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WITH EMPHASIS ON THE SOUTHERN NORTH SEA

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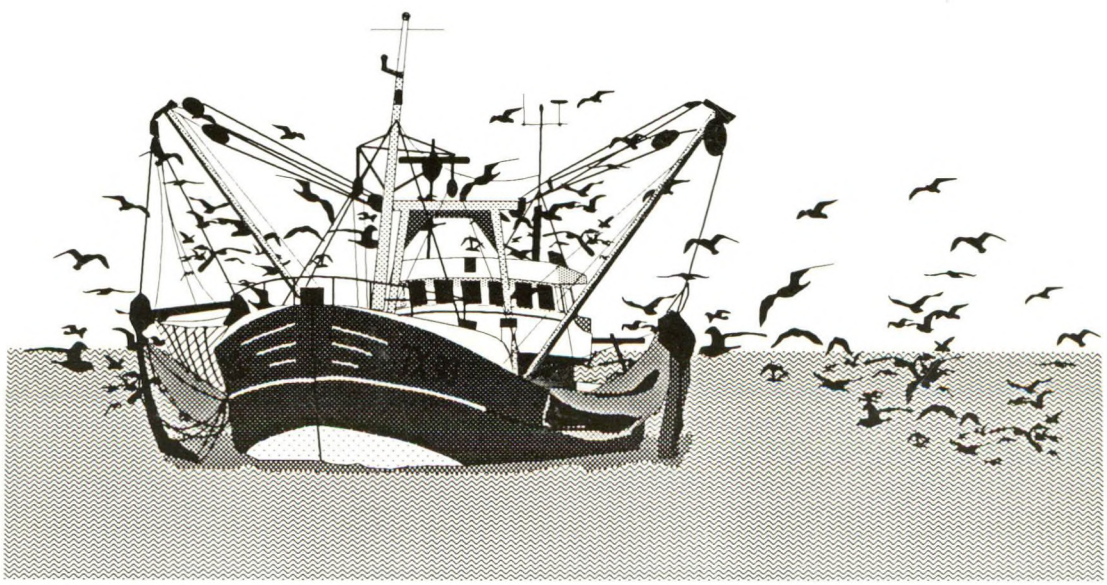

Nederlands Instituut voor Onderzoek der Zee

Netherlands Institute for Sea Research (NIOZ)
P.O. Box 59, 1790 AB Den Burg,
Texel, The Netherlands

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SUMMARY

The relative importance of scavenging offal and discards in the feeding ecology of seabirds is not well known. The first part of this report consists of a literature review of results of earlier studies of scavenging seabirds at boats, mainly in the NE Atlantic. The second part consists of an analysis of recent sightings of trawlers and associated seabirds during ship-based surveys in the southern North Sea. The analysis aimed at the identification of and a first quantification of the seabirds which take advantage of fishery waste in the southern North Sea, using previously unpublished data. The third part of this report is a review of the breeding distribution and breeding numbers of (potentially) scavenging seabirds in the southern North Sea, using a mixture of data taken from recent literature and unpublished sources. In the final section, in a discussion of the information included in this report, current knowledge is summarized and suggestions for future research are given.

The review of results of earlier work in the NE Atlantic is focussed on seabird species composition behind trawlers, feeding methods, feeding success, and discard/offal provision (quantity, type of fishery). Results of earlier studies of scavenging seabirds behind fishing vessels, range from more qualitative approaches (*e.g.* Van der Heide 1938, Reinsch 1969, Hillis 1971, 1973, Munsterman 1971, Brandt 1975, Boswall 1977, Nelson 1978) through more quantitative work (*e.g.* Boswall 1960, Manikowski 1971, Watson 1981, Hudson & Furness 1988, Berghahn & Rösner 1992).The most important scavengers behind trawlers in the NE Atlantic region are:

Fulmar	offshore
Great Shearwater	offshore
Sooty Shearwater	offshore
Gannet	offshore
Great Skua	mainly offshore
Black-headed Gull	mainly coastal
Common Gull	coastal
Herring Gull	mainly coastal
Lesser Black-backed Gull	mainly coastal
Great Black-backed Gull	coastal and offshore
Kittiwake	mainly offshore

Since March 1987, the distribution of seabirds in the southern North Sea has been studied by means of ship-based surveys. So far, the records of seabirds attending fishing vessels in these databases were not analysed. The fishing vessels with associated bird flocks were extracted from the database, in order to find species composition, and spatial and temporal distribution of the associated flocks (species by species). Distribution maps for the most important species are provided and discussed. The most abundant and most frequent scavenger in the Dutch sector of the North Sea was the Herring Gull (287 records, 30,898 individuals, present throughout the year). Second, there is a group of 'common' scavengers, comprising Fulmar, Common Gull, Lesser Black-backed Gull, Great Black-backed Gull and Kittiwake (140-190 records, >6000 individuals, only the Fulmar is present through the year). Scarce, but still rather

frequently reported, were Gannet and Black-headed Gull (>50 records), while occasional scavengers were Great Skua, Little Gull, and Common Tern. Fulmar, Gannet, Great Skua and Kittiwake were typical scavengers in the offshore zone, Common Gull, Herring Gull and Lesser Black-backed Gull were typical inshore species. In summer, Lesser Black-backed Gulls ventured further out to sea than Herring Gulls. Fulmar and Herring Gull were observed in most months at trawlers. Winter scavengers were Gannet (Aug-Apr), Black-headed Gull (Oct-Mar), Common Gull (Oct-Apr), Great Black-backed Gull (Aug-Apr), and Kittiwake (Jul-Mar), while the Lesser Black-backed Gull mainly occurred in summer (Mar-Oct).

Breeding populations of all seabirds in the North Sea which are known to obtain a substantial part of their food at trawlers have increased during most of this century. The overall increase may partly be attributed to relaxation of persecution, but also to increased availability of food as a result of an increase in fishing effort in the North Sea. Recent estimates of numbers of breeding seabirds (pairs) on southern North Sea coasts are 3479 pairs of Fulmars, 781 pairs of Gannets, 196258 pairs of Black-headed Gulls, 10554 pairs of Common Gulls, 32424 pairs of Lesser Black-backed Gulls, 113757 pairs of Herring Gulls, 1 pair of Great Black-backed Gulls, and 123545 pairs of Kittiwakes.

Scavenging seabirds compete for fishery waste at trawlers. This conclusion can be drawn from the facts that (1) most of the offal and a high proportion of discarded fish are eaten by seabirds, (2) feeding success varies among species, (3) the presence of one species at a trawler clearly reduces the feeding success of another, (4) adults generally have higher feeding success rates than immatures, (5) high rates of kleptoparasitism occur. Complex dominance hierarchies are found amongst seabirds at trawlers, often with Gannet, Fulmar and Great Black-backed Gull as most powerful, or aggressive scavengers. Kittiwake, Lesser Black-backed Gull and Sooty Shearwater are examples of more timid scavengers, often feeding at the periphery of feeding flocks. Scavenging seabirds tend to select fish they can handle easily and swallow without much delay. Most of the discarded roundfish are swallowed by seabirds while flatfish and benthos (which both sink faster) are more often ignored. Larger flatfish are obviously not favoured because of their body shape. Feeding efficiency at trawlers is very much dependent on species composition and on the manner in which discards and/or offal are released. The constant release of small quantities of offal and single fish from a moving trawler offered excellent feeding opportunities for Kittiwakes, which were feeding close to the stern of the ship, away from the general scrumble for discards in the wake of the vessel. The release of larger quantities at once reduced the feeding possibilities from this and other rather 'timid' species, while the more aggressive species obtained most of the fishery waste in a massive fight behind the ship

The information on the use of fishery waste by seabirds is still far from complete. Few detailed, quantitative studies have been performed. Even the most basic information, the relative abundance and species composition of seabirds at trawlers, is often not available. In many parts of the North Sea it is still not clear which type of fishery is more attractive to seabirds than the other. Information on the quantity and composition of discards and offal in different fisheries is not readily available and needs to be collected on board commercial trawlers. In the Netherlands, the beamtrawl fishery is the major fishery in terms of tonnes of

fish landed. Therefore, the quantity of offal and discards which is put overboard in this fishery in the southern North Sea, the proportion of discarded biota which is consumed by seabirds, and the (possible) effects on seabird populations should be studied. Basic questions are:

(1) how much biota are discarded by the Dutch beamtrawl fishery (species composition, quantity, spatial and temporal distribution),

(2) which are the birds scavenging in the southern North sea (species composition, relative abundance, diet, spatial and temporal distribution),

(3) what proportion of the discarded biota are consumed by seabirds, and

(4) what is the effect of discards/offal provision to populations and breeding success of scavenging seabirds in the southern North Sea.

(5) is the beamtrawl fishery the most important fishery in terms of food provisioning to scavenging seabirds

Counts of seabirds associated with commercial trawlers are needed. The turnover rate of scavengers at a trawler deserves much more study. The status of Fulmars scavenging at trawlers in summer in the southern North Sea is not clear. Herring Gulls and Lesser Black-backed Gulls, assumed to compete at trawlers during the breeding season in the coastal zone, should be studied in particular detail. Diet studies in gull colonies at the Waddensea islands could be coupled with the discharge of large quantities of tagged fish at sea at various distances off these coast, in areas where these birds are presumed to feed at trawlers. The effect of the establishment of a 'protected area' off Texel and Vlieland, from which all fishing activities are removed, should be investigated. Base-line data should be collected, now that such an area is only planned. The effects of other meauseres which resulted into a decline of fishing effort on breeding performance of gulls and other scavenging seabirds should be studied in detail. The scavenging habits of Common Gulls and Black-headed Gulls (in winter) have not sufficiently been studied. When Little Gulls or terns are present in the flock of birds at a trawler, it should be tried to observe whether these birds are actually feeding on fishery waste.

1. Introduction

Biota that are caught by fisheries but not landed are discarded at sea. Large quantities of offal (*i.e.* entrails of gutted fish) and discards (unmarketable fish or bycatch) are set overboard in commercial fisheries. Offal and discards are an important source of food for scavenging marine animals, most notably for seabirds like Fulmar *Fulmarus glacialis*, Gannet *Sula bassana*, and several species of gulls *Larus* spp., *Rissa tridactyla* (Fisher 1952, Furness 1992). Recent studies of seabirds at sea have demonstrated a strong affinity between several species of seabirds and trawlers (Wahl & Heinemann 1979, Tasker *et al.* 1987). Several authors have concluded that the provision of this source of food by commercial fisheries is an important factor behind the high breeding success, spread and immense population growth of species like Fulmar or Herring Gull *Larus argentatus* in the North Atlantic (*e.g.* Gross 1951, Fisher 1952, 1966, Fisher & Lockley 1954, Harris 1970, Furness 1977, Evans 1984). During this century, the breeding populations of the Lesser Black-backed Gull *Larus fuscus* and Herring Gull in the southern North Sea have increased spectacularly. It is believed that a better protection of colonies in combination with an increase in the availability of food as found on rubbish tips, on fish-markets in harbours and as discards behind trawlers has been responsible for these trends (*e.g.* Harris 1970, Møller 1981, Noordhuis 1987).

Despite all this, the relative importance of scavenging offal and discards in the feeding ecology of seabirds is not well known. Data of Furness *et al.* (1988), collected around the Britsh Isles, suggested that the quantities of offal and discarded fish made available to scavenging seabirds are indeed enormous and could support as many as 2.5 million '1000-gram' seabirds. Obviously, even if discards and offal are taken only opportunistically, this source of food is potentially of great importance for seabirds in the North Sea. But scavenging, as a very 'visible' foraging behaviour of seabirds, should perhaps not be overestimated in the absence of less easily gathered data on natural feeding (*cf.* Brown 1970, Watson 1981). Moreover, species composition and, hence, dominance hierarchies and discard consumption, differ between sea areas and few areas have been studied in sufficient detail (*e.g.* Furness *et al.* 1992).

The first part of this report consists of a review of results of earlier work, mainly in the NE Atlantic. The literature search was mainly meant to find out what is currently known about scavenging seabirds and how these data were collected. The second part of this report consists of an analysis of recent sightings of trawlers and associated seabirds during ship-based surveys in the southern North Sea. The analysis aimed at the identification and a first quantification of the seabirds which take advantage of fishery waste in the southern North Sea, using previously unpublished data. The third part of this report is a review of the breeding distribution and breeding numbers of (potentially) scavenging seabirds in the southern North Sea, using a mixture of data taken from recent literature and unpublished sources. In the final section, in a discussion of the information included in this report, current knowledge is summarized and suggestions for future research are given.

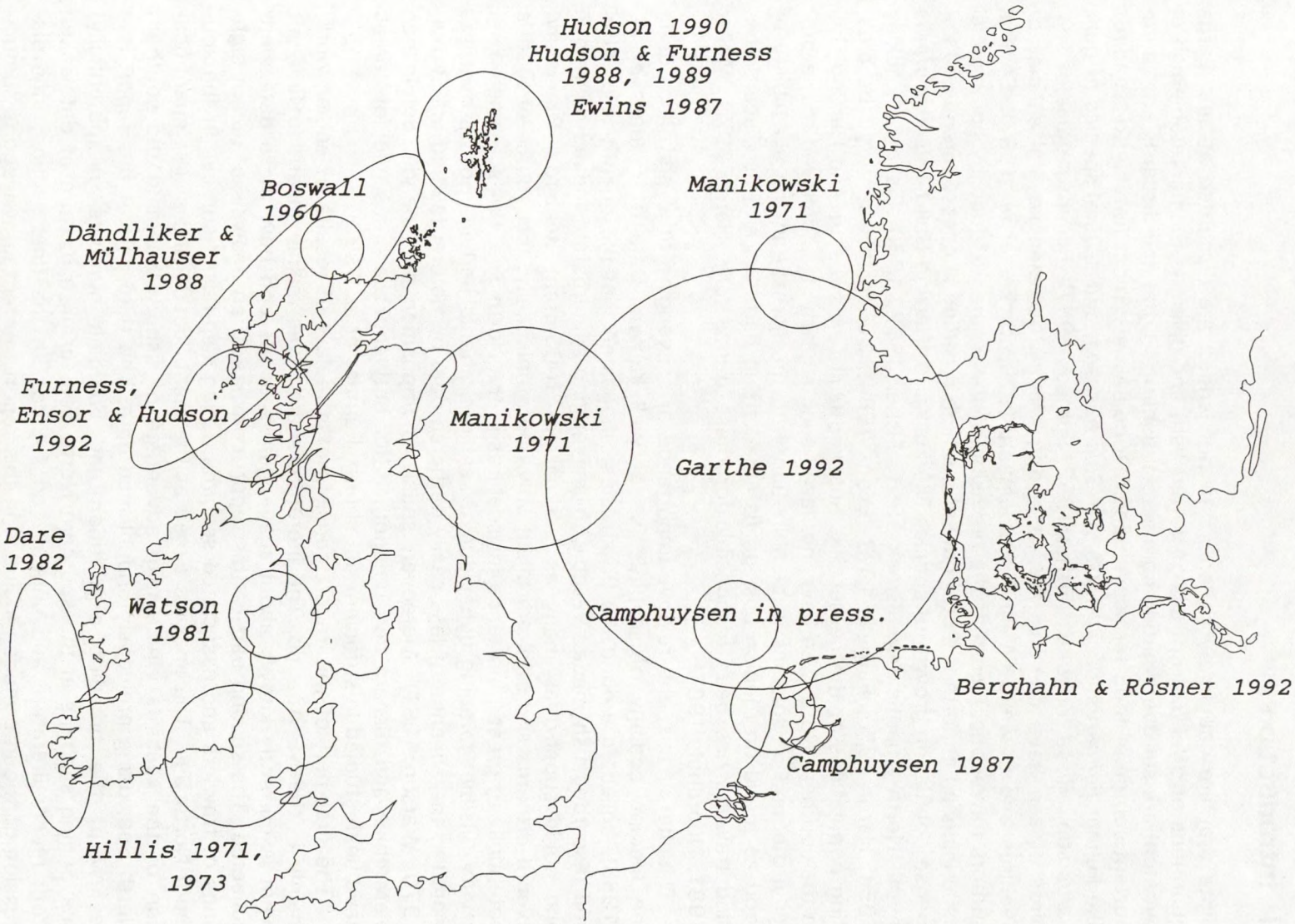


Figure 1. Earlier studies on scavenging seabirds behind trawlers around the North Sea.

2. Review of earlier studies on scavenging seabirds

In this review of results of earlier work in the NE Atlantic, attention is focussed on seabird species composition behind trawlers, feeding methods, feeding success, and discard/offal provision (quantity, type of fishery). Results of earlier studies of scavenging seabirds behind fishing vessels, range from more qualitative approaches (*e.g.* Van der Heide 1938, Reinsch 1969, Hillis 1971, 1973, Munsterman 1971, Brandt 1975, Boswall 1977, Nelson 1978) through more quantitative work (*e.g.* Boswall 1960, Manikowski 1971, Watson 1981, Hudson & Furness 1988, Berghahn & Rösner 1992). The sea areas where earlier studies were conducted are indicated in figure 1.

2.1 Irish Sea, Western Isles, Atlantic seaboard

Lockley & Marchant (1951) visited Rockall to the west of the St Kilda archipelago on board a steam trawler in June 1948. Fulmars immediately gathered around the trawler as soon as the ship stopped for whatever reason and the birds were abundant (300-5000 individuals) when offal was discharged in large quantities in the Rockall Bank area (57°-58°N, 14°W). Great Shearwaters *Puffinus gravis* were observed in considerable numbers (up to 500 in a flock), and this was the only other common scavenger in the area, coming close to the trawler during each throw-out of fish offal. Sooty Shearwaters *Puffinus griseus* were feeding on offal at greater distance of the ship and in small numbers. Fulmars seemed to dominate the shearwaters in the scramble for offal, but the shearwaters secured a slight advantage over the Fulmar in diving more deeply after sinking offal. Storm Petrels *Hydrobates pelagicus* were ocassionally seen feeding in the wake of the vessel when offal had been thrown overboard. Great Skuas *Catharacta skua*, although daily seen, were not joining in the general scramble for offal.

Boswall (1960) reported on seabirds scavenging behind a 'motor fishing vessel' in August 1959 around North Rona and Sula Sgeir (off NW Scotland). The vessel was attended night and day, while fishing was in progress, by up to 300 seabirds of 6 different species (in brackets are the result of a particular count which was considered an indication of the specific proportion):

Fulmar *Fulmarus glacialis*	(110)
Gannet *Sula bassana*	(6; 3 immature)
Great Black-backed Gull *Larus marinus*	(90; 3 imm.)
Lesser Black-backed Gull *Larus fuscus*	(2)
Herring Gull *Larus argentatus*	(5; 2 imm.)
Kittiwake *Rissa tridactyla*	(40; 1 imm.)

Rarer species seen in the vicinity of the boat were

Storm Petrel *Hydrobates pelagicus*	(up to 25 each day)
Manx Shearwater *Puffinus puffinus*	(2)

Sooty Shearwater *Puffinus griseus*	(2)
Great Shearwater *Puffinus gravis*	(2)
Great Skua *Catharacta skua*	(4)

A careful description is provided of the catch, the offal and the discards. When the ship was not moving, Fulmars obtained virtually all the offal. When the ship moved, gulls and Gannets had a distinct advantage over the Fulmars. The fate of 100 pieces of fish gut thrown overboard from a moving fishing vessel near North Rona was studied on 6 Aug 1959:

Fulmar (155 individuals)	39.5
Gannet (5)	1
Great Black-backed Gull (90)	32.5
Lesser Black-backed Gull (1)	3
Herring Gull (15)	14
Kittiwake (35)	5
Lost	5

Five pieces were divided, each by a Great Black-backed Gull *Larus marinus* and a Fulmar. Two immature Herring Gulls were not seen to eat at all. The total catch included 119 boxes (1 box is 98lb = 36.3kg) of marketable fish (103 Haddock *Melanogrammus aeglefinus*, 15 skate *Raia* spp., 1 Plaice *Pleuronectus platessa*. For each box of gutted fish landed, at least 14lb (= 5kg) of gut was thrown overboard. Hence, the amount of offal thrown overboard must have been some 238lb (= 88kg). The amount of discarded, unsaleable fish was highly variable and was estimated at 8 boxes (784lb = 290kg) for the entire trip. All fish were dead and the vast majority consisted of gurnards *Trigla* spp., 7-9 inches long, most of which were eaten by Great Black-backed Gulls, some by Gannets, while very few sank. Small flatfish, 6-8 inches long, were sometimes eaten by the three *Larus*-gulls and by Gannets, but many sank.

Hillis (1971) describes observations of seabirds scavenging at fishing vessels during 1960-71, covering all seasons, in the Irish Sea between the latitudes of Dublin and Kilkeel and from the Irish coast to 5°30'W. A species list is provided for the Irish Sea (IS), Galway Bay (GB) and Co. Cork (CC). To summarize, the only species occurring regularly as scavengers during these trips were:

Manx Shearwater	(most numerous Aug-Sep, rare mid-winter)
Herring Gull	(chief scavenging species, up to 500 or more at once, immatures increasingly numerous near the coast IS, in GB and CC most numerous, but less numerically dominant)
Kittiwake	(most numerous after Herring Gull; always present, maximum 200-300 at a time)
Great Black-backed Gull	(always present, up to 50)
Gannet	(frequent, scarce close inshore; up to 50)
Fulmar	(usually present but numbers small, rarely >20)
Lesser Black-backed Gull	(normally up to 10 in summer IS, CC)

Occasional scavengers were:

Sooty Shearwater	(1 IS, 1 GB, up to 20 CC)
Great Shearwater	(5 or more after W storms IS, up to 5 CC)
Balearic Shearwater *Puffinus mauretanicus*	(1 IS)

Storm Petrel	(occ. IS, frequently GB and CC)
Cormorant *Phalacrocorax carbo*	(up to 5 CC)
Shag *Phalacrocorax aristotelis*	(up to 10 CC)
Great Skua	(IS Jun-Nov, usually singly, CC few)
Pomarine Skua *Stercorarius pomarinus*	(1 IS)
Arctic Skua *Stercorarius parasiticus*	(frequent Aug-Sep, occ May IS, 2 GB)
Black-headed Gull *Larus ridibundus*	(1 IS)
Iceland Gull *Larus glaucoides*	(1 GB)
Glaucous Gull *Larus hyperboreus*	(few IS)
Common Tern & Arctic Tern *Sterna* spp.	(few IS)
Guillemot *Uria aalge*	(up to 20 when trawl was being hauled IS)
Razorbill *Alca torda*	(2 when trawl was hauled Bantry Bay)

Specific differences in feeding success are described. Common Gull *Larus canus* and Black-headed Gull *Larus ridibundus* appear not great scavengers of fish, for as well as being rare or absent on the trawling grounds, they are very few in number at fishing ports. Regarding the scavenging of Guillemots *Uria aalge*, the interesting feature is the timing, as sudden acquisition of the habit on a fairly large scale coincided closely with the great auk mortality in the Irish Sea of 1969 (Furphy *et al.* 1971). The change of habit could have been due if not to scarcity of food then to enfeeblement by other means of the birds, making normal fishing difficult.

Munsterman (1971) briefly reports on scavenging seabirds seen from a fishing vessel fishing Herring *Clupea harengus* west of Orkney in August 1971. Common scavengers were Fulmar, Gannet, and Kittiwake *Rissa tridactyla*, slightly less numerous were Great and Lesser Black-backed Gull *Larus fuscus*, while Great and Arctic Skua *Stercorarius parasiticus* were rather frequently seen when fishing closely inshore.

Hillis (1973) reports on a few more data collected during trawling in the Irish Sea on board a fishery research vessel. No new species on the list were added, but some of the information published previously was corrected. Great, Pomarine *Stercorarius pomarinus* and Arctic Skuas appeared remarkable common as scavengers in autumn 1971. Scavenging Guillemots, attracted during hauling of the trawl, were again observed.

Verbeek (1977) briefly reports on scavenging of Herring Gulls and Lesser Black-backed Gulls at trawlers in the Irish Sea, off Morecombe Bay, Cumbria, England. Lesser Black-backed Gulls were most abundant as scavengers and these were considered the intermediate size class between Kittiwakes and Great Black-backed Gulls in the offshore zone. Feeding bouts at the trawlers comprised (1) hauling the net, (2) sorting the catch and discarding unwanted animals, (3) gutting the marketable fish. It is noted that Herring Gulls obtain starfish *Asterias rubens* at mussel banks, while Lesser Black-backed Gulls catch many of them when they are thrown overboard.

Watson (1981) gathered data during 1968-75 (mainly Jan 1972 to March 1974) on board Northern Irish commercial vessels trawling mainly for Norway lobsters *Nephrops norvegicus* and Whiting *Merlangius merlangus* in a mixed

demersal fishery, mainly in an area to the west and southwest of the Isle of Man (NW Irish Sea). 62 spot counts of birds attending the trawlers were made at intervals during the various fishing activities (i.e. shooting net (5 counts), towing but no sorting (10), lifting net (14), steaming and sorting (4), and towing and sorting (29)) in all months of the year. Of 21,500 scavenging seabirds recorded during these counts, only six species occurred regularly:

Herring Gull	(65.9%)
Kittiwake	(25.6%)
Great Black-backed Gull	(2.9%)
Gannet	(2.7%)
Fulmar	(2.6%)
Lesser Black-backed Gull	(0.3 %) in spring and summer

Occasional scavengers:

Sooty Shearwater	(3)
Manx Shearwater	(up to 20 scavenging, most regular in Sep)
Balearic Shearwater	(2)
Storm Petrel	(occasionally June-Sep)
Great Skua	(up to 6; occ Jul-Oct, regularly Sep)
Pomarine Skua	(up to 6; occ May-Oct)
Arctic Skua	(up to 13; regularly Sep, occ May-Jul, Oct)
Black-headed Gull	(rare, up to 6 close to the coast)
Iceland Gull	(2)
Glaucous Gull	(3)
Common Tern & Arctic Tern	(up to 50, Sep)
Roseate Tern *Sterna dougallii*	(occ Sep)
Sandwich Tern *Sterna sandvicensis*	(up to 6; occ)

The commonest by-catch of fish in Norway lobster boats caught and discarded during the study, based on 1567 fish in 7 samples from unsorted catches when fishing between 27 and 37m depth, were:

Whiting *Merlangius merlangus*	(36%),
Dab *Limanda limanda*	(31%),
Sprat *Sprattus sprattus*	(14%),
and 18 other species	(19%),

and, of a total of 1171 fish when fishing between 38 and 91m depths, were:

Whiting	(39%)
Poor Cod *Trisopterus minutus*	(26%)
Norway Pout *Trisopterus esmarkii*	(16%)
and 16 other species	(19%)

All of which, except >25cm long Whitings and some of the larger Dabs, were thrown overboard. Therefore, the bulk of the food available to scavenging seabirds comprised small to medium whole fish (5-24cm), while offal was available only when larger fish (mainly Cod *Gadus morhua* and Saithe *Pollachius virens*) were caught and gutted. The Northern Irish fleet provided an estimated rejection at sea of 25 and 34 million Whitings alone in 1972 and 1973 respectively (Watson & Parsons 1974), equivalent to 685 and 910 tonnes. During 1968-71, from 9 to 17 million Whitings were discarded in any one year.

