

The behaviour of seabirds foraging at fishing boats around Shetland

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Among the different types of fishing vessels around Shetland, whitefish trawlers attract the largest numbers of scavenging seabirds and provide the most food. Offal was almost all consumed by seabirds, predominantly by Fulmars *Fulmarus glacialis*, which excluded other species by their aggression. Fulmars generally ignored discarded whole fish, which were mainly taken by Great Black-backed Gulls *Larus marinus*, Gannets *Sula bassana* and Great Skuas *Catharacta skua*. Although flatfish were usually ignored because seabirds found them difficult to swallow and they sank faster, most discarded roundfish were consumed. Herring Gulls *L. argentatus*, Lesser Black-backed Gulls *L. fuscus* and Kittiwakes *Rissa tridactyla* were rarely able to obtain offal or discards. Herring Gulls and Lesser Black-backed Gulls spent much time on the periphery of feeding flocks while Kittiwakes rarely attempted even to join these. Most of the birds at trawlers were in adult plumage, and it is suggested that the low proportion of immature birds present was a further reflection of the highly competitive feeding conditions at trawlers. We suggest that likely changes in fishing practice and seabird population sizes in the immediate future may result in Herring Gulls, Lesser Black-backed Gulls and Great Skuas finding feeding on waste around trawlers increasingly difficult, so they may be further displaced by Fulmars, Gannets and Great Black-backed Gulls.

Although there is little doubt that Fulmars *Fulmarus glacialis*, large gulls and some other seabirds find a ready food supply from the fish waste of trawlers, the role of these supplementary food supplies in the population increases of seabirds has been hotly disputed. Cramp *et al.* (1974) summarized the position by stating that further information on seabird diets and feeding ecology would be essential before any reasonable conclusion could be drawn regarding the causes of population increase.

Since then, it has become apparent that some seabird populations may consume large quantities of fish by comparison with local fish stock biomasses. Reductions in fish stocks can result in dramatic breeding failures or population declines of seabirds, as seen recently off Peru (Furness 1982) and in west Norway (Lid 1981, Barrett & Vader 1984). However, the exploitation of fishery waste by seabirds has received scant attention, apart from brief descriptions of seabirds associated with Norway Lobster *Nephrops norvegicus* trawlers in the Irish Sea (Watson 1981), and at trawlers off Plymouth (Lake 1984), northwest Scotland (Boswall 1960, 1977), and east Scotland (Hillis 1971). From a study of Great Skua *Catharacta skua* pellets and regurgitates, Furness & Hislop (1981) suggested that this species may sometimes consume a large proportion of the fish discarded by fishing boats around Shetland, but no observations of the methods by which skuas fed at boats were presented.

Furness *et al.* (1988) used fisheries' catch data and observations of discarding from boats to estimate that the quantities of food made available to seabird in this

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way might support the annual energy needs of some 2 or 2.5 million 1-kilogram seabirds throughout the sea areas surrounding the British Isles. Since this seems to be a food supply of great importance to several species of large scavenging seabird, and since the foraging behaviour of seabirds at trawlers has not been documented in detail, we describe in this paper the numbers and ages of seabirds associating with Shetland fishing vessels, their feeding behaviour and interspecific interactions.

Methods

During 1984 and 1985, observations were made on the fishing practices of different kinds of boats from Shetland ports, on numbers of scavenging seabirds feeding on discarded waste, and on the behaviour of the different species of seabird.

Data were collected mainly by travelling on boats and observing seabirds associated with that boat, but some observations were made from aerial surveys. Most boat trips were made on trawlers or seiners fishing for whitefish (principally haddock *Melanogrammus aeglefinus* and whiting *Merlangius merlangus*) within 50 km of Shetland, since it was soon found that boats fishing for industrial fish (sandeels *Ammodytes marinus* or Norway pout *Trisopterus esmarkii*) or for herring *Clupea harengus* or mackerel *Scomber scombrus*, provided few feeding opportunities for seabirds.

Birds were counted at regular intervals, from when the net first began to be hauled to the time when all gutting and discarding had ceased and the boat had been hosed down. Maximum counts of each bird species were recorded for every haul and the average maximum number of birds of each species present for all the hauls was calculated for each trip. Details were reported by Hudson (1986).

Percentages of birds in adult plumage were recorded for Great Black-backed Gulls *Larus marinus*, Herring Gulls *L. argentatus*, Lesser Black-backed Gulls *L. fuscus*, and Gannets *Sula bassana*. For Great Skuas and Fulmars, ages could not be determined from fishing boats.

