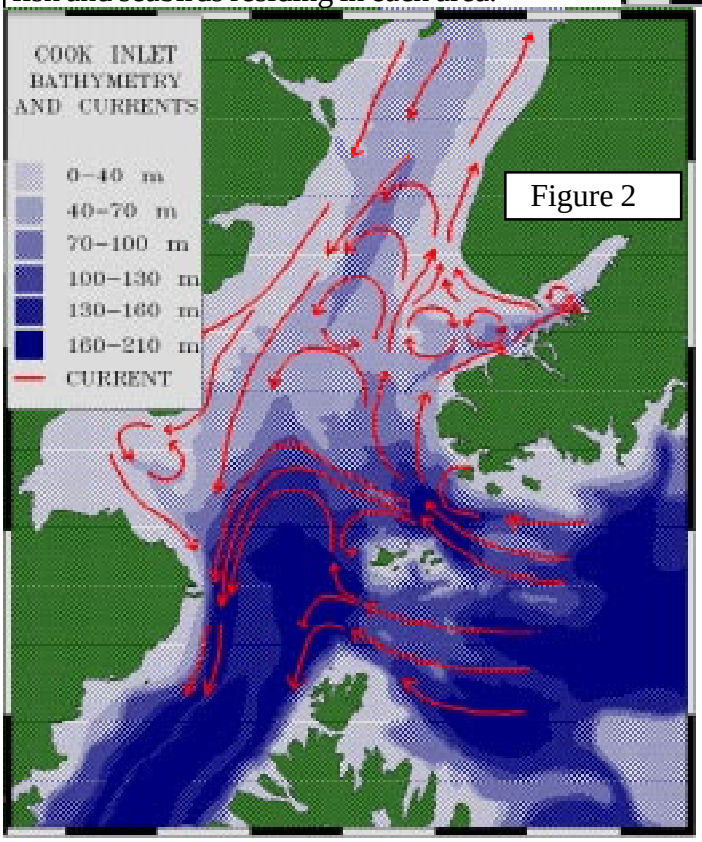


Figure 2

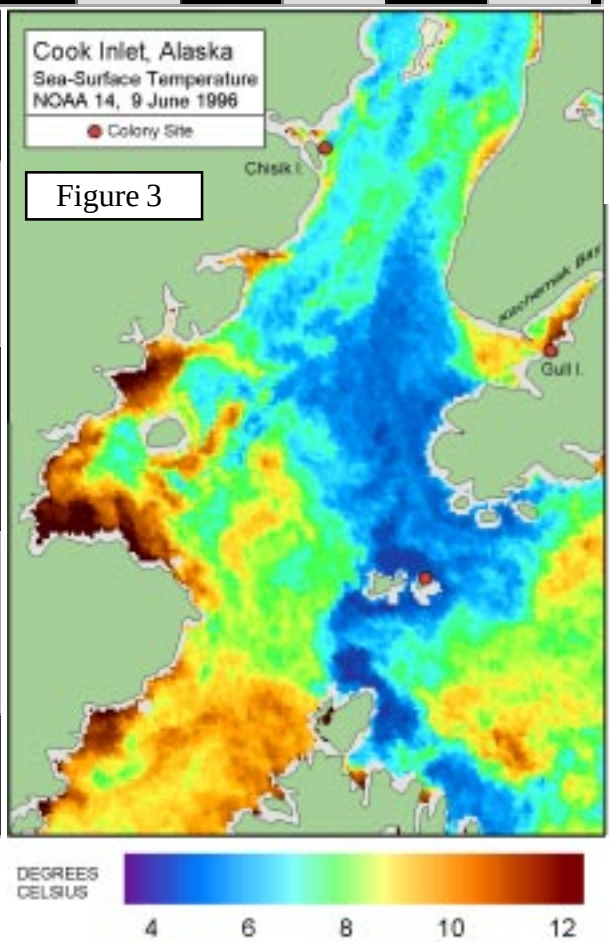


Figure 3

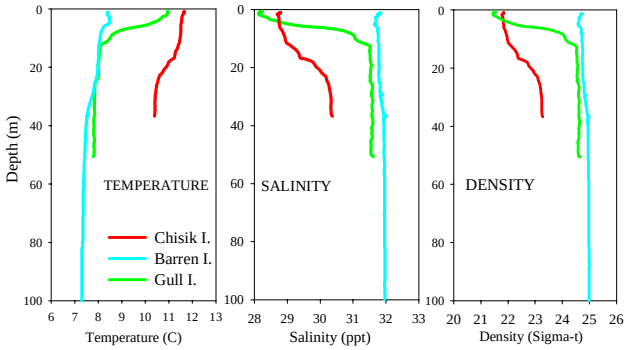


Figure 4. Temperature, salinity and density profiles of the water column at the three study colonies obtained from CTD casts in July, 1996