Dare (1982) discusses scavenging seabirds observed when he worked on board a commercial stern trawler (1600 tons), fishing along the 80-130 fathom line to the west and south of Ireland. The most detailed observations were made during 15-22 June 1980, when fishing was concentrated in the rectangle between 51°30'N-49°30'N and 10°W-11°15'W, *i.e.* from some 15 miles SW of the Skelligs (Co. Kerry) to 175 miles W of the Scilly Isles. Hauls were made at 3-5 h intervals and 90% of the fish caught were Horse Mackerel *Trachurus trachurus* and Mackerel *Scomber scombrus*. The paper does not provide any details on catch and quantities of discarded biota. The regular fishing acitivity attracted birds from a vast area, and many maintained station during daylight. Some apparently stayed through the night when the ship usually steamed slowly to new fishing area. Auks, Manx Shearwater *Puffinus puffinus* and Cory's Shearwater *Calonectris diomedea* showed no signs of attraction to the ship. Common scavengers off W and SW Ireland were:

Fulmar	(maximum at a haul usually 10-50, exceptionally 125)
Storm Petrel	(maximum usually 25-125, exceptionally 225)
Gannet	(maximum 300-500)
Lesser Black-backed Gull	(maximum 5-10, exceptionally 50 near the Scilly Isles)
Kittiwake	(maximum 10-30)

Scarce scavengers were:

Great Shearwater	(1-2 per day)
Sooty Shearwater	(3-5 per day)
Pomarine Skua	(2)
Arctic Skua	(2)
Great Skua	(1-3 per day)
Sabine's Gull *Larus sabini*	(0-2 per day)
Herring Gull	(maximum at a haul 20, often totally absent)
Great Black-backed Gull	(maximum at a haul 10, often 1-5 or totally absent)

Dändliker & Mülhauser (1988) report on scavenging seabirds following large French trawlers (*Julien Queré* and *Ludovic Jego*) operating in waters to the west of the Outer Hebrides, around North Rona and Sula Sgeir and to the west of Orkney and Shetland. Large numbers of birds following the ship were only seen when working the fishing grounds. The quantity of offal produced was roughly estimated as 10-15% of the amount of fish landed (*cf.* Boswall 1960, Bailey & Hislop 1978). The quantity of discarded fish was highly variable. Earlier estimates, quoted in this report, were 7% of the landed fish (Boswall 1960), 5-10% as an overall estimnate of the landed catch in NE Atlantic fisheries (Bailey & Hislop 1978, and even 30% from trawlers in the North Sea (Furness & Monaghan 1987). In this study, it was found that 15-25% of the catch, and in some cases even 30-35% of the catch was discarded. The paper describes in considerable detail the positions which the various species as scavengers take during hauling and steaming, as well as intra- and interspecific interactions of ship-followers. Three phases are described when offal and discards become available for seabirds. (1) When hauling the net, some small fish escape, which can be taken by birds, (2) when the net is set out to sea again, the water washes remaining fish out, and (3) when the fish is sorted, offal and unmarketable fish is

put overboard. Most numerous scavengers were:

Fulmar	(up to 2500 at a time)
Gannet	(up to 1000 in an exceptional case, usually less than 50)
Sooty Shearwater	(5-100)
Great Shearwater	(1-50)
Storm Petrel	(up to 100, usually 5-20)
Lesser Black-backed Gull	(up to 100)
Kittiwake	(up to 40)

Scarcer species were

Great Skua	(1-6)
the three other species of skuas *Stercorarius* spp.	(1-3).
Herring Gull	(0-10)
Glaucous Gull	(up to 2)
Great Black-backed Gull	(up to 10)

Furness, Ensor & Hudson (1992) describe the use of offal and discards by seabirds around Shetland and in West Scotland (the Clyde). The availability of offal and discards, the numbers and species at fishing boats, and foraging interactions between species are described. Common scavengers in Shetland are listed later (see Hudson & Furness 1989). Common scavengers in the Clyde were:

Gannet
Herring Gull
Lesser Black-backed Gull
Kittiwake
Fulmar
Great Black-backed Gull

The difference between fishing practices in Shetland and the Clyde are described, including the time spent discarding and the activities of fishing vessels which proved to be most attractive to seabirds (Shetland: during hauling and gutting, Clyde: for 49% of the time between lifting the first haul of the day and the end of the day's fishing). Numbers of Kittiwakes at boats in the Clyde were larger than found at boats in Shetland, but represented a small part of the local population. Seasonal changes in numbers of Herring Gulls at boats in the Clyde differed from those recorded on rubbish tips. Herring Gull numbers appeared to be depressed in the Clyde in those months during which Gannets attend fishing boats in largest numbers. Herring Gulls appeared to move away from the Clyde Sea in the face of increased competition with Gannets. It is concluded that, geographical variation in the use of fishery waste by gulls is not well known and deserves further study.

2.2 Icelandic waters, Norwegian and Barents Seas

Reinsch (1969) describes the scavenging behaviour of the Gannet, mainly from his personal experiences on board *Anton Dohrn* in May 1967 near the Vestmann Islands (SW Iceland). Apparently, Gannets do not so much to accompany trawlers, like Fulmars and gulls do, but do stream out to boats which are operating

nearby if discards and/or offal is actually provided (*cf.* Nelson 1978). According to Reinsch, Gannets are attracted to non-moving fishing vessels when the noice of winches can be heard. Obviously, the behaviour of other scavengers (most notably other Gannets) is a great stimulus for the birds to alter course and have a look at a trawler. Fish listed as being taken by Gannets behind the trawler (excluding species which are taken during 'normal' feeding) includes *Sebastes* spp., *Micromesistius poutassou*, Coryphaenoides spp., *Molva byrkelange*, *Anarhichas* spp., *Microstomus kitt*, *Limanda limanda*, *Hippoglossoides platessoides*, and *Pleuronectus platessa*. Offal was also taken. From a captive Gannet, a daily consumption of 1000-1200g of fish was estimated (*i.e.* 6-7 herrings).

Brandt (1975) reports on 60 Fulmars and a single Sooty Shearwater being attracted by a small fishing vessel in the Varanger Fjord in northern Norway. The birds tried to scavenge the bait from hooks which were attached on each 2 m of the 5 km long line set out by the vessel. Several Fulmars were hooked on and drowned or were killed by the fishermen.

Boswall (1977) observed scavenging seabirds on board a 2-man fishing vessel off SE Iceland on 25 June 1974. Offal thrown overboard attracted at a given moment 140 Fulmars, 15 Great Skuas, 2 Great Black-backed Gulls, and 1 Lesser Black-backed Gull. Two other vessels in the vicinity were similarly attended. Great Skuas with their larger size and greater manoeuvrability seemed at an advantage over the Fulmars. No details on catch or quantity of offal are given.

Camphuysen & IJzendoorn (1988) report hundreds of Pomarine Skuas joining the fishing fleet around the Faeroer Islands in October 1985, prior to the largest influx of this species in western Europe since 1879. Later that autumn and winter, hundreds were scavenging in fish-markets and in harbours in Britain, Norway, Denmark, Germany, The Netherlands, and Belgium. The scale on which this species was recorded as a scavenger was atypically large, the result of the birds being in an extremely poor condition when they arrived at the latitude of the North Sea on their way south to the normal wintering areas.

Erikstad, Bustnes & Jacobsen (1988) studied the time which Kittiwakes (caught and dye-marked with picrid acid) spent behind a trawlers in the Barents Sea in August 1986. The ship trawled every 20-30 nautical miles and most of the trawl contents were fed to associated seabirds. Kittiwakes followed the ship on average for 480-591 min (departure 4.2-5.1% per hour, turnover 32 hours).

Strann & Vader (1992) found the nominate race of the Lesser Black-backed Gull *Larus f. fuscus* in northern Norway feeding mainly offshore on the wing on pelagic fish and discards. It avoided competition with other large gulls in concentrated stationary food sources, such as garbage dumps and fish-factories. It was also inferior to Herring Gull and Great Black-backed Gull when competing for large food items behind stationary or slow-moving fishing vessels. However, it was found to be superior in obtaining small items from fast-moving boats. The Lesser Black-backed Gulls took small pieces of offal twice as often as did Herring and Great Black-backed Gull in a test series from

stationary and slow-moving boats, there was little difference for the medium-sized pieces of offal, but *fuscus* took significantly fewer pieces of the larger pieces of offal than the other two species. The Lesser Black-backed Gull simply avoided the tight flocks of fighting Herring and Great Black-backed Gulls, picking up smaller pieces of offal floating away from the 'battlefield' instead. This behaviour pattern was shared with Common Gulls *Larus canus* and Arctic Terns *Sterna paradisaea*.

2.3 Orkney & Shetland

Ewins (1987) reports on a rather unexpected species scavenging behind small sandeel trawlers in Shetland was the Black Guillemot *Cepphus grylle*. When the boats began hauling the net off Mousa, Shetland, up to 30 adult Black Guillemots swam or flew into the area aft of the trawler and commenced rapid diving sequences. As the net was hauled in, the loose diving flock moved closer to the boat, indicating that the birds were actually diving to the vicinity of the net. Black Guillemots were sometimes seen surfacing with 12-15cm sandeels, but may have swallowed smaller fish underwater. Guillemots were only once seen joining in these scavenging groups of auks (2 individuals), despite the large numbers present in the area. Herring and Lesser Black-backed Gulls invariably attended the net hauls, but were never seen to chase Black Guillemots.

Hudson & Furness (1988) report on studies on board whitefish trawlers around Shetland. The report provides details on fish species and sizes discarded, fish species and sizes swallowed, dropped and stolen by seabirds and the maximum sizes of discards consumed by seabirds. Feeding efficiency, kleptoparasitism and fish species preferences are discussed. Observations were conducted during April-August 1984 and 1985. In 1985, random samples of fish being discarded by the fishermen were set aside and examined to determine the species composition and sizes of fish available for exploitation by seabirds. In total, 7605 fish were identified to species, their total length measured to the nearest cm and then discarded singly from the stern of the trawler. The measured discards were then watched and foraging attempts by seabirds were recorded by video camera or by dictating into a tape recorder. Nearly half of the fish experimentally discarded were seen to be swallowed by seabirds, but it was often difficult to record the ultimate fate of discards. Some fish sank before being consumed, but less than 10% of fish were known not to have been swallowed by a bird. Over 70% of all fish discarded were Haddock and Whiting, flatfish comprised 15% of the discards and gurnards another 10%, while 2% consisted of Cod, Saithe and Norway Pout *Trisopterus esmarkii*. Haddock and Whiting discards ranged from 14-39cm, with median lengths of 28 and 29 cm respectively.

Hudson & Furness (1989) report on their studies on board whitefish trawlers around Shetland. These vessels were soon found to attract the largest numbers of scavenging seabirds among the different types of fishing vessels around Shetland and provide the most food. During July and August 1984 and from March to October 1985, observations were conducted on 23 separate fishing

trips on board whitefish trawlers, covering 33 days, during which data from 151 hauls were collected. 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. Additional to this work, 18 flights were made in a programme of aerial surveys of fishing boats from an aerial pollution patrol plane to determine seasonal changes in bird numbers, species, and trawler distribution. Experimental discarding of known numbers of pieces of offal was performed to allow the foraging success of gulls to be quantified. The most numerous scavengers during these trips were:

Fulmar	(maximum 2500 recorded at a single haul)
Great Black-backed Gull	(up to 1100 at a single haul)
Herring Gull	(in summer usually 0-50, sometimes up to 400)
Great Skua	(present at most hauls)
Kittiwake	(often present in small numbers, but absent during many hauls)
Gannet	(present on all trips, not at all hauls)
Lesser Black-backed Gull	(often present in small numbers, but absent during many hauls)

Occasional scavengers were:

Sooty Shearwater
Storm Petrel
Shag
Arctic Skua
Black-headed Gull
Arctic Tern *Sterna paradisaea*

The effect that distance from the shore might have on bird numbers and species composition was tested. It was obvious that the proportions of Herring Gulls and Fulmars interchanged, with Herring Gulls becoming increasingly more plentiful close to land. Detailed accounts on behaviour and fish consumption of the common seabirds are provided in this paper. Offal was almost all consumed by seabirds, predominantly by Fulmars, which excluded other species by their aggression. Fulmars generally ignored discarded whole fish, which were mainly taken by Great Black-backed Gulls, Gannets and Great Skuas. Flatfish were usually ignored, because seabirds found them difficult to swallow and they sank faster, but most discarded roundfish were consumed. Herring Gulls, Lesser Black-backed Gulls and Kittiwakes were rarely able to obtain offal or discards. The first two species spent much time at the periphery of feeding flocks, while Kittiwakes rarely attempted even to join these.

2.4 North Sea

Van der Heide (1938) reports on skuas and Procellariiformes scavenging behind Dutch herring-trawlers working the Dogger Bank area in late Sep-early Oct 1936. Great Skuas were seen regularly when the net was lifted, the three smaller skuas were seen occasionally. Manx, Sooty, and Great Shearwater were observed in small numbers (6x, 2x, and 4x respectively). Fulmar and Kittiwake were abundant. Fulmars were seen to swallow whole fishes, but also to tear fish apart to eat only liver and entrails.

Manikowski (1971) performed studies on board trawlers in the northern North Sea. The time spent on board the trawlers *Hańcza* (3 Feb-9 Mar 1964), *Biała* (22 Aug-19 Sep 1968), and *Przemsza* (4-25 Oct 1968) lasted 48 days altogether. Areas visited were off the Norwegian coast (58-60°N, 3-5°E), off east Scotland and northeast England. The most common species found attending the trawlers were:

Fulmar	(maxima 600, 28 August, 430, 29 August, 400, 30 August)
Gannet	(maxima 1000, 16 October, 500, 17 October, 130, 6 October)
Great Black-backed Gull	(maxima 2000, 16 October, 1500, 17 October, 900, 22 February)
Kittiwake	(maximum 2000, 10 October)

and only these species were considered in the analysis in this study. Fulmars were most abundant off northeast England in August and September. Kittiwakes were most abundant off southwest Norway and off northeast England in October, February and March. Gannets were most numerous in October and least abundant in February and March. The fluctuations in numbers behind the trawlers in relation to weather conditions are described in detail (*e.g.* state of sea, wind-speed, cloudiness, barometric pressure, front passage).

Camphuysen (1987) discussed the occurrence of large flocks of Fulmars associated with trawlers during seawatching in The Netherlands. Large numbers of Fulmars at trawlers seen from coastal sites in the 1970s were unusual. In May 1979, just over 400 Fulmars entered IJmuiden harbour in the wake of a fishing vessel (*cf.* Van Dijk 1980). In the early 1980s, large flocks of Fulmars associated with fishing vessels were observed more frequently, particularly in April and May but also in summer. Most sightings are from Texel, but some are from sites in Noord-Holland (Hondsbossche Zeewering, IJmuiden). In spring and summer 1980, 1982, and 1985, fishing vessels with associated Fulmars were rather frequently seen, but in recent years, there have been no sightings of large flocks of Fulmars following trawlers from seawatching sites (Van der Ham, *pers. comm.*).

Tasker *et al.* (1987) described the distribution of seabirds in the North Sea, mainly from systematic ship-based surveys during 1979-1986. A strong correlation was found between the presence of (fishing) trawlers and high densities of Fulmars in April, July, and October. Weaker, but still significant correlations were found in February, March, June and September. It was concluded that fishing activities are an important determinant in Fulmar distribution and hence are likely to represent an important food source, but the influence of trawlers was variable throughout the year and other factors obviously affect distribution. Of Herring Gulls, significantly higher densities were found in areas near active trawlers than when trawlers were absent during November, December, February and April. Outside the breeding season, also Great Black-backed Gulls were clearly attracted to trawlers. During September-April (with the exception of November), significantly higher densities were found to occur near fishing trawlers than when these were absent. For Kittiwakes, significant associations between birds and trawlers were only found in December and February. It is suggested that trawlers represented an important source of food only during late winter, perhaps due to a reduction in the availability of their natural prey at

this time.

Van der Schot (1989) reports on feeding methods of Sooty Shearwaters off The Netherlands coast as observed during 'pelagic trips' of bird watchers on board a vessel meant for sport fishing trips. Sooty Shearwaters were seen ocassionally (3x 1987, 1x 1988, maximum 12 on 3 October 1987). Scavenging flocks of Fulmars and Gannets were sometimes joined by Sooty Shearwaters, which were found to behave rather timidly, often waiting at some distance and apparently hesitating to actually join the flock. Eventually, however, the birds would join the fight over the fish remains.

Berghahn & Rösner (1992) decribe re-catch experiments using a stow net which was towed behind a shrimp (*Crangon crangon*) vessel in the German (North Frisian) Wadden Sea, between Nordstrand and the Eiderstedt peninsula, in September 1988, November 1989, and August 1990. Defined numbers of Smelt *Osmerus eperlanus* and Whiting were discarded within short time intervals. Discards which were not taken by scavenging seabirds between the vessel and the stow net were recaptured. Most numerous scavengers behind these trawlers were:

Black headed Gull
Common Gull
Herring Gull

Total numbers of associated gulls varied between 50 and 1900 individuals, and the proportion of each species differed between each cruise. The differences were related to the species composition of gulls resting on the nearby coastline at high tide. Scarce scavenging species behind these shrimp trawlers were:

Great Black-backed Gull
Common Tern *Sterna hirundo*
Arctic Tern

The proportion of discards taken by the birds ranged from 68.4 to 89.8% for Smelt and from 73.0 to 82.0% for Whiting. In the experiments, it was demonstrated that discarded Whiting and Smelt which were caught the preceding day and kept in a refrigerator during the night had a much higher sinking rate than freshly caught fish. Using 'old' fish would lead to an underestimate of the catching efficiency of the scavenging gulls.

Garthe (1992) published one of the more comprehensive studies on quantities of fishery waste (discards and offal) in German fisheries and the use of it by seabirds. Discards in the German Sole-fishery were estimated at 19,500 tonnes in 1990 and 12,700 tonnes in 1991, with Plaice, Dab and Flounder as dominating species. From trips on board RV *Uthörn*, it was found that common scavengers in summer around Helgoland were:

Herring Gull	mean 82, range 20-180
Lesser Black-backed Gull	mean 43, range 6-240

scarcer species were: Fulmar (range 0-1), Common Gull (0-2), Great Black-backed Gull (0-22), Kittiwake (0-13). Rare scavengers were Black-headed Gull (max 4), Yellow-legged Gull *Larus cachinnans* (2), Sandwich Tern *Sterna sandvicensis* (2), Gannet (1), commic tern (1), and Guillemot (1). Common scavengers in winter around Helgoland were:

Common Gull	mean 7, range 0-41
Herring Gull	mean 104, range 37-225
Great Black-backed Gull	mean 251, range 20-800
Kittiwake	mean 14, range 0-60

scarce were Fulmar (0-10) and Lesser Black-backed Gull (0-1). Trips on board RV *Walter Herwig* in Jan/Feb 1991 and May-Aug 1992 all over the North Sea showed that the following species were common scavengers:

Fulmar	winter max 110, summer max 1000
Gannet	winter max 203, summer max 150
Common Gull	winter max 7, summer max 15
Herring Gull	winter max 270, summer max 250
Lesser Black-backed Gull	summer max 360
Great Black-backed Gull	winter max 120, summer max 25
Kittiwake	winter max 400, summer max 700

Scarcer species were Arctic Skua (1), Great Skua (max 11), Black-headed Gull (17), Arctic Tern (10), Common Tern (3). Rare species were Glaucous *Larus hyperboreus* and Iceland Gull *L. glaucoides*.

Discard experiments were conducted around Helgoland and in the whole North Sea in order to see how seabirds use this type of food. Of experimentally discarded fish, 51-79% were consumed by birds, whereas 83% of the offal and 11-56% of marine invertebrates were taken. After a period of very bad weather in November 1992, seabirds took virtually everything what was thrown overboard. Prey selection and dominance hierarchies were studied and significant differences between species and age-classes of birds were found and amply described. Near Helgoland, Great Black-backed Gulls were most successful in consuming discarded fish, whereas in the North Sea as a whole, Gannets were the most successful species. Kittiwakes were the most successful species in consuming offal. Common Gull and Black-headed Gull were less successful than the more common ship-followers. It is concluded that seabirds do benefit from fisheries, because (1) a high proportion of discarded biota were consumed, (2) high numbers of seabirds were attending trawlers, (3) significant correlations between ship-followers and fish catch data were found.

Camphuysen (*in press*) described the results of counts seabirds attending the fishery research vessel *Tridens* in November 1992, 90 km northwest of IJmuiden, The Netherlands, and of the experimental discarding of fish and offal. Considerably larger numbers of birds were joining the vessel when it provided discards/offal, than compared to normal steaming or towing without discarding or gutting. Most numerous seabirds attending the vessel were:

Fulmar	(mean number attending 5.8 (0-16) without dicards, 14.1 (0-35) with discards)
Gannet	(mean 2.0 (0-10) without dicards, 4.4 (0-35) with discards)
Great Black-backed Gull	(mean 3.8 (0-17) without dicards, 15.2 (0-30) with discards)
Herring Gull	(mean 7.4 (0-46) without dicards, 23.1 (1-70) with discards)
Kittiwake	(mean 15.4 (1-35) without dicards, 70.7 (2-190) with discards)

Scarcer scavengers were:

Great Skua	(maximum 2)
Black-headed Gull	(maximum 3)
Common Gull	(maximum 10)
Yellow-legged Gull	(maximum 1)

Fish and offal were sampled on board and discarded experimentally, recording the fate of fish after measuring to the nearest cm. The various species of associated seabirds were found to stay in different positions behind the ship: small gulls (*e.g.* Kittiwake and Common Gull) flew close to the stern, while larger gulls followed the ship at a larger distance. Fulmars and Gannets kept on flying large circles, while Great Skuas visitied the associated flock only briefly. Two-thirds (67.2% in numbers) of all discarded biota were consumed by seabirds. Kittiwakes proved to be very successful in picking up the offal and smaller fish near the stern, alighting immediately after the offal was thrown into the sea. When fish were dropped, or when larger quantities were thrown at once, the biota were floating further away from the ship (which kept on steaming during all activities), and Kittiwakes were driven away by the other seabirds. All discarded Whitings, the most numerous fish in the discard fraction, could be consumed by one or the other seabird species. Kittiwakes picked up most of the smaller specimens (< 23 cm), but were unsuccessful when trying to lift larger fish (up to 26 cm). Behind the ship, a dominance hierarchy was found, in which Gannet and Great Black-backed Gulls were most powerful. However, Kittiwakes, being small, fast and manoeuvrable, obtained an impressive part of the discarded biota. The constantly moving ship made it impossible to discard and record more than a few particles at a time; a situation which is only partly realistic. Hence, the data were seriously biased towards the smaller, more agile scavengers near the vessel.

2.5 General accounts and quantitative studies abroad

Rees (1963) counted seabirds on 81 occasions when they gathered around the fishery research vessel *A.T. Cameron* as the net was handled at the surface in the Gulf of St Lawrence and the Strait of Belle Isle, Canada, in November 1960 and 1961. Common species scavenging behind the ship were Fulmar (maximum count 25), Herring Gull (150), Great Black-backed Gull (200), and Kittiwake (250). Kittiwakes were frequently observed taking food which had been ejected from fish stomachs and which washed out of the net as it came to the surface.

Felton (1969) and **Vernon (1969)** report on Black-headed Gulls picking up food at night by the lights of boats and landing stages. Apparently, it is not uncommon for Black-headed Gulls to follow ships at night and the habit is proba-

bly widespread where conditions are right.

Rodriguez (1972) estimated that 46,000 albatrosses and petrels relied on discards provided by some 125 fishing vessels operating in an area between 23-27°S, and 13-15°E (off SW Africa) in June and July 1967. The paper describes numbers, prey choice, and behaviour of the scavenging seabirds. Daily, some 576 tonnes of fish and offal were discarded in these fisheries.

Wahl & Heinemann (1979) conducted 46 one-day censuses of seabirds off Grays Harbor, Washington, during April-October from 1971 to 1977. The studies aimed to quantitatively examine the scavenging at trawlers of seabirds, in terms of the effect of fisheries discards on the dispersion of different seabird species. In this paper, an evaluation is provided of the relative abundance of several species recorded in the vicinity of fishing vessels with those recorded, on the same day, away from fishing vessels. The mean abundance (birds per 30 minutes) with potential attractants present was significantly above the situation without potential attractants for Black-footed Albatross *Diomedea nigripes*, Fulmar, Pink-footed Shearwater *Puffinus creatopus*, Flesh-footed Shearwater *P. carneipes*, Pomarine and Arctic Skua, Western *Larus occidentalis* and Glaucous-winged Gull *L. glaucescens*, California Gull *L. californicus*, and Sabine's Gull *L. sabini*. The same difference was not significant for Buller's Shearwater *Puffinus bulleri*, Sooty Shearwater, and Fork-tailed Stormpetrel *Oceanodroma furcata*. It was observed that attracted birds were more numerous within 6 km of the attractants, suggesting that birds were attracted from distances greater than 6 km. They conclude, but with a slender factual basis, that birds may be attracted from an area of over 12 km to the trawler.