During July and August in 1984, observations were conducted from whitefish trawlers on four separate fishing trips and for 23 hauls. In 1985, observations on the numbers of seabirds feeding behind whitefish trawlers were conducted from March to October. In all, 23 trips were made, covering approximately 33 days, during which data from 151 hauls were collected.

An aerial pollution patrol is operated from Scatsa by the Shetland Islands Council in connection with the Sullom Voe oil terminal. Trawlers fish in the areas patrolled by the pollution aeroplane, although not in tanker lanes. Aerial surveys of fishing boats from this plane provided information about birds feeding behind a number of boats at any one time and on the general distribution of trawlers in Shetland waters. On some occasions, the boats were passed over very quickly so that accurate assessment of the species composition of the bird flocks was not possible, and then birds were classed as unidentified. During August and September in 1984, three flights were made, totalling about 4½ hours. On each flight, the numbers of whitefish boats and the birds behind them were counted, or estimated where flocks were large. During 1985, aerial observations were conducted from March–October, so that any seasonal changes in bird numbers and species could be determined. In all, 18 flights were made, totalling approximately 22 hours. The trips conducted in March were during the pre-breeding season and the October trip was after the breeding season. The intervening months were divided into the breeding season (April–July) and the post-breeding season (August and September).

Experimental discarding of known numbers of pieces of offal was performed by AVH on three occasions to allow the foraging success of gulls to be quantified.

Results

Fishing methods and food made available to seabirds

Industrial fishing around Shetland is primarily for sandeels. In addition, some foreign trawlers fish for Norway pout. Sandeel boats trawl very fine nets, generally for a couple of hours, before landing the catch aboard. Sandeels are usually loaded directly into the trawler's hold and little becomes available to seabirds. Whitefish were occasionally caught in sandeel nets resulting in small discards and offal (from fish that were large enough to be gutted) being made available to seabirds. Apart

from those instances, few sandeels were spilled overboard, although gulls generally gathered around the hauling boats on the off chance of obtaining some scraps.

Herring and mackerel were caught by large purse-seine trawlers, which upon locating a shoal, encircled the area with a net and hauled in. The fish were sometimes floated to allow evacuation of their stomachs before being loaded into the trawler's hold. Little waste food was made available to seabirds, other than spilt stomach contents, and these attracted mainly Fulmars and Kittiwakes.

Whitefish were caught by a variety of trawler types, from small boats little more than 7 m long, to light trawlers and seiners up to 20 m in length, and large, generally foreign, stern trawlers well in excess of 20 m long. Seine trawlers operated by releasing a buoy attached to one end of a warp, steaming ahead and letting the net out, before steaming around to collect the buoy, thus leaving the net in a circle. The net was then towed along near the seabed for approximately 2 hours, at which stage it was hauled in. The two ends of the rope pulled the net mouth together. Light trawlers let their nets out behind the boats and steamed ahead fast until the net had sunk. Otter boards were used to hold open the mouth of the net near the sea bed until it was ready to be hauled. Trawls lasted anything from 2 to 5 hours, depending on the size of the boats. As with the seine boats, fish were forced into the codend of the net before being landed on deck.

Some of the older boats do not have shelter decks so the fish are landed on the open deck. Nowadays, more of the boats are having shelter decks fitted and the fish are landed inside these. In the former situation, fish are sorted on deck and offal and small and unwanted fish discarded overboard. On boats with shelter decks, the discard fish and offal are thrown into a gutter along the edge of the shelter deck and these are washed out at frequent intervals. Thus, the major differences are that during sorting of the catch on boats without shelter decks there is a continual stream of fish and offal going overboard, but on boats with shelter decks the scuppers are emptied every few minutes releasing large amounts of waste together, although there is often also a steady out-pouring of small amounts of offal. When each catch has been sorted and gutted, the gutted fish are boxed in ice and stored below deck. Then the decks are hosed down, releasing the last scraps of waste food for the seabirds. Once a haul is aboard, the boats either let out the net immediately or else go to a new area before repeating the above procedure.

During the first haul of a trip, when the net was still being towed, few birds attended the trawlers but numbers built up once the net began to be hauled in, with at least a couple of hundred birds generally present when the net reached the surface (Fig. 1). Numbers peaked during the gutting and discarding process but peak numbers varied enormously from haul to haul. Numbers fell off once the decks had been hosed down and the boat was towing again or steaming to a new area. Towing the net lasted for several hours, while lifting the net took some minutes. The duration of the sorting, gutting and discarding process depended on the size and composition of the catch. Gutting and discarding were normally completed well before the next occasion that the net was lifted to the surface, so that seabird numbers attending the boat would always fall between periods when food was made available. Birds would either land on the sea surface to rest, or fly off towards land or to the nearest boat at which other birds were obtaining food.