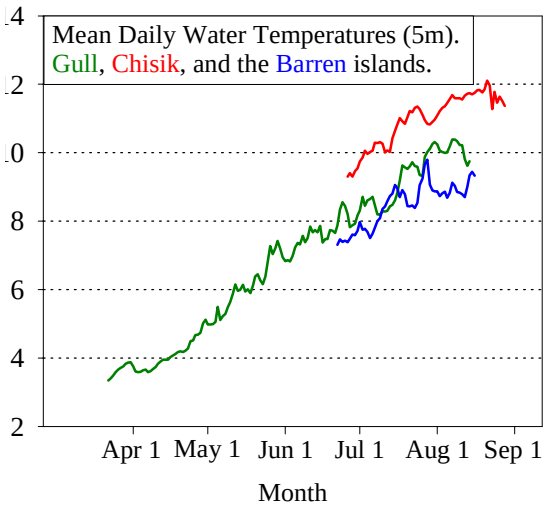


Figure 5. Mean daily water temperatures at 5 m depth obtained from continuously recording temperature probes at the three study colonies in Cook Inlet.

FISH

The abundance and species composition of fish in Cook Inlet were examined by conducting mid-water and benthic trawls (Figures 6&8), beach seines (Figures 7&8), and hydroacoustic surveys (Figures 9&10). Pelagic forage fish abundance increased by about an order of magnitude (Fig. 10), and diversity decreased (Fig. 8), as we sampled from North (Chisik) to South (Barrens). Benthic trawls revealed a similar pattern for bottom fishes. Pacific sandlance dominated in both coastal and offshore waters around Gull Island (Kachemak Bay), although capelin and pollock were also common offshore. Around the Barrens, juvenile pollock and capelin dominated offshore catches, while coastal beach seines caught sandlance almost exclusively. The abundance of fish in coastal waters varied seasonally (Figure 7), with peak seine catches in June-August for most species.

"The Mighty Sandlance", watercolor by William Spear (1994)