Griffiths (1982) studied the reactions of seabirds to a research vessel, in order to find out which species were generally avoiding vessels and which were obviously attracted. The reactions of 31 species of seabirds (mainly albatrosses, shearwaters and petrels) to a moving and a staionary ship were investigated in the Southern Ocean. Species strongly attracted to the ship were scavengers and food was believed to be the prime factor influencing the attraction of seabirds to ships. The implications of assessing avian abundance and biomass from a stationary ship are discussed. The main conclusion was, that the accumulation of species around the stationary ship results in inaccurate censuses, whereas counts of seabirds from the moving ship accurately reflect species' abundances.

Abrams (1983) reports on counts of seabirds attending stern-trawlers in the southern Benguela Current region, off SW Africa. The counts are analysed according to seasonal changes in species richness, Shannon-Wiener diversity index, mean abundance and mean biomass at 540 observation stations. Patterns of occurrence of species in 4 food-types (*i.e.* plankton, cephalopods, fish, or mixed) and 6 feeding-methods (*i.e.* dipping & pattering, pursuit plunging, pursuit diving, surface filtering, surface seize/scavenging, piracy) are identified. These patterns are compared with the composition of the avifauna predating large-scale, commercial mid-water and demersal trawl-fisheries in the region. It is

concluded that seabirds in the Benguela region could experience both a behavioural and a food crisis, if the trawling industry ceases to operate.

Furness, Hudson & Ensor (1988) review the interactions between scavenging seabirds and commercial fisheries around the British Isles (ICES rectangles 4a-7k). Information on catch, quantities of offal and discards in certain fisheries, feeding behaviour and interspecific interactions of scavengers, foraging efficiency, prey selection, and calculations of the numbers of seabirds supported by fishery waste are provided. Details on the offal mass as a proportion of total fish mass (*e.g.* offal = 11.0% of mass of gadoid fish caught and 6.5% of mass of flatfish caught) are compared with similar information taken from literature (offal = 10-15% of mass of fish caught). Similarly, information on the calorific value of offal and whole fish is provided and compared with information found in literature. Calculations are given that demonstrate that daily energy requirements a '1,000-gram seabird' are approximately 478 kJ. It is concluded that if all of the offal and discards in fisheries around the Britsh Isles were taken, then some 2.8 million '1,000-gram seabirds' might be supported by this food supply. Since part of the offal and discards sinks or is too large to be handled by seabirds, fisheries around the British Isles could support as many as 2.5 million '1,000-gram seabirds'.

Keijl, Van Roomen & Veldhuijzen van Zanten (1989) provide a case study of the feeding ecology of the Common Gull in a colony in Noord-Holland, The Netherlands. The behaviour of gulls joining mass-feedings at 1-6 km off the coast was described. The study deals with mass-feedings of gulls and terns off the coast, which were actually fishing themselves. Gulls soaring over the dunes along the coast were attracted to and reached the spot with rich food supply either by changing route and flying in a straight line (Common Gull, energetically expensive route, arriving earlier), or by soaring on along the coast only to change course 90° when at the same height as the flock (Herring and Lesser Black-backed Gull, energetically sensible route, arriving slighly later). The idea was, that Common Gulls, being rather low positioned in the dominance hierarchy in mass-feedings, aimed at getting their share just before the more powerful, larger gulls arrive at the spot. The same principle could be valid for gulls attending trawlers.

Harris & Poiner (1990) report on the quantity and composition of the bycatch of commercial prawn trawling in Torres Strait, Australia. A wide range of marine organisms, including cephalopods, crabs, rock lobsters, scallops, sharks, rays, snakes and turtles were caught, but teleost fish were the largest component (79.6% by weight in 1985, 62.9% in 1986). Almost all the bycatch was discarded. Samples of trawl bycatch from trawl surveys in 1988 were used to estimate the component which floated (available to surface feeders) and that which sank (available to mid-water and demersal scavengers). Five minutes after landing the catch, a sample of about 14kg was divided into four bins, each containing 35cm depth of water. After 5 minutes, the animals that floated were separated from those that sank and each of the two groups were sorted and identified. The weights and numbers of the taxa that floated or sank were recorded.

Most of the discards sank, but an estimated 40% of the teleost fish floated. Of the fish, over 75% of the Apogonidae, Nemipteridae, and Monacanthidae, whereas all Synodontidae, Mullidae and Bothidae sank.

Wassenberg & Hill (1990) describe the composition of discards from prawn trawlers in Moreton Bay, Queensland, Australia. Some 3000 tonnes of material is discarded annually, of which 3% floats and the rest sinks. The floating component is almost entirely fish. At night, floating discards were eaten by Silver Gulls *Larus novaehollandiae*, Crested Terns and to a lesser extent Bottlenosed Dolphins *Tursiops truncatus*. There was little trawling during the day, but discards dumped at dawn were also taken by Pied Cormorants joining the scavengers. Birds and dolphins scavenged only fish and cephalopods, and not crustaceans nor echinoderms.

Ryan (1991) reports on the impact of commercial lobster (*Jasus tristani*) fishery on seabirds at the Tristan da Cunha (South Atlantic Ocean). The most serious impact was the large number of seabirds being killed when dazzled by the ships' lights at night. These night-strikes affect thousands of individuals of eight or more species annually. Dietary supplementation of the fishery is considered unimportant, because few seabirds scavenge from the fishery relative to the large breeding populations occurring at the islands.

Thompson (1992) provides a quantitative analysis of the use of discards from squid (*Loligo gahi*) trawlers by Black-browed Albatrosses *Diomedea melanophris* near the Falkland Islands. This fishery has developed near Beauchêne Island, with a major breeding colony of Black-browed Albatrosses, in the past decade. The diet of the Black-browed Albatross in the breeding season and its use of discards generated by the *Loligo*-fishery are described. Albatross chicks are fed extensively on commercially exploited species of squid and fish, including *Loligo gahi* and Southern Blue Whiting *Micromesistius australis*. Discards and offal from the *Loligo*-fishery amounts to 5% of the reported catch (1987-1990 mean 54,990 tonnes), while just over 50% of it is scavenged by adult Black-browed Albatrosses. The total quantity scavenged during chick rearing amounted to 1000-2000 tonnes per year, equivalent to 10-15% of the total food requirement of the breeding Black-browed Albatross population on Beauchêne Island.

Furness (1992) discussed a number of scenarios for future changes in fisheries regulations and the impacts of these on scavenging seabirds. This is a comprehensive review of studies on scavenging seabirds. Is focusses on (1) current breeding population size of scavenging seabirds, (2) numbers and distribution of scavenging seabirds in the North Sea, (3) changes in breeding numbers of scavenging seabirds in the North Sea since 1900, (4) evidence regarding the extent to which scavenging seabird population sizes may be limited by amounts of offal and discards. The report makes extensive use on papers on scavengers at whitefish trawlers near Shetland and at *Nephrops*-trawlers in the Clyde (*e.g.* Hudson & Furness 1988, 1989, Furness *et al.* 1992), on seabirds at sea data as published in Tasker *et al.* 1987, and on the compilation of breeding numbers of seabirds in the North Sea as published in Lloyd *et al.* 1991. Fulmar, Gannet,

Great Skua, Herring Gull, Lesser Black-backed Gull, Great Black-backed Gull, and Kittiwake are considered to constitute the bulk of the birds at fishing boats in the North Sea. Black-headed Gull and Common Gull are not considered in this review, because numbers scavenging at fishing vessels are considered small in relation to their total populations, because they occur only in harbours in close to the shore and because there are no data on their use of fishery waste.

It is estimated that 1,212,000 pairs of scavenging seabirds bred on North Sea coasts in the 1980s, of which 49% in the northern area of Britain and 23% in east Britain. Breeding numbers of scavenging seabirds on North Sea coasts have increased at least ten-fold from 1900-1990. Dietary data indicate that discards can be important in the diet of Gannets, Great Skuas, Great Black-backed Gulls, Herring Gulls and Lesser Black-backed Gulls, while offal can be important for Fulmars, Herring Gulls and Kittiwakes. It is considered that discards and offal may be most important outside the breeding season or early and late during breeding. Many lines of evidence indicate that there is a strong scramble competition for offal and discards in the North Sea. Fulmars obtain most offal when they are present in numbers, while Gannets have the highest success in obtaining discards. Herring Gulls and Kittiwakes have low success rates, as do Fulmars because they have difficulty in swallowing discards whole. Adults do better than immatures. There is some evidence listed, to support the idea that scavenging seabird numbers are limited by offal and discard availability.

Reduced fishing effort and increased net mesh size would considerably reduce waste available to seabirds. Crude calculations suggest that a 30% reduction in effort and increase in net mesh to 120mm might result in the loss of the food supply required by 0.5 million scavenging seabirds. A smaller numbers of discards and an increase in the size of discarded fish would especially impact Herring Gulls, Lesser Black-backed Gulls and Great Skuas.

2.6 Diet studies of scavenging seabirds (indirect information)

The diet of many of the species which are commonly found scavenging behind fishing vessels is extremely varied. Moreover, in case of most of the gulls, a considerable proportion of time is spent feeding on land. In several studies of seabird diets, indirect information on the importance of scavenging behind commercial trawlers was provided. The summaries below are no attempt to describe the respective diets and feeding grounds in detail, but to list some of the more remarkable papers on the relative importance of scavenging in the ecology of seabirds.

Arbouw (1980) and **Arbouw & Swennen (1985)** report on the diet of Common Gulls breeding on Texel. In June, feeding flights to and from the North Sea were regularly seen and mixed flocks of fishing gulls were observed near the beach (comprising Common, Herring and Black-headed Gulls). It was found that fish gained importance in the diet of Common Gulls during chick rearing. Fish species were Gadoid fish (28 pellets), mainly Whiting (13.5-20.0 cm length) but some Bib, sandeels (8 pellets), Plaice (3 pellets), Dab (1 pellet), Smelt *Osmerus*

eperlanus (1 pellet), and Sprat (1 pellet). It is considered that some of these fish could have been caught during fishing (Sprat, Smelt, sandeel, small flatfish) while the larger Gadoid fish probably were taken as discards from trawlers. Considering the absence of Flounder *Platichtys flesus* in the diet of these gulls, it was assumed that most fish was taken in the North Sea rather than in the Wadden Sea.

Furness (1981) studied the diets of Great Skua and Great Black-backed Gull on Shetland and concluded that a major part of the diet of these species consitute of discarded Haddock and Whiting. Populations of Great Skuas and Great Black-backed Gulls on Shetland are relatively large and increasing rapidly. In contrast, in the Faeroes, where a much larger net mesh is used so that virtually no fish have to be discarded, Great Skua and Great Black-backed Gull populations are very much smaller, are not increasing, and exist mainly by predation on other seabirds or scavenging. Furness concludes that the suggested increase in mesh size in Shetland waters would almost certainly lead to a shortage of food for these species, decreased breeding success and a considerable increase in the extent of predation on other seabird populations in the vicinity of their colonies.

Prüter (1986) lists the diet of wintering gulls shot around Helgoland. The diet of wintering Black-headed Gulls and Common Gulls on Helgoland consists only partly of fish. During October-April, 31.8% of 22 stomachs of Black-headed Gulls with food remains contained fish. Fish species found were Sprat (2), gadoids (2), sandeels (1), and gobies *Pomatoschistus* spp., and it is likely that most fish were obtained by scavenging behind trawlers. During October-April, 75.8% of 25 stomachs of Common Gulls contained fish. Fish species found most often were clupeids (3), gadoids (9), and sandeels (3), and it is thought that most fish were obtained by scavenging behind trawlers. The diet of wintering Herring Gulls and Great Black-backed Gulls on Helgoland consists mainly of fish. During October-February, 53.2% of 203 stomachs of Herring Gulls contained fish. Most fish were gadoids (82.3, n= 79 stomachs with identified fish), and it is thought that all fish were obtained by scavenging behind trawlers. In March and April, 81.8% of the stomachs were found to contain fish (n= 148), but the species composition had changed from mainly gadoids towards a more mixed diet including Eel *Anguilla anguilla* (12.1%, n= 99), gadoids (22.2%), sandeel (24.3%), and Hooknose *Agonus cataphractus* (46.5%). It is suggested, from species composition rather than field observations, that in the pre-breeding season, a considerable proportion of the fish was taken by fishing themselves. During October-February, 74.4% of 90 stomachs of Great Black-backed Gulls contained fish. Most fish were gadoids (95.3%, n= 43 stomachs with identified fish), and it is thought that all fish were obtained by scavenging behind trawlers. In March and April, all stomachs were found to contain fish (n= 44), and species composition had changed from mainly gadoids towards a more mixed diet including Eel (31.6%, n= 38), gadoids (36.8%), sandeel (26.3%), Hooknose (23.7%), and Dab (13.2%). Again it is suggested that in the pre-breeding season, a considerable proportion of the fish was taken by fishing themselves. When comparing the present diet with the diet of this species in the 1970s, it appears that gadoids (hence, scavenging) have declined

with 17%, while Eel and Hooknose (hence, own fishing) have proportionally increased in the diet.

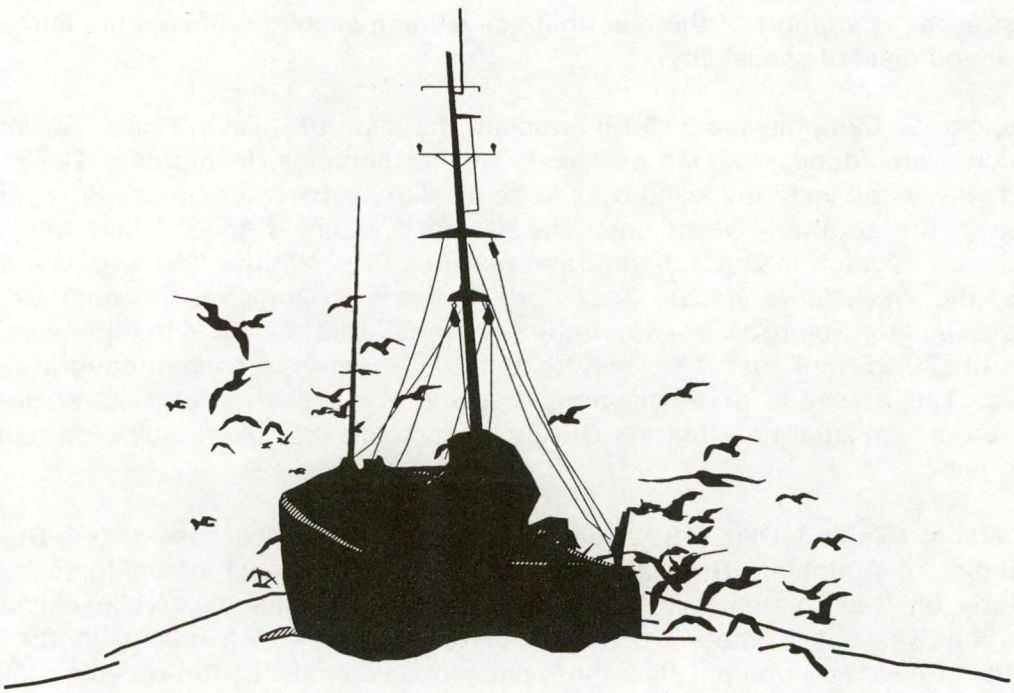
Blaber & Wassenberg (1989) discuss the diets of the Pied Cormorant *Phalacrocorax varius*, Little Pied Cormorant *P. melanoleucos*, and the Crested Tern *Sterna bergii*, three piscivorous seabirds in Moreton Bay, Queensland, Australia, from a 14 months monitoring programme (April 1986-September 1987). The three species had similarly narrow diets, and there was a significant rank correlation between the diet of the Pied Cormorant and the by-catch of prawn trawlers. This, together with observations of feeding behaviour, the similarity of the diets and the benthic and benthopelagic nature of most prey species, suggested that the three species were primarily dependent on food from fishery discards. The relationships between the fishery and the piscivorous birds is discussed in relation to size of bird populations and its possible dependence on the fishery.

Spaans & Noordhuis (1989) and **Noordhuis & Spaans (1992)** concluded that the breeding numbers of Herring Gulls and Lesser Black-backed Gulls on Terschelling, The Netherlands, have increased since the late 1960s, while the ratio between these numbers has changed in favour of the latter species. This was paralleled by a change of the diet of the Herring Gull during the breeding season. The total annual numbers of pellets and faeces with marine fish (to a great extent specimens discarded by fishing boats), dropped to 14% of those in the 1960s, while Lesser Black-backed Gulls still ate primarily marine fish. Lesser Black-backed Gulls were assumed to have forced Herring Gull to concentrate on other food resources. The change in feeding habits has considerably contributed to the Herring Gull's decrease in breeding success which has taken place since the late 1960s. Furness (1992) considered these studies as some of the strongest cases in support of the idea that scavenging seabird numbers are limited by offal and discard availability.

Leopold & Camphuysen (1992) studied the diet of heavily oiled Guillemots which were found stranded at Texel, The Netherlands, in february 1992. The birds had been instantly killed by a large oil slick, somewhere in the Brown Bank area in the southern North Sea. The stomach included several fish which are common bycatch in Dutch beamtrawl fisheries (*e.g.* Whiting *Merlangius merlangus*, Bib *Trisopterus luscus*, Poor Cod *T. minutus*, Dragonet *Callionymus lyra*, and Solenette *Buglossidium luteum*) in this area. Most of the Whitings were of a length (20-26 cm) that it is likely that the fish were unfit when caught by the auks. The presence of these large fish and the presence of several species which are unusual prey for the Guillemot, indicate that these auks took discarded fish.

Paterson, Vilalta & Dies (1992) describe a low breeding success at two Spanish colonies of Audouin's Gull *Larus audouinii* during the 1991 breeding season. A colony on the Columbretes islands failed almost completely, while chick production was approximately half that of recent years in a colony in the Ebro Delta. It became apparent that the most probable cause of the breeding failures

was the implementation of a voluntary moratorium on inshore fishing in the waters of both Tarragona and Castellón in an attempt to permit undisturbed egg-laying by depleted fish stocks and the regeneration of the seabed during May-June. These are exactly the areas where the Audouin's Gulls feed and the months when they would be incubating.



3. Seabirds scavenging at trawlers in the southern North Sea

Several studies of seabirds at sea in the North Sea have demonstrated a strong affinity between seabirds and trawlers (*e.g.* Wahl & Heinemann 1979, Tasker *et al.* 1987). Unfortunately, very few data are available for the southern North Sea. Since March 1987, the distribution of seabirds in the southern North Sea has been studied by means of ship-based surveys (Nederlandse Zeevogelgroep (NZG) & Dienst Getijdewateren (DGW), Rijkswaterstaat, March 1987-Dec 1990; NIOZ, May 1987-present). So far, the records of seabirds attending fishing vessels in these databases were not analysed. For this review, the recorded fishing vessels with associated bird flocks were extracted from the database, in order to find species composition, and spatial and temporal distribution of the associated flocks (species by species). Distribution maps for the most important species are provided and discussed.

3.1 Study area and methods

The area under study in this analysis was bordered by 51° and 56°N latitude, and 2° and 7°E longitude. In the ship-based surveys, birds present in strip-transects were counted in order to assess densities at sea (n/km²; *cf.* Tasker *et al.* 1984). Separately, notes were made of trawlers with associated seabirds and if larger groups of birds were encountered which were obviously associated with a nearby fishing vessel or fishing fleet, these birds were labelled as being 'associated with a fishing vessel'. Only fishing vessels with associated flocks of scavenging seabirds were listed, including date, time (GMT), geographic position, activity of the vessel, number of birds of each species, and age and plumage. Observer effort was calculated per 1x1° square, expressed as 'number of kilometers travelled during observations'.

In the analysis, data were grouped by month, while maps were usually prepared for half year periods (Apr-Sep and Oct-Mar), or quarters (Jan-Mar, ..., Oct-Dec). For each species, all records were plotted on maps for summer (Apr-Sep) and winter (Oct-Mar), using different symbols for small (1-10), rather small (11-50), rather large (51-100), large (101-1000), and very large numbers (>1000 individuals). Seasonal patterns were prepared, in which the frequency of occurrence behind trawlers was calculated per quarter of a year as a percentage of the total number of trawlers observed (n= 461). Of quite a number of associated flocks, the gulls, or part of the gulls, were not identified as to species. If less than 50% of the gulls were specifically identified, the record was omitted in the analysis of species composition in gulls. Hence, the 'sample' was n= 461 for Fulmar and Gannet, and n= 368 for gulls (see also table 1). Further, it was assessed at what distance from the coast substantial numbers were seen scavenging off the eastern Wadden Sea islands, off Texel and Vlie-

Table 1. Sightings of fishing vessels and associated scavenging seabirds per month. (a) all vessels, (b) all vessels with >50% of the associated gulls specifically identified.

Month	(a) all vessels n	%	(b) >50% of gulls identified n	%
January	63	14	57	15
February	50	11	42	11
March	39	8	26	7
April	34	7	25	7
May	44	10	35	10
June	28	6	23	6
July	28	6	19	5
August	34	7	28	8
September	28	6	23	6
October	65	14	50	14
November	36	8	29	8
December	12	3	11	3
Total number	461	100	368	100

Table 2. Frequency of occurrence of trawlers with scavenging seabirds (n = 461) in five distance zones off The Netherlands' coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	29	13	8	2	13	65
Off Texel & Vlieland	29	11	6	30	56	132
Off mainland coast	54	14	16	42	33	159
Off Delta area	27	22	32	10	14	105
Total	139	60	62	84	116	461
%	30.1	13.0	13.4	18.2	25.2	

land, off the mainland coast of Noord- and Zuid-Holland, and off the delta area. Finally, it was worked out where the species was (occasionally) found dominating behind trawlers (>50% of all scavengers).

3.2 Fishing vessels and scavenging seabirds

In all, 461 fishing vessels with flocks of associated seabirds were recorded (figure 2), most of which were in the vicinity of The Netherlands' coast. The number of trawler- sightings per month is given in table 1, while the frequency of sightings within five distance zones from the coast are given in table 2. When corrected for observer effort, it appears that rather more trawlers with seabirds were found in the coastal waters, particularly in winter, spring and early summer (October-June; figure 3). In late summer (July-September), trawlers were considerably more widespread in the study area. In the species ac-

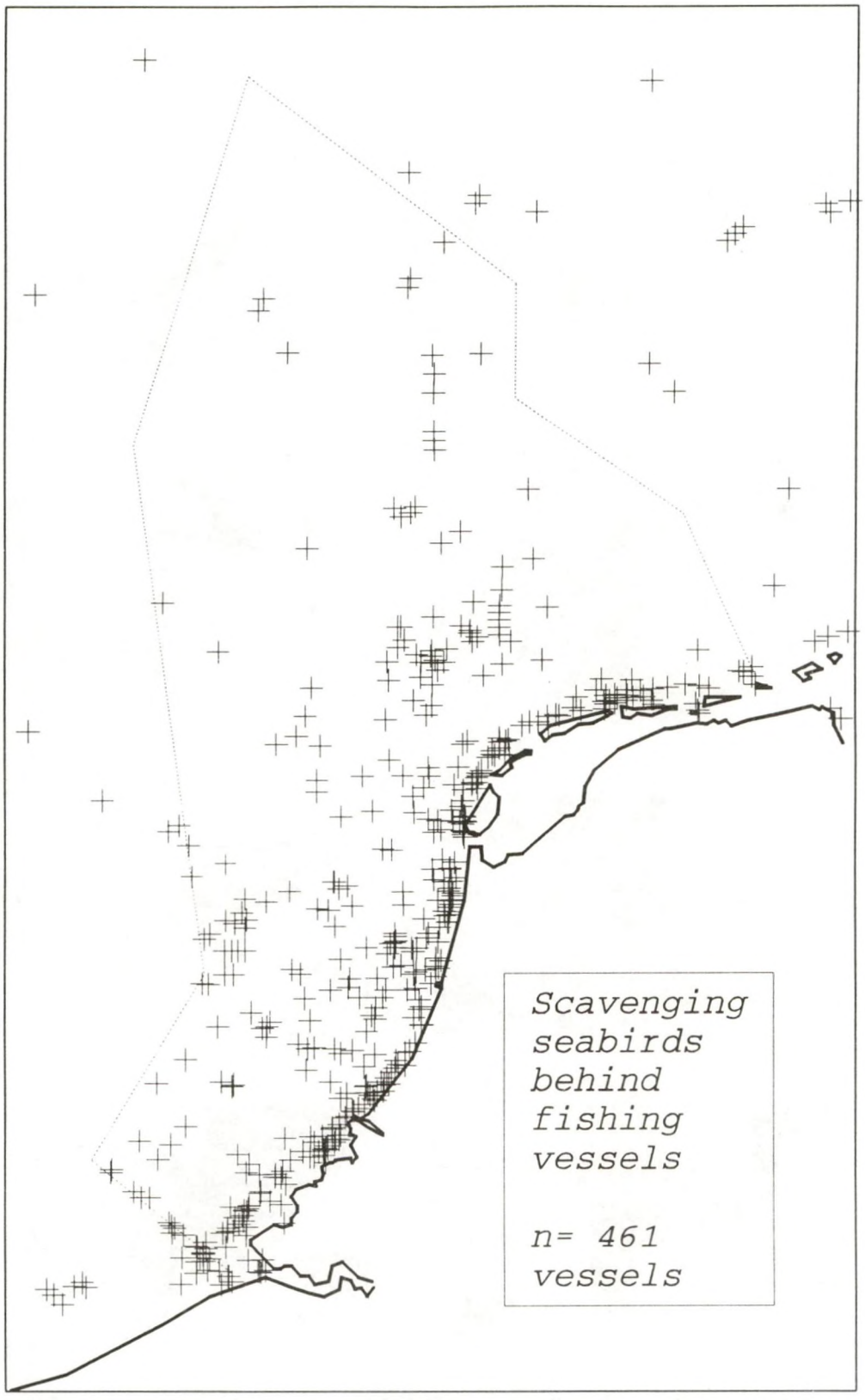


Figure 2. All fishing vessels with associated flocks of scavenging seabirds, as observed during ship-based surveys, February 1987-June 1992 (n= 461).