Birds observed from trawlers

The maximum number of each bird species present around a trawler for each haul was noted for all fishing trips made on whitefish trawlers in 1984 and 1985, and the average calculated (Table 1). The Fulmar was generally the most numerous species

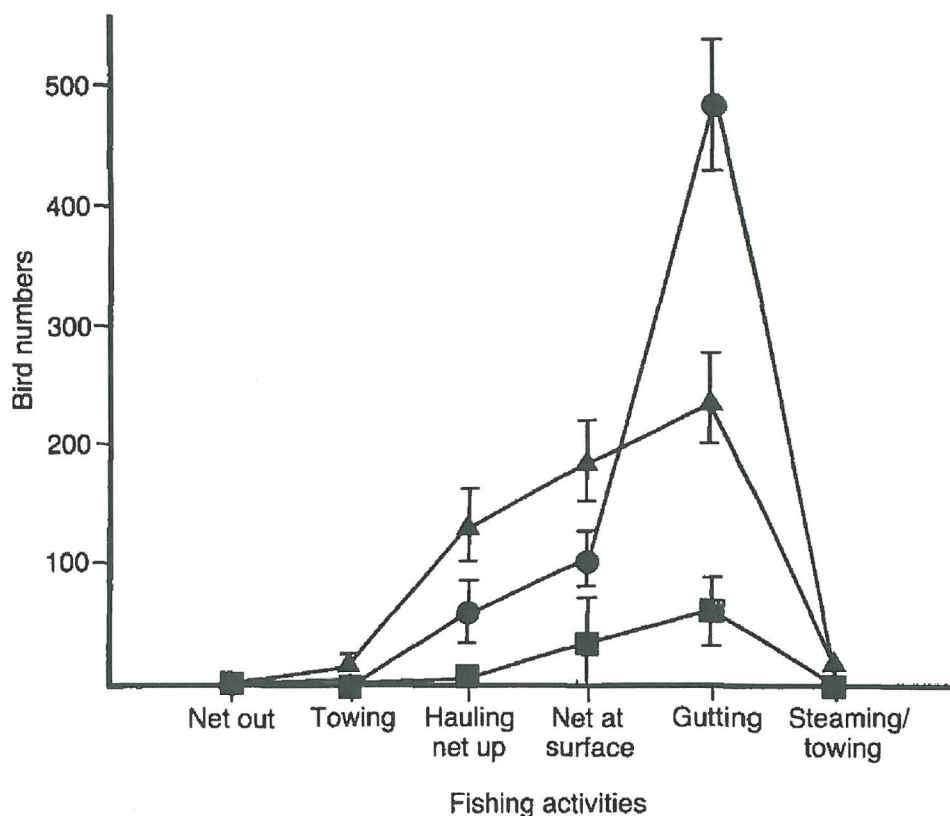


Figure 1. Numbers of each seabird species following whitefish trawlers in Shetland at different stages in the fishing procedure. Counts were made from the vessels during summer 1985. Altogether, 145 separate hauls were sampled. Data points are means with 95% confidence limits shown for Fulmar (●), Great Black-backed Gull (▲) and Herring Gull (■).

and the Great Black-backed Gull was the next most abundant. Maxima of 2500 Fulmars and 1100 Great Black-backed Gulls were recorded at a single haul. During the summer, Herring Gulls normally occurred in smaller numbers, usually ranging from 0 to 50 but sometimes up to 400 birds. On four occasions the numbers of Herring Gulls recorded increased substantially during the final haul, with up to 800 birds present as the trawler approached Scalloway Harbour. These birds flew out from the Scalloway Islands and had not attended the trawlers further out to sea, so that they only obtained food from the last haul. Great Skuas were present at most hauls and Gannets were present on all trips but not at all hauls. Lesser Black-backed

Table 1. Means of the maximum counts of each scavenging seabird species attending trawlers around Shetland

Period	Number of hauls	Fulmar	Great Black-backed Gull	Great Skua	Gannet	Herring Gull	Lesser Black-backed Gull	Kittiwake	Total
July 1984	17	472	69	12	1	38	1	5	598
August 1984	6	967	1	15	1	0	0	1	985
March 1985	6	850	143	0	5	1633	1	7	2639
April-July 1985	92	498	240	11	8	33	5	2	797
August-September 1985	53	423	207	11	6	31	1	1	680

Gulls and Kittiwakes *Rissa tridactyla* were often present in low numbers, but they were absent altogether for many hauls. Very small numbers of Black-headed Gulls *Larus ridibundus*, Storm Petrels *Hydrobates pelagicus*, Arctic Skuas *Stercorarius parasiticus*, Arctic Terns *Sterna paradisaea*, Sooty Shearwaters *Puffinus griseus*, Shags *Phalacrocorax aristotelis* and Puffins *Fratercula arctica* were recorded close to fishing boats. Sooty Shearwaters were seen to surface-dive behind the boat, which would suggest feeding, but whether they took fishery waste could not be ascertained. As numbers of all of these species were always low, their role in discard consumption was minimal.