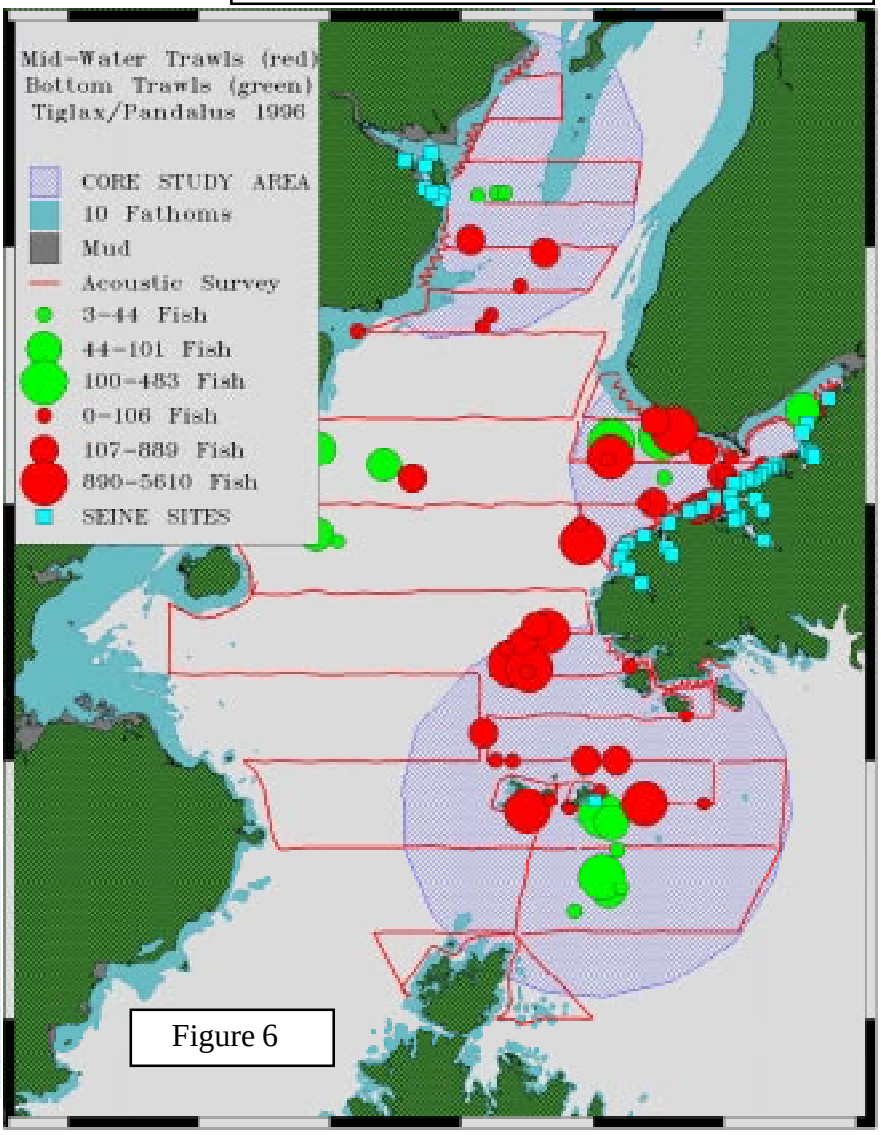


Figure 6

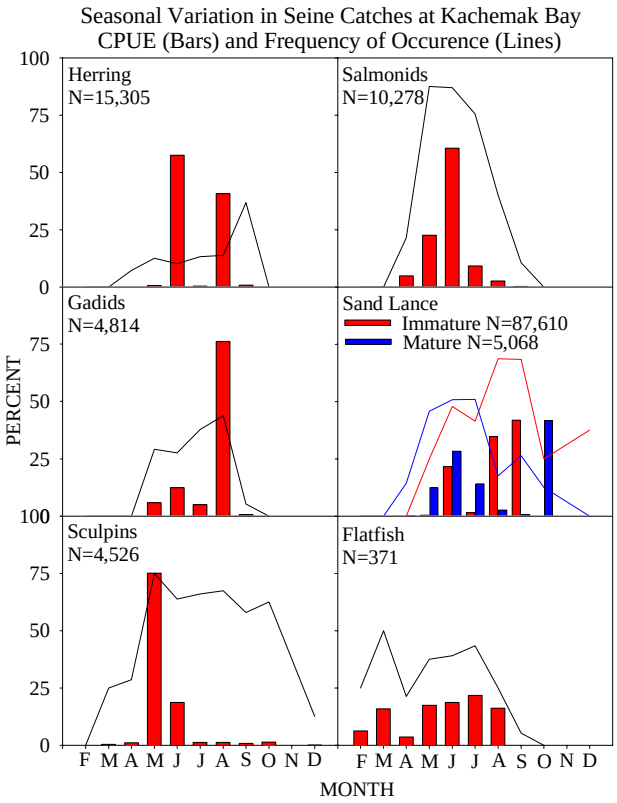


Figure 7. Catch per unit effort (CPUE) and frequency of occurrence of fish caught in beach seines in Kachemak Bay, 1996.

