

OBSERVATIONS OF A MIXED-SPECIES FLOCK OF BIRDS FORAGING ON EUPHAUSIIDS NEAR ST. MATTHEW ISLAND, BERING SEA

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ABSTRACT.—We observed mixed-species flocks of birds foraging for euphausiids near Cape Upright, St. Matthew Island. Murres (*Uria* spp.) predominated, and the number present was equivalent to 79% of the murres breeding at Cape Upright, or 11% of the total St. Matthew population. All bird species actively feeding were catching the euphausiid *Thysanoessa raschii*. SCUBA divers determined that murres were diving deeper than 30 m; schools of euphausiids were not observed above that depth. Injured and disoriented euphausiids were present near the surface where surface-feeding Black-legged Kittiwakes (*Rissa tridactyla*) captured them. Received 20 April 1987, accepted 16 January 1988.

LARGE mixed-species seabird flocks feed in the vicinity of the Pribilof Islands (Hunt et al. 1978, Hunt unpubl. data) and at St. Matthew Island. The flocks are composed typically of large numbers of diving species, the majority murres (mostly Thick-billed Murres, *U. lomvia*, with some Common Murres, *U. aalge*), with smaller numbers of Crested Auklets (*Aethia cristatella*), Least Auklets (*A. pusilla*), Parakeet Auklets (*Cyclorhynchus psittacula*), and Horned Puffins (*Fratercula corniculata*). In addition to these diving species, several surface-foraging species are regularly in attendance. These include Northern Fulmars (*Fulmarus glacialis*), red Phalaropes (*Phalaropus fulicaria*), and Black-legged Kittiwakes (*Rissa tridactyla*). For these mixed-species flocks, when prey identity was known, euphausiids were the primary food item in the guts of all species.

Euphausiids occur in the diets of most species of seabirds in the Bering Sea (Sanger and Baird 1977, Hunt et al. 1981a). These crustaceans are particularly important for migratory Short-tailed Shearwaters (*Puffinus tenuirostris*) and for several species of breeding alcids (Bédard 1969, Hunt et al. 1981a, Schneider et al. 1986). During the day euphausiids usually migrate away from the surface, and in the shallow (30–60 m) shelf regions of the Bering Sea probably aggregate close to the bottom (S. Smith pers. comm.), where they are relatively inactive and densely packed (Mauchline and Fisher 1969). The diurnal capture of euphausiids by birds able to dive to depths where euphausiids concentrate is not

surprising. However, the regular occurrence of euphausiids in the gut contents of diurnal, surface-foraging Black-legged Kittiwakes raises the question of how they obtain this prey.

On 21, 27, and 28 June 1984 we encountered large mixed-species flocks near St. Matthew Island over water approximately 62–64 m deep (Fig. 1). We investigated one segment of the flock on 27 June. We mapped the distribution of foraging birds, collected birds for stomach-content analysis, and put SCUBA divers in the water to observe underwater prey distribution and bird foraging.

METHODS

We counted birds along a series of transects east of Cape Upright (Fig. 1). Continuous counts were made of all birds within a 90° arc from the bow to the beam and extending to 300 m from the ship on the side with the best visibility. The sea was calm, and visibility was excellent for counting birds. Birds on the water were tallied separately from flying birds, and only birds on the water were used to determine foraging distributions. Data were entered directly into a microcomputer custom programmed with data-entry software (Updegraff and Hunt 1985) that permitted continuous records of bird numbers.

From approximately 1500 to 1900 local time, we collected actively foraging seabirds. Diving species observed returning to the surface were selected, as were surface-foraging species seen dipping or pecking at the surface. We removed stomachs from birds within 1 h of collection and preserved the crops, stomachs, and their contents in 80% ethyl alcohol.

We obtained information on the near-surface and

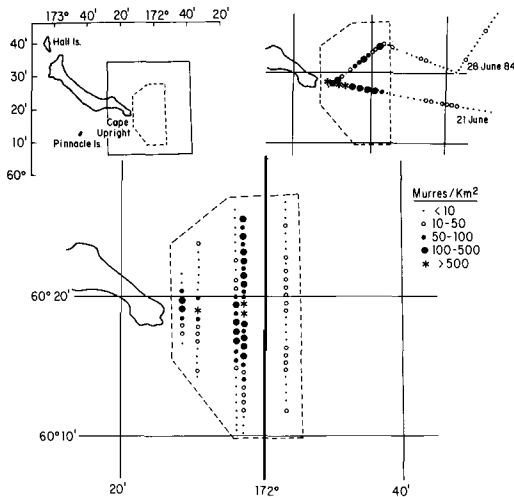


Fig. 1. Numbers of murres observed along 5 transects east of Cape Upright, St. Matthew Island, 27 June 1984. Inset: numbers of murres in same region on 21 June and 28 June 1984.

subsurface distributions of birds and their prey from a group of four divers using SCUBA and blue-water diving techniques (Hamner 1975). The divers made observations to depths of 30 m and recorded the numbers, behavior, and depths of both seabirds and their euphausiid prey. Groups of divers entered the water approximately 100 m from the murre flocks and then swam to the murres. The murres avoided the dive boat, but divers could swim close to the murres while snorkeling at the surface. Dives were made both away from the murre flock and beneath it.