The effect that distance from the shore might have on bird numbers and species composition was tested. On the occasions when gutting continued until the boats were close to land, it was obvious that the proportions of Fulmars and Herring Gulls interchanged, with Herring Gulls becoming increasingly more plentiful close to land (Table 2). For all species that could be aged from plumage characteristics, most of the birds at trawlers were adults (Table 3).

Aerial observations

The mean numbers of birds per boat counted behind whitefish trawlers during aerial observations (Table 4) did not differ significantly between seasons ($\chi^2_{31.08}$, n.s., Kruskal-Wallis one-way ANOVA by ranks test); the October count was omitted from the comparison as it involved only one boat. The numbers of birds behind whitefish trawlers were significantly higher more than 25 km from land than closer to shore (Table 5, $\chi^2_1 = 5.17$, $P < 0.05$, Kruskal-Wallis test). The Fulmar was the most numerous species at trawlers. On those occasions when counts of each species could not be made with accuracy, it was still obvious that Fulmars made up the bulk of the flock. Excluding the October count, numbers of Fulmars behind trawlers (Table 6) showed no significant differences between seasons $\chi^2_3 = 1.19$, n.s., Kruskal-Wallis test). However, significantly more Fulmars were present behind trawlers far from land (Table 7) than close to shore ($\chi^2_1 = 5.28$, $P < 0.05$, Kruskal-Wallis test).

Behaviour of seabirds at trawlers

In this paper only the general behaviour of the birds consuming offal and discards is discussed, while some quantitative relationships are described elsewhere (Hudson & Furness 1988).

Table 2. Comparison of numbers of Fulmars and Herring Gulls around whitefish trawlers when more than 5 km from shore and when less than 5 km from shore during the gutting and discarding process following the final haul

Date	Numbers when more than 5 km from shore		Numbers when less than 5 km from shore	
	Fulmars	Herring Gulls	Fulmars	Herring Gulls
17 July 1984	500	0	50	500
29 July 1985	600	10	10	300
9 August 1985	300	150	10	800
2 September 1985	500	0	0	800

$P < 0.001$ for all occasions (χ^2 comparisons).

Table 3. Percentages of birds in flocks at whitefish trawlers around Shetland in 1985 that were in adult plumage

Date	Great Black-backed Gull	Lesser Black-backed Gull	Herring Gull	Kittiwake	Gannet
30 April	80	100	100	0	100
8 May	90	90	50	95	95
14 May	85	95	—	—	—
20 May	—	85	—	—	—
10 June	80	95	—	—	70
17 June	85	—	85	—	—
19 June	85	—	—	—	—
24 June	85	—	90	—	75
22 July	90	—	—	—	75
24 July	80	—	85	—	90
29 July	90	—	—	—	75
31 July	75	—	—	—	55
7 August	90	—	90	0	—
12 August	—	—	—	—	100
18 August	90	—	90	—	95
27 August	85	—	—	—	60
2 September	75	—	70	100	90
5 September	50	—	—	—	100
9 September	70	—	—	75	100
10 September	70	—	—	80	80

Table 4. Mean numbers of birds observed behind whitefish trawlers in different periods of the year during aerial counts around Shetland 1984 and 1985 (some birds counted could not be identified to species), so means for individual species are for six, 40 and 16 counts in March, April–July and August–September 1985, respectively)

Season	Number of counts	Mean (\pm s.e.) number of birds per boat	Mean number of birds per boat			
			Fulmars	Great Black-backed Gulls	Great Skuas	Gannets
Aug-Sept 1984	16	481 (\pm 183)	379	101	1	1
March 1985	8	810 (\pm 368)	852	0	0	2
Apr–July 1985	43	881 (\pm 274)	861	9	2	4
Aug–Sept 1985	19	787 (\pm 163)	471	45	1	43
October 1985	1	1500 —	1500	0	0	0