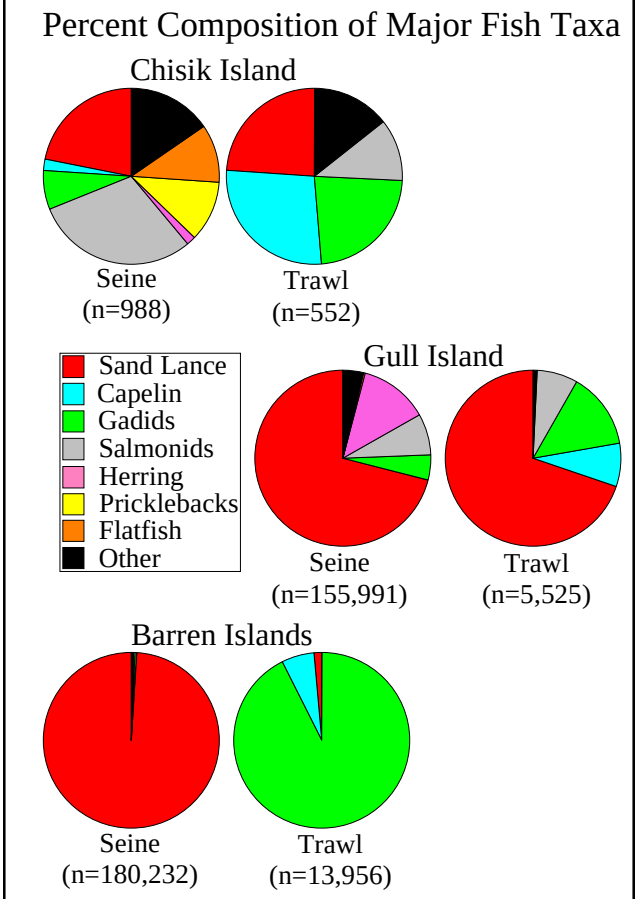


Figure 8. Species composition of fish catches in mid-water trawls and beach seines in lower Cook Inlet, summer 1996.

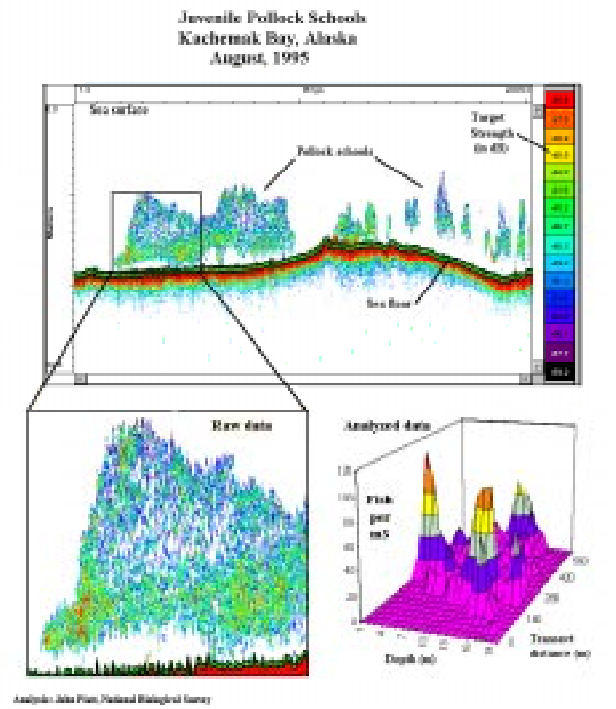


Figure 9. Example of fish schools recorded on a Biosonics DT4000 Digital Echosounder, and integration to obtain absolute fish densities.

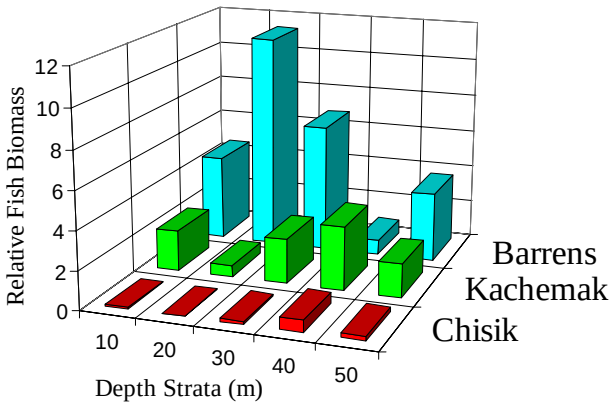


Figure 10. Relative abundance of fish in each of the three core colony study areas (Fig. 1) as determined by hydroacoustic surveys in summer, 1995. (Similar results in 1996).

