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Northern Lesser Black-backed Gulls: What do They Eat?

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Abstract.—The Norwegian population of the nominate subspecies of Lesser Black-backed Gull, *Larus fuscus fuscus*, has declined strongly but the causes are unknown. The diet of these gulls breeding in two regions on coast of northern Norway was assessed over five years (2005-2009). In the southern region, chicks (n = 58) were fed predominantly gadoids (~75% ABP [aggregated percentage of prey biomass] and ~80% frequency; 70-130 mm length), probably saithe, *Pollachius virens*, whereas 0-group herring, *Clupea harengus* (40-50 mm length) accounted for ~20% ABP and were fed to ~20% of the chicks. In the northern region (n = 23), slightly larger 0-group herring comprised ~60% of the prey mass and were fed to 65% of the chicks. In this area, gadoids and sandeel, *Ammodytes* spp., each accounted for ~17% ABP of prey, and were fed to 20% and 30% of the chicks, respectively. Other species made up smaller proportions of chick diets. For adults, only regurgitated pellets (28 in the southern region) were available. Of 23 pellets from 2006 and 2007, 17 (74%) contained pipefish (probably Snake Pipefish, *Entelurus aequoreus*), whereas three contained herring, two gadoids, and one sandeel. In the poor breeding season of 2009, adult gulls also fed on blue mussels, *Mytilus edulis*, crabs (Brachyura), sea urchins (Echinoidea) and seabird eggs. Thus, Northern Lesser Black-backed Gulls are probably mainly piscivorous during breeding, and other prey are probably exploited only when fish are not readily available. Further, herring seems to be less important for *L. f. fuscus* than previously thought. *Received 17 November 2009, accepted 26 February 2010.*

Key words.—feeding ecology, Gadidae, herring, *Larus fuscus fuscus*, reproduction.

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Seabirds feed predominantly on fish, but gulls (*Larus* spp.) are often generalists and also feed on invertebrates such as crustaceans, echinoderms, molluscs and terrestrial prey. There are large differences among gull species and individuals with regard to diet specialization, including most populations of Lesser Black-backed Gull (*Larus fuscus*), whose feeding ecology is well known (Cramp and Simmons 1983; Götmark 1984; Kubetzki and Garthe 2003). However, there are no published records of the diet of the nominate subspecies *L. f. fuscus* in northern Norway.

L. f. fuscus breeds along the northern half of the Norwegian coast and the Baltic Sea region. Since the 1970s its population has declined strongly throughout its geographic range (Bevanger and Thingstad 1990; Strann and Vader 1992; Hario *et al.* 1998, 2004). In some locations in Norway, numbers decreased by 80-90% between 1980 and 2000 (Lorentsen 2004). Reasons for the declines are unknown, but poor feeding conditions following the collapse in Norwegian spawning herring (*Clupea harengus*) stock in the late 1960s may have been an important factor in Norway (Myrberget 1985; Røv 1986; Loen 1987; Bevanger and Thingstad 1990; Strann and Vader 1992). Although herring has been assumed to be a preferred prey of breeding Lesser Black-backed Gulls (reflected in the Norwegian name of the species; *sildemåke* that translates directly and confusingly to *herring gull*), the magnitude of the impact of the herring collapse cannot be assessed as dietary data on this subspecies are lacking (Bustnes *et al.* 2010). Thus, the aim of this study was to determine the diet of *L. f. fuscus* in Norway by collecting food samples from its southern and northern distribution range on the Norwegian coast (Fig. 1). However, in the 1980s a greyish-mantled subspecies, either *L. f. intermedius* (that breeds in southern Norway) or *L. f. graellsi* (that breeds in the North Sea and Iceland), was discovered in the northern *L. f. fuscus* region, replacing the dwindling black-mantled

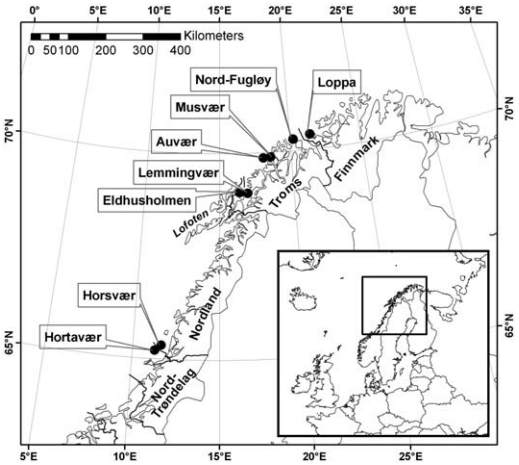

Fig. 1. Study locations in the southern and northern distribution range of the nominate race of Lesser Black-backed Gull *Larus fuscus fuscus* along the coast of northern Norway.