Fulmar

On all trips virtually all of the offal discarded was seen to be consumed by seabirds. Furthermore, most was taken by Fulmars. During the early stages of gutting and discarding, gulls and Great Skuas occasionally obtained offal before large numbers of Fulmars had gathered. Thus, when few Fulmars were in attendance at trawlers at the beginning of gutting they obtained rather little, but as their numbers increased during the gutting procedure, so the percentage of offal taken by Fulmars increased. This was demonstrated by counts of the number of whole pieces of experimentally discarded offal seen to be swallowed by seabirds over successive 5-minute periods. On three occasions, the percentage of offal consumed by Fulmars rather than by other birds increased from 51 to 94% over the first 15 minutes of offal discharge,

Table 5. Mean numbers of each bird species observed behind whitefish trawlers near and far from land during aerial counts around Shetland 1984 and 1985

	Numbers per boat < 25 km from land	Numbers per boat > 25 km from land
Number of boats counted	54	33
Mean seabirds per boat	621	1050
Standard error	147	260
Fulmars	488	1008
Great Black-backed Gulls	57	25
Great Skuas	2	1
Gannets	17	1
Kittiwakes	0	2
Unidentified seabirds	57	13

Table 6. Amount of offal consumed by Fulmars, as a percentage of all offal consumed by seabirds, around whitefish trawlers in Shetland 1985

	Observation occasion								
	1	2	3	4	5	6	7	8	9
No. of Fulmars present	500	300	250	350	275	125	165	200	200
No. of Great Black-backed Gulls	150	75	75	150	100	350	350	700	200
No. of Herring Gulls	0	5	10	10	20	0	20	20	200
Fulmars as a % of all birds	70	72	74	67	66	24	30	21	32
Mean % of offal taken by Fulmars	99	94	92	86	82	78	71	61	35
Mean % taken by Herring Gulls	0	2	4	4	6	0	4	6	45
Mean % taken by other seabirds*	1	4	4	10	12	22	25	33	20

* Other seabirds were almost exclusively Great Black-backed Gulls but included occasional Great Skuas, Lesser Black-backed Gulls and Kittiwakes.

from 54 to 81% in the first 20 minutes and from 49 to 84% in the first 15 minutes, as Fulmar numbers increased in the immediate vicinity of the trawler where the offal was being discharged. On most occasions, nearly all of the offal discarded by fishermen was consumed by Fulmars as these were usually already present in large numbers when offal discarding commenced.

Determining the consumers of individual pieces of offal was difficult. Large gulls and Great Skuas generally took whole pieces of offal if they were available, or intestine without liver, which was less favoured by Fulmars, whereas groups of Fulmars tended to fight over offal, particularly fish livers, with many individuals obtaining tiny scraps. Thus, an accurate assessment of the amount of offal consumed per bird by each species present was not possible. However, Fulmars generally obtained over 90% of the offal going overboard, the exceptions being either when very few Fulmars were present or when a very large number of gulls was present in relation to the number of Fulmars (Table 6). Both situations were rare in Shetland during the summer months, except close to land.

Fulmars were clearly superior to all other scavenging species in their ability to obtain offal. When the boat was stationary, Fulmars gathered in such dense flocks around the trawler that other bird species were prevented from landing in the area. When the boat moved, Fulmars flew alongside, quickly dropping down to snatch the

offal as it was discharged. When large volumes of offal were discharged at once, e.g. when the scuppers were washed out at the end of gutting, very tightly packed groups of 30–100 Fulmars collected almost immediately and the offal was consumed within seconds. Fulmars were able to reach the offal exceedingly quickly by 'paddling' across the water while at the same time flapping their wings, rather than by taking off and flying as the gulls and skuas did. Fulmars closest to the boat chose the livers by preference, with those birds furthest from the boat taking the guts.

Fulmars did swallow some whole fish, although these tended to be very small and were only consumed during periods when no offal was being discarded. Alternatively, Fulmars ripped open the bellies of discarded whole fish to feed on the liver and guts when there was a lull in the discharge of offal. However, while they were tackling whole fish, which often took Fulmars several minutes to rip open and remove the offal, the larger gulls, Gannets and Great Skuas often stole the fish. Thus Fulmars obtained almost all of the offal but hardly any of the discarded whole fish.