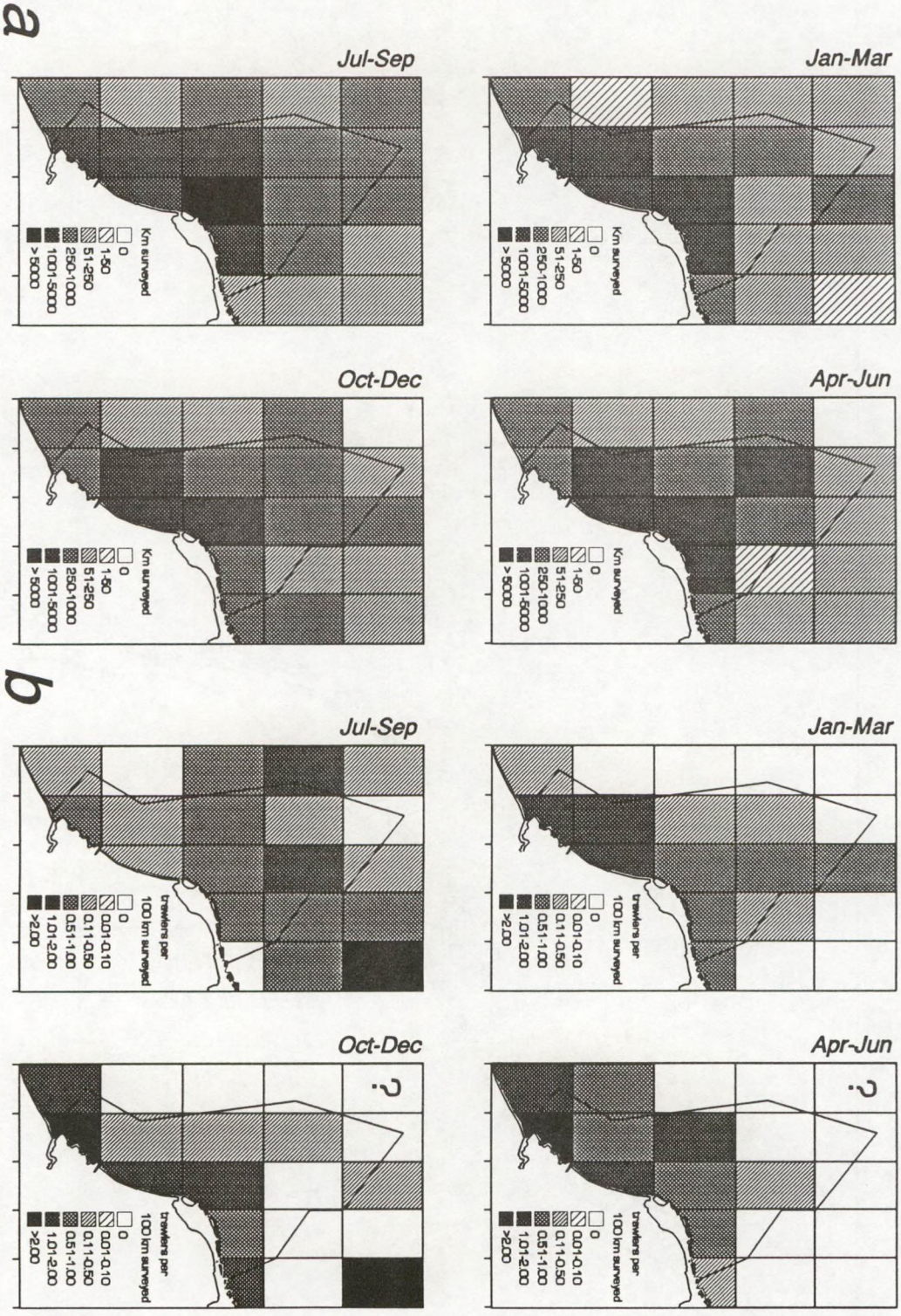


Figure 3. (a) Observer effort through the year (kilometres travelled per square) and (b) number of trawlers with associated seabirds per 100 km of survey. Ship-based surveys, February 1987-June 1992.

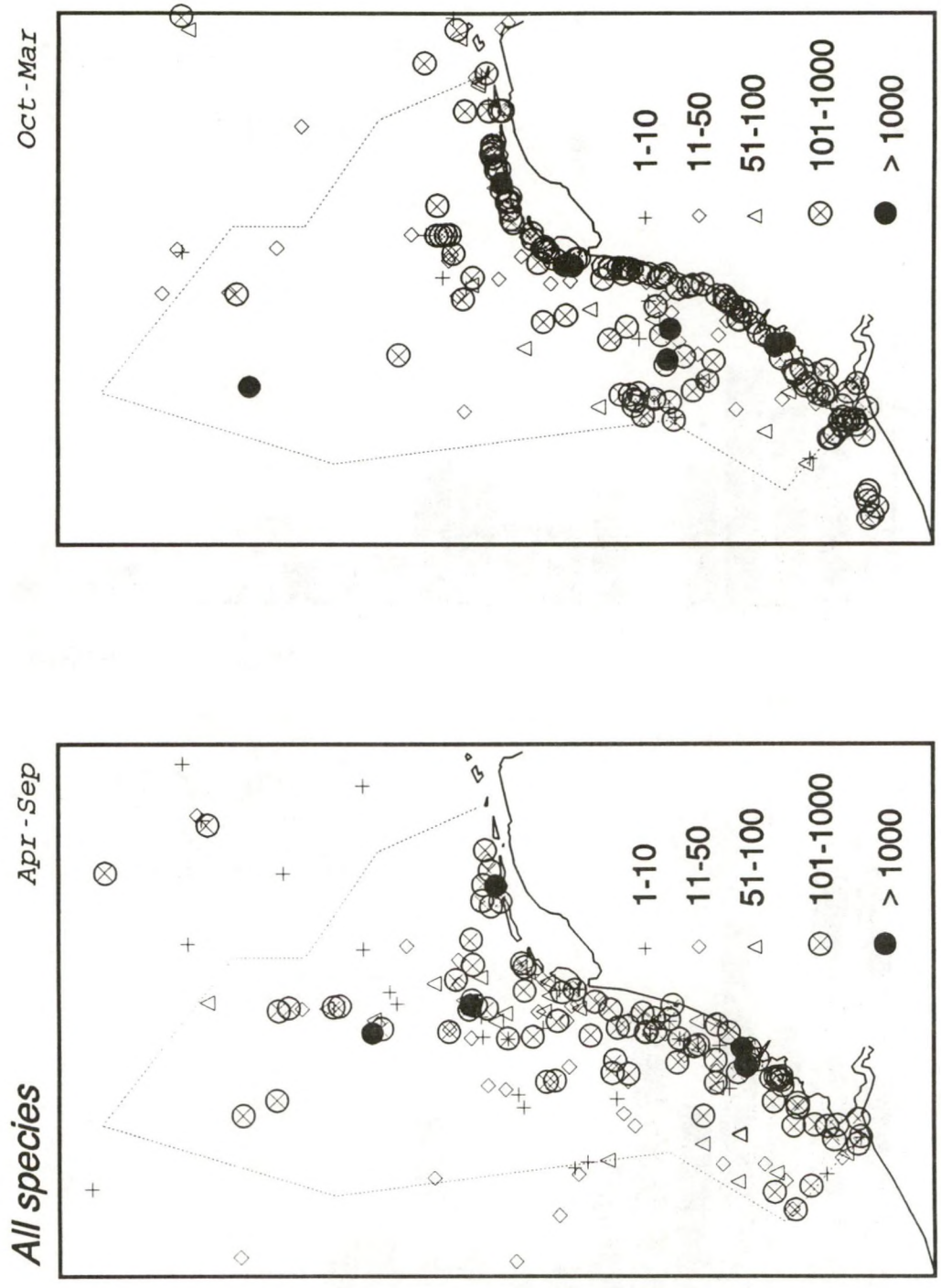


Figure 4. Sightings of scavenging seabirds behind commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October-March), 1987-1992.

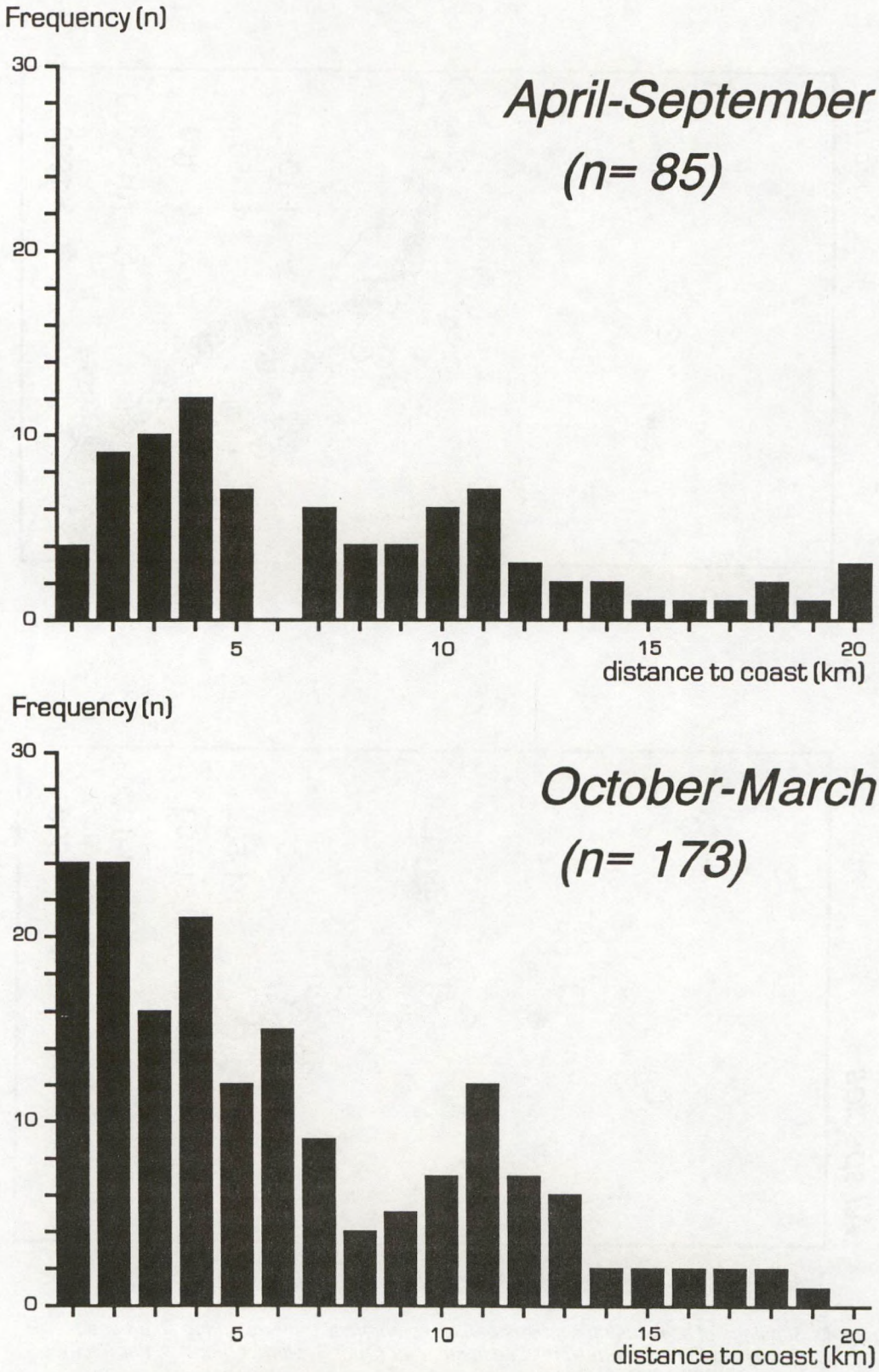


Figure 5. Distance to the coast of trawlers with scavenging seabirds within 20 km from the shore in summer (April-September) and winter (October-March), 1987-1992.

Table 3. Species seen scavenging behind fishing vessels in the southern North Sea, 1987-1992 (n = 461 associated flocks of birds). Number of birds seen, frequency (%), and maximum number seen in one flock.

Species	number	records	frequency	maximum
Fulmar *Fulmarus glacialis*	8800	150	32.5 %	1010
Sooty Shearwater *Puffinus griseus*	1	1		
Gannet *Sula bassana*	837	57	12.4 %	160
Great Skua *Catharacta skua*	37	15	3.3 %	16
Arctic Skua *Stercorarius parasiticus*	6	5	1.1 %	2
Little Gull *Larus minutus*	122	9	2.0 %	85
Mediterranean Gull *Larus melanocephalus*	1	1		
Black-headed Gull *Larus ridibundus*	1642	52	11.3 %	755
Common Gull *Larus canus*	6752	141	30.6 %	929
Herring Gull *Larus argentatus*	30898	287	62.3 %	1930
Yellow-legged Gull *Larus cachinnans*	3	1		
Lesser Black-backed Gull *Larus fuscus*	10244	170	36.9 %	1060
Great Black-backed Gull *Larus marinus*	6037	188	40.8 %	400
Kittiwake *Rissa tridactyla*	7824	151	32.8 %	500
Unidentified gulls	24284			
All gulls	87807	441	95.7 %	2442
Common Tern *Sterna hirundo*	54	4	0.9 %	30
'Commic' tern *Sterna hirundo/paradisaea*	4	1		
Sandwich Tern *Sterna sandvicensis*	4	2	0.4 %	3

Table 4. Monthly sightings of fishing vessels with associated scavenging seabirds and relative frequency (%) of common scavengers per month in the southern North Sea, 1987-92 (NZG/DGW data and NIOZ data combined). Monthly records of (a) all trawlers, (b) all trawlers with >50% of the associated gulls specifically identified, and per species relative frequency of flocks of ≥10 individuals.

Month	trawlers (a)	(b)	*F. glac.*	*S. bas.*	*L. rid.*	*L. can.*	*L. arg.*	*L. fus.*	*L. mar.*	*R. tri.*
January	63	57	3.2	0	5.3	40.4	73.7	3.5	29.8	17.5
February	50	42	18.0	8.0	9.5	26.2	73.8	4.8	31.0	28.6
March	39	26	30.8	5.1	3.8	34.6	57.7	15.4	11.5	23.1
April	34	25	26.5	5.9	0	12.0	76.0	52.0	4.0	0
May	44	35	15.9	0	0	0	62.9	54.3	0	0
June	28	23	14.3	0	0	4.3	47.8	60.9	0	0
July	28	19	21.4	0	5.3	0	57.9	84.2	0	10.5
August	34	28	50.0	2.9	0	0	0	21.4	7.1	7.1
September	28	23	14.3	10.7	0	0	4.3	21.7	21.7	17.4
October	65	50	12.3	4.6	10.0	42.0	56.0	20.0	38.0	30.0
November	36	29	22.2	2.8	6.9	24.1	55.2	6.9	44.8	41.4
December	12	11	50.0	8.3	0	9.1	54.5	0	54.5	81.8
Total	461	368	20.0	3.7	4.3	20.7	54.9	25.3	21.5	19.6
Sample (n)			461	461	368	368	368	368	368	368

counts below, the distribution of scavengers behind trawlers in summer (breeding season) and winter (non-breeding season) is discussed separately. When plotting trawler distribution for April-September and October-March (figure 4) it appears that trawlers are slightly further offshore in the breeding season. The offshore distribution patterns (>20 km distance from the coast) are similar, but in the shallow coastal waters, particularly within 5 km from the shore, rather more trawlers were recorded in winter (figure 5).

3.3 Species accounts

During 1987-1992, 16 species were observed scavenging behind fishing vessels, of which only 8 species were recorded frequently (>50 records; table 3). In the species accounts below, sightings of scavenging seabirds are discussed in detail, including seasonal pattern, distribution, distance to the coast, and flock size.

Fulmar *Fulmarus glacialis*

One of the commoner scavengers in the southern North Sea is the Fulmar, but these occurred rather irregularly through the years. In autumn 1987, for example, Fulmars were virtually absent in large parts of the southern North Sea. The Fulmar is seen throughout the year, but more frequently and in larger numbers in (late) summer (table 4). Most Fulmars were observed in August, when 11 trawlers (32.4% of all trawlers studied, n= 34) in the offshore zone were followed by over 100 Fulmars. The largest number of Fulmars was recorded on 23 August 1990 (1010 individuals; figure 5). Examples of large flocks of Fulmars are:

date	geogr. position	number	distance	other scavengers
23 Aug 1990	54°11'N, 04°17'E	1010	107.1 km	
30 Jul 1987	53°38'N, 04°32'E	525	48.9 km	510 L.Bl.-b. Gulls, 165 Kitt.
05 Feb 1991	54°54'N, 03°29'E	400	202.2 km	630 gulls, various species
23 Aug 1990	54°09'N, 04°20'E	360	102.6 km	
22 Mar 1988	52°43'N, 03°27'E	350	85.5 km	380 gulls, various species

Obviously, the Fulmar is of minor importance as a scavenger behind trawlers in the coastal zone: scavenging Fulmars occurred mainly over 20km from the coast (94.6%, n= 92; table 5), while as a dominating species (>50% of all scavengers observed behind a particular fishing vessel), Fulmars were mainly found in waters at over 50km from The Netherlands coast. Only off Texel and Noord-Holland, Fulmars were frequently found dominating between 20 and 50km from the coast. Larger flocks of Fulmars (>50 individuals) were rather scarce off the Delta area, although scores of several tens were reported a few times. The distribution of records of >10 Fulmars at boats over 5 distance zones off the coast was significantly different from expected frequencies, as based on the distribution of 461 trawlers where birds were scavenging; G= 120.9, $p<0.001$, df= 4; tables 5, 13). Wider surveys for trawlers in winter

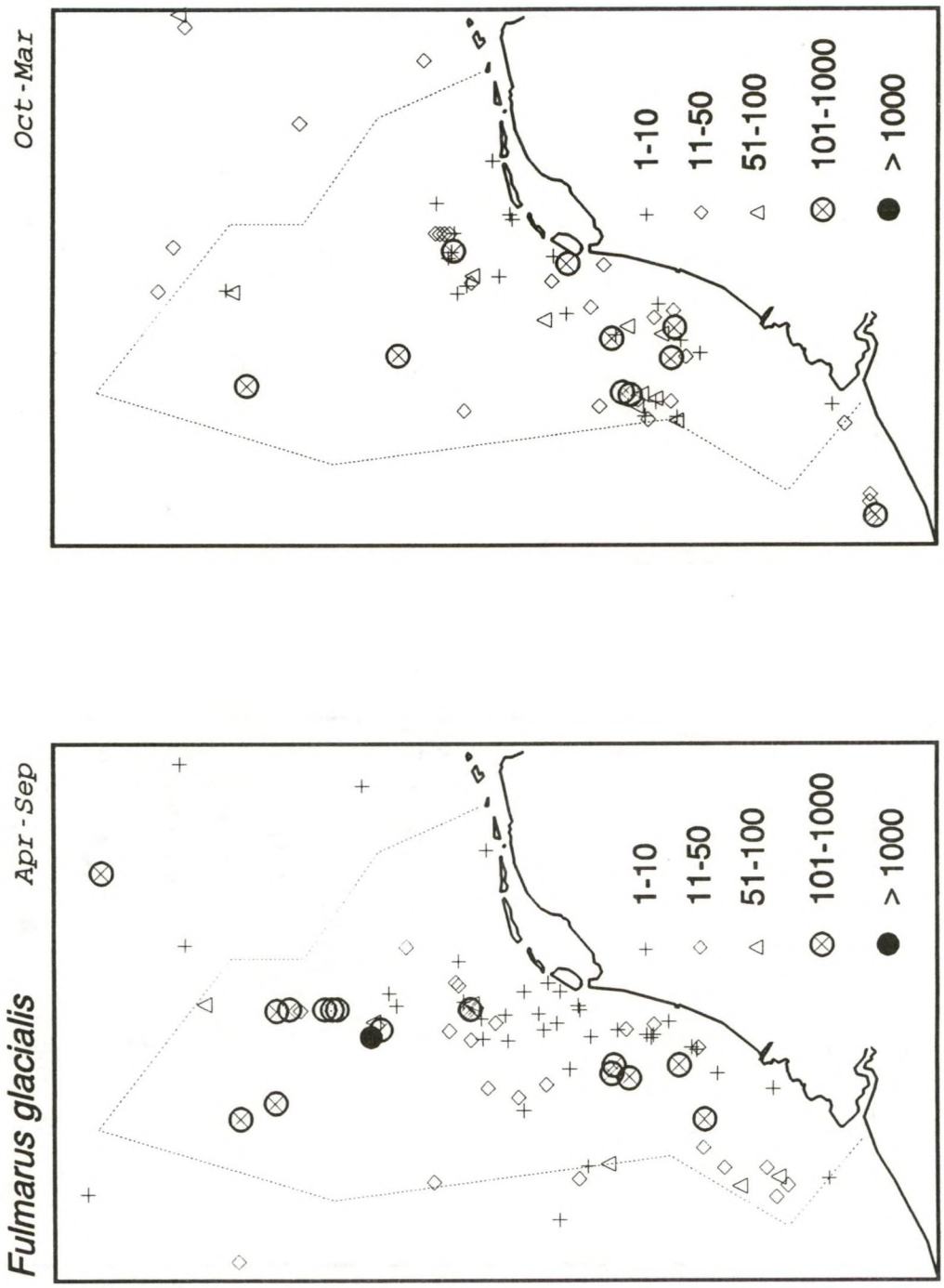


Figure 6. Sightings of Fulmars (Fulmarus glacialis) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October-March), 1987-1992.

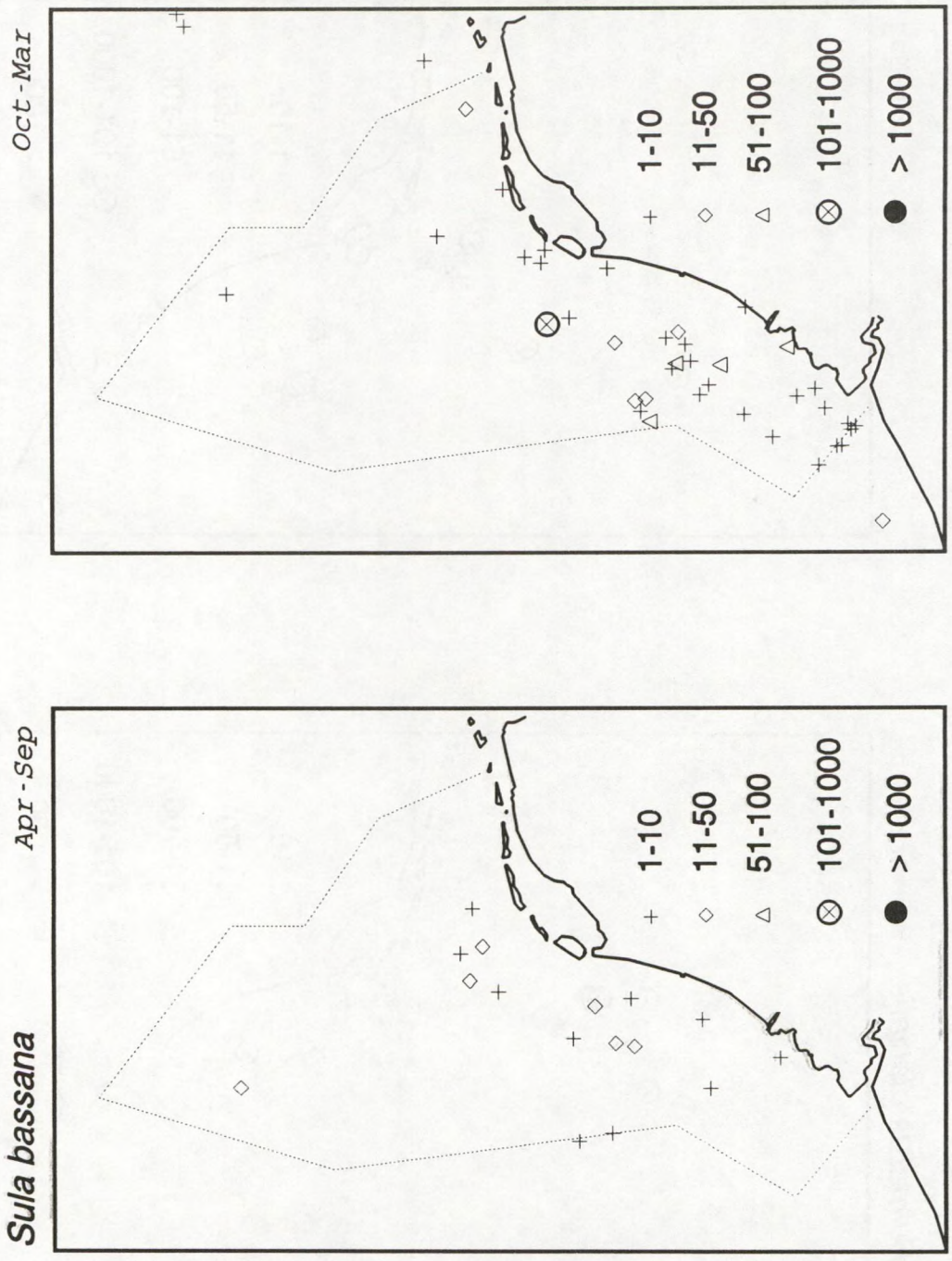


Figure 7. Sightings of Gannets (Sula bassana) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October- March), 1987-1992.

(Jan-Mar) will probably lead to a considerably larger number of sightings of scavenging Fulmars. The offshore distribution pattern in winter (figure 6) is biased by a disproportional large number of cruises between the mainland coast and the Brown Bank Area, but few fishing vessels with (any) scavengers were observed north of the Wadden Sea islands in these months (*cf.* figures 2-4).

Table 5. Frequency of occurrence of groups of ≥ 10 Fulmars as scavengers behind 461 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschell-Rottum	0	0	0	1	5	6
Off Texel & Vlieland	0	1	0	12	32	45
Off mainland coast	1	0	2	13	16	32
Off Delta area	0	0	1	0	8	9
Total	1	1	3	26	61	92
%	1.1	1.1	3.2	28.3	66.3	

Sooty Shearwater *Puffinus griseus*

The database contains a single record of a Sooty Shearwater, feeding on the outer edge of a large, mixed group of scavengers, (comprising 53 Fulmars, 160 Gannets, 2 Black-headed Gulls, 1 Common Gull, 11 Herring Gulls, 23 Great Black-backed Gulls, 500 Kittiwakes, 16 Great Skuas, and 1 Arctic Skua) some 24 km offshore (53°13'N, 04°06'E; 13 October 1987).