L. f. fuscus population. Currently, at least half the population from Lofoten (Fig. 1) and northwards is comprised of one of the southerly subspecies. In the southern part of our study area the dark-mantled subspecies still makes up nearly 100% of the population (Helberg *et al.* 2009). Whether these two partly sympatric breeding subspecies have the same diets is not known.

METHODS

The southern study locations were two small archipelagos, Horsvær, Nordland (up to 400 breeding pairs) and Hortavær, Nord-Trøndelag (up to 200 pairs) (Fig. 1). Horsvær was visited in the nesting season in mid June and in the nestling season in late July in all years from 2005 to 2009, whereas Hortavær was visited in late July 2008 and 2009. In the northern region, samples were collected from Lemmingvær, Eldhusholmen, Musvær, Auvær and Nord-Fugløy in Troms, and Loppa in Finnmark (Fig. 1) in July 2007 and 2009.

Food samples from adults were collected in the nesting period in the latter half of June at Horsvær. Most were regurgitated pellets found at the nest, but a few were from a resting place for adults, where only Lesser Black-backed Gulls were observed to sit. The samples from the chicks were all regurgitated food collected when the chicks were banded in the latter half of July. The samples were collected in plastic bags, labeled and frozen at -18°C within a few hours.

Laboratory Procedures

On return to the laboratory, each sample was thawed, weighed to the nearest 0.1 g and teased apart under water in a Petri dish. All items were identified to the lowest possible taxon under a binocular microscope and the relative mass of each taxon in each regurgitant was estimated. Whole or partly digested fish were identified from gross morphological characters, whereas more digested fish were identified from sagittal otoliths using Breiby (1985), Härkonen (1986), a reference collection, and the appearance of scales or the presence of pro-otic bullae (especially characteristic for herring). Otoliths were often extracted from the undigested skulls of fish or found floating free in the sample. After the above treatment, each sample was further digested in a saturated solution of biological washing powder (Bio-tex© Denmark) in an oven at 50°C for at least 24 h after which undigested remains were rinsed thoroughly and sorted under the microscope. Any additional otoliths were collected and identified as above, and fish vertebrae were identified using Watt *et al.* (1997) and a reference collection.

To avoid bias, for example due to different stages of digestion or degrees of oesophagus "fullness" in the small sample sizes, the mean overall diet composition for a given season was calculated using Swanson *et al.*'s (1974) aggregated percentage of prey biomass (APB) method. The frequency of occurrence of each taxon in the samples was also calculated.

Fish Length Calculations

Otolith lengths were measured using a calibrated eye-piece graticule in the binocular microscope and were used to determine fish length using published equations for fish from the southern Barents Sea (herring FL (fish length mm) = 58.406*OL (otolith length mm)-8.5, sandeel FL = 58.81*OL + 14.93, saithe FL = 23.5*OL-4.24, Jobling and Breiby (1986)). To avoid pseudoreplication through measurements of both otoliths of a pair, otoliths were either paired before measurement or, in samples with many small otoliths, they were later paired by size. In the absence of otoliths, approximate lengths of herring were calculated from the length of anterior caudal vertebrae (ln(FL) = 4.4552 + 1.024ln(VL) where FL = total fish length and VL = vertebra length, Watt *et al.* 1997). Because the regurgitants were not fully digested, there were no signs of erosion among the otoliths or bones thus eliminating an important source of error when calculating fish lengths (Jobling and Breiby 1986).

RESULTS

Chicks

In the southern region, chicks (n = 58, Table 1) were fed predominantly gadoids and herring in the five years of the study. Gadoids (Gadidae) made up 63-88% (ABP) and occurred in 75% or more of the samples in 2005, 2006 and 2007, and 50% (ABP and % frequency) in 2008 (Table 1). Herring made up 50% ABP of the samples in 2008 and 67% ABP in 2009 (Table 1). Other prey items were pipefish (probably snake pipefish

Table 1. Relative importance of food items the diet of Lesser Black-backed Gull chicks expressed as aggregate percent mass (Swanson *et al.* 1974) and percentage frequency. Data from two regions of North Norway.

			Herring		Gadoids		Sandeel		Pipefish		Other	
		N	Aggr. %	% freq.	Aggr. %	% freq.	Aggr. %	% freq.	Aggr. %	% freq.	Aggr. %	% freq.
Southern Region	2005	10	20.0	20.0	75.0	80.0					5.0	10.0
	2006	35	10.7	11.4	88.3	91.4			6.0	17.1		
	2007	4	12.5	25.0	63.1	75.0			24.4	50.0		
	2008	6	50.0	50.0	50.0	50.0						
	2009	3	66.7	66.7	26.7	33.3	6.7	33.3				
	Total	58	19.3	20.7	74.2	81.0	0.3	1.7	5.3	13.8	0.9	1.7
Northern Region	2007	10	48.5	60.0	28.8	40.0	20.7	50.0	2.0	10.0		
	2009	13	69.2	69.2	7.7	7.7	15.4	15.4			7.7	7.7
	Total	23	60.2	65.2	16.9	21.7	17.7	30.4	0.9	4.3	4.3	4.3