Gannet

Gannets were very successful in obtaining discarded fish. They were observed diving deep for fish that had sunk and also shallow-diving for fish only just submerged. Gannets were rarely observed to take offal. Often, a Gannet would approach the trawler from a distance and, almost immediately, dive and obtain a fish, repeat this procedure two or three times and then fly away. Each Gannet can consume several fish in a very short period of time, and fish over 30 cm in length can be swallowed. The turn-over rate of Gannets at trawlers can be rapid; one can fly in, feed, and depart within a few minutes. Gannets therefore differ from gulls and Fulmars in that they do not usually spend long periods lingering around trawlers waiting for food to become available. Thus, the average number of Gannets recorded at an instant at a trawler may give little indication of the total number of Gannets that feed behind trawlers, and may not emphasize the importance of Gannets as consumers of discards enough. Gannets take little account of gulls and skuas when plunging for discarded fish. Gannets are usually noisy as they arrive and the smaller birds appeared to make way for them.

Great Black-backed Gull

Great Black-backed Gulls gathered on the water during hauling above the point where the net would hit the surface and, by the time the net was visible, hundreds of gulls were generally waiting (Fig. 1). At this stage, the net was some distance from the boat so that the feeding behaviour and success of individuals could not readily be distinguished. As the net was drawn in towards the boat, Great Black-backed Gulls tended to linger behind, while Fulmars crowded close to the trawler. Once gutting and discarding began, Great Black-backed Gulls obtained offal only if few Fulmars were present. They usually waited for fish to be discarded and then quickly snatched them from the sea surface. Great Black-backed Gulls often stole fish from other birds, particularly from Fulmars near to the boat. Fights frequently broke out amongst a group of gulls, with many birds fighting over one fish. Either one bird alone was the victor, or the fish was torn apart so that more than one gull obtained food.

Great Skua

Great Skuas obtained little offal, owing to the presence and aggression of large

numbers of Fulmars. They often tried to plummet down amidst a group of Fulmars fighting over offal but they were rarely successful in stealing any pieces, and were forced to flee by aggressive threats of Fulmars.

The Great Skuas concentrated, instead, upon taking whole fish. They obtained some as the net was hauled towards the boat, either by pulling fish through the codend or by taking small fish that had already been forced out through the codend. This behaviour of Great Skuas was characteristic and was rarely performed by gulls. Great Black-backed Gulls generally waited for discarding to begin, while Herring and Lesser Black-backed Gulls tended to remain on the boat superstructure or on the fringe of the gull flock some distance behind the net. Great Skuas sometimes stood on the net itself as it was being lifted and so obtained many Norway Pout and, in particular, small Whiting that were squeezed through the meshes at this stage. However, most fish taken by Great Skuas were those that had been discarded by the fishermen. They sometimes took fish close to the trawler but, as a rule, Fulmars were there waiting for offal so the skuas stayed behind the trawler with Gannets and gulls. They either took fish directly from the sea surface or stole them from other Great Skuas or from gulls and, in turn, their own fish were often stolen by gulls. Great Skuas were chased by Great Black-backed Gulls surprisingly frequently, and were forced to drop fish. Indeed, contrary to the reputation of the Great Skua as a pirate, as a result of the large number of Great Black-backed Gulls present and the ability of these larger birds to swallow large discarded fish more readily than could Great Skuas, skuas had more fish stolen from them than they managed to steal. However, Great Skuas would frequently threaten Great Black-backed Gulls in order to obtain a better position to drop onto discarded fish, and were often successful in doing so.

Herring Gull

Herring Gulls were generally not very successful in obtaining fish or offal. Much of their time was spent sitting on the trawler rather than searching for food and, although Herring Gulls formed only a small proportion of the scavenging seabird flocks, they were the most frequent species to be seen perched on the superstructure of the boat itself. This gave them an opportunity to steal some fish and offal directly from the deck, which other seabird species did not do.

When offal was discarded, Herring Gulls succeeded in obtaining some when they were present in large numbers. However, once Fulmar numbers built up and they settled on the water, Herring Gulls hovered overhead; when offal was then discharged, Fulmars scuttled across the water and had consumed most of the offal before the Herring Gulls had flown across and dipped down to try to obtain some. Small numbers of Herring Gulls were successful, however, even when many Fulmars were present. They managed to snatch pieces of offal on deck and from the sides of the boats whereas Fulmars waited for the offal to go overboard and land on the sea. Because they tended to sit on the boat, Herring Gulls obtained more offal than did the Great Black-backed Gulls, relative to the numbers of each species present (Tables 6 and 7). Herring Gulls did manage to swallow a few discarded fish but, as a rule, they were displaced from discards by the larger Great Black-backed Gulls and Great Skuas.