SEABIRDS AT SEA

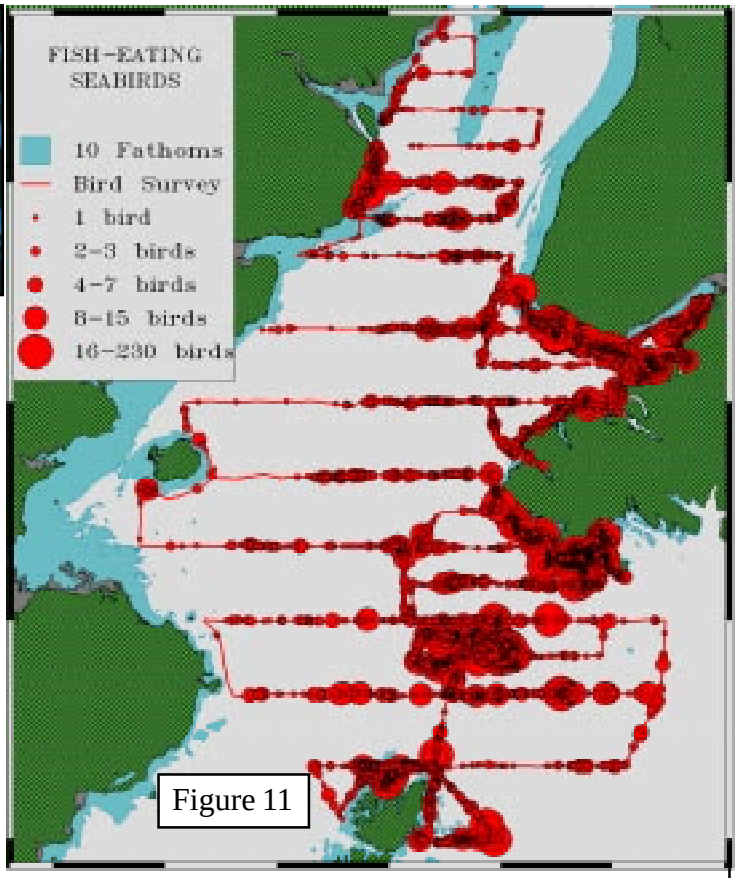


Figure 11

The abundance and distribution of fish-eating seabirds corresponded to patterns of oceanography and fish distribution in lower Cook Inlet. Seabirds were concentrated around the Barrens (Fig. 11), northeast along the Kenai coast, and in Kachemak Bay. Shallow coastal habitats were particularly rich, whereas birds were conspicuously scarce in the west half of lower Cook Inlet. A detailed look at Common Murre distribution (Figure 12) reveals that high-density murre foraging areas are close to Gull Island in Kachemak Bay, and further away from the Barrens in several directions. Chisik murres forage little in the vicinity of Chisik Island, and appear to fly southeast to good foraging areas in Kachemak Bay. Kittiwakes reveal a similar pattern (Figure 13), except many appear to forage within 40-50 km of Chisik, and birds from the Barrens forage a long distance north along the coast of the Kenai Peninsula.

