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Distribution of ship-following seabirds and their utilization of discards in the North Sea in summer

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ABSTRACT: Prey availability is one of the factors determining the distribution of seabirds at sea. Northern fulmars *Fulmarus glacialis* and black-legged kittiwakes *Rissa tridactyla* were the most regular and frequent ship-followers across the central and northern North Sea during 2 surveys with a fishery research vessel in May-June and July-August 1992. Sixteen other species occurred less often and/or in lower numbers. Birds consumed 84 % of experimentally discarded roundfish and 8 % of discarded flatfish. On average, northern gannets *Morus bassanus* took the largest individuals of most fish species, black-legged kittiwakes the smallest. The average size choices of herring gulls *Larus argentatus*, lesser black-backed gulls *Larus fuscus* and northern fulmars lay between these 2 extremes. The choice of fish lengths by birds varied with different fish species. Northern gannet was the most successful species in consuming discards. Northern fulmars' success rates decreased with the presence of larger ship-followers but were never high. Black-headed gull *Larus ridibundus* and common gull *Larus canus* were less successful than the more frequent, typical ship-following species.

KEY WORDS: Seabirds · North Sea · Fisheries · Discards · Feeding ecology

INTRODUCTION

The distribution of seabirds at sea is patchy at various scales. The processes responsible include hydrographical mechanisms, active and passive movements of prey and the social behaviour of birds (Hunt 1988). These factors are of variable relative importance in different parts of the world's oceans. Although the location of breeding sites influences seabird feeding distribution, fisheries also have a strong influence at a smaller scale on the distribution of seabirds at sea, as seen in the North Sea (Tasker et al. 1987), the Benguela Current (Ryan & Moloney 1988) and the Eastern Pacific (Wahl & Heinemann 1979).

Studies near the Shetland Islands and in the Clyde area west of Scotland, UK, gave first information on the use of fishery wastes by seabirds (Furness et al. 1988). A first study covering the whole North Sea in winter 1993 confirms the assumption that seabirds benefit enormously from this type of food resource (Camphuysen et al. 1993). Populations of most seabird and some coastal bird species in the North Sea have grown considerably in the last few decades, probably as a result of improved food conditions provided by whaling and fisheries (Vauk et al. 1989, Dunnet et al. 1990, Lloyd et al. 1991). Presently, about 1.2 million seabirds, feeding at least partially on discards and offal, breed around the North Sea (Furness 1992).

Interspecific competition evoked by the supply of discards and offal has already led to changes in the avifauna of seabirds and coastal birds (Furness et al. 1992, Noordhuis & Spaans 1992). Further changes in catch composition due to larger mesh sizes will probably cause higher competition for discards and offal. Decreasing populations of the weaker scavenging species are to be expected. Therefore it is essential to obtain detailed data about the utilization of discards by scavenging seabirds. This includes not only the choice of different fish species and their lengths but also the rates at which discards are taken by birds. To evaluate interspecific competition and its possible consequences, it is also important to know the distribution and numbers of ship-followers.

This study examines both distribution and numbers of scavenging seabirds, and their utilization of discards in the North Sea in summer.

METHODS

Observations and experiments on the utilization of discards by seabirds were carried out on board the German fishery research vessel 'Walther Herwig' (Federal Research Board for Fisheries, Hamburg). Two observers participated in each of 2 cruises in the central and northern North Sea: S. Clorius and K. Janssen, 12 May to 8 June 1992, and S. Bräger and S. Garthe, 14 July to 3 August 1992. These journeys were part of the International Bottom Trawl Survey, a sampling scheme about the distribution of demersal fish in the North Sea recommended by ICES (International Council for the Exploration of the Sea; Anonymous 1990).

During most days, 1 haul was conducted per ICES square [an area of about 30 × 30 nautical miles (n miles) arranged in a grid; a unit for registration of fishing effort]. This amounted to a total of 4 or 5 hauls per day. All trawls lasted 30 min. The mesh size of the inner cod end was 10 mm. Therefore the fish caught tended to be much smaller than those caught by commercial fishing vessels in the North Sea. The vessel normally travelled 30 to 40 n miles (= 3 to 3.5 h of sailing between the different hauls). Additionally, fishing was carried out on a few days in 'boxes' (on small, exactly defined areas at sea and within shorter intervals). The aim of this fishing was to investigate how representative single hauls are for a certain sea-area. In each box, 7 to 9 hauls were conducted per day on 3 consecutive days. There was a maximum travel time of 30 min of sailing at 13 knots or less between trawling. Three boxes were investigated during the May–June survey, 1 box during the July–August survey.