[*Entelurus aequoreus*] - see Discussion) in 2006 and 2007 (occurring in 17% and 50% of the samples respectively), and sandeels (*Ammodytes* sp., in one of the three samples in 2009) (Table 1). Assuming the gadoids were saithe (*Pollachius virens*; see discussion), most were young 0-group fish (fish hatched in the year in question) in the size range 70-120 mm, although one sample in 2008 contained otoliths of a ca. 200 mm fish (Table 2). The herring were in the 40-50 mm size range (Table 2), *i.e.* small 0-group fish (Husebø *et al.* 2007).

In the northern region, herring were more common than gadoids and comprised 40 and 70% ABP of the prey in 2007 and 2009 respectively, and were fed to 60-70% of the chicks, respectively. Sandeels were relatively common in the same samples (20% ABP in 2007 and 15% ABP in 2009) whereas gadoids comprised 30% and 8% ABP in the same years (Table 1). Pipefish occurred in one of the ten samples in 2007. The mean size of the gadoids in 2007 ranged between 65-95 mm (0-group), whereas in 2009 one sample contained otoliths from ca. 110-130 mm fish. Herring fed to chicks in 2007 were 30-170 mm long and in 2009 were 200 mm long, i.e. again within the range of 0-group fish (Husebø *et al.* 2007) whereas 50-80 mm sandeels were found in both years (Table 2).

Adults

Twenty-eight regurgitants were collected from adults at Horsvær (Fig. 1), 17 in 2006, six in 2007 and five in 2009. All except two pellets in 2009 contained only one food item. In 2006 and 2007, twelve (71%) and five (83%) respectively contained pipefish only, whereas three contained herring, two gadoids, and one sandeel. In 2009, one sample contained herring, one contained blue mussels (*Mytilus edulis*), one contained a crab (Brachyura), and two contained fragments of bivalve shells (Bivalvia), seabird eggshells and sea urchins (Echinoidea). No attempts were made to estimate prey size in any of the adult samples due to erosion of the otoliths and vertebrae.

Table 2. Approximate lengths (mm) of fish fed to Lesser Black-backed Gull chicks in two regions of North Norway.

			Mean	SD	Range	N
Southern Region	2005	Herring	42.1	3.2	38.2-46.5	6
		Saithe	112.2	6.6	104.3-119.8	7
	2006	Herring	44.5	4.4	39.6-49.2 3	1
		Saithe	105	8.4	81.8-121.3	45
	2007	Saithe	97.8	19.5	71.9-131.2	7
	2008	Saithe	200.2			1
	2009	Herring	46.5			1
		Sandeel	160.6			1
Northern Region	2007	Herring	156.5	32.4	123.4-170.4	4
		Herring	31.6	2.4	27.2-32.7	9
		Saithe	76.1	8.9	64.9-93.1	10
		Sandeel	61.6	8	50.8-80.6	32
	2009	Saithe	121.6	11.1	111.4-132.5	4
		Sandeel	60.7	6.4	50.8-77.0	32
		Herring	200.1	44.3	116.5-237.2	6

DISCUSSION

Using regurgitants and pellets as a source of diet information may be biased due to remains of some food types being regurgitated whereas others, e.g. soft-bodied invertebrates, are not. Unless other methods can be used or unless detailed quantitative data are needed for the assessment of complete diet breadth or total food consumption, this method is, however, simple, non-invasive, valuable and far preferable to forcing birds to regurgitate or even killing them (see Barrett *et al.* (2007) for detailed discussion). With these factors in mind, the main finding of this study was that the Lesser Black-backed Gulls in northern Norway were predominantly piscivorous during the breeding season, and only in years with very poor breeding conditions, such as in the southern region in 2009 (J. O. Bustnes, unpubl. data), did the birds take other prey such as crabs and mussels.

Overall 0-group gadoids were the commonest prey in chick diets, but the small otoliths precluded species determination. However, since the Lesser Black-backed Gull is a surface feeder and the only commonly occurring pelagic gadoid in the area is the saithe, this species probably makes up the bulk of the gadoids in the gull diets. Similarly, small 0-group fish dominated the herring in both regions, but with larger fish in the north.