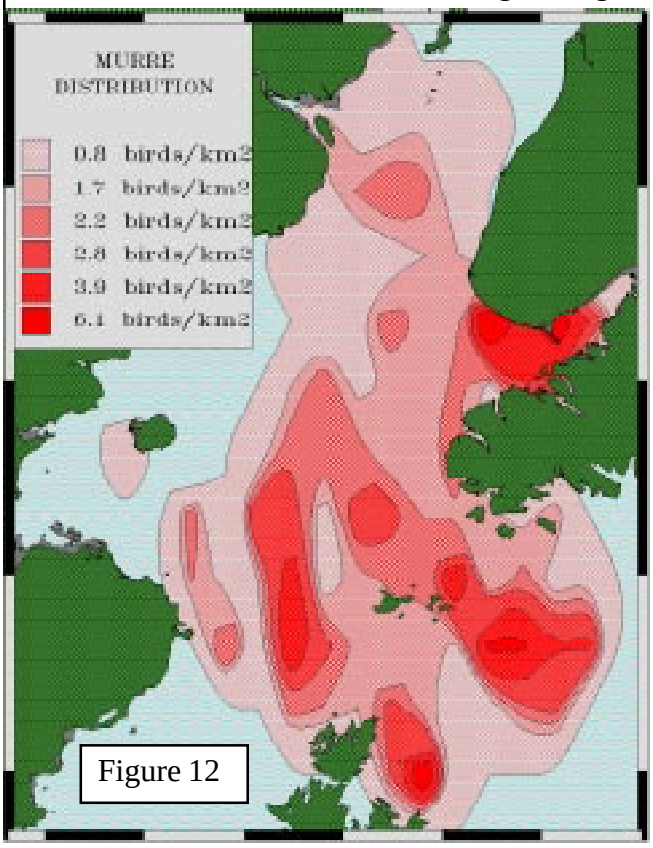


Figure 12

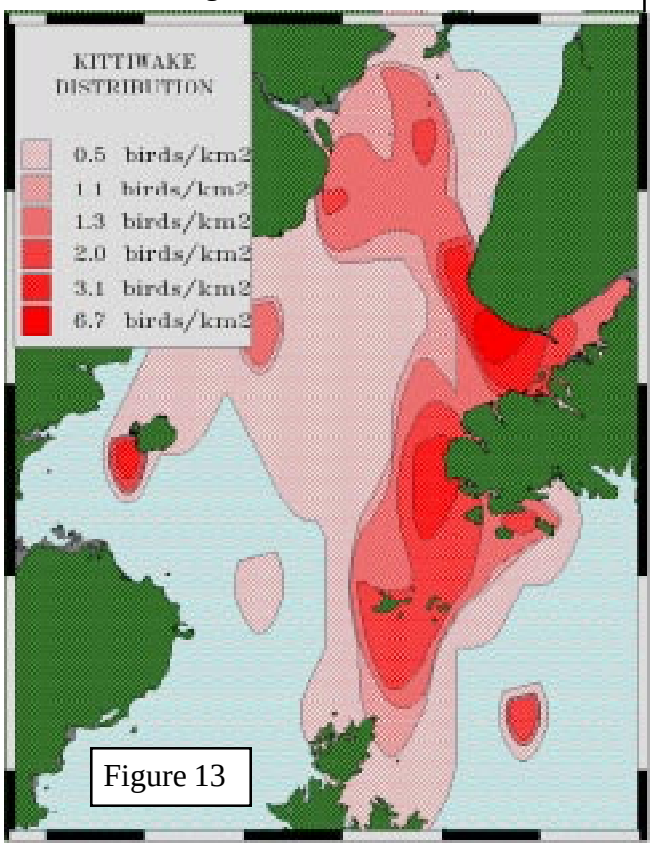


Figure 13

SEABIRDS AT COLONIES
— THE BOTTOM LINE—

We consider here preliminary analyses of data on Common Murres and Black-legged Kittiwakes. Diets of chicks fed by adults in 1996 (Figure 14) reflect the patterns observed from fish and bird surveys at sea. Diet diversity decreases from North to South. Kittiwakes feed chicks more on sandlance in coastal areas (especially in the North), whereas murre chick diets include more offshore species such as capelin and pollock (especially in the South). Adult murres preferentially feed chicks energy-rich capelin. In 1996, adult diets comprised more than 70% pollock, while chicks were fed more than 90% capelin (Figure 14).