RESULTS

We observed large numbers of birds, mostly murres, on the water in an arc east of Cape Upright to a distance of about 15 km (Fig. 1). The longest dimension of this aggregation of birds was 23 km north-south. The highest numbers of murres were observed 8 km east of Cape Upright. The murres were not evenly spread over the entire region, but aggregated into smaller flocks of hundreds to low thousands. Within these flocks murres were evenly dispersed on the water, with individuals constantly diving and reappearing. We estimated the area of the grid sampled at 339 km² (outlined by dashed line in Fig. 1). The mean density of murres in this area was 186/km², for a total of 62,900 murres in the sample area.

Murres were the most common diving bird

in the mixed flocks. All of the murres in a given flock faced the same direction and swam slowly forward at the surface between dives. Birds that surfaced after a dive often reappeared meters to tens of meters ahead of the front of the slowly moving flock. These individuals then swam back to the main aggregation, turned, and resumed swimming at the surface in the same direction as the rest of the birds. Each flock of murres swam in a different compass direction. Occasionally a flock changed its direction, veering slowly to the right or left, then swimming again along a fixed course. The directional surface swimming of the murre flocks was unusual in our experience.

Kittiwakes were the most common surface feeders. They were scattered on the surface to the sides and behind the murres, but never in front of the moving murre flock. Kittiwakes also hovered above the murres, frequently dropping to the water's surface and picking at the surface briefly before taking off again.

The SCUBA divers found that the dominant macroplankters in the water column to a depth of 30 m were larvaceans, the ctenophore *Beroe*, and the hydromedusan *Aglantha*. Few euphausiids were seen. At about 100 m from the murre flock, three individual euphausiids were encountered swimming in the horizontal plane at the thermocline, at 15 m. Below the murre flock the divers saw diving murres and small numbers of individual euphausiids in the water column and near the surface. The euphausiids near the surface were disoriented or damaged. One that swam in rapid circles had no head. These injured euphausiids were the prey captured by plunging kittiwakes. The euphausiids beneath the surface were "whirling around and orienting obliquely upward to the downwelling light in contrast to the normal orientation [horizontal] of animals seen at the thermocline" (Obst field notes). Divers at the surface watched the murres begin their dives. The birds were "diving rapidly, then disappeared from view at depths of 10-13 m [beyond the limit of visibility from the surface], making a zigzag pattern as they dived. Trails of small bubbles were observed streaming from the plumage of the birds as they descended" (Obst field notes). When divers were at 22 m, below the thermocline, they saw "identical bubble trails . . . coming up from below, although the birds were not in view" (Obst field notes). Vertical visibility was

TABLE 1. Percentages of collected birds containing prey. Sample sizes are given in parentheses.

	Fresh prey			Remnants of older prey			
	<i>Thysanoessa raschii</i>	Unidentified euphausiids	Unidentified crustaceans	Unidentified fish	Fish otoliths	Squid beaks	Nereid beaks
<i>Fulmarus glacialis</i> (1)						100	
<i>Rissa tridactyla</i> (8)	100		25	12	12	37	12
<i>Uria aalge</i> (8)	100				12		
<i>Uria lomvia</i> (7)	100						
<i>Fratercula corniculata</i> (2)	50	50					
<i>Aethia pusilla</i> (3)	100						
<i>Cyclorhynchus psittacula</i> (3)	66	33					

approximately 10 m, so the murres must have been below 30 m. Murres were not observed feeding above 30 m.

Birds other than murres were most frequently observed and collected in areas where the density of murres was relatively low. Kittiwakes were collected while foraging near where murres were resurfacing, but not in the areas of the murre flock with the highest density. Of the 32 birds collected in the mixed-species foraging flock, all but one, a fulmar with no fresh food, contained *Thysanoessa raschii* (Table 1). The euphausiids were all fresh, and some kittiwakes had them in their mouths when shot.

DISCUSSION

The large numbers of murres counted within the grid area on 27 June represented a significant portion of the murres breeding on St. Matthew Island (Fig. 1). The Cape Upright colony contains 80,000 murres, while St. Matthew Island as a whole supports 600,000 murres (Sowls et al. 1978). This foraging aggregation therefore represented 79% of murres nesting at Cape Upright, or 11% of the total St. Matthew population. Thus, during a period when murres were producing eggs (one female shot had a fully formed egg in the oviduct), the area east of Cape Upright remained an important foraging center for at least 8 days; 96% of the murres counted on 21 June and 85% of those counted on 28 June fell within the grid. We believe that foraging on inshore aggregations of euphausiids can be of considerable local importance at St. Matthew Island. This concentration of inshore foraging is very different from the long offshore flights described by Gaston and Nettleship (1981).