Gannet *Sula bassana*

The Gannet was regularly recorded behind fishing vessels, but was never very numerous (figure 7). Gannets were most frequently seen scavenging in February (22% of all trawlers, n= 50), September (25.0%, n= 28), and October (29.2%, n= 65), while larger numbers (*i.e.* over 50 Gannets attending at a ship) were seen only in February (2x), October (2x), and November (1x):

date	geogr. position	number	distance	other scavengers
13 Oct 1987	52°13'N, 04°06'E	160	44.5 km	53 Fulmars
21 Nov 1989	52°15'N, 03°43'E	95	37.2 km	
21 Feb 1989	52°30'N, 03°44'E	82	54.9 km	263 Fulmars
23 Oct 1989	51°53'N, 03°53'E	61	2.0 km	
21 Feb 1989	52°39'N, 03°12'E	61	92.8 km	2 Fulmars

The maximum number, 160 individuals, was recorded in a large mixed group of scavengers, 24 km offshore in October, in an area were a fishing fleet was operating. The Gannet was typically an offshore species as a scavenger, with most sightings of substantial numbers well over 20 km from the coast (88.2%, n= 17; table 6). The distribution of records of >10 Gannets at boats over 5 distance zones off the coast was significantly different from expected frequen-

cies, as based on the distribution of 461 trawlers where birds were scavenging; $G = 15.8$ $p < 0.001$, $df = 4$; table 13). The overall seasonal pattern (table 4) was not quite in accordance with that known of Gannets in Dutch coastal waters (Camphuysen & Van Dijk 1983). Along the coast, Gannets gradually increase, both in numbers and in frequency of sightings, from March through October, after which a rapid decline is recorded: the species is rather scarce in January and February near the coast. As a scavenger, Gannets were most common between August and April, and virtually absent in mid-summer. Apparently, scavenging is of relatively greater importance in winter, for the (few) specimens remaining in the southern North Sea.

Table 6. Frequency of occurrence of groups of ≥ 10 Gannets as scavengers behind 461 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	0	0	1	0	0	1
Off Texel & Vlieland	0	0	0	2	2	4
Off mainland coast	0	0	0	6	4	10
Off Delta area	1	0	0	0	1	2
Total	1	0	1	8	7	17
%	5.9	0	5.9	47.0	41.2	

Great Skua *Catharacta skua*

Scavenging Great Skuas were recorded on 15 occasions. Most skuas were feeding (as kleptoparasites) solitary, but one group of 16 (see Sooty Shearwater), one of 4 and one of 5 skuas were reported. Records were widely distributed over the study area, but most were well offshore (<5 km 1, 5-10 km 1, 10-20 km 1, 20-50 km 8, >50 km 3 records, a distribution of records over 5 distance zones off the coast which is significantly different from expected frequencies, as based on the distribution of 461 trawlers where birds were scavenging $G = 12.0$, $p < 0.025$, $df = 4$; table 13). Great Skuas were usually seen in mixed groups of scavenging gulls, mainly including Herring Gull, Lesser Black-backed Gull, Great Black-backed Gull, and Kittiwake. One group where a Great Skua was active comprised only 150 Fulmars. Some Great Skuas were seen scavenging in April (once) and May (once), but most were reported in late summer and autumn (Jul 2x, Aug 4x, Sep 3x, Oct 3x, Nov 1x).

Arctic Skua *Stercorarius parasiticus*

Arctic Skuas were seen attending trawlers on 5 occasions (4x solitary, 1x two individuals). All records were in autumn (Aug 1x, Sep 2x, Oct 2x), and all on comparatively large distances from the coast (11, 45, 132, 172, and 205 km distance). Four records of Arctic Skuas were of (kleptoparasitising) individuals in substantial groups of scavenging gulls (3x), or Fulmars (1x). One record comprised only 3 Kittiwakes and 2 Arctic Skuas attending a trawler.

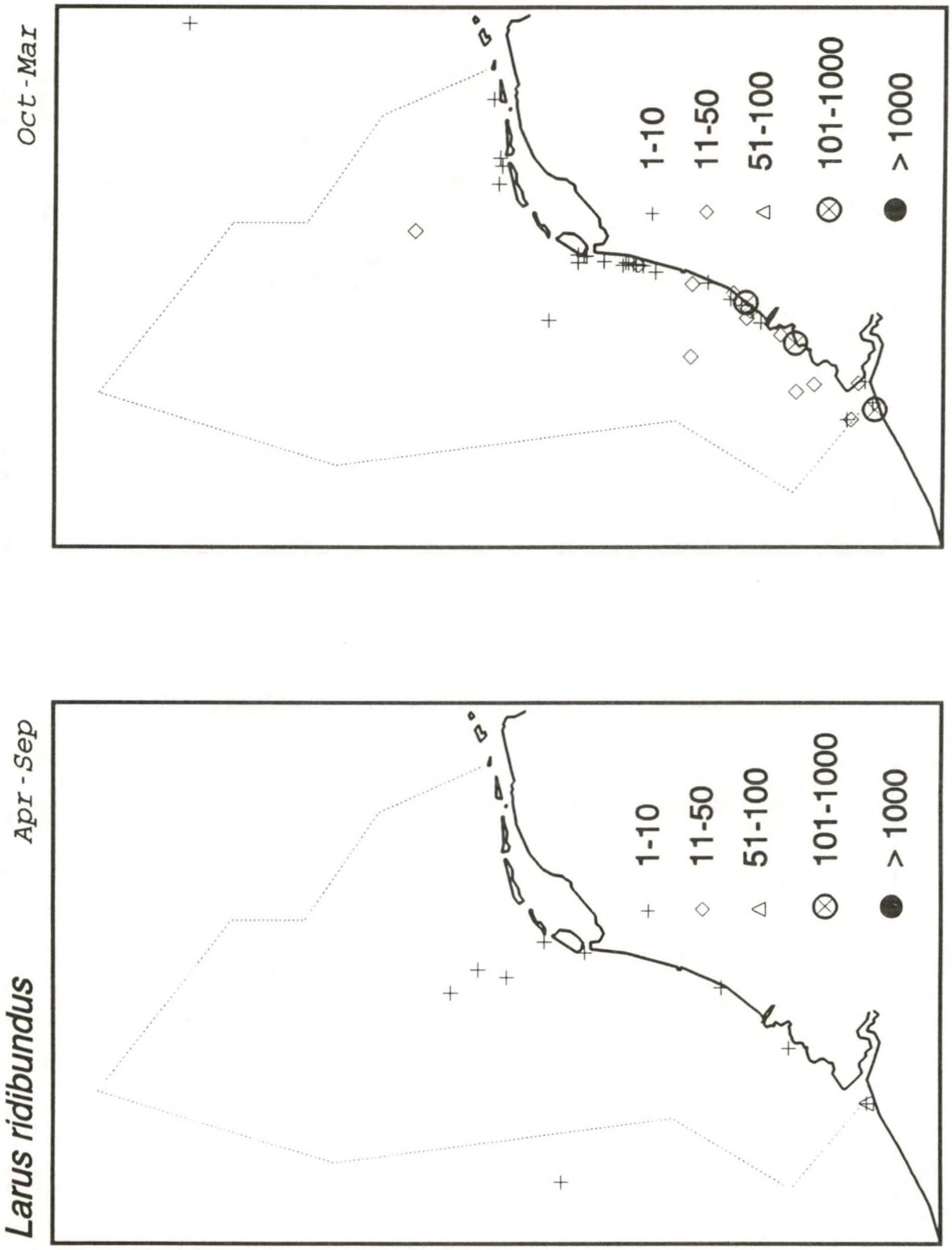


Figure 8. Sightings of Black-headed Gulls (Larus ridibundus) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October- March), 1987-1992.

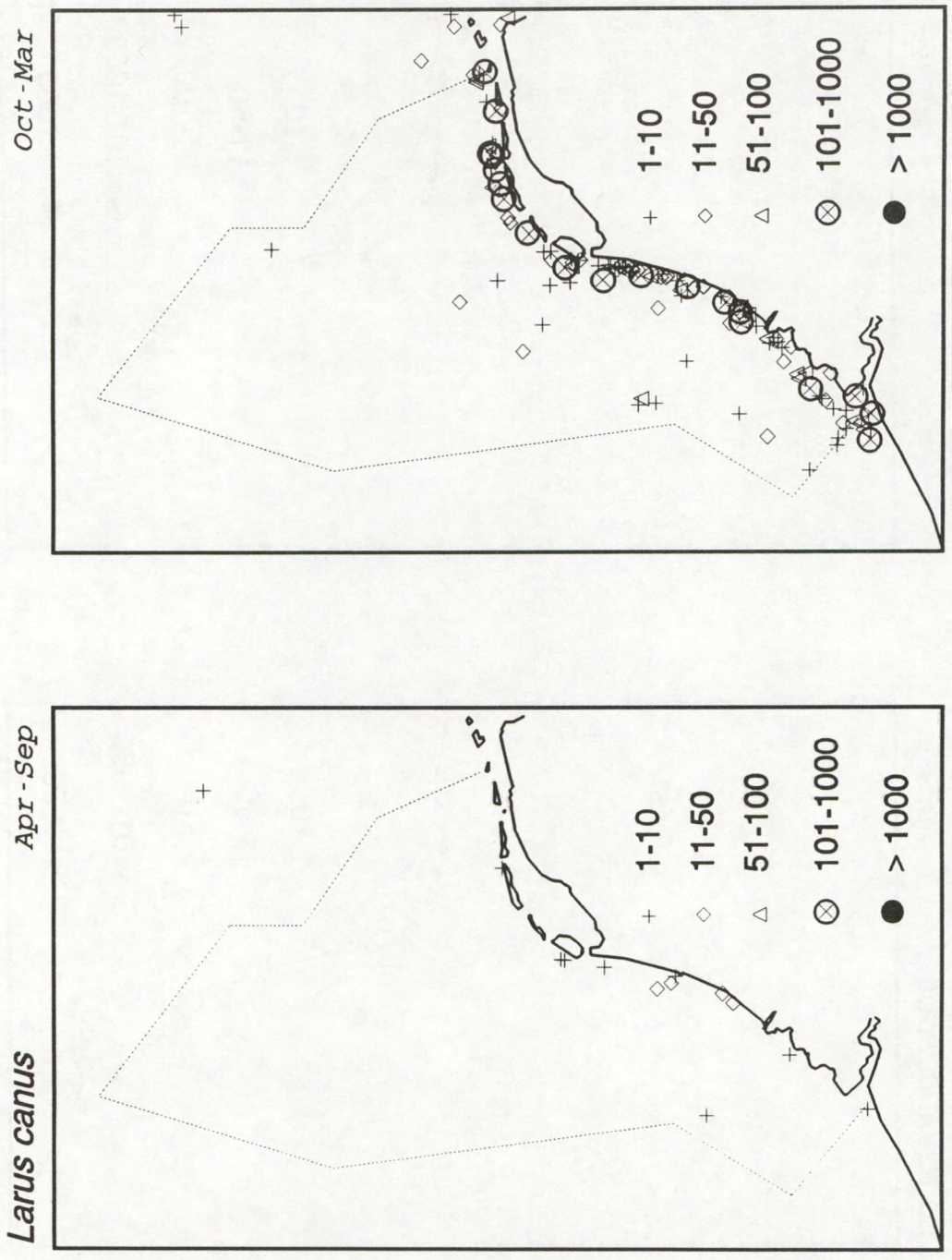


Figure 9. Sightings of Common Gulls (Larus canus) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October-March), 1987-1992.

Mediterranean Gull *Larus melanocephalus*

One adult was seen scavenging in a large, mixed group (comprising 1 Gannet, 1 Arctic Skua, 34 Black-headed Gulls, 182 Common Gulls, 340 Herring Gulls, 25 Lesser Black-backed Gulls, 20 Great Black-backed Gulls, 1 Kittiwake, and 200 unidentified gulls) behind a trawler at some 11 km from the coast, off the Delta area (51°43'N, 03°30'E; 23 October 1990).

Little Gull *Larus minutus*

Nine records, of a total of 122 individuals, with a maximum of 85 (dominating species at a trawler with 5 Black-headed Gulls, 40 Common Gulls, 6 Herring Gulls, and 5 unidentified Gulls; 29 March 1990, 2 km from the coast of Zuid-Holland). Three records of Little Gulls were within 5 km from the coast, two between 5 and 10 km, and four between 20 and 50 km.

Black-headed Gull *Larus ridibundus*

Some 11.3% of all trawlers were attended by Black-headed Gulls, with a maximum of 755 individuals at a time. As a scavenger, this species was only frequently reported in winter (October-March; table 4) and at first glance, the Black-headed Gull appeared to be an inshore scavenger (figure 8). However, small groups of scavenging seabirds were observed in a wider area off the Dutch coast (table 7), and the distribution of records over the five distance zones was not significantly different from the null-hypothesis (*i.e.* an equal distribution over all trawlers; see table 13). Nevertheless, larger aggregations (*i.e.* >50 Black-headed Gulls) were only seen within 2 km from land. Examples of large flocks of scavenging Black-headed Gulls are:

date	geogr. position	number	distance	other scavengers
22 Nov 1990	51°50'N, 03°53'E	755	2.0 km	mixed gull group
4 Feb 1991	51°23'N, 03°16'E	300	1.0 km	300 Common Gulls
	52°06'N, 04°15'E	200	1.0 km	50 Common Gulls and 200 Herring Gulls
13 July 1987	51°25'N, 03°18'E	80	1.5 km	80 large gulls

Table 7. Frequency of occurrence of groups of ≥ 10 Black-headed Gulls as scavengers behind 368 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	0	0	0	0	0	0
Off Texel & Vlieland	0	0	0	0	1	1
Off mainland coast	4	2	0	1	0	7
Off Delta area	4	1	2	1	0	8
Total	8	3	2	2	1	16
%	50.0	18.8	12.5	12.5	6.3	

Few Black-headed Gulls were seen scavenging off the Wadden Sea islands. As a dominating species, Black-headed Gulls were only seen close inshore off Zuid-Holland and the Delta area.

Common Gull *Larus canus*

Common Gulls were frequent scavengers (10.6% of all identified gulls at trawlers, n= 63,523, 141 records), but only in winter and mainly in a narrow band along the coast (table 4, figure 9). Only few summer and early autumn records are available (1 record in May, 2 in June, 1 in July, none in August, 2 in September; usually less than 10 individuals), and it was frequently found during October-March (36-62% of all trawlers). Larger groups, >100 individuals, were only reported in the latter period and virtually all these groups were recorded within 10 km from the nearest shore (the only exception was seen at 12.5 km off the delta area). The frequency distribution of Common Gulls in five distance zones off the coast is significantly different from expectation based on the distribution of recorded trawlers ($G = 53.3$, $p<0.001$, $df = 4$; tables 8, 13). Larger groups of scavenging Common Gulls were:

date	geogr. position	number	distance	other scavengers
31 Jan 1991	52°28'N, 03°26'E	929	3.5 km	54 Herring Gulls
22 Oct 1990	52°40'N, 04°33'E	340	3.5 km	540 large gulls
29 Jan 1992	53°29'N, 06°04'E	300	5.5 km	100 Herring Gulls
04 Feb 1991	51°23'N, 03°16'E	300	1.2 km	300 Black-headed Gulls

With the group of 929 Common Gulls seen near Vlissingen being by far the largest scavenging group seen. As a dominating species at a trawler (>50% of the attracted birds), Common Gulls were only found in a narrow strip all along The Netherlands' coast.

Table 8. Frequency of occurrence of groups of ≥10 Common Gulls as scavengers behind 368 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	10	7	0	3	0	20
Off Texel & Vlieland	4	1	0	0	2	7
Off mainland coast	20	6	3	1	1	31
Off Delta area	7	6	4	0	1	18
Total	41	20	7	4	4	76
%	53.9	26.3	9.2	5.3	5.3	

Herring Gull *Larus argentatus*

Herring Gulls are the most numerous and most frequent scavengers behind commercial trawlers in Dutch waters (48.6% of all identified gulls (n= 63,523), 287 records; table 3). It is essentially a coastal species as a scavenger, of

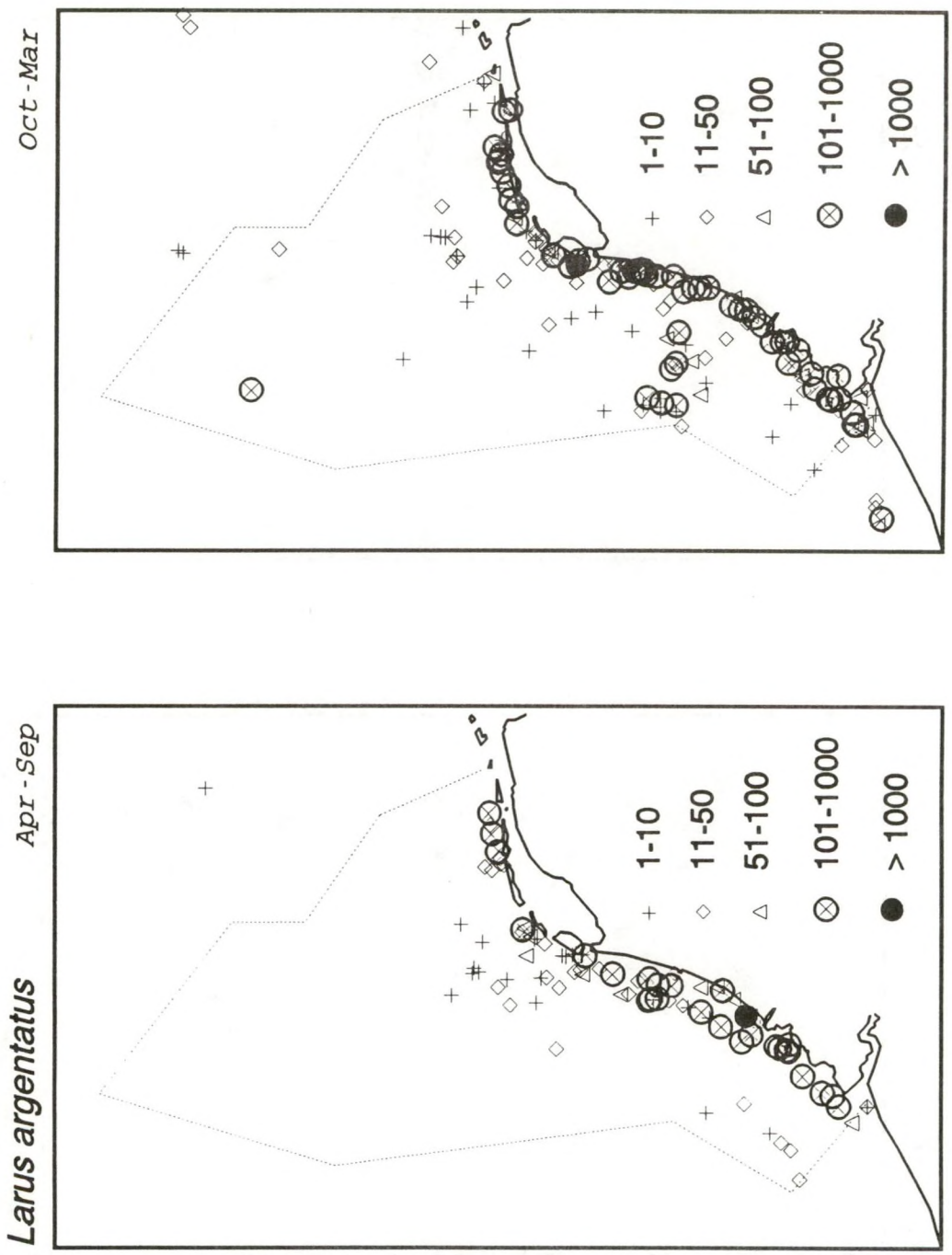


Figure 10. Sightings of Herring Gulls (Larus argentatus) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October- March), 1987-1992.

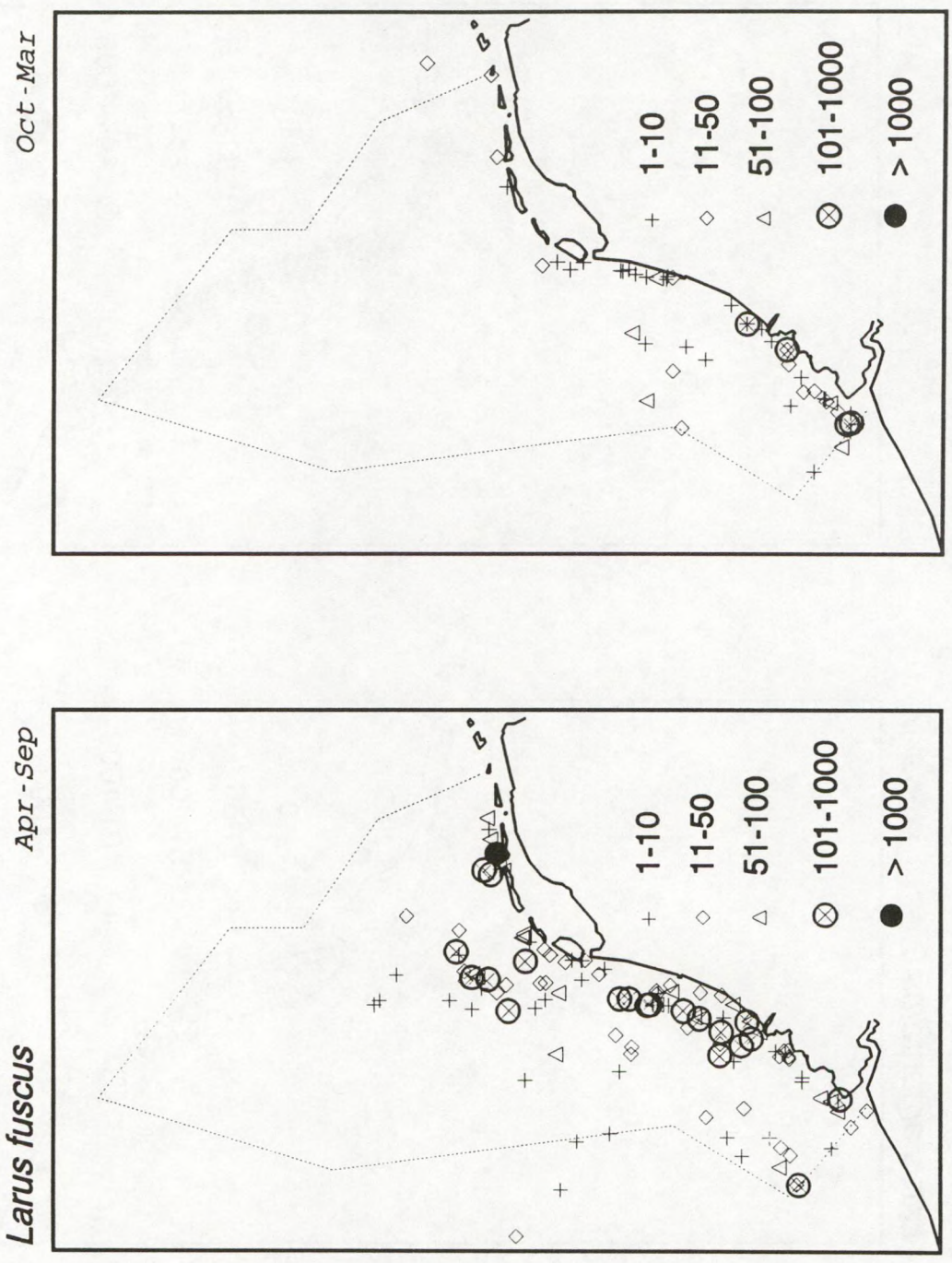


Figure 11. Sightings of Lesser Black-backed Gulls (Larus fuscus) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October- March), 1987-1992.

which occasional flocks are recorded further offshore (figure 10). The distribution of records (of flocks over 10 Herring Gulls) over 5 distance zone off the coast was significantly different from expected frequencies, as based on the distribution of 368 trawlers where >50% of the gulls were identified ($G = 54.7$, $p < 0.001$, $df = 4$; tables 9, 13), and as a dominating species, Herring Gulls were mainly found within 10 km from the coast off the Delta area and off the Wadden Sea islands and within 20 km from the shore off the mainland coast. In winter however, Herring Gulls move further away from the shore and pilot studies in autumn 1992 indicate that it is fairly frequent and numerous as a scavenger within at least 100 km from the coast (Camphuysen *in press*). Within the Brown Bank area, a large fleet of Dutch beamtrawlers is known to fish on flatfish and this may provide a quite predictable source of food for Herring Gulls outside the breedins season.

Herring Gulls have been observed as scavengers through the year, but least frequent in late summer (July-September; table 4). Larger groups (>50 individuals) were most frequent from October through July (24-50% of all trawlers with scavenging seabirds), but remarkably absent in August and September (in total 9 flocks of scavenging Herring Gulls, 8 of which less then 10 individuals). Some very large flocks of scavenging Herring Gulls were observed in July, but other large groups of scavenging Herring Gulls (>500 individuals), sometimes joined by Common Gulls and/or Great Black-backed Gulls, were reported during January-March, usually within 10 km from the shore:

date	geogr. position	number	distance	other scavengers
6 Jul 1987	52°05'N, 04°08'E	1930	3.5 km	510 Lesser Bl.-b. Gulls
10 Mar 1987	53°03'N, 04°38'E	1100	4.3 km	50 Common Gulls
29 Jan 1991	51°30'N, 03°10'E	970	12.4 km	
26 Jan 1989	53°27'N, 05°24'E	850	3.0 km	mixed gull group
7 Jul 1987	52°03'N, 03°58'E	800	10.1 km	200 Lesser Bl.-b. Gulls
8 Jul 1987	53°29'N, 05°40'E	720	2.5 km	1060 Lesser Bl.-b. Gulls
10 Jan 1989	52°46'N, 04°32'E	700	5.4 km	33 Kittiwakes

Table 9. Frequency of occurrence of groups of ≥ 10 Herring Gulls as scavengers behind 368 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	17	9	1	2	1	30
Off Texel & Vlieland	15	7	4	8	4	38
Off mainland coast	34	11	10	13	9	77
Off Delta area	16	14	19	1	7	57
Total	82	41	34	24	21	202
%	40.6	20.3	16.8	11.9	10.4	

Age composition of groups of scavenging Herring Gulls was studied in all flocks of at least 10 individuals, if >50% was aged (n = 62). Obviously, in larger aggregations ageing can never be very accurate and especially older imma-

tures (>3rd calender year) are easily overlooked among adults. However, juveniles, immatures (2nd-5th calender year) and adult birds were separated whenever possible. In 43 cases, adults predominated (69.4%, n= 62), while 8 flocks comprised ónly adults (12.9%). Immature Herring Gulls were comparatively numerous in October and November (dominating in 9 flocks of scavengers, n= 15). Most of these birds were juveniles (84.2%, n= 285). Of 7 summer flocks, over 90% were adult birds (July-August). When plotting flocks of Herring Gulls of which age-compisition is known, it is remarkable that flocks where adult birds predominate were wide-spread in the coastal zone off the Delta area, the mainland coast and the Wadden Sea islands, while flocks where immatures predominated were rather clustered in Westerschelde, Europoort, IJmuiden, and Den Helder (all near larger harbours).