Subsamples from the catch were taken to conduct discard experiments. These experimentally discarded fish usually originated from the previous haul. Both age and length composition were often not representative for the haul they originated from. However, no fish species or length class was favoured overall.

Before discarding, fish were identified to species, their total length measured to the nearest cm (to the nearest half-cm in the May–June survey); they were then discarded one after the other from the stern of the vessel. The fate of each fish was recorded. For this report we distinguished only between fish 'taken' (assumed to be swallowed by a bird) and 'not taken' (fish that sank). Here, we do not consider kleptoparasitic interactions but only the ultimate fate of each fish.

During each trawl we counted the birds actively following the vessel ('ship-followers'). For distribution maps and calculations we used the highest number of individuals per species and age class (northern gannet *Morus bassanus*, gulls) which was counted during the period from the time that the net was set until the end of processing of the haul. Usually binoculars (10× magnification) were necessary to carry out precise counts. Only bird species interested in fishery waste were taken into account.

For the analysis of the distribution of the ship-following bird species, only the standard hauls were considered, because the number of ship-followers often increased during fishing in boxes. Individuals rarely left the vessel, but several 'new' individuals joined it, resulting in higher numbers than at single hauls.

As a measure of the ability of the different bird species to obtain fish, a success index was calculated. It is defined as the number of fish caught by a single bird species divided by the number of ship-followers of that species. Because of the high variability of birds present and of fish thrown overboard, the index of the species with the highest success was arbitrarily set to 100, the other species achieving lower indices depending on their success. An average of the indices of all single hauls was calculated for all species. If the birds took less than one-third of offered fish during a trawl, the results of these hauls were removed from the final calculation. We assume that at least part of these ship-followers were not really hungry, and thus a comprehensive success calculation could have led to results deviating from the actual success rate. Due to low sample size we excluded trawls with less than 50 fish offered.

The lengths of the individuals of most fish species were not normally distributed (determined by Kolmogorov-Smirnov test). For comparisons between 2 samples we hence used the Mann-Whitney *U*-test, for comparisons between 3 or more samples the Kruskal-Wallis *H*-test. For any analysis of length we only used the results of those trawls where all the major 5 ship-following bird species (northern fulmar *Fulmarus glacialis*, northern gannet, lesser black-backed gull *Larus fuscus*, herring gull *Larus argentatus* and black-legged kittiwake *Rissa tridactyla*) were all present with at least 1 individual.

For most analyses data from both journeys were pooled because of identical methods in the experiments and the similar season. Statistical tests were chosen according to Sokal & Rohlf (1981) and were performed using the software package SPSS/PC+ 4.0.

RESULTS AND DISCUSSION

The work on board a research vessel within a wide-scale fisheries program using standardized methods gave us a unique opportunity to study the behaviour of ship-following birds across a large part of the North Sea over a short time under fairly similar conditions.

How far are our results comparable to the situation in commercial fisheries? What is actually different from a study on board a commercial fishing vessel? One major point is the processing of the hauls. Normally, only a small part of the catch is needed for scientific purposes. This means that nearly the total catch has to be thrown back into the sea a short time after hauling and is thus available for birds and other scavenging organisms (e.g. marine mammals, fish). Furthermore, the type of 'discard' varies enormously, from 7 or 8 cm (e.g. small Gadidae or Clupeidae) due to the small inner cod end up to very large individuals (40 cm and more) because the catch is not marketed. Hence, this fishery waste is not coincident with the term 'discard' as defined by Hudson & Furness (1988). Another point is the short time spent on trawling and often the comparatively large distance between the trawling stations compared to commercial fisheries. Furthermore, commercial fishing vessels are restricted only to those areas that promise good catches, resulting in concentrations of scavengers. Finally, the method of experimental discarding (one fish after the other, as opposed to large quantities of fish discarded simultaneously) is in no way representative of commercial fishery.

However, the number of individuals at the trawl stations should not be affected much by the situation where a fishery research vessel is actually fishing. The same holds true for the studies concerning choice of fish species and length. In conclusion, this means that since the use of recatch devices (cf. Berghahn & Rösner 1992) in rough sea conditions is often not feasible, our method seems to be the only way of analyzing discard utilization.