Murres have also been observed to forage on

inshore aggregations of euphausiids at the Pribilof Islands (Ford et al. 1982, Hunt et al. 1982). Most murres were foraging within 24 km of the Pribilofs, and many were taking euphausiids within 3-4 km of St. George. The euphausiids near St. George were concentrated in the vicinity of a nearshore frontal circulation (Schneider et al. MS). As with our observations at St. Matthew Island, Black-legged Kittiwakes were observed feeding on injured euphausiids at the surface.

We do not know why there was a concentration of euphausiids in this region east of St. Matthew Island. We have no evidence of flow gradients (fronts) influencing these euphausiid patches, as found by Schneider et al. (MS). Observations of drogues suggest that tidally driven eddies stream from the island (Hamner and Hunt pers. obs.). These eddies may mechanically concentrate zooplankton prey (Pingree et al. 1978, Alldredge and Hamner 1980, Hamner and Hauri 1981).

It seems reasonable to suggest that the euphausiids at St. Matthew Island aggregated at or near the bottom (60 m) and that the murres were feeding on these aggregated prey. Murres are easily capable of diving to depths in excess of 60 m (Piatt and Nettleship 1985), and euphausiids of the genus *Thysanoessa* are known to migrate vertically and to form routinely schools and swarms (Komaki 1967, Mauchline and Fisher 1969). Although euphausiids occasionally occur in surface waters in daytime (Komaki 1967, Nicol 1984), *T. raschii* is typically found at depths of 50-300 m during the day and makes a nightly vertical migration to the surface waters (Mauchline 1980). In daytime, in the shallow waters near St. Matthew Island, *T. raschii* is most likely aggregated in dense patches near

the bottom, and we have seen only scattered individuals in the upper water column. When at depth, euphausiids have been found to be relatively inactive (Marr 1962, Youngbluth 1975), under which circumstances murre could capture them more easily.

We observed murre flocks to move in various directions independently of one another, even though they were close together. It is unlikely that these directional movements were in response to tidally driven movements of the water or the prey. Rather, we infer that the murre at the surface were tracking, between dives, localized patches of euphausiids that moved in the same direction. Patches of euphausiids may be swarms, with no directional alignment of individuals, or schools, with directional alignment of individuals. We infer that the euphausiid patches were true schools and not swarms because the flocks of murre moved slowly and directionally at the surface at the same speeds schools of euphausiids have been observed to travel, at 10–20 cm/sec (less than about half a knot; Hamner et al. 1983, Hamner 1984). The vertical dives to the bottom by the murre occurred rapidly without any horizontal swimming or searching by the murre. Euphausiids, presumably damaged by murre, swam upward quickly in disoriented spirals to the surface. These damaged and disoriented prey apparently reach the surface after the murre flocks have moved forward, and consequently kittiwakes foraged behind and to the sides of the murre flocks.

Our observations of the capture of injured or disoriented euphausiids by surface-feeding kittiwakes differ from the observations of Sealey (1973), Brown et al. (1979), Braune and Gaskin (1982), and Grover and Olla (1983), who also recorded surface-seizing birds feeding on euphausiids, often in association with diving species. In these accounts prey were herded by subsurface predators or forced by currents to the surface where larids or other near-surface foragers captured live prey directly. We did not observe prey driven to the surface; instead, the surface foragers obtained debris from the murre's subsurface foraging. We have seen kittiwakes, fulmars, and Red Phalaropes in association with murre elsewhere in the Bering Sea take fragmented or injured euphausiids in daytime (Schneider et al. MS). Rather than competing with surface foragers for prey, under

some circumstances diving species may make prey available to surface foragers.

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The International Council for Bird Preservation is publishing the Proceedings, edited by J. E. Cooper, of a Symposium on Disease and Management of Threatened Wild Bird Populations held in Canada in 1986. With growing interest in, and appreciation of, the importance of disease and wildlife conservation it was agreed to include a **register of persons and organizations working on all aspects of avian pathology and disease**. We are anxious to include those interested in being consulted about problems relating to morbidity and mortality and to facilitate exchange of information and material between those working on avian disease. Anyone who would like to be listed in the register should write as soon as possible for details and a questionnaire to **N. Hillgarth, Department of Zoology, South Parks Road, Oxford OX1 3PS, England**; or **J. E. Cooper, Royal College of Surgeons, 35/43 Lincoln's Inn Fields, London WC2A 3PN, England**.