Small schooling fish are a very important food source for most Lesser Black-backed Gull populations (Cramp and Simmons 1983), and for *L. f. fuscus* herring may be a keystone prey, both in the Baltic Sea (Hario 1990) and in Norway. Although declines in the Norwegian *L. f. fuscus* population may be mainly due to food shortage following the collapse of the herring stock in the late 1960s (Myrberget 1985; Røv 1986; Loen 1987; Bevanger and Thingstad 1990; Strann and Vader 1992), lack of data from the pre-decline period precludes a test of this hypothesis. However, in the pure *L. f. fuscus* colonies in the southern region of this study, gadoids dominated the diet and herring made up only 20% of the overall diet in both 2006, a very good breeding season, and in 2007, a poor year (Bustnes *et al.* 2010; J. O. Bustnes, unpubl. data). Moreover, Bustnes *et al.* (2010) found no relationship between gull breeding numbers at Horsvær and the strength of year classes of 0-group herring between 1980 and 2005. Nevertheless, it is likely that herring was important for *L. f. fuscus* as it has been a very abundant food source, and the colonies on the coast are situated along the northerly drift path of the 0-group fish that

hatch in western Norway (Sætre *et al.* 2002). When the herring stock collapsed, the reproduction of the gulls may have been impaired for many years, and the population declined as breeders started to die off, a situation mirrored in the status of the Atlantic Puffin (*Fratercula arctica*) in NW Norway where the population steadily declined during the absence of herring as a result of many years of chick starvation and recruitment failure (Anker-Nilssen and Aarvak 2006). Although the herring returned in the late 1980s, changes in larval herring drift patterns or growth rates may have reduced its availability causing the population of *L. f. fuscus* to continue to exploit other food sources. This again was the situation for the Atlantic Puffin whose population has continued to decline since 1990, though much more slowly than it did during the preceding ten years (Anker-Nilssen and Aarvak 2006). Higher proportions of herring (60%) in the Lesser Black-backed Gull diet were, however, found in the northern region. In addition, sandeels were found in the northern diet, but not in the southern region and could reflect a difference in the availability of different fish species; i.e. herring might have been more accessible than in the southern region in the years of study. It is also possible that the 0-group herring had not reached a suitable size during their drift northwards by the time they reached the southern colonies, but had done so when they reached Troms and Finnmark.

The Lesser Black-backed Gull is in general not so much a scavenger but more a piscivorous, open-sea feeding gull than other larger gulls, such as the Herring Gull (*L. argentatus*) and Great Black-backed Gull (*L. marinus*) (Schwemmer and Garthe 2005; Kubetzki and Garthe 2003). Nominate *L. f. fuscus* are rarely seen scavenging during the breeding season (Strann and Vader 1992) and may be even more dependent on catching live fish than the somewhat larger *L. f. intermedius* and *L. f. graellsi* subspecies. For example, in the North Sea *graellsi* obtain much of their food from offal from fishing boats (Noordhuis and Spaans 1992; Kubetzki and Garthe 2003; Schwemmer and Garthe 2005), whereas in this study there was no evidence of *L. f. fuscus* exploiting this potential food source, despite considerable fishing activity in all areas studied here, especially from small vessels. It is possible that this type of food is not readily available with few fish being discarded from the boats, making it less worthwhile for birds to follow the boats. Strann and Vader's (1992) suggestion that *L. f. fuscus* is more conservative in its choice of diet than other subspecies of Lesser Black-backed Gull might be reflected in the situation on the Norwegian coast where *intermedius* increased strongly in southern Norway while *L. f. fuscus* declined (Lorentsen 2004), and the fact that a greyish-mantled subspecies has invaded northern Norway. There might thus also be differences in diets between the two subspecies in the northern region, although we have no data to test this. However, some of the *L. f. fuscus* from northern Norway have been observed on Finnish rubbish dumps during migration (Helberg *et al.* 2009), showing that outside the breeding season they may use terrestrial food sources.

The high frequency of pipefish in the diet of adults in the 2006 and 2007 seasons coincided with the appearance of *Enterlurus aequoreus* in northern European seas in 2003 and subsequent years and corroborates other records of the same species being taken by other seabirds in Norway and other North European seas in the same period (Anker-Nilssen and Aarvak 2006; Harris *et al.* 2007; Håland 2006). Pipefish are difficult to swallow and their stiff vertebrae and body armor are difficult to digest completely (Harris *et al.* 2006), such that frequency of regurgitants containing pipefish would be expected to be much higher than, for example, small gadoids, which may even be totally digested by the adults.

In conclusion, this study suggests that the Lesser Black-backed Gull in northern Norway is almost exclusively piscivorous during the breeding season, and only in very poor years do adults feed on other prey types such as crustaceans and bivalves. Herring is clearly an important prey for seabirds in the Norwegian Sea, but, in this study, comprised surprisingly little of the diet in the *L. f. fuscus*

colonies, where gadoids made up the bulk of the diet. One important shortcoming of this study is, however, the small sample sizes, making it impossible to test for differences among years and regions. The paucity of samples is a result of the limitations imposed when working with a rare and vulnerable species, which preclude any invasive studies. However, this study is a first step toward a better understanding of the conditions needed for successful breeding and we encourage further collection of data from this subspecies.

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