Front affecting the distribution of seabirds in the northern Bering Sea

(*Extended abstract*)

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We observed seabirds aggregated at a front marking the boundary between two water masses in the Bering Sea. Least Auklets (*Aethia pusilla*) were most abundant at the front; surface-feeding species including Northern Fulmars (*Fulmarus glacialis*), Black-legged Kittiwakes (*Rissa tridactyla*) and Red Phalaropes (*Phalaropus fuscus*) were also present.

The study area, just north of Gambell on St. Lawrence Island, was visited during the breeding seasons (July–August) of 1984 to 1986. The front separates the well mixed oceanic water of the Anadyr Current from layered water resident on the shelf. The Anadyr Current passes up the west side of the northern Bering Sea and through the Bering Strait (Coachman et al. 1976). The shelf is shallow north of St. Lawrence Island (30–50m) and the water of the current is mixed from top to bottom. The Bering Shelf water is characterized by strong vertical temperature, salinity and density gradients.

The physical structure of the front was studied by measuring changes in temperature, salinity and density using a CTD probe. To assess the distribution of birds, continuous counts were made of all birds on the water in a 300 m arc from bow to beam. A small collection of Least Auklets and more extensive dietary studies from concurrent research nearby showed that large calanoid copepods dominated the diet of the Least Auklet (Hunt et al. 1989). Zooplankton biomass in the water and the vertical distribution of zooplankton was determined using a Biosonics echo-sounder (200 kiloHertz) and echo-integrator. Integrations of biomass were made each tenth of a nautical mile with vertical intervals of 2 m from 5 m below the surface to the bottom. In order to identify the animals responsible for the acoustic scattering plankton was sampled by making vertical tows with a net (1 m diameter, 505 micron mesh). Net tows identified the calanoid

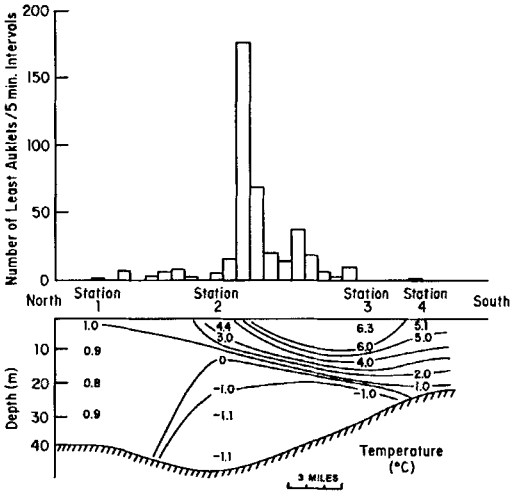

Fig. 1. Temperature profile and Least Auklet numbers for a transect extending due north of Gambell, St. Lawrence Island. Station 2 was in the middle of the front as indicated by the thermocline reaching the surface. The peak in bird numbers is just to the south of the front where the thermocline is very shallow.

copepod *Neocalanus plumchrus* as the dominant pelagic zooplankton in the study area.

In 1984, large numbers of Least Auklets were observed at the front along the margin of Anadyr water. In Fig. 1 the Anadyr water can be identified (on the far left) as the cold, mixed area with similar temperatures at the top and bottom. The Bering Shelf water has a strong thermocline (Fig. 1). Least Auklets, which had been nearly absent over the mixed Anadyr current, were extremely abundant at this front. Over the Bering Shelf water numbers declined with distance from the front.

Because the Anadyr current has a meandering path along the international border between the U.S.A. and the U.S.S.R., we were unable to find the front on the east side of the political border on several runs of our original transect north of Gambell in 1985 and 1986. However, other meanders of the Anadyr Current were located within 20 km northeast of the original transect. The structure of the front was similar at each crossing.

One crossing of the front in 1985 is shown in Fig. 2. This figure illustrates the front at a much smaller scale, and pictures only 4 nautical miles of the transect. Above the shallow thermocline near the surface expression of the front there were concentrations of zooplankton, with a biomass as high as 16 g/m^2. In the mixed Anadyr water there was virtually no plankton (< 2 g/m^2). Plankton levels fell with distance away from the front into the structured Bering Shelf water.

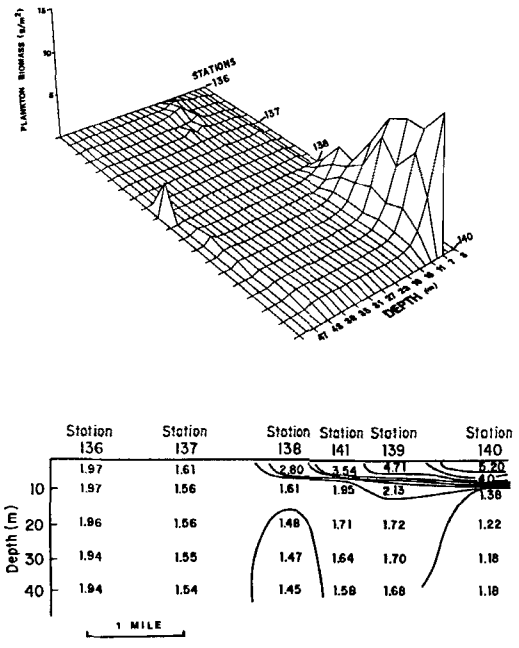

Fig. 2. Temperature profile and acoustic biomass for another crossing of the front. High plankton biomass was at the surface over the shallow thermocline.

In 1986, a particularly strong convergence was located. There was little wind, and distinct streaking on the water. Among the 108 surface-feeding birds counted along the streaks were Fulmars, Black-legged Kittiwakes and Red Phalaropes which were all sitting on the water pecking at the surface. The acoustic record identified a very sharp peak in plankton biomass (11 g/m^2) in the upper 10 m (range of 5 to 10 m) directly in line with the convergence streak (the areas to either side having <1 g/m^2 in the same depth range). These species have distinctly different requirements than Least Auklets, requiring prey within the top few cm.

The front otherwise showed a familiar pattern of birds, with hundreds of Least Auklets on the water over the area with the shallowest thermocline. Their numbers dropped to 0 over the mixed Anadyr water. Again we observed shallow peaks in biomass in the structured water, with the greatest peaks nearest the front.

Some seabird species appear to require a concentration of prey, rejecting dispersed prey. Aggregations of prey at fronts are particularly important for these predators. There was frequently a higher prey density at the front north of Gambell. Although Anadyr water is high in nutrients, densities of plankton are low and dispersed by turbulence. Nutrients are entrained across the front into the nutrient poor surface layer of the stratified water. Here phytoplankton are held in the euphotic zone resulting in an enhanced production near the front. The very large biomass of zooplankton sometimes seen there is probably in part a response to this production.

Calanoid copepods are known to respond to strong property gradients, and often concentrate at the thermocline in the north Pacific (Barroclough et al. 1969). Their behavioural response to the physical structure near the front is likely to be the direct explanation of why they are concentrated near the surface there. This distribution near the surface appears to be favourable for Least Auklets.

The term 'front' describes a variety of physical phenomena at varying temporal and spatial scales, and we cannot generalize that fronts are important for Least Auklets. However, our observations here support our other data on this species at sea: they appear to selectively forage at hydrographic structures where prey accumulate near the surface (Hunt et al. 1989). In this case the circulation at a front forced the thermocline up towards the surface and resulted in shallower prey concentrations.

References

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