Numbers and distribution of ship-followers

During the surveys in May–June and July–August, a total of 10 and 18 bird species respectively were found following the vessel. In May–June, northern fulmar (all of 19 standard hauls), black-legged kittiwake (14 of 19 hauls), lesser black-backed gull (10 of 19 hauls) and herring gull (9 of 19 hauls) were the species most regularly present. Northern fulmar (1000 individuals), black-legged kittiwake (700), herring gull (250) and northern gannet (150) showed the highest numbers for all hauls (including box-hauls). In July–August, black-legged kittiwake (all 61 standard hauls), northern fulmar (60 of 61 hauls) and northern gannet (56 of 61 hauls) were present on nearly all hauls; lesser black-backed gull (39 of 61 hauls), common gull *Larus canus* (30 of 61 hauls) and herring gull (27 of 61 hauls) ranked next in occurrence. Highest numbers were attained by northern fulmar (600 individuals), lesser black-backed gull (360), black-legged kittiwake (350) and herring gull (115). Further, scarce ship-following seabirds (not listed in success indices; see Table 3) were, in order of descending numbers: arctic skua *Stercorarius parasiticus*, European storm petrel *Hydrobates pelagicus*, sooty shearwater *Puffinus griseus*, Manx shearwater *Puffinus puffinus*, yellow-legged gull *Larus cachinnans* and Atlantic puffin *Fratercula arctica*.

During the breeding period in May–June, only low numbers of ship-followers (species and individuals) were found in extensive areas of the North Sea. Close to the colonies high concentrations were present, resulting in maximum numbers of northern fulmar, northern gannet, black-legged kittiwake and herring gull. During the July–August-survey, i.e. at the end of the breeding period and the beginning of the dispersal, some discrepancies were revealed. The presence of common gulls, black-headed gulls *Larus ridibundus* and arctic terns *Sterna paradisaea*, often in associations of adult and juveniles, was characteristic. At that time these species were probably migrating from their breeding grounds in Scandinavia and the Baltic area to their winter grounds (Cramp & Simmons 1983, Horton et al. 1984, MacKinnon & Coulson 1987). Overall, most of the species were present in higher frequencies than in May–June. Reasons may be movements of early migrators and nonbreeding individuals as well as an increasing activity of foraging parents caring for large chicks at the end of the breeding period (Wanless & Harris 1992).

The distribution of northern fulmars at the vessel showed high numbers in the central and western part of the study area in the North Sea (Fig. 1a). In general, more were seen in the north than in the south of the study area. Lowest numbers were found in the southeastern North Sea. It was the only common species present in maximum numbers far offshore. Near the coast, the numbers decreased noticeably. The map deviates from that in Tasker et al. (1987), since those data showed lower concentrations of northern fulmars in the central area of the North Sea. However, those surveys were not taken during trawling. Northern fulmars do not start to breed before a mean age of 9 yr (Dunnet & Ollason 1978). In contrast to all other species studied here, they are known to spend an average of up to 29 h away from the breeding sites, flying as far as 120 km to forage (Furness & Todd 1984). This could explain their high numbers throughout the whole area.