Lesser Black-backed Gull

Lesser Black-backed Gulls occurred in low numbers and obtained only small quantities of fish and offal. Their behaviour resembled that of Herring Gulls rather than that of Great Black-backed Gulls, in that they tended to sit on the gunwale and

Table 7. Mean number of pieces of offal consumed per bird present for Herring Gulls and Great Black-backed Gulls behind whitefish trawlers in Shetland in 1985

	Number of trials	Mean number (\pm s.e.) pieces of offal per bird	
		Herring Gull	Great Black-backed Gull
Test 1	25	0.434 (\pm 0.061)	0.038 (\pm 0.006)
Test 2	14	0.128 (\pm 0.024)	0.018 (\pm 0.008)
Test 3	5	0.394 (\pm 0.132)	0.007 (\pm 0.015)

t-test between means for Herring Gull and Great Black-backed Gull
 $P < 0.001$ in each case.

shelter deck and watch other birds take the food for much of the time. Lesser Black-backed Gulls took little offal, and were generally displaced from the best positions over discards by Great Black-backed Gulls and Great Skuas. They also tended to avoid dense aggregations of Herring Gulls on the few occasions when these occurred, choosing instead to feed individually rather than within tight flocks.

Kittiwake

In contrast to the situation in some other areas, such as the Clyde and the Irish Sea, Kittiwakes around Shetland rarely attempted to take fish or offal at trawlers and were only observed in small numbers behind boats. They kept well clear of dense flocks of larger birds and usually only attempted to pick small scraps off the sea well behind fishing boats.

Discussion

Fulmars were found to be the most abundant scavenger species at trawlers around Shetland during the summer and autumn. Great Black-backed Gulls were next in numerical importance. Herring Gulls were commonest close inshore but were generally scarce further from shore, where the proportion of Fulmars present increased. This has also been noted elsewhere (Lockley & Marchant 1951, Hillis 1971).

Aerial observations allowed the determination of a mean count of bird numbers per fishing vessel (Table 4). The mean values did not only refer to boats that were hauling but included boats in all activities. Compared with shipborne counts, aerial observations provided much more extensive data, albeit with more birds not identified to species. The mean numbers of birds recorded behind trawlers in Shetland were generally higher than the value of 517 noted (by shipborne counts) in the Irish Sea between 1972 and 1975 from 62 spot counts around small trawlers during all fishing activities (Watson 1981). In the Irish Sea, rather low numbers of Fulmars were observed (maximum 100) and the Herring Gull was the most numerous species (maximum 1000), while in Shetland the Fulmar was present in much greater numbers (Table 8); the difference in the mean number of seabirds attending trawlers between the two areas largely stems from the relative abundance of the Fulmar. Near Rockall, the Fulmar was again the most abundant bird species in association with trawlers. Frequently 2000–3000 were present when large amounts

Table 8. Mean numbers of seabirds associated with fishing boats in different areas. Minimum and maximum counts are given in parentheses. The seasons are defined as 'summer' (April-July) and 'winter' (October-February)

Species	Shetland Summer ¹	Irish Sea		Clyde Winter ³	N Rona Summer ⁴	E Scotland Winter ⁵
		Summer ²	Winter ²			
Fulmar	485 (10-2500)	23 (0-100)	3 (0-30)	< 1 (0-3)	155 —	1 (0-4)
Gannet	9 (0-200)	11 (0-50)	6 (0-50)	6 (0-167)	5 —	15 (0-51)
Great Black-backed Gull	234 (10-1000)	213 (0-800)	251 (10-900)	6 (0-80)	15 —	2 (0-24)
Lesser Black-backed Gull	6 (0-20)	2 (0-10)	< 1 (0-1)	3 (0-88)	1 —	2 (0-28)
Herring Gull	30 (0-400)	5 (0-30)	16 (0-60)	241 (0-1340)	90 —	87 (0-380)
Kittiwake	3 (0-50)	75 (0-200)	78 (2-400)	24 (0-285)	35 —	0 —
Great Skua	12 (0-50)	< 1 (0-6)	< 1 (0-6)	< 1 (0-1)	0 —	0 —

Sources and sample sizes are: ¹ this study $n = 72$ counts from trawlers; ² Watson (1981) $n = 18$ in summer, 32 in winter; ³ Ensor & Hudson unpubl. $n = 149$; ⁴ Boswall (1960) n not given; ⁵ Anstey (1984) $n = 18$.

of offal were discharged and on one occasion approximately 5000 were observed (Lockley & Marchant 1951). These figures compare with the aerial surveys of trawlers fishing further from Shetland than the boats from which observations were actually conducted, with up to 8000 Fulmars present around two large stern trawlers fishing close to each other north west of Unst. By comparison, rather smaller numbers of Fulmars have been reported from more southerly locations (Boswall 1960, Hillis 1971).