Yellow-legged Gull *Larus cachinnans*

A single record of three (adult) scavengers in a mixed group (6 species) of 60 gulls, some 50 km off the coast of the Delta area (51°43'N, 02°45'E).

Lesser Black-backed Gull *Larus fuscus*

Lesser Black-backed Gulls were frequent scavengers in the southern North Sea in summer (table 4). Between April and July, between 72.0 and 91.3% of the trawlers with scavenging seabirds were joined by one or more Lesser Black-backed Gulls (Apr-Jul n= 25, 35, 23, 19), between 52.0 and 84.2% were joined by flocks of over 10. In August, this frequency fell considerably (42.9% with any Lesser Black-backed Gulls, 21.4% with flocks of >10; n= 28) and it subsequently declined to a low in December (9.1% with any/0.0% with flocks >10; n= 11) and January (8.8% with any/3.5% with flocks > 10; n= 57). Large flocks (≥ 500) of scavenging Lesser Black-backed Gulls were observed during May-July:

date	geogr. position	number	distance	other scavengers
8 Jul 1987	53°29'N, 05°40'E	1060	2.5 km	720 Herring Gulls
24 May 1991	52°14'N, 04°02'E	550	19.6 km	400 Herring Gulls
6 Jul 1987	52°05'N, 04°08'E	510	3.5 km	1930 Herring Gulls
30 Jul 1987	53°38'N, 04°32'E	510	48.9 km	165 Kittiwakes
20 Sep 1988	52°21'N, 04°09'E	400	22.2 km	400 Great Black-b. Gulls
22 May 1991	52°38'N, 04°17'E	400	21.3 km	100 Herring Gulls

This species was found dispersed at considerably larger distances from the shore than the Herring Gull (*cf.* figures 10-11, tables 9-10), but it should still be considered a coastal species. The distribution of records (of flocks over 10 Lesser Black-backed Gulls) over 5 distance zones off the coast was significantly different from expected frequencies, as based on the distribution of 368 trawlers where >50% of the gulls were identified ($G = 19.6$, $p < 0.001$, $df = 4$; tables 10, 13). As a dominating species (>50% of the birds behind a trawler), Lesser Black-backed Gulls were frequently encountered in a zone within 50 km from the coast. Off the mainland coast, Herring Gulls were always dominating over Lesser Black-backed Gulls within 20 km from the shore.

Table 10. Frequency of occurrence of groups of ≥10 Lesser Black-backed Gulls as scavengers behind 368 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	7	1	1	1	1	11
Off Texel & Vlieland	2	2	2	12	3	21
Off mainland coast	9	3	8	13	5	38
Off Delta area	6	3	9	1	4	23
Total	24	9	20	27	13	93
%	25.8	9.7	21.5	29.0	14.0	

Lesser Black-backed Gulls are migratory birds and most leave the North Sea area in winter. As a result, the few scavenging Lesser Black-backed Gull that were found in winter were distributed further to the south, *i.e.* significantly more frequently off the Delta area and the mainland coast as could be expected from trawler distribution alone (Oct-Mar, $G = 13.56$, $df = 3$, $p < 0.005$; figure 11). In August and September, relatively large numbers are seen migrating south in Dutch coastal waters (Camphuysen & van Dijk 1983) and in this period Lesser Black-backed Gulls appeared most abundant off the Dutch coast. Apparently, trawlers were not particularly attractive during these movements, for small numbers were attending trawlers in these months.

Great Black-backed Gull *Larus marinus*

Great Black-backed Gulls were frequently encountered as scavengers at trawlers (9.5% of all identified gulls, n = 63,523, 188 records; table 3). However, this species was mainly found during August-April, and was virtually absent in summer (table 4). Its seasonal pattern as a scavenger is well in accordance with that found in Dutch coastal waters, where it was found most frequently during September-February and least frequently during May and June (Camphuysen & Van Dijk 1983). Scavenging Great Black-backed Gulls were seen in a wide area (table 11, figure 12), and the distribution of records over the five distance zones was not significantly different from the null-hypothesis (*i.e.* an equal distribution over all trawlers; see table 13). Hence, Great Black-backed Gulls can neither be labelled as typically inshore, nor as offshore scavengers. As a dominating species (>50% of all scavengers at a trawler), Great Black-backed Gulls were seldom observed close inshore, but often at 10-20 km from the coast. Larger flocks were:

date	geogr. position	number	distance	other scavengers
20 Sep 1988	52°21'N, 04°09'E	400	22.2 km	400 Lesser Black-b. Gulls
21 Feb 1989	52°30'N, 03°44'E	365	54.9 km	504 Herring G., 200 Kittiw.
05 Feb 1991	54°54'N, 03°29'E	300	202.2 km	250 Herring G., 80 Kittiw.
30 Nov 1987	53°24'N, 05°03'E	217	7.3 km	mixed gull group
08 Nov 1987	53°44'N, 04°44'E	204	49.5 km	28 Herring G., 50 Kittiwake

Table 11. Frequency of occurrence of groups of ≥10 Great Black-backed Gulls as scavengers behind 368 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	5	4	0	1	0	10
Off Texel & Vlieland	5	2	1	7	5	20
Off mainland coast	11	2	1	7	7	28
Off Delta area	4	5	5	3	4	21
Total	25	13	7	18	16	79
%	31.6	16.5	8.9	22.8	20.3	

Table 12. Frequency of occurrence of groups of ≥10 Kittiwakes as scavengers behind 368 trawlers in different zones off the Dutch coast.

	<5 km	5-10 km	10-20 km	20-50 km	>50 km	total
Off Terschelling-Rottum	0	2	1	1	2	6
Off Texel & Vlieland	2	1	0	6	12	21
Off mainland coast	1	3	2	9	11	26
Off Delta area	2	3	4	3	7	19
Total	5	9	7	19	32	72
%	6.9	12.5	9.7	26.4	44.4	

Kittiwake *Rissa tridactyla*

Kittiwakes were common scavengers in the Dutch sector in late summer, autumn and winter, while the species was virtually absent in April, May and June (table 4). This seasonal pattern is well in accordance with its status in coastal waters as recorded during seawatching (Camphuysen & van Dijk 1983). The species occurred both offshore and inshore, but larger numbers were usually seen at considerable distances from the coast (figure 13, table 12). The distribution of records (of flocks >10 Kittiwakes) over 5 distance zones off the coast was significantly different from expected frequencies ($G = 25.6$, $p < 0.001$, $df = 4$; tables 12, 13) and the Kittiwake can be considered an offshore species as a scavenger in the southern North Sea. The most notable exception were 350 Kittiwakes scavenging behind a trawler together with 750 large gulls on 20 February 1989 at only 1.7 km from the beach (see below). Large groups were:

date	geogr. position	number	distance	other scavengers
13 Oct 1987	53°13'N, 04°06'E	500	44.5 km	(few, dominating)
23 Feb 1989	52°29'n, 04°04'E	390	36.0 km	186 Herring G., 90 GrBl.bG.
10 Dec 1987	51°22'N, 02°24'E	350	55.6 km	(few, dominating)
20 Feb 1989	51°52'N, 03°52'E	350	1.7 km	mixed gull group
22 Nov 1990	51°31'N, 03°11'E	303	13.0 km	mixed gull group

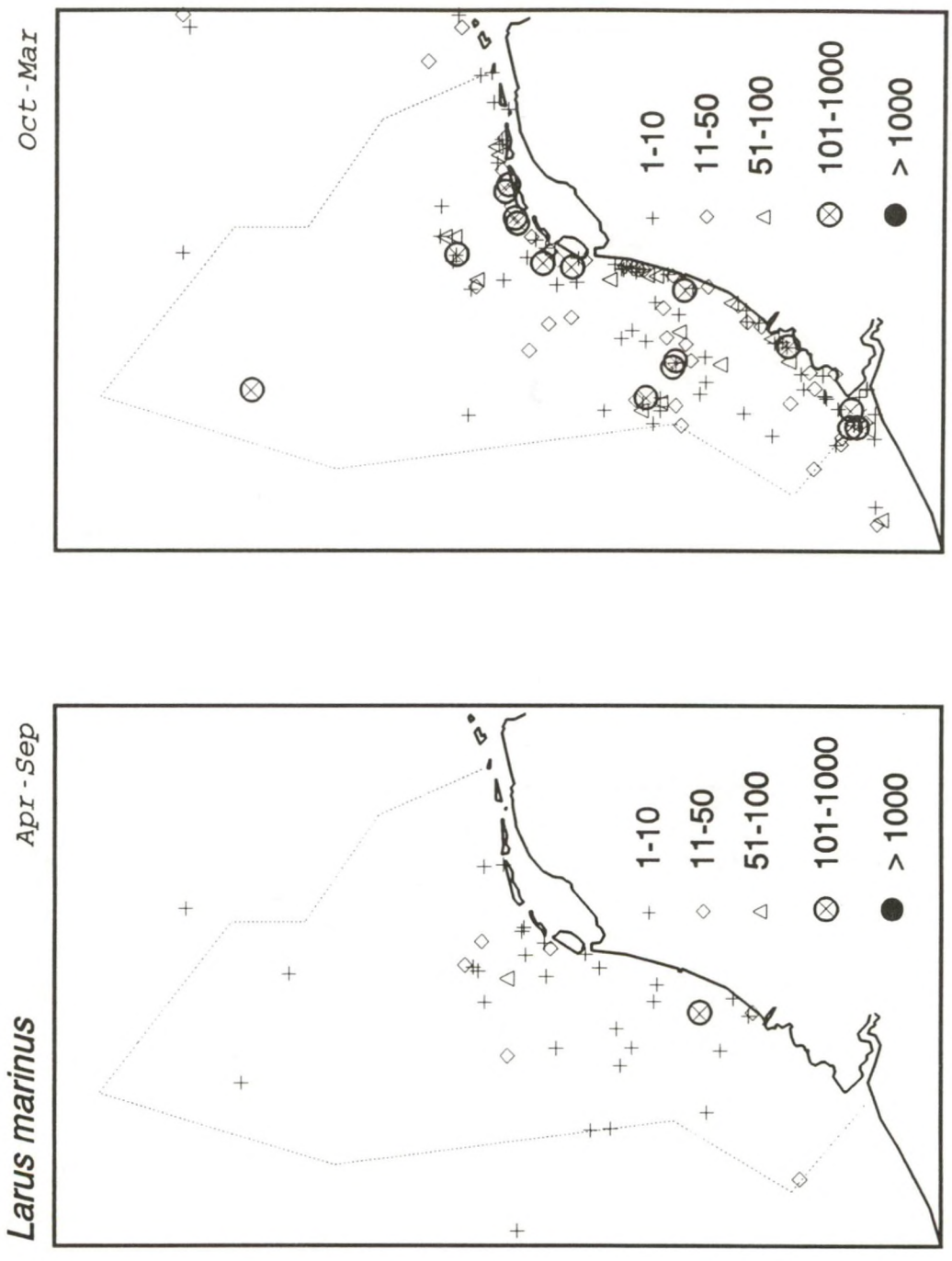


Figure 12. Sightings of Great Black-backed Gulls (Larus marinus) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October- March), 1987-1992.

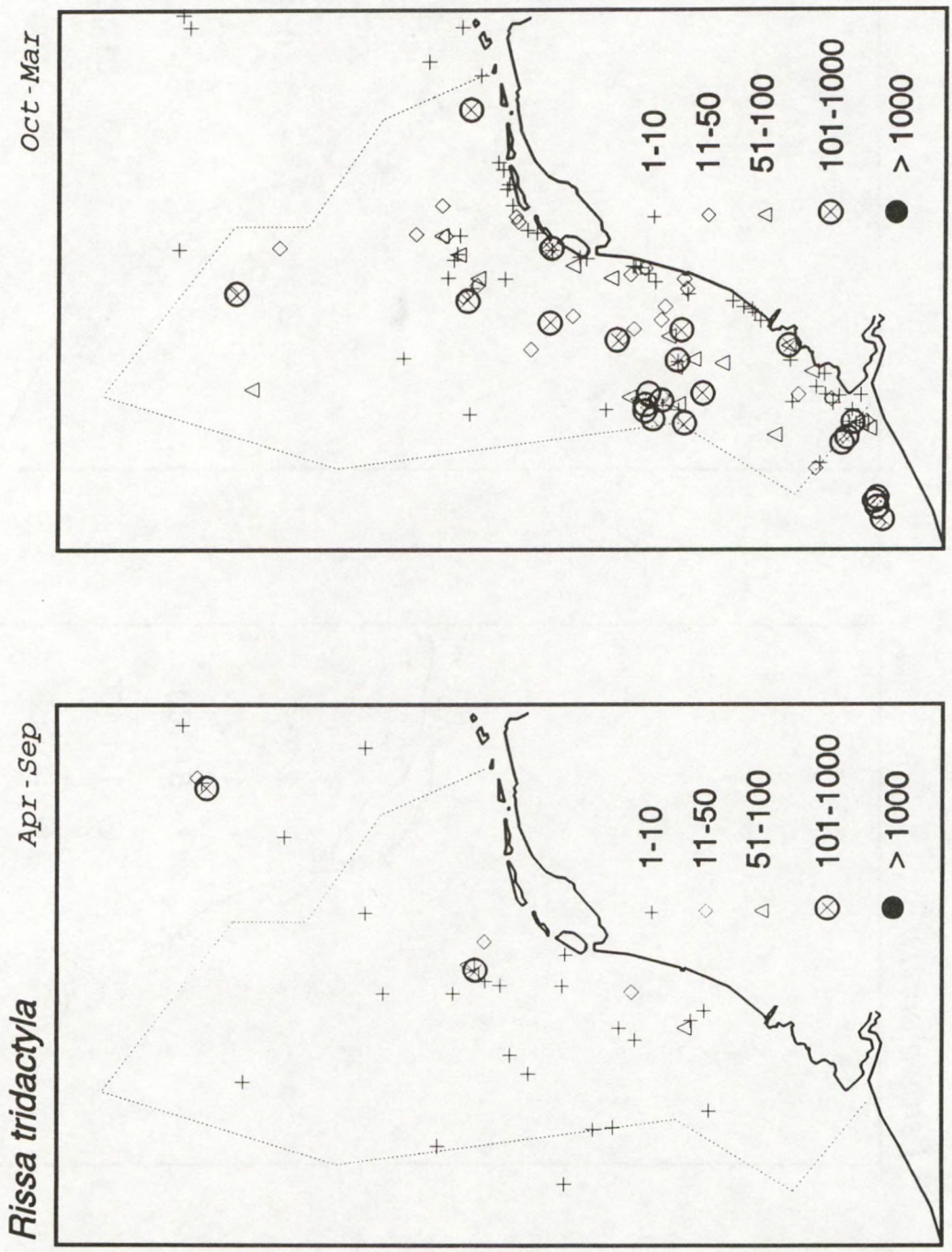


Figure 13. Sightings of Kittiwakes (Rissa tridactyla) at commercial trawlers during ship-based surveys in the southern North Sea in summer (April-September) and winter (October-March), 1987-1992.

Common Tern *Sterna hirundo*, **commic tern** *S. hirundo / paradisaea*

Four records of scavenging Common terns (3, 5, 20, and 26 individuals, all May-July), one record of 4 'commic terns' (June). Four records were within 5 km from the coast, one at 12 km distance. Three records were off the Delta area, one off Zuid-Holland, one off Ameland.

Sandwich Tern *Sterna sandvicensis*

Two records of Sandwich Terns attending trawlers, one at 20 km from the coast with 150 large gulls and a Fulmar (52°36'N, 04°17'E; 22 May 1991), and three at 1.5 km from the coast with 120 large gulls and 2 Common Gulls (53°27'N, 05°32'E; 7 May 1992).

3.4 Discussion

The most abundant and most frequent scavenger in the Dutch sector of the North Sea was the Herring Gull (287 records, 30,898 individuals, present throughout the year). Second, there is a group of 'common' scavengers, comprising Fulmar, Common Gull, Lesser Black-backed Gull, Great Black-backed Gull and Kittiwake (140-190 records, >6000 individuals, only the Fulmar is present through the year). Scarce, but still rather frequently reported, were Gannet and Black-headed Gull (>50 records), while occasional scavengers were Great Skua, Little Gull, and Common Tern. The other species listed in table 3 can be considered unusual at trawlers in this area.

Fulmar, Gannet, Great Skua and Kittiwake were typical scavengers in the offshore zone (most records >20 km from the shore, distribution of sightings significantly different from the expectation based on trawler distribution; table 13), Common Gull, Herring Gull and Lesser Black-backed Gull were typical inshore species. In summer, Lesser Black-backed Gulls ventured further out to sea than Herring Gulls (figure 10, 11). Detailed studies of these two species at trawlers during the breeding season (April-July) showed a feeding range of 30 km away from the nearest colony for Herring Gulls and 65 km for Lesser Black-backed Gulls (Camphuysen *in prep.*). The distribution of groups of >10 scavenging Black-headed Gulls and Great Black-backed Gulls was not significantly different from the null-hypothesis (*i.e.* an equal distribution over all trawlers; table 13). Still, considering the area where these species were most abundant and occasionally even dominating at trawlers, the first may be considered an inshore scavenger and the latter an offshore species. Fulmar and Herring Gull were observed in most months at trawlers (table 4). Winter scavengers were Gannet (Aug-Apr), Black-headed Gull (Oct-Mar), Common Gull (Oct-Apr), Great Black-backed Gull (Aug-Apr), and Kittiwake (Jul-Mar), while the Lesser Black-backed Gull mainly occurred in summer (Mar-Oct).

Since all birds were observed at a distance, it could obviously not be ascertained whether (all) associated birds were actually scavenging on discards or offal or whether they foraged upon some natural prey in the wake of the vessel. Especially in case of the terns and the Little Gulls *Larus minutus*, the turbulence

caused by the propellor of the ship may have been equally, or perhaps even more, 'interesting' as a source of food. Feeding flocks of these species have often been seen feeding in the wake of non-fishing vessels or in turbulences caused by river outlets or floodgates.

Table 13. Frequency of occurrence of seabirds at trawlers in different zones off the Dutch coast (tables 5-12 summarized). Fulmars, Gannets and Great Skua behind (a) all trawlers (n = 461) and Larus*-gulls behind (b) all trawlers with >50% of the associated gulls specifically identified (n = 368). The null-hypothesis of equal distribution of trawlers and attending seabirds was tested (G-test, Sokal & Rohlf 1981).*

	<5	5-10	10-20	20-50	>50 km	total	G =	p<
Fulmar	1	1	3	26	61	92	120.9	0.001
Gannet	1	0	1	8	7	17	15.8	0.001
Black-headed Gull	8	3	2	2	1	16	6.7	n.s.
Common Gull	41	20	7	4	4	76	53.3	0.001
Herring Gull	82	41	34	24	21	202	54.7	0.001
Lesser Black-b. Gull	24	9	20	27	13	93	19.6	0.001
Great Black-b. Gull	25	13	7	18	16	79	4.3	n.s.
Kittiwake	5	9	7	19	32	72	25.6	0.001
All trawlers (a)	139	60	62	84	116	461		
All trawlers (b)	106	47	44	68	103	368		

4. Breeding scavenging seabirds in the (southern) North Sea

During the last 20 years, most of the important seabird breeding areas in the North Atlantic have been visited and numbers of most breeding seabirds, and in some cases also the breeding success, are now reasonably well known (Cramp *et al.* 1974, Cramp & Simmons 1977, 1983, Croxall *et al.* 1984, Cramp 1985, Nettleship & Evans 1985, Lloyd *et al.* 1991). The breeding numbers of seabirds in Britain have been studied quite well since the pioneer work in this field was carried out in the late 1960s/early 1970s (Cramp *et al.* 1974) and again in the mid-1980s (Lloyd *et al.* 1991). Mapping and counting of seabirds have also taken place in Denmark (Danielsen *et al.* 1986), Germany (Becker & Erdelen 1987) and The Netherlands (SOVON 1987, Teixeira 1979). However, not all countries maintain regular monitoring programmes to assess changes in status and breeding success. One of the more productive and 'accessible' schemes is the 'Seabird Colony Register' which was established at the Joint Nature Conservation Committee in Aberdeen (*e.g.* Walsh *et al.* 1992). Regular updates of breeding seabird distribution, numbers and breeding success are provided in this system. In Denmark, the most recent review of breeding and wintering numbers (Danielsen *et al.* 1986), is already rather old. In Germany the status and changes in numbers of seabirds are studied quite well and what is known is frequently updated (*e.g.* Moritz 1980, Berndt 1981, Vauk 1982, Prüter 1983, Fleet 1984, Taux 1984, 1986, Vauk-Hentzelt, Schrey & Vauk 1986, Becker & Erdelen 1987). In The Netherlands, where only terns and gulls breed, it is hard to obtain recent updates of numbers and trends. Locally the situation is often quite well known, but few general accounts appeared in recent years (*e.g.* Teixeira 1979, SOVON 1987).

4.1 North Sea breeding population

Recent estimates of the numbers of seabirds breeding in the North Sea have varied considerably, from 1,987,000 (including Baltic; Bourne 1978) to

Table 14. Recent estimates of numbers of breeding seabirds (pairs) on North Sea coasts (after Tasker et al. 1987 and Dunnet et al. 1990).

Species	Breeding pairs
Fulmar	307599
Gannet	43778
Great Skua	7303
Black-headed Gull[1]	129342
Common Gull	73332
Lesser Black-backed Gull	49311
Herring Gull	237114
Great Black-backed Gull	24436
Kittiwake	415427

[1]Estimate excluding The Netherlands.

4,527,000 pairs (including seabirds breeding on Scottish and English west coast; Dunnet 1987). For 25 seabird species breeding in the North Sea area, recent population estimates are summarized by Tasker *et al.* (1987) and Dunnet *et al.* (1990). Within the North Sea, some 1.3 million pairs (= 2.6 million individuals) of scavenging seabirds are found breeding, with Fulmar (300,000 pairs), Herring Gull (250,000 pairs), and Kittiwake (400,000 pairs) being most numerous (table 14). There is probably an equal number of immature birds of each of these species, which leads to a conservative estimate of at least 5 million, potentially scavenging seabirds in the North Sea. Most of the pelagic seabirds (*i.e.* Fulmar, Gannet, Kittiwake) and all Great Skuas, breed in the northwestern North Sea, while most of the Larus-gulls are found in the southern and southeastern North Sea.

4.2 Breeding distribution and recent trends in numbers in the southern North Sea

The southern North Sea, defined between 51° and 56°N latitude and 2°W and 10°E longitude, has not often been studied as one unit. The area includes the coast of east England (Northumberland, Tyne & Wear, Durham, Cleveland, North Yorkshire, Humberside, Lincoln, Norfolk, Suffolk, Essex, and Kent), the Danish Wadden Sea area and a small part of SW Jutland, the North Sea coast of Schleswig-Holstein and all the coast of Nieder-Sachsen, and the coast of The Netherlands, and Belgium. Steep cliffs, and, hence, cliff-breeding seabirds, occur only in England and on Helgoland, whereas the majority of the eastern coasts consist of estuarine areas, mud flats, sand dunes, sandbeaches, and dikes. In The Netherlands, in this century, coastal protection works have enclosed rather large salt water systems (former Zuiderzee, Delta area).

From the analysis in chapter 3, it can be deduced that within the southern North Sea nine seabird species are often encountered at trawlers and, hence, obtain a substantial part of their food as scavengers. Of these, seven do breed in large or rather large numbers in the area:

Fulmar *Fulmarus glacialis*
Gannet *Sula bassana*
Black-headed Gull *Larus ridibundus*
Common Gull *Larus canus*
Herring Gull *Larus argentatus*
Lesser Black-backed Gull *Larus fuscus*
Kittiwake *Rissa tridactyla*

Information on population size and breeding distribution of the common breeding species are summarized below. Distribution maps of breeding populations in the southern North Sea were compiled using the most recent data as currently available in Britain (Lloyd *et al.* 1991), Denmark (Danielsen *et al.* 1986), Germany (de Vries 1990, Hansohn 1992, Hüppop 1992), The Netherlands (A.J. van Dijk, SOVON unpublished data) and Belgium (P. Meire, Institute for Nature Conservation in Hasselt unpublished data and De Scheemaeker 1992). Most data were collected in the 1980s or early 1990s. It should be noted that in

many of the gull species, numbers in colonies are subject to large fluctuations from one year to the other. Hence, the maps and tables below give an impression of the distribution and numbers of these species, or an estimate rather than an accurate count. For The Netherlands, the recent situation with respect to coastal gull colonies is discussed in more detail.