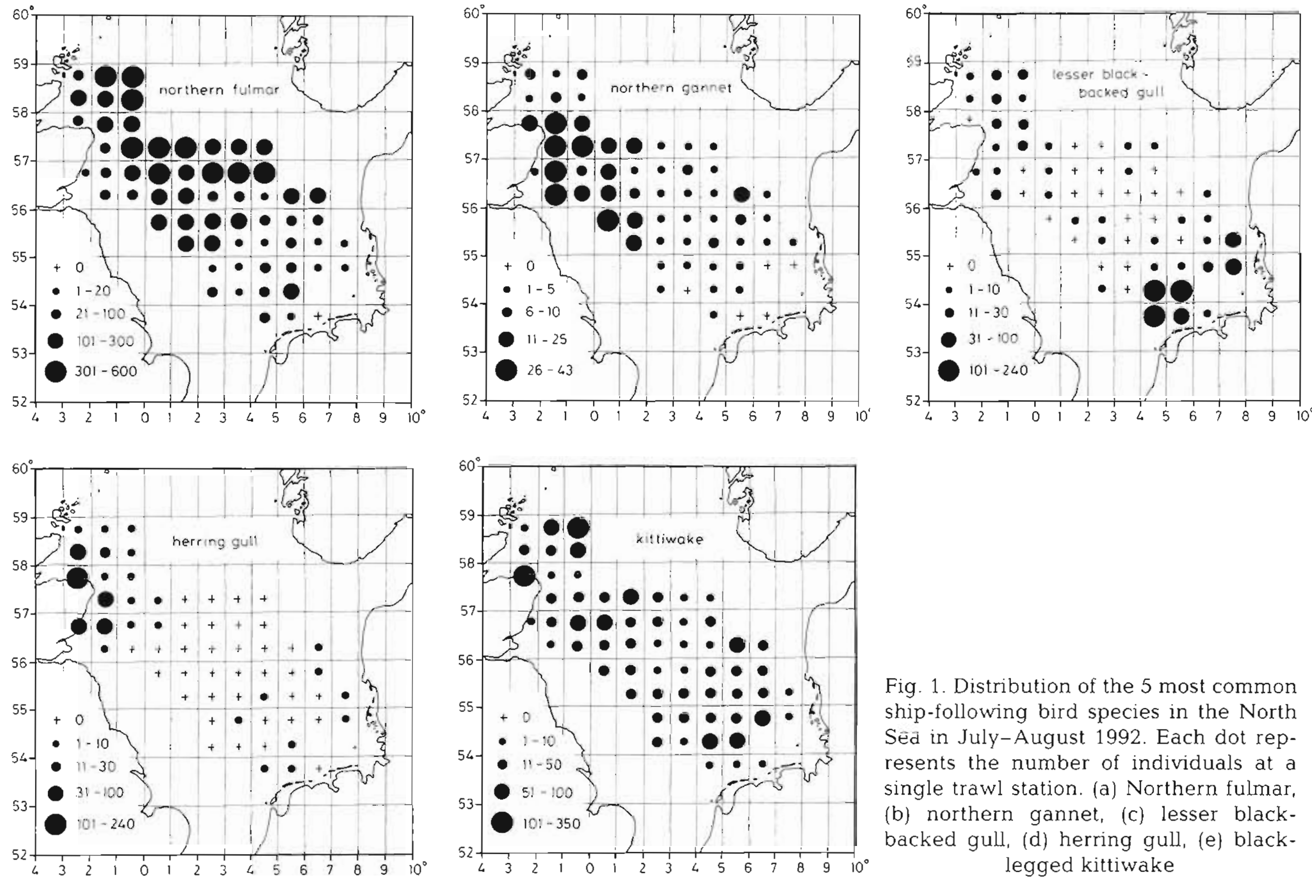

Fig. 1. Distribution of the 5 most common ship-following bird species in the North Sea in July–August 1992. Each dot represents the number of individuals at a single trawl station. (a) Northern fulmar, (b) northern gannet, (c) lesser black-backed gull, (d) herring gull, (e) black-legged kittiwake

Northern gannets were seen in higher numbers in the western part of the North Sea than in the other areas (Fig. 1b). They were numerous only near the colony at Bass Rock in the Firth of Forth, Scotland, but they were present in low numbers at nearly all trawl stations, except a few in the German Bight.

Lesser black-backed gulls occurred in considerable concentrations close to the Dutch and German coast, and in lower numbers near the Scottish coast (Fig. 1c). The highest numbers of herring gulls were found close to the Scottish coast, with low numbers in the southeastern part of the study area (Fig. 1d). Both herring gull and lesser black-backed gull were hardly recorded in central parts of the North Sea. Their maps resemble those presented in Tasker et al. (1987). Despite a much lower breeding population in the southeastern part of the study area (Furness 1992), the numbers of lesser black-backed gulls there were many times higher than those of herring gulls, presumably because lesser black-backed gulls may utilize fishery wastes near the Wadden Sea to a higher degree than herring gulls (see Noordhuis & Spaans 1992).

Black-legged kittiwakes were more evenly distributed. Slightly higher numbers were found in the southeastern and northwestern parts of the North Sea (Fig. 1e). Even in the central and eastern part of the study area, black-legged kittiwakes were found in surprisingly high numbers, which stands in contrast to the maps in Tasker et al. (1987).