Herring Gulls and Kittiwakes appear to be most abundant near to shore and around small vessels, especially those employed in mixed shellfish/demersal trawling (Norway lobster trawlers). These boats catch many undersized fish, much too small for market, and many are therefore discarded and available to smaller bird species (pers. obs., Hillis 1971, Watson 1981). Off North Rona a higher proportion of Great Black-backed Gulls occurred, rather than Herring Gulls, although Fulmar numbers were low here, at 100-150 (Boswall 1960). Further north, the same observer noted similar numbers of Fulmars, up to 15 Great Skuas but very few gulls (Boswall 1977). Thus, the range in numbers of different seabird species behind trawlers is great (Table 8).

Close to the west coast of Shetland are fishing grounds suitable for, and widely used by, small trawlers. The small size of these boats limits their catch size and therefore the amount of waste discarded which, in turn, probably affects the numbers of birds present. The larger boats fish further from the coast and their fishing practices may be rather different. Whilst no direct information was gathered from such boats during this study, it is very likely that each trawl would be of several hours duration and that more fish would be caught per haul than by the small seine trawlers. Certainly, the enormous numbers of birds following in their wake would suggest that this is the case.

Seabirds feeding on fishery waste behind Shetland whitefish trawlers fell into two quite distinct categories. First, Fulmars fed to a great extent on offal, a point similarly noticed off North Rona (Boswall 1960). Competition among Fulmars for the offal was great. Such competition has been discussed by Enquist *et al.* (1985). The aggressive behaviour of Fulmars was also recorded during observations from the research platform Nordsee, where Fulmars were seen to be dominant to all species of *Larus* gulls in competition for food, and were also observed to be very aggressive towards Pomarine Skuas *Stercorarius pomarinus* (Rosler 1980). Secondly, gulls, Great Skuas and Gannets fed more on discarded fish and a distinct hierarchy was noted. Great Black-backed Gulls swallowed most fish, followed by Great Skuas and Gannets, but Herring Gulls took few fish and Lesser Black-backed Gulls took very few. However, Great Black-backed Gulls were also most abundant; Great Skuas and particularly Gannets appeared to be highly successful in relation to their smaller numbers.

Herring Gulls were not generally present in very large numbers behind Shetland trawlers in summer, and they did not often obtain large amounts of food, although they did appear to be more successful than the Great Black-backed Gulls in obtaining offal. In winter, according to the fishermen, the situation is quite different, with many more Herring Gulls attending trawlers and obtaining food, both offal and discards. Many of these gulls may be migrants from further north (Coulson *et al.* 1984); these birds are larger than their British counterparts and this may account for their reputedly higher success. The fishermen also report that gulls are bolder after the Christmas break, taking more food from the deck and also taking food directly from their hands. They attribute this to starvation, as all Shetland boats stop fishing for the holiday period and thus a large food source is denied the birds. Gulls and skuas take offal if allowed to do so but were usually denied access to this by the Fulmars. The increase of the Fulmar population may have reduced the chances for gulls and skuas to obtain offal.

The high proportion of birds in apparently adult plumage in flocks around trawlers was unexpected. Rather than providing an easy source of food that could be exploited lazily by inexperienced birds with no demands on their time, feeding at fishing boats appeared to be highly competitive and demanding, and predominantly undertaken by older birds. However, Furness & Hislop (1981) found that immature Great Skuas make at least as much use of discards as do breeding Great Skuas. Our results may be biased by the fact that most trips were made in waters close to major breeding colonies, and boats fishing further from land may attract a higher proportion of immature birds.

The high numbers of Great Black-backed Gulls at Shetland boats is noteworthy since the local breeding population is thought to be about 3000 pairs, suggesting that many may be non-breeders from the much larger Norwegian population.

While the exact role of offal and discards in the dynamics of seabird populations remains to be elucidated, this study has shown that Fulmars, Great Black-backed Gulls, Gannets and Great Skuas now make extensive use of fishing boat waste around Shetland and that each species has a distinct feeding niche. Although the situation in the past can only be a matter for speculation, competition for fishery waste is now clearly intense, so that Kittiwakes, Herring Gulls and Lesser Black-backed Gulls obtain very little food because they are generally unable to compete successfully with the larger species. Further population increases of the largest species or reductions in the quantities of offal and discards made available may have detrimental effects on the species lowest in the current foraging hierarchy; namely Herring Gull, Lesser Black-backed Gulls, and perhaps Great Skuas. The influence

of current increases in net-mesh size to reduce discarding should be viewed with interest.

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