Fulmar *Fulmarus glacialis*

The north Atlantic population of the Fulmar increased spectacularly during the last 200 years (Fisher 1952). Breeding in the British Isles (except St Kilda) was first recorded on Foula in 1878 and a rapid colonization of Britain took place since that time. At present, the North Sea population is estimated at *ca.* 310,000 occupied sites, with Shetland (208,314) and Orkney (63,358) as strongholds (Tasker *et al.* 1987). Very small numbers breed in SW Norway (approximately 60 sites). The Fulmar has colonized the southern North Sea only quite recently. The colony at Bempton Cliffs, North Yorkshire, established in 1939 or 1940, was the first to be prospected in (eastern) England (Fisher 1952). Fulmars are now widespread, with scattered small colonies all along the coast (figure 14; Lloyd *et al.* 1991). The total number of pairs is still rather small: 3445 Apparently Occupied Nests (AON), or 1.1% of the total North Sea breeding population of the Fulmar (table 14). The population increase in eastern England is rather slow because nesting habitat is limited by the low coastline. In Kent and East Sussex, however, between 1969/70 and 1985/87, a spectacular 13-fold increase occurred (Lloyd *et al.* 1991). The only other colony in the area is found on Helgoland, Germany. The colony was established in the late 1960s (first prospecting birds in 1968, 1-2 pairs 1970, first young hatched 1972) and has increased considerably: 1976 5 pairs, 1981 15 pairs, 1989 22 pairs, 1992 34 pairs (Moritz 1980, Vauk 1982, Liber 1990, Hüppop 1992).

Gannet *Sula bassana*

The Gannet increased over most of its range during this century (Nelson 1978, Wanless 1987). In Britain, Ireland, France and Channel Islands the numbers are still increasing, but with a slight decrease in rate since 1949-69. In the southern North Sea, Gannets breed in small numbers at Bempton Cliffs, North Yorkshire (figure 15). Between 1969 and 1987, this colony increased in size rapidly (*i.e.* 18 pairs in 1969, 100 sites in 1974, 240 pairs in 1979, 529 AON in 1984, 780 AON in 1987; Wanless 1987, Lloyd *et al.* 1991). On Helgoland, the first breeding case was recorded in 1991, following a number of years with prospecting Gannets on the cliffs. In 1992, two pairs bred here (Hüppop 1992). The nearest large colony of this species is found on Bass Rock, Firth of Forth (21,591 AON in 1985; Lloyd *et al.* 1991).

Black-headed Gull *Larus ridibundus*

Black-headed Gulls increased markedly in most of Northwest Europe in the 19th, but mainly in the 20th century (Cramp & Simmons 1983). Only in Denmark numbers declined, possibly as a result of increased competition with

Herring Gulls. Most British colonies of Black-headed Gulls are concentrated in Northumberland (4753 pairs), around The Wash (7342 pairs) and in Suffolk, Essex and Kent (13,026 pairs; figure 16; Lloyd *et al.* 1991). The English breeding population has shown an overall increase in numbers (Sharrock 1976). In the late 1950s, an estimated 46,000-51,000 pairs of Black-headed Gulls were found in England and Wales (Gribble 1962). In 1973, this figure had doubled (100,000-110,000 pairs; Gribble 1976). Coastal colonies in England numbered 53,071 pairs in 1969-70 (Cramp *et al.* 1974), and 68,900 pairs in 1985-87 (Lloyd *et al.* 1991). However, certain sub-populations declined while others increased. Colonies on the west side of the Wash, listed by Gribble (1976) as 7800 pairs and one of the 21 largest colonies in England and Wales, had declined quite dramatically to 2625 pairs in 1986 (Lloyd *et al.* 1991).

Information on coastal colonies in The Netherlands is quite scarce, mainly because these were not studied separately from inland sites. The total Dutch population numbered 65,000-95,000 pairs in 1961 (Higler 1962), while it was estimated at >200,000 pairs in the mid-1970s (Teixeira 1979) and 225-275,000 pairs in the early 1980s (SOVON 1988). In the 1960s, 12,000-18,000 Black-headed Gulls were breeding in the Delta area, 9,000-14,000 in Zuid-Holland, 8,000-12,000 in Noord-Holland, 5,000-7,000 in Friesland and on the Frisian islands, and 2,700-4,000 in Groningen (in all, 36,700-55,000 pairs in coastal provinces; substantial numbers of the Dutch population were not breeding near the coast). For 1990/91, the size of coastal colonies is better known. In the Wadden Sea region, some 74,732 pairs were found breeding, only 547 pairs bred along the mainland coast of Noord- and Zuid-Holland, and another 40,752 pairs were found in the Delta area (A.J. van Dijk, SOVON unpublished data). This indicates that the coastal population has at least doubled since the early 1960s.

Coastal colonies of Black-headed Gulls in Belgium have increased considerably during the last 30 years. The total population in West-Vlaanderen in the early 1960s numbered some 40-60 pairs (Higler 1962). Substantial numbers were only found near Antwerpen (14,000-21,000 pairs; not considered a coastal population in this compilation). In 1991, some 4000 pairs were found in Het Zwin nature reserve, another 975 pairs around Zeebrugge and 100 pairs in Veurne (P. Meire *pers. comm.*).

Common Gull *Larus canus*

Common Gull increased in numbers in most of its range during the 20th century, except in Denmark (Cramp & Simmons 1983). Common Gulls are remarkably scarce as breeding birds in east England, with only 34 coastal breeding pairs (3 pairs Norfolk, 23 Suffolk, 8 Kent; table 15, figure 17; Lloyd *et al.* 1991). In 1969-70, the same English coastal breeding population of Common Gulls numbered only 6 pairs (2 pairs Norfolk, 4 Kent; Cramp *et al.* 1974). The Dutch population of the Common Gull, which was established in 1908 with 2 pairs, increased rapidly since the late 1940s. In the late 1940, some 100 pairs were found breeding, in 1960 the population was estimated at 377 pairs (Braaksma 1964). Some 7000 pairs were found in the mid-1970s (Teixeira 1979) and 11,000 Common Gulls were counted in 1985 (SOVON

1988) and again in the early 1990s (A.J. van Dijk, SOVON unpublished data). In recent years, however, mainland colonies suffered from increased predation of eggs, chicks and adults by Red Fox *Vulpes vulpes* and some important colonies were totally abandoned (Woutersen 1992, Costers 1992). The largest colony in The Netherlands, established in the dunes of Schoorl (Noord-Holland) in 1931, increased to some 6000 pairs in the mid-1980s, but declined to less than 2000 pairs in the early 1990s (Woutersen 1992). New, smaller colonies were established on alternative sites in the region, often outside the dunes (Costers 1992, Groot & Cottaar 1992, Woutersen & Roobeek 1992).

Herring Gull *Larus argentatus*

Of the about 181,000 pairs of Herring Gulls which were estimated to have bred in coastal colonies in Britain and Ireland, only 7631 pairs bred along the coast of east England (4.2%). In almost all coastal towns in this area, Herring Gulls also nested on buildings and other artificial structures (Lloyd *et al.* 1991). Herring Gull numbers declined in almost all parts of Britain and Ireland between 1969/70 and 1985/87, most notably in colonies in the west and northwest. The main exception to the downward trend in numbers during the 1970s and 1980s was at Orfordness in Suffolk, where numbers grew from 150 pairs in 1969 to nearly 1400 pairs in 1973. The colony remained approximately stable at this level until 1981 and increased again to 3390 pairs in 1986 (Lloyd *et al.* 1991).

The Herring Gull population at Helgoland, both of the breeding birds and the non-breeding birds, has been kept low in order to protect the Guillemots breeding on the island. Of the non-breeding birds, some 75 individuals were shot each year during 1960-80. Of the breeding birds the average annual kill was 11 adults and 14 chicks per annum (Vauk 1982). Peak numbers were found breeding in the 1950s, when some 500 pairs bred in the dunes. This habitat became unsuitable for breeding later, due to increasing tourism.

In the Netherlands, the Herring Gull increased quite spectacularly during this century (Spaans 1987a). In 1926, when the first national census was organised, some 10,000 pairs were found breeding. Until the mid-1960s, Herring Gulls were severely persecuted and numbers were kept around 20,000 pairs between the 1930s and 1960s (Noordhuis & Spaans 1992). The effect of persecution was clearly shown some three years after it stopped: the annual increase rate became 15% until 1976 (Spaans 1987a). During 1976-1984, numbers increased with some 8% per annum. Breeding numbers peaked during 1984-85 (*ca.* 88,500 pairs; Spaans 1987ab) but have declined since. In 1990, the total population was estimated at 69,936 pairs (A.J. van Dijk, SOVON unpublished data; table 15, figure 18). Terschelling has always been an important colony in The Netherlands. In the late 1960s, some 6000-8000 pairs of Herring Gulls bred on the island. In 1982-83, the number had increased to the maximum of just over 21,000 pairs (Noordhuis & Spaans 1992). In 1985, however, this colony numbered 16,800 pairs (Spaans 1987b), and in 1990 the colony was found to have declined to 8099 pairs (A.J. van Dijk, SOVON unpublished data). The colony which became established at the Maasvlakte (Delta area) has increased spectacularly during the last few years. In 1985, this colony was estimated to number 800 pairs, whereas in 1990 some 2500 Herring Gulls nested here

(Spaans 1987b, A.J. van Dijk, SOVON unpublished data). Other important colonies in 1990 were Rottumeroog/-plaat (8658 pairs), Vlieland (10,000 pairs), Texel (8804 pairs), Schouwen, Delta area (7006 pairs), and Saeftinge (7000 pairs; A.J. van Dijk, SOVON unpublished data; figure 18).

In 1992, some 77 pairs of Herring Gulls were found breeding in Belgium (not > 50,000 as stated in Lloyd *et al.* 1991!): including 54 pairs in the Zwin nature reserve (P. Meire *pers. comm.*), and 23 pairs near Zeebrugge (De Scheemaeker 1992). The Belgian population has more than doubled since 1985 (Anselin & Devos 1992).

Lesser Black-backed Gull *Larus fuscus*

Of 64,500 pairs of Lesser Black-backed Gulls in Britain and Ireland, 6134 pairs (9.5%) were found along the coast of east England. The largest colonies along the east coast of England are found on the Farne Islands and in Suffolk (figure 19). Most English Lesser Black-backed Gull colonies remained rather stable during 1969/70-1985/87 but the colony at Orfordness (Suffolk) increased from 150 pairs in 1969-70 (Cramp *et al.* 1974) to just over 5000 pairs in 1986 (Lloyd *et al.* 1991). This colony became established on Ministry of Defence land in the mid 1960s. The size of the colony was monitored carefully, because of its proximity to a nature reserve at Havergate Island and to a Little Tern colony on Orfordness beach.

The Lesser Black-backed Gull has bred on the German North Sea coast since 1927. Since the mid-1970s, the population increased very rapidly from 125-957 breeding pairs, and also the number of non-breeding birds in summer has increased dramatically (Prüter 1983). The oldest and largest colony is found on the island of Memmert (1000 pairs in 1988), while substantial numbers are found on Spiekeroog (450 pairs), Mellum (120 pairs), and Amrum (349 pairs; De Vries 1990).

Lesser Black-backed Gulls bred first in 1926 in The Netherlands, and numbers increased steadily since, particularly since the late 1960s (Noordhuis & Spaans 1992). In 1985, the Dutch population numbered an estimated 19,000 pairs (14,100 pairs Waddensea area, 2800 mainland coast, 2100 Delta area; Spaans 1987b). In 1990, the population was estimated at just over 24,000 pairs (12,332 pairs Waddensea area, 3547 mainland coast, 9279 Delta area; A.J. van Dijk, SOVON unpublished data; table 15, figure 19). Terschelling has always been the most important colony in The Netherlands. In the late 1960s, only several hundreds of pairs of Lesser Black-backed Gulls bred on the island. In 1985, this colony numbered 13,000 pairs (Spaans 1987b), but in 1990 the colony was found to have declined to 10,200 pairs (A.J. van Dijk, SOVON unpublished data). The colony which became established at the Maasvlakte (Delta area) has increased spectacularly during the last few years. In 1985, this colony was estimated to number 400 pairs, whereas in 1990 some 6500 Lesser Black-backed Gulls nested here (Spaans 1987b, A.J. van Dijk, SOVON unpublished data).

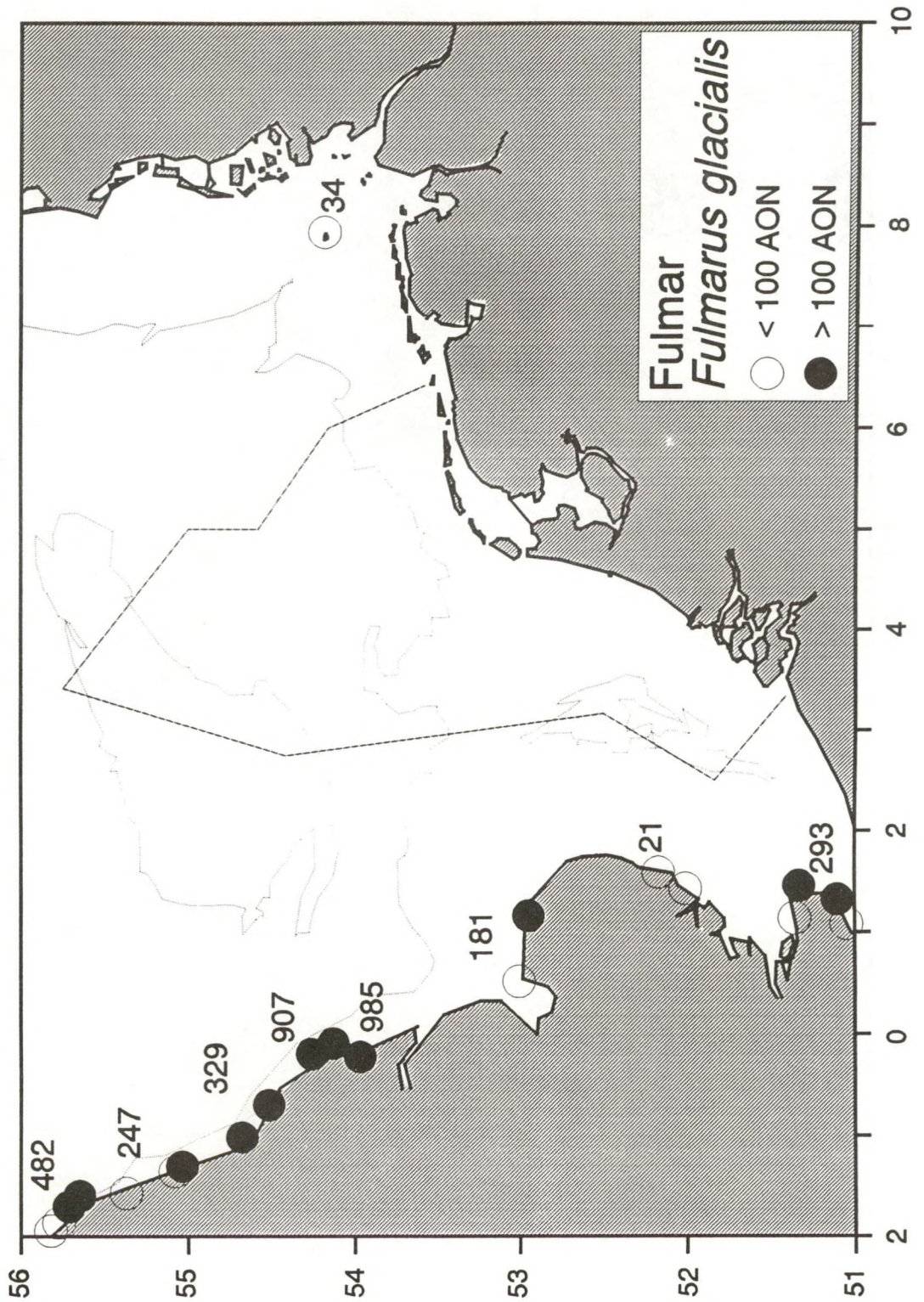


Figure 14. Breeding distribution of the Fulmar (Fulmarus glacialis) in the southern North Sea (AON = Apparently Occupied Nests).

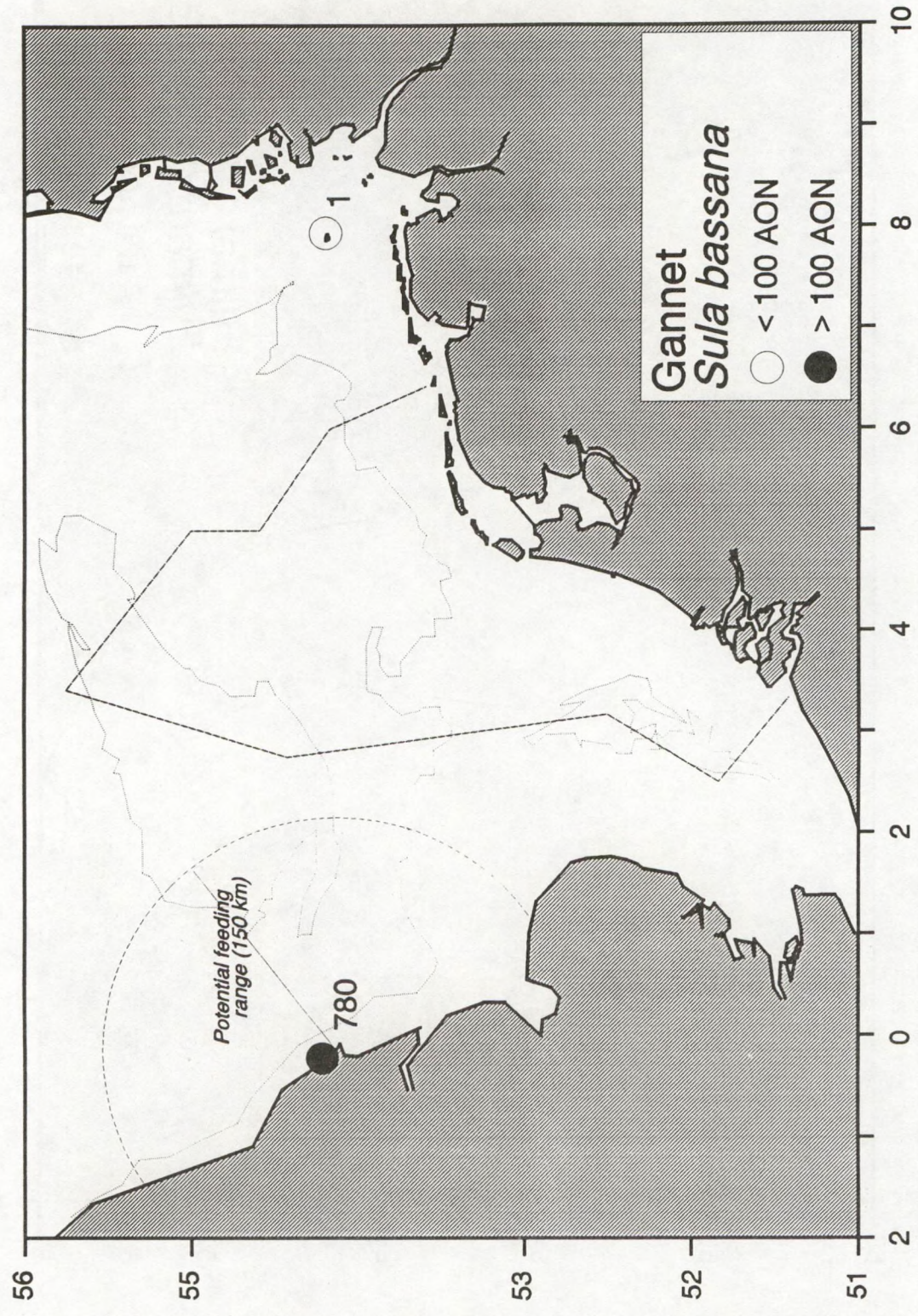


Figure 15. Breeding distribution of the Gannet (Sula bassana) in the southern North Sea (AON = Apparently Occupied Nests).

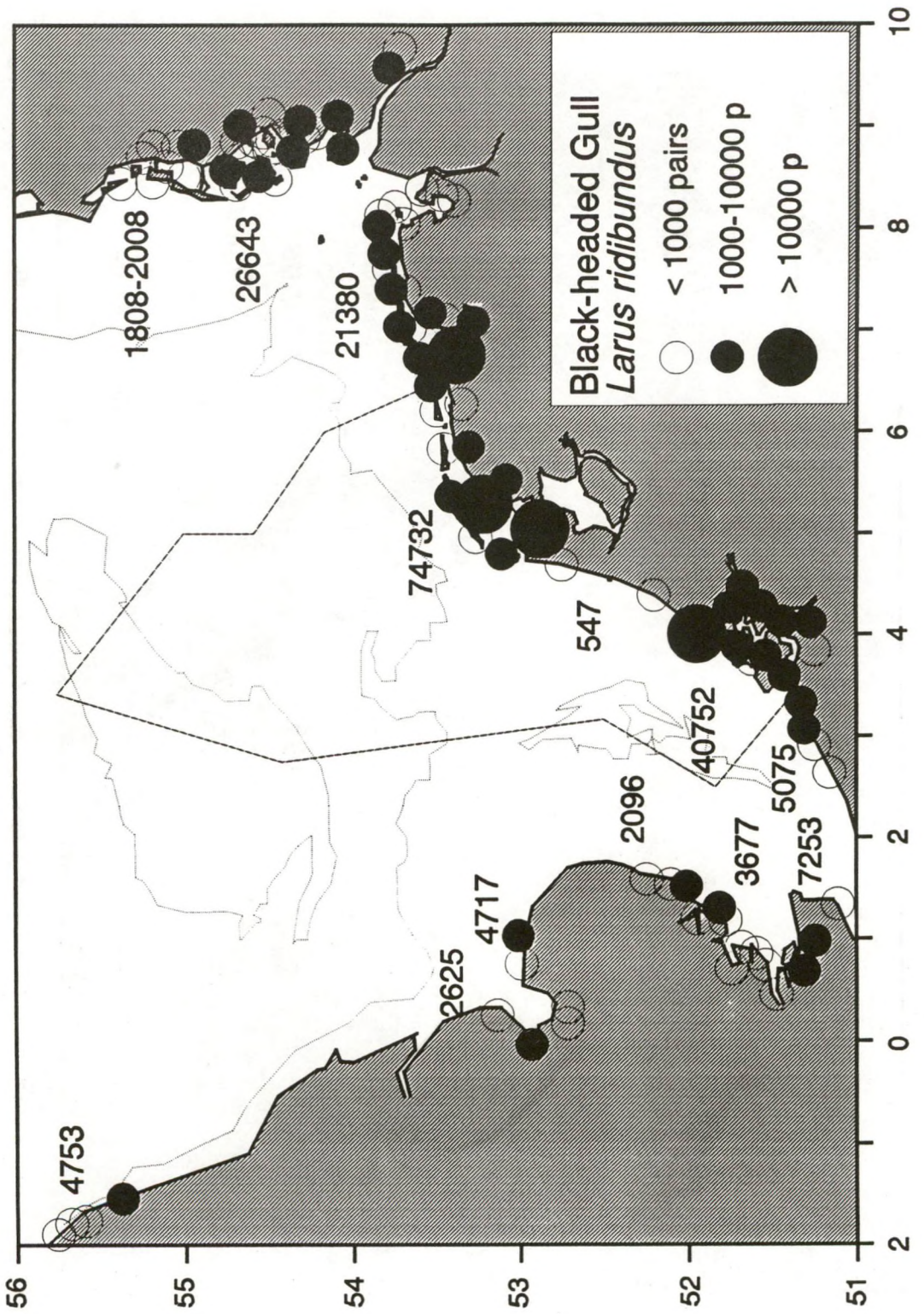


Figure 16. Breeding distribution of the Black-headed Gull (Larus ridibundus) in the southern North Sea (pairs; only coastal colonies).

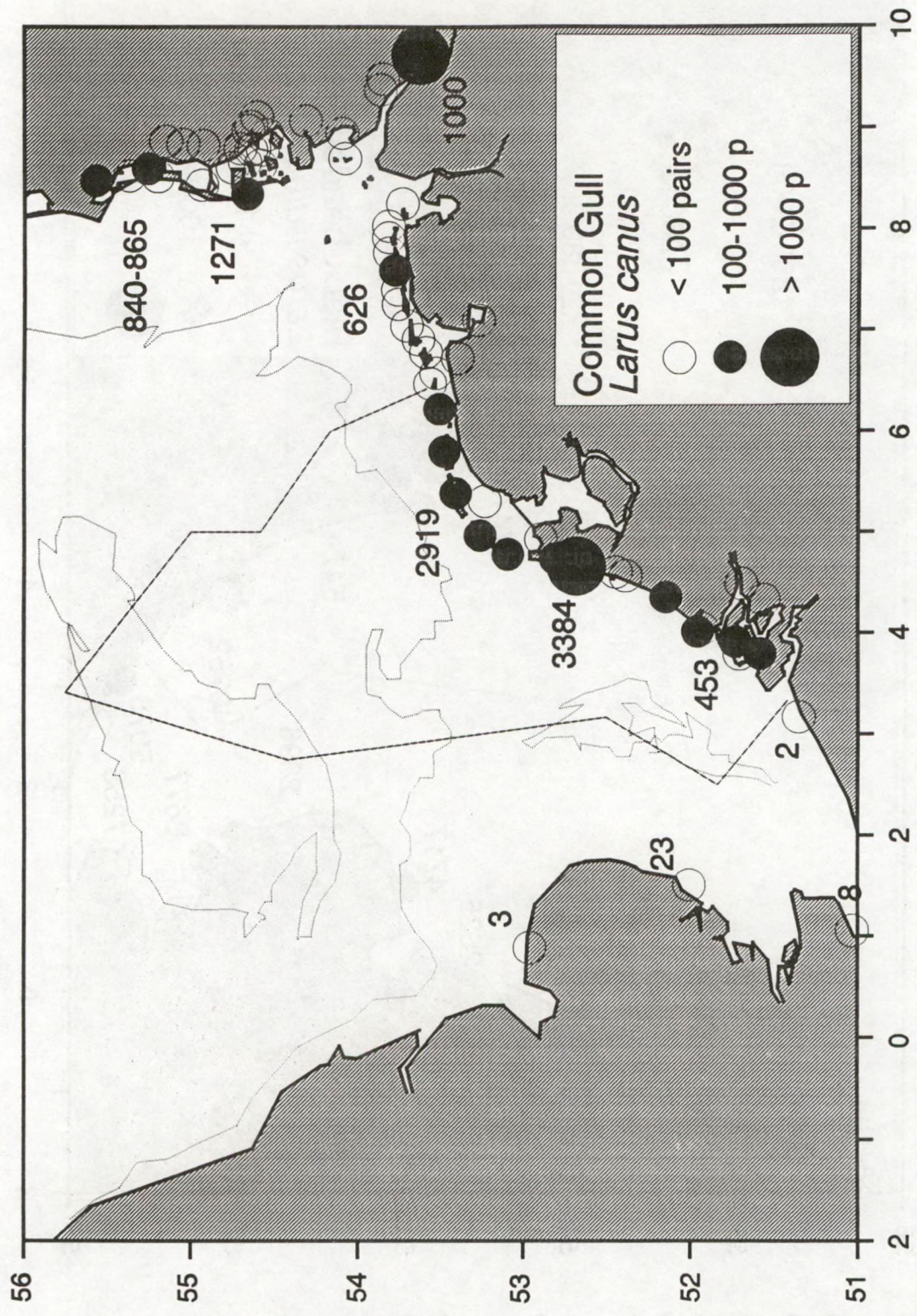


Figure 17. Breeding distribution of the Common Gull (Larus canus) in the southern North Sea (pairs; only coastal colonies).