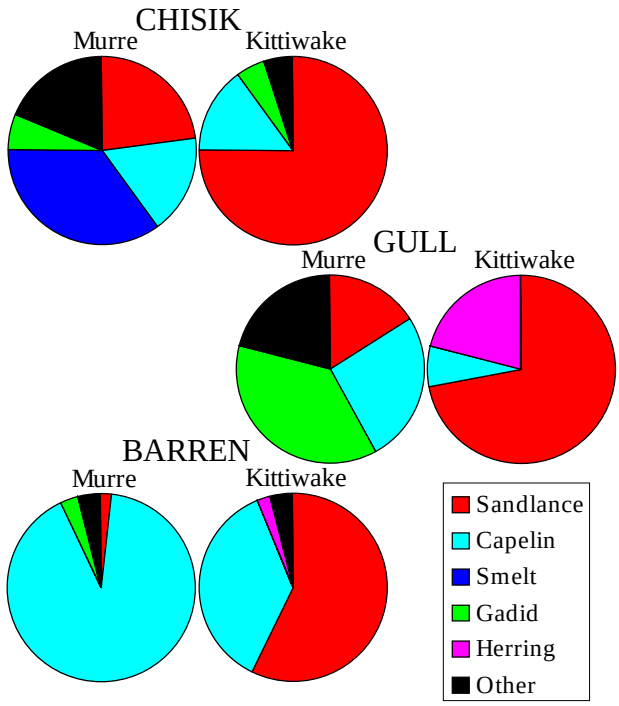
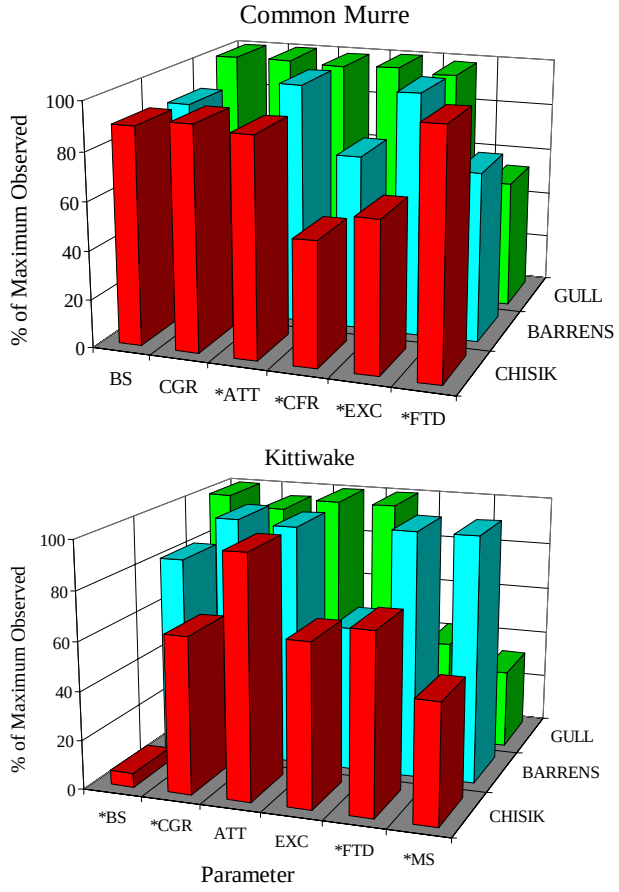


Figure 14. Diet composition of Common Murre and Black-legged Kittiwake chicks in lower Cook Inlet, summer, 1996.

Figure 15. Variation in different parameters of breeding and behavior for murres and kittiwakes at each of 3 study colonies in 1996.



Parameters: BS- Breeding Success, CGR- Chick Growth Rate, ATT- Attendance by Adults, CFR- Chick Feeding rate, EXC- Exchange Rate of Brooding Adults, FTD- Foraging Time Duration, MS- Mean Meal Size. Asterisk (*) indicates significant difference in parameter values between colonies.

The results of studies at colonies and at sea can be integrated by contrasting murre and kittiwake population parameters at the three study colonies. Data are expressed as percentages of highest observed parameter values (Figure 15). For example, murre breeding success was highest at Gull Island (100%=0.87 chicks/pair), and proportionally lower at Chisik (0.78 ch/pr) and the Barrens (0.77 ch/pr). There was no statistical difference in chick production between colonies, despite the apparent regional differences in fish availability. Murre chick growth rates also did not differ between Chisik and Gull islands (no data from Barrens). However, murres at Chisik spent more time foraging (mean trip = 243 min), fed chicks less frequently (only 2.58 meals/day), and had fewer brooding exchanges (usually after feeding chicks), than murres at the Barrens or Gull Island. As one indication of this extra effort , murres at Chisik spent less time in attendance (“loafing”) at nest-sites compared to Gull Island (Figure 16). However, even Gull Island birds appeared stressed during late chick-rearing (29 August). Despite the extra effort required at Chisik, murres there managed to maintain high chick production.