Choice of fish species and length

Nearly all length classes of offered fish were utilized by ship-following seabirds due to the broad spectrum of bird species (Fig. 2). In all fish species (see Table 2 for scientific names) we notice much overlap in their utilization by bird species. However, *average length* choices of the fish species taken varied among the most common ship-following bird species, northern fulmar, northern gannet, lesser black-backed gull, herring gull and black-legged kittiwake. Significant differences (Kruskal-Wallis *H*-test) between these bird species occurred in the choice of lengths of whiting ($\chi^2 = 210.9$, $p < 0.0001$, $n = 864$), poor cod ($\chi^2 = 131.6$, $p < 0.0001$, $n = 259$), Norway pout ($\chi^2 = 48.7$, $p < 0.0001$, $n = 1318$), haddock ($\chi^2 = 183.5$, $p < 0.0001$, $n = 497$), herring ($\chi^2 = 266.1$, $p < 0.0001$, $n = 1046$), sprat ($\chi^2 = 36.9$, $p < 0.0001$, $n = 240$) and grey gurnard ($\chi^2 = 9.72$, $p < 0.05$, $n = 86$). No differences were found for sand eels (χ^2 = 3.38, not significant, n = 173). Northern gannets took the largest mean lengths of all fish species except poor cod, black-legged kittiwakes the smallest. Common gulls and black-headed gulls, which were not present as often as other species, behaved much like black-legged kittiwakes in their length choices. In most cases, northern fulmars, great skuas *Catharacta skua*, lesser black-backed gulls, herring gulls and great black-backed gulls *Larus marinus* were intermediate between northern gannets and black-legged kittiwakes in their choices of fish lengths. Great black-backed gulls and great skuas tended towards greater lengths, whereas herring gulls and lesser black-backed gulls were inclined to select intermediate lengths. Some of the variability in the mean lengths of fish chosen by different ship-following bird species can be explained by their body measures (Table 1): body lengths of birds correlated with length choice in 4 out of 6 fish species, body mass and bill length on 2 occasions each.