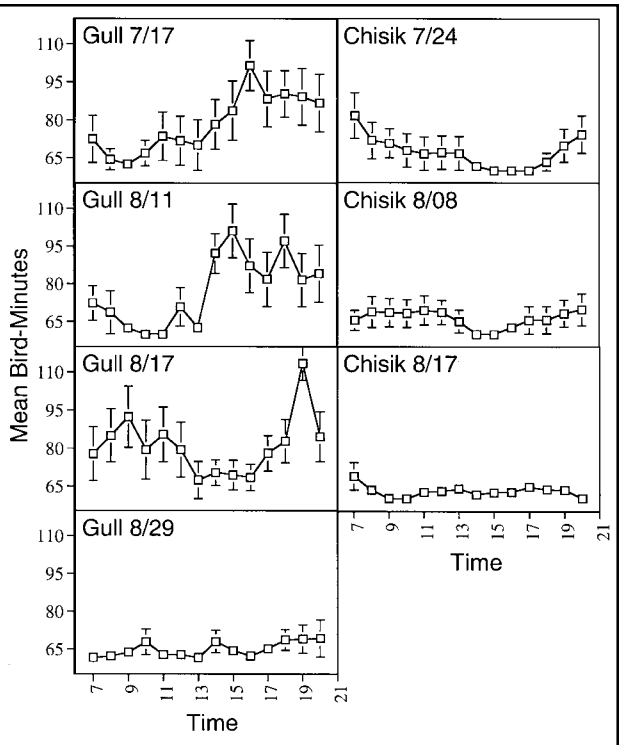
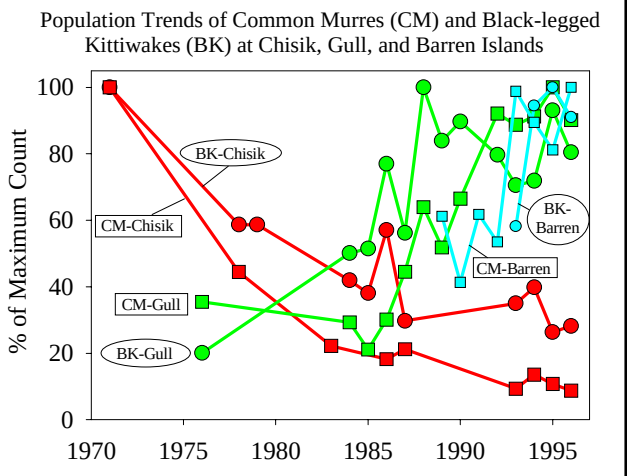


Figure 16. Diurnal attendance patterns of murres at Gull and Chisik Islands during incubation (July) and chick-rearing (August). Note >60 bird-minutes = "Loafing"

Kittiwakes exhibited a very different response (Figure 15). While productivity was high at Gull Island (0.87 ch/pr), kittiwakes almost failed to fledge chicks at Chisik. Similarly, chick growth rates were much lower at Chisik (11.1 g/day). Attendance at nest-sites did not vary between colonies, but this is because rarely was more than one bird present at a nest (unlike murres where the "off-duty" bird often spent hours "loafing" at the site). Chick meal deliveries are difficult to measure as kittiwakes regurgitate many times at "one feeding", but brooding exchange rates were low at both Chisik and the Barrens compared to Gull Island. Correspondingly, Barrens (mean=5.4 h) and Chisik (4.0 h) kittiwakes spent far more time away on foraging trips. Unlike murres, which can carry only one fish at a time, kittiwakes may carry many fish in their crop to regurgitate later to chicks. It appears that Gull Island kittiwakes make many short foraging trips, and deliver many small loads to chicks. Barrens kittiwakes make fewer and much longer foraging trips, but deliver large loads (mean=18.3 g). Chisik kittiwakes make long foraging trips, but deliver loads only slightly bigger than those at Gull Island. Apparently, the latter combination was inadequate to support chick production.

In summary, murres can compensate for shortage of food in adjacent waters by flying further, and using some of their "loafing time" to feed chicks. Kittiwakes may compensate by flying further, and carrying larger loads back to the colony— if prey are available within some threshold distance (ca. <45 km, which is less than for murres, ca. <70 km). Such was not the case at Chisik in 1996, and this problem may account for the steady decline in populations there over the past 25 years (Fig. 17). Kittiwakes have produced almost no chicks during this period. In contrast, murres at Chisik have had high breeding success during the past two years (only data available), and yet their population has been declining at a rate similar to kittiwakes. It may be that the stress of chick-rearing at Chisik increases over-winter mortality of adult murres. Alternatively, adult murres and kittiwakes may be emigrating from Chisik to Gull Island, where populations have increased substantially during the past 20 years.

Figure 17



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