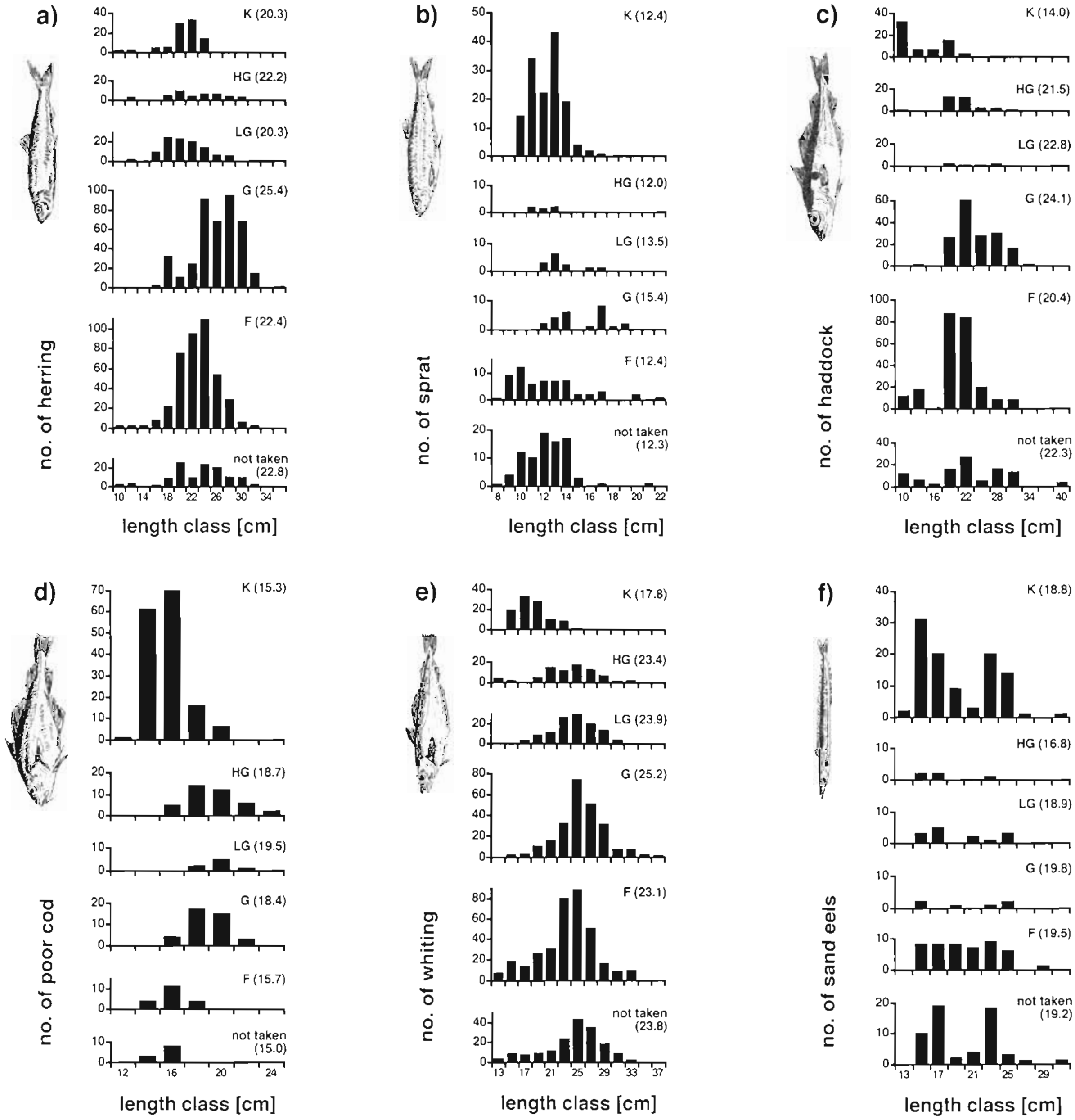

Fig. 2. Length choices of 6 fish species by seabirds in May–June and July–August 1992. The *x*-axis shows the length classes with their approximate centre. F: northern fulmar; G: northern gannet; LG: lesser black-backed gull; HG: herring gull; K: black-legged kittiwake. (a) Herring (n = 1189, mean length offered = 23.2 cm), (b) sprat (n = 335, 12.6 cm), (c) haddock (n = 604, 21.1 cm), (d) poor cod (n = 270, 16.4 cm), (e) whiting (n = 1166, 23.1 cm), (f) sand eels (n = 235, 19.0 cm)

Table 1. Body masses, body lengths (after Bezzel 1985) and bill lengths (after Cramp & Simmons 1977, 1983) of the most numerous bird species and their correlations with average fish lengths. Significant correlations ($r > r_{0.05;4,1}$) are underlined

Species	Body mass (g)	Body length (mm)	Bill length (mm)
Black-legged kittiwake	371	390	34.0
Northern fulmar	781	475	39.3
Lesser black-backed gull	792	595	51.9
Herring gull	1061	610	54.9
Northern gannet	3015	935	98.4
Coefficient of correlation			
$r_{sand\ eel}$	0.360	0.234	0.273
r_{sprat}	0.875	0.866	0.886
$r_{herring}$	0.927	0.840	0.857
$r_{haddock}$	0.666	0.794	0.721
$r_{poor\ cod}$	0.409	0.631	0.557
$r_{whiting}$	0.662	0.770	0.697

Length *ranges* of fish species taken also differed considerably between the different bird species (Table 2). Northern gannets and northern fulmars took the longest individuals of most fish species. Northern fulmars showed a highly variable utilization of offered fish lengths due to their pecking of offal out of the fish bodies, especially from large specimens of which the remains sank later on. In this manner they achieve an expanded length spectrum. Common gulls, black-headed gulls and black-legged kittiwakes took predominantly smaller fish, i.e. the maximum lengths of the fish species chosen often lay distinctly below those selected by larger bird species.

Black-legged kittiwakes and the other 4 bird species had a clear size separation for whiting, poor cod and haddock (Fig. 2). In contrast, length choices for sand eels, sprat and herring overlapped considerably between these bird groups. Similarly, a clear separation between northern gannets and northern fulmars/large gulls occurred for haddock and herring, but not for sand eels and only slightly for whiting and poor cod. In most cases, northern fulmars and large gulls overlapped to a great extent in their length choices of offered fish.

Different natural lengths of fish may explain some of these results. It is often not possible, especially for smaller bird species, to swallow larger fish such as cod. On the other hand, all common ship-following seabirds can manage sprats at any time. Realistic comparisons may only be applicable if other parameters of fish body dimensions are considered. The lack of significance in the comparison of length choices for sand eels and the largest mean of taken sand eels by the smallest bird species, the black-legged kittiwake, showed that length is not the only parameter of interest for birds, as already shown by Swennen & Duiven (1977) for 3 species of alcids.

Success index

In both the May–June and July–August surveys, northern gannet was the species most successful at getting fish (Table 3). Herring gull, black-legged kittiwake, pomarine skua *Stercorarius pomarinus*, lesser black-backed gull, great black-backed gull and northern fulmar followed within a close range. Even lower success indices were found for great skua, common gull, black-headed gull and finally common tern *Sterna hirundo* and arctic tern *Sterna paradisaea*.

Northern gannets were most successful in taking offered fish. The success of northern fulmars depended strongly on the quantitative composition of other ship-followers but was never very high. They succeeded least during trawls where all bird species were present. Absence of species with food piracy behaviour, such as great skua, northern gannet and great black-backed gull, leads to higher success indices. Black-headed gull and common gull were less successful than the other, more typical ship-following species. However, the extra food provided by fishing vessels could help them satisfy their energy demands during migration.

Analyses of those hauls during which all the bird species considered were present gave more detailed results: northern gannet and black-legged kittiwake showed a relatively constant success rate, whereas northern fulmar was more successful in the absence of larger species such as northern gannet, great skua and great black-backed gull. Success indices of lesser black-backed gull and herring gull were highly variable, showing no clear tendencies.

How accurate is this mean success index? Since we have no information about the length of time birds stay behind vessels, we do not know how many individuals per species actually attend a trawl and the consecutive processing. Erikstad et al. (1988) determined an average of 480 to 591 min for black-legged kittiwakes following a ship in the Barents Sea in August 1986. The vessel trawled regularly every 20 to 30 n miles. Between the trawl stations the birds rested on the ship. With few exceptions, this observation could not be confirmed on either of the 'Walther Herwig' journeys. Thus, a shorter following time seemed probable. Hudson & Furness (1989) mention that the average

Table 2. Numbers of fish offered to and eaten by birds, and length ranges (in cm) of fish not taken and eaten by birds in the North Sea

Species	No. of fish offered	Fish eaten (%)	Length: Not taken	Northern fulmar	Northern gannet	Great skua	Black-h. gull	Common gull	LBB gull	Herring gull	GBB gull	Black-l. kittiwake
Total number	13991	82	2485	4451	2251	57	20	54	948	604	146	2963
Norway pout *Trisopterus esmarki*	3279	96	12–20.5	10–22	12–20	15–16	15–16	14–18	12–20.5	12–20	14–20	11–21.5
Poor cod *Trisopterus minutus*	279	96	13–16	13.5–19.5	16–21	–	–	–	18–21	15.5–24	–	12–20
Herring *Clupea harengus*	2419	90	10–31	10–31	12–36	23–31	15–17	12–20	11–28	11–31	16–33	9–24
Lesser argentine *Argentina sphyraena*	55	84	15–22	15–23	17	–	–	–	17–20	–	17–19	16–19
Whiting *Merlangius merlangus*	3629	82	7–34	11–43	15–37	18–31	11	19–21	13–31	13–36	17–32	13–27
Haddock *Melanogrammus aeglefinus*	1458	80	10–40.5	10–38	12–39.5	29	13	12–13	11–28	11–31	12–29	10–21
Sprat *Sprattus sprattus*	862	77	8–21	7.5–22	9–19	–	10–14	11–12	11–17	11–13	–	9–17
Pilchard *Sardina pilchardus*	30	73	25–28	–	–	–	–	–	23–28	25–27	–	–
Sand eels *Ammodytes* sp., *Hyperoplus* sp.	641	72	14–31	14–28	14–25	–	16	–	15–25	14–23	–	13–31
Cod *Gadus morhua*	187	70	14.5–42	8–37	21–33	–	7	10	14–32	16.5–29	29	10–18
Grey gurnard *Eutrigla gurnardus*	276	55	12–37	17–34	16–33	–	13	–	13–24	14–22	18–28	19
Mackerel *Scomber scombrus*	161	52	23–35	24–25	25–36.5	–	–	–	21–29	24–28	–	–
Rocklings *Rhinonemus cimbrius* etc.	24	42	17–28	18	–	–	–	–	17–24	–	–	17–21
Dragonet *Callionymus lyra*	19	37	16–23	17	20–21	–	12	–	16–22	24	–	–
Scad *Trachurus trachurus*	110	36	21–33	28–30	25–33	–	–	–	21–30	22–30	–	17
Lemon sole *Microstomus kitt*	19	21	18–35	–	22	–	–	–	–	–	18–25	–
Long rough dab *Hippoglossoides platessoides*	53	8	10–25	–	16.5	–	–	–	19–20	–	–	–
Dab *Limanda limanda*	322	7	12–26	13–17	14–22	–	–	–	11–24	17–19	–	–
Other/not identified roundfish	165	79										
Other flatfish	3	0										

number of northern gannets recorded at any particular instant near a trawler is merely an indication of the total number, since they appear to have a high turnover rate in following ships.

Proportion of discarded fish consumed

The ship-following bird species showed a different utilization of discarded fish species and lengths. The proportion of discards taken by birds varied between 7 and 96%, depending on the fish species (Table 2). Gadidae and Clupeidae were taken at highest rates: almost all Norway pout and poor cod were eaten with herring, lesser argentines, whitings and haddocks ranging next. The slightly lower rate for cod may be explained by its greater mean length compared to haddock and whiting. Because of the small mesh size, some species, such as poor cod and especially Norway pout, were often too small to be caught in commercial nets. Also larger individuals of herring and Gadidae (e.g. haddock, whiting, cod) are normally marketed and not discarded from commercial vessels. Flatfish were hardly taken because they are difficult to handle (Hudson 1989, pers. obs.). Since all fish discarded were dead, the possibility of a higher survival rate of flatfish at discarding (Berghahn et al. 1992) can be ruled out. On the whole, 84% of all roundfish and 8% of all flatfish offered were taken by birds. Despite the quite different conditions on a vessel, our figures come close to the proportions eaten by birds following Scottish trawlers (minima of 58 and 5% respectively; Hudson & Furness 1988, Furness pers. comm.) or trawlers in the German Wadden Sea (68 to 90% for smelt *Osmerus eperlanus* and 73 to 82% for whiting; Berghahn & Rösner 1992).

This study helps to develop a quantitative approach to the interactions of fishery and seabirds. The ultimate question (how much fishery waste do seabirds actually consume?) could not be answered, since especially the feeding rate (Table 2) is assumed to be lower in commercial fisheries discarding large quantities all at once (Camphuysen et al. 1993) compared to our study discarding single fish. Also, the type and amount of discards are different from com-

Table 3. Success indices of the most common ship-following bird species in the North Sea 1992. Average values for all hauls with presence of the species are shown in the first 3 columns, the next 2 columns give the number of hauls in which the species occurred, the final 2 columns present these as percentages of total hauls. May–June: n = 56 hauls; July–August: n = 51 hauls; –: not present

	May–June	July–August	Both journeys combined	No. of hauls with species present May–June (n)	July–August (n)	May–June (%)	July–August (%)
Northern gannet	80	71	76	46	43	82	84
Herring gull	34	45	38	38	28	68	55
Black-legged kittiwake	34	40	37	56	49	100	96
Pomarine skua	–	36	36	0	2	0	4
Lesser black-backed gull	33	38	35	40	38	71	75
Great black-backed gull	40	28	31	6	19	11	37
Northern fulmar	37	25	31	56	51	100	100
Great skua	30	23	24	3	21	5	41
Common gull	0	24	23	1	29	2	57
Black-headed gull	0	20	17	3	18	5	35
Common tern / arctic tern	–	4	4	0	11	0	22

mercial fisheries. However, 2 quite tangible examples illustrate the importance of discard use: on 15 July 1992, a ca 4 yr old northern gannet was observed to swallow 5 mackerel (25 cm, 3 × 26 cm, 28 cm) and a whiting (22 cm) which were experimentally discarded, in less than 10 min. Using length-mass relationships in Daan (1975) and energetic values provided in Sidwell (1981) for mackerel muscle and Hislop et al. (1991) for whiting, the total energy consumed was 5875 kJ. Assuming an utilization efficiency of 80% (Wiens 1984, Castro et al. 1989), 4700 kJ remained for the northern gannet. Birt-Friesen et al. (1989) determined a field metabolic rate (FMR) of 4865 kJ d^{-1} for feeding adults in Newfoundland, Canada. This implies that the northern gannet observed in the southern North Sea met its energy demands for more than a day as a nonbreeding individual with less energy costs than a breeding adult within those 10 min.

Another energy consideration could be formulated as follows: how many fish does a herring gull need each day? Hüppop (1987) estimated that nonbreeding individuals require 940 kJ d^{-1}. Thus, herring gulls can meet their energy demands for 1 day by eating a cod of 31 cm or 2 plaice of 25 cm estimated by length-mass relationships in Daan (1975) and by energetic values in Sidwell (1981). These energetic aspects show the enormous potential of fishery wastes in providing a supplementary food source to seabirds. Further studies, e.g. on the turnover rate of species and their age groups at the vessels, would describe the situation of competition more precisely.

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