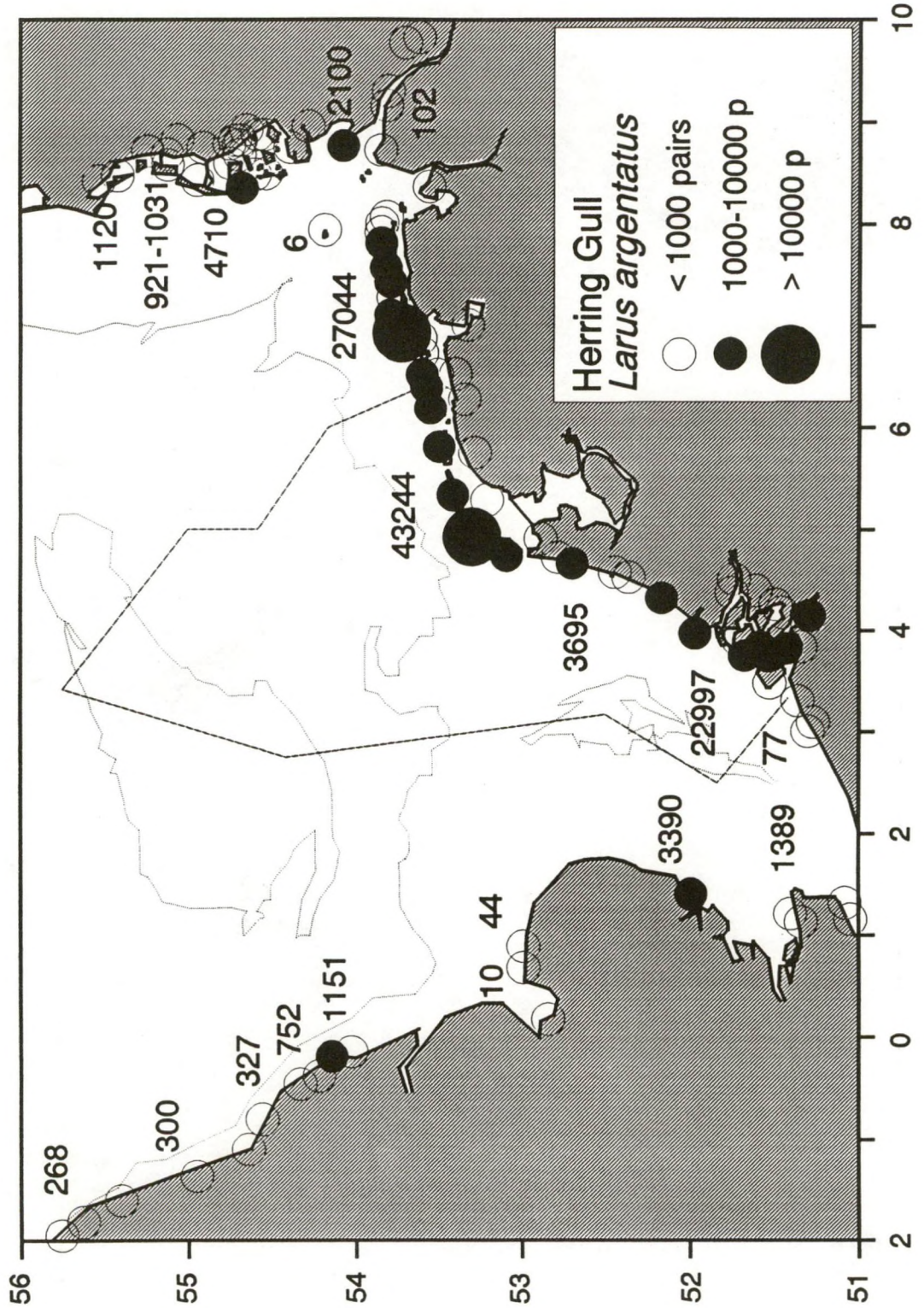


Figure 18. Breeding distribution of the Herring Gull (Larus argentatus) in the southern North Sea (pairs; only coastal colonies).

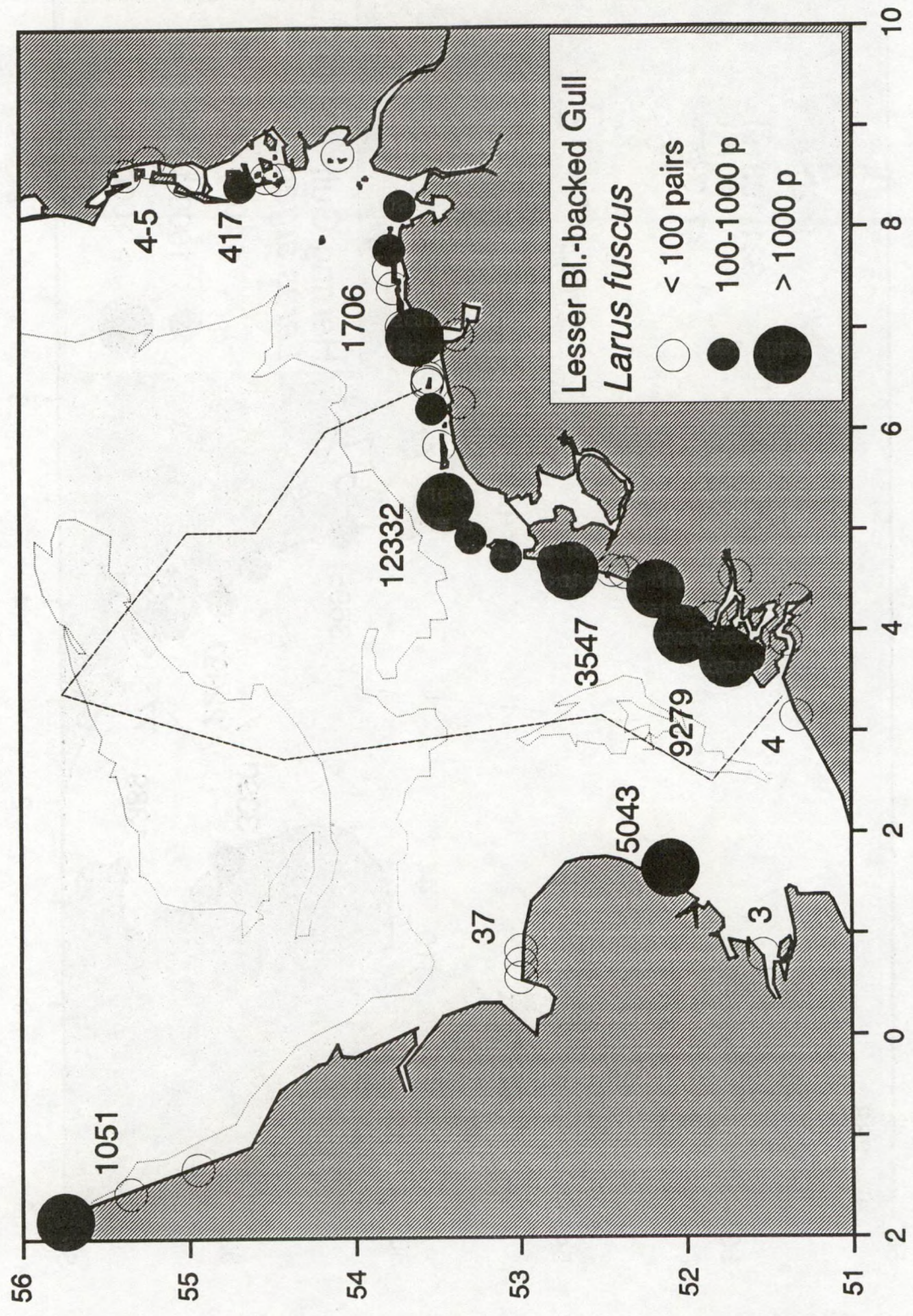


Figure 19. Breeding distribution of the Lesser Black-backed Gull (Larus fuscus) in the southern North Sea (pairs; only coastal colonies).

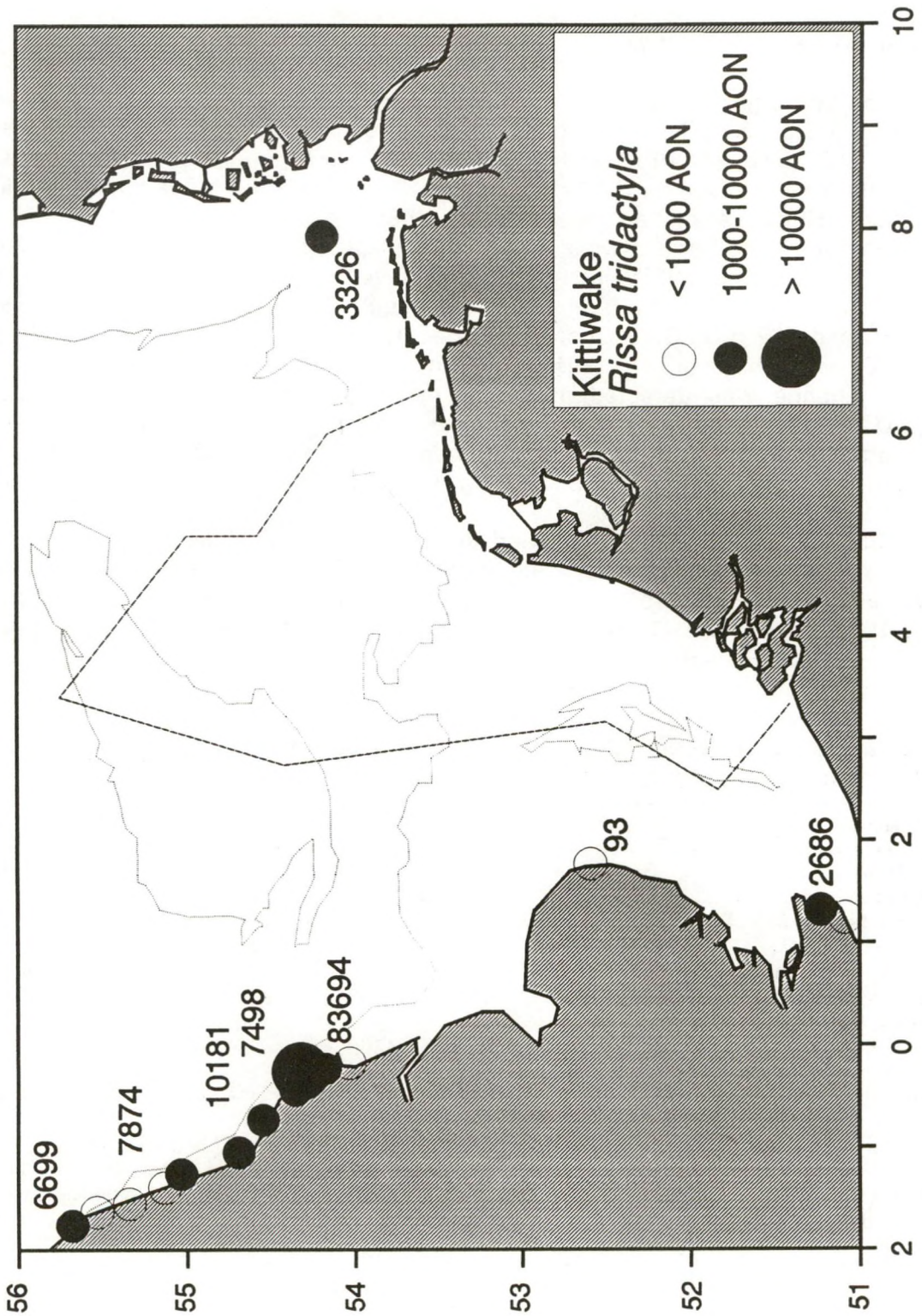


Figure 20. Breeding distribution of the Kittiwake (Rissa tridactyla) in the southern North Sea (AON = Apparently Occupied Nests).

Kittiwake *Rissa tridactyla*

By far the largest colonies of the (cliff-breeding) Kittiwake in east England are found in Cleveland, North Yorkshire, and Humberside (approx. 100,000 AON; figure 20). Between 1959 and 1969, the Kittiwake population in England and Wales had increased by 3-4% per annum. The Bempton and Flamborough cliffs colony (Humberside) had increased to 30,800 pairs (Cramp *et al.* 1974). In 1979, when another Kittiwake survey took place, an overall increase of 7% per annum in England and Wales appeared to have been due to a massive increase at the largest colony, the Bempton-Flamborough cliffs (10% per annum between 1969 and 1979; 83,000 pairs; Lloyd *et al.* 1991). However, between 1979 and 1986, while the overall increase in all other colonies was about 8% per annum, little change was detected at the huge Bempton-Flamborough cliffs colony (+0.2% per annum). When comparing the East English population in 1969-70 (Cramp *et al.* 1974) with the most recent surveys in 1985-87 (Lloyd *et al.* 1991), it appears that this population has nearly tripled (respectively 43,471 and 118,725 pairs).

Kittiwakes recolonised Helgoland in 1938, after an absence of about 150 years (Fleet 1984). The colony increased from 120 pairs in 1960, to 400 pairs in 1970, and even more rapidly since that year: 1100 pairs in 1975, 2342 pairs in 1980, 2964 in 1988 to the current population of 3326 pairs (Vauk 1982, Meyer 1989, Hansohn 1992).

Table 15. Recent estimates of numbers of breeding seabirds (pairs) on southern North Sea coasts (for sources see bottom of table).

Species	Britain[1]	Denmark[2]	Germany[3]	Netherl.[4]	Belgium[5]	Total
Fulmar	3445	0	34	0	0	3479
Gannet	780	0	1	0	0	781
Black-headed Gull	25121	1808-2008	48023	116031	5075	196258
Common Gull	34	840-865	2897	6756	2	10554
Lesser Black-backed Gull	6134	4-5	2123	24158	4	32424
Herring Gull	7631	2041-2151	33962	69936	77	113757
Great Black-backed Gull	0	+?	1	0	0	1
Kittiwake	118725	0	4800	0	0	123545

[1]Britain: Northumberland-Kent during censuses in 1985-87; after Lloyd *et al.* 1991, [2]Denmark: Hvide Sande-Rejsby during 1978-84; after Danielsen *et al.* 1986 and Dybbro 1976, [3]Germany: Nieder-Sachsen and Schleswig-Holstein in 1988 after de Vries 1990, and Helgoland in 1992 after Hüppop 1992, [4]The Netherlands in 1990 (complemented with data collected during 1988-91), after A.J. van Dijk/SOVON unpublished data, [5]Belgium 1991, after P. Meire/INB unpublished data, Anselin & Devos 1992, and De Scheemaeker 1992.

5. Discussion

The information on the use of fishery waste by seabirds is still far from complete. Few detailed, quantitative studies have been performed. Even the most basic information, the relative abundance and species composition of seabirds at trawlers, is often not available. Local studies of the behaviour and feeding efficiency of the different species at trawlers have shown that much more data are required to allow calculations on a larger scale (*e.g.* a North Sea scale). In many parts of the North Sea it is still not clear which type of fishery is more attractive to seabirds than the other. New studies have recently been set up and new data will become available in due time. This literature search and data analysis was in the first place meant to find out what is currently known about scavenging seabirds and how these data were collected. It is important that comparable results are obtained in future studies.

5.1 Scavenging seabirds at trawlers in the NE Atlantic region

From literature sources and from data collected during ship-based surveys of seabirds at sea, it is clear that quite a few species obtain at least part of their food as scavengers behind fishing vessels in commercial fisheries in the NE Atlantic region (table 16). The most important scavengers behind trawlers in the NE Atlantic region are:

Fulmar	offshore
Great Shearwater	offshore
Sooty Shearwater	offshore
Gannet	offshore
Great Skua	mainly offshore
Black-headed Gull	mainly coastal
Common Gull	coastal
Herring Gull	mainly coastal
Lesser Black-backed Gull	mainly coastal
Great Black-backed Gull	coastal and offshore
Kittiwake	mainly offshore

Locally, *e.g.* in the Irish Sea and the open ocean, scavenging Manx Shearwaters and Storm Petrels may be numerous, while another 19 species occur only occasionally and usually in rather small numbers in feeding flocks at trawlers. Shearwaters are of no significance within the southern North Sea, but these are numerous scavengers west of Britain. Black-headed, Common, Herring and Lesser Black-backed Gull are comparatively important in the southern North Sea.

In the central southern North Sea (51-56°N, 2-7°E), at 461 trawlers with scavenging seabirds at varying distances from the Dutch coast, the species composition was assessed. Frequency distributions of the common species were calculated for five distance zones from the coast (table 13). Fulmar, Gannet, and Kittiwake were typical offshore species as scavengers, while Common Gull, Herring Gull, and Lesser Black-backed Gull became increasingly more

Table 16. Seabirds recorded scavenging at trawlers in the NE Atlantic region.

Species	Atlantic[1]	Irish Sea[2]	Shetland[3]	S North Sea[4]
Fulmar *Fulmarus glacialis*	abundant	common	abundant	abundant
Great Shearwater *Puffinus gravis*	common	some	rare	rare
Sooty Shearwater *Puffinus griseus*	common	some	some	rare
Manx Shearwater *Puffinus puffinus*	some	common	some	rare
Balearic Shearwater *Puffinus mauretanicus*	-	rare	-	-
Storm Petrel *Hydrobates pelagicus*	common	some	some	-
Gannet *Sula bassana*	common	common	common	common
Cormorant *Phalacrocorax carbo*	-	some	-	-
Shag *Phalacrocorax aristotelis*	-	some	some	-
Pomarine Skua *Stercorarius pomarinus*	some	some	some	-
Arctic Skua *Stercorarius parasiticus*	some	some	some	some
Long-tailed Skua *Stercorarius longicaudus*	rare	-	-	-
Great Skua *Catharacta skua*	some	some	common	some
Little Gull *Larus minutus*	-	-	-	some
Sabine's Gull *Larus sabini*	rare	-	-	-
Mediterranean Gull *Larus melanocephalus*	-	-	-	rare
Black-headed Gull *Larus ridibundus*	rare	some	some	common
Common Gull *Larus canus*	-	-	-	common
Herring Gull *Larus argentatus*	some	abundant	common	abundant
Yellow-legged Gull *Larus cachinnans*	-	-	-	rare
Lesser Black-backed Gull *Larus fuscus*	common	common	common	abundant
Iceland Gull *Larus glaucoides*	-	rare	rare	rare
Glaucous Gull *Larus hyperboreus*	rare	rare	rare	rare
Great Black-backed Gull *Larus marinus*	common	common	abundant	abundant
Kittiwake *Rissa tridactyla*	common	abundant	abundant	abundant
Common Tern *Sterna hirundo*	-	some	-	some
Arctic Tern *Sterna paradisaea*	-	some	some	some
Roseate Tern *Sterna dougallii*	-	rare	-	-
Sandwich Tern *Sterna sandvicensis*	-	some	-	some
Guillemot *Uria aalge*	-	some	rare	some
Razorbill *Alca torda*	-	some	-	rare
Black Guillemot *Cepphus grylle*	-	-	some	-

[1] **Atlantic seaboard**: off SW Ireland, St Kilda, Rockall, off the Outer Hebrides and west of Orkney and Shetland; Lockley & Marchant 1951, Boswall 1960, Munsterman 1971, Dare 1982, Dändliker & Müllhauser 1988; [2] **Irish Sea**; Hillis 1971, 1973, Watson 1981; [3] around **Shetland & Orkney** and **northern North Sea**; Manikowski 1971, Ewins 1987, Furness 1988, Furness, Ensor & Hudson 1992, Furness & Hislop 1981, Furness, Hudson & Ensor 1988, Hudson 1988, 1990, Hudson & Furness 1988, 1989; [4] **southern North Sea**; van der Heide 1938, Camphuysen 1987, van der Schot 1989, Berghahn & Rösner 1992, Leopold & Camphuysen 1992, Garthe 1992, Camphuysen *in press*, this study.

plentiful close to land. In Black-headed Gull and Great Black-backed Gull, the distribution of records over the five distance zones was not significantly different from the null-hypothesis (*i.e.* an equal distribution over all trawlers). However, considering the numbers observed at trawlers, the Black-headed Gull is mainly an inshore scavenger.

The presence of scavenging seabirds at trawlers has been studied directly (*i.e.* observations from fishing vessels, or sightings from fishing vessels during aerial or ship-based surveys) or indirectly (abundance estimates in areas with and without fishing vessels; *e.g.* Wahl & Heinemann 1979, Tasker *et al.* 1987). Only sightings from fishing vessels can be used to demonstrate the use, and the scale of use of fishery waste by different species of seabirds. Direct observations from some distance are second best when assessing species composition

and relative abundance at trawlers. Indirect observations, or rather calculations of abundance and analysis with hindsight *cf.* Tasker *et al.* (1987), could produce misleading results. In these calculations, areas with trawlers and densities were linked. However, it is quite possible that species which occur in higher densities in areas with fishing vessels are not focussing on the vessels but rather on the same area that the vessels are working (*cf.* Wahl & Heinemann 1979). In fact, many fishermen at sea are attracted to areas with fishing seabirds, obviously because both fishermen and birds have the same target.

On the other hand, some species appear to feed on discards while they are seldom or never recorded as scavengers behind trawlers. Ewins (1987) recorded Black Guillemots as scavengers near sandeel trawlers in Shetland, while Guillemots appeared to ignore these vessels. From diet studies of Guillemots washed ashore in The Netherlands, however, it was suggested that Guillemots do feed on (sinking?) discards, despite their absence behind trawlers (Leopold & Camphuysen 1992). Only Hillis (1971) reports on scavenging Guillemots at trawlers (Irish Sea), but described it as 'a change of habit' rather than a normal feature. Furness (1992) omitted Common Gulls and Black-headed Gulls in his comprehensive analysis, mainly because there were no data available for his study. results of pilot studies in the southern North Sea lead to the conclusion that scavenging as an activitity for these two species has previously been underestimated (*cf.* Berghahn & Rösner 1992, S. Garthe *pers. comm.*, this report). The argument that these to species need no consideration because they scavenge only close to the shore (Furness *1992*) is not very strong. Much of the southern North Sea fisheries, particularly those in winter, are concentrated well inshore. The presence of Little Gulls and terns behind trawlers needs further study. Obviously, these species are seldom very numerous behind trawlers. However, the southern North Sea is a very important area for Little Gulls during spring and autumn migration and in winter and for terns in summer, so it should be worked out whether Little Gulls are actually scavenging on fishery waste or rather forage upon some natural prey in the wake of the fishing vessel (*cf.* Sabine's Gull, Wahl & Heinemann (1979)).

5.2 Breeding population and population trends

Breeding populations of all seabirds in the North Sea which are known to obtain a substantial part of their food at trawlers have increased during most of this century. However, a general increase in numbers throughout the present century was noted in most countries, while local populations were subject to massive fluctuations in response to a variety of factors (*e.g.* culling, ground predators, inter-specific competition). The overall increase may partly be attributed to relaxation of persecution, but also to increased availability of food as a result of an increase in fishing effort in the North Sea. In most countries, the population increase was most pronounced during the 1970s and early 1980s. On the other hand, several seabird populations have stabilized during the 1980s or even declined, partly in response to reduced breeding success, partly as a result of recruitment failures.

5.3 Potential number of scavengers in the southern North Sea

Within the southern North Sea, some 480,000 pairs (= 960,000 individuals) of gulls, Gannets and Fulmars are found breeding, with Black-headed Gull (196,258 pairs), Kittiwake (123,545 pairs), and Herring Gull (113,757 pairs) being most numerous (table 15). Assuming an equal number of immature birds of each of these species, this would lead to an estimate of some 2 million potentially scavenging seabirds in the area during the breeding season. Considering the presence at trawlers from sightings data of these species (chapter 3), and assuming an equal number of immature birds for each species, the number of potential scavengers during the breeding season in the southern North Sea can be estimated at *ca.* 1,000,000 individuals (Fulmar, Gannet, Herring Gull, Lesser Black-backed Gulls, and Kittiwake).

In winter, the situation is more complicated. Most Lesser Black-backed Gulls have left the area, Common and Black-headed Gulls appear as coastal scavengers, unknown numbers of Fulmars, Common Gulls, Great Black-backed Gulls and Kittiwakes move into the southern North Sea as winter visitors. From ship-based surveys in the southern North Sea during the 1980s (Tasker *et al.* 1987) it is known that during winter, rather high densities of Fulmars occur in the central and northwestern part of the study area (53°30'N-56°N), while few were seen in the Southern Bight. Gannets were widespread, but in very low numbers. Black-headed Gulls reached highest densities at sea in January and February, being a typical inshore species and occurring most abundantly in the Southern Bight. Common Gulls were widespread and abundant at sea, most notably in the Southern and German Bight (<54°N), with highest densities during November-March. Lesser Black-backed Gulls were only encountered in numbers in the northern Channel (*ca.* 51°N). Herring Gulls were abundant and widespread in the study area, but most notably near the coast, with highest densities (remarkably) to the west of 2°E. Great Black-backed Gulls and Kittiwakes were similarly widespread and occurred locally in high densities. It should be noted that these data are biased towards British waters, to which most effort was directed for the atlas. Important areas, as we now know, off The Netherlands, Germany and SW Denmark were overlooked. The many blanks in our knowledge make an estimate of wintering numbers at sea from ship-based surveys a tricky excercise and more recent data, collected by NIOZ during 1987-92, by NZG/DGW during 1987-1990 and by Danish and German researchers are not yet available.

5.4 Diet studies of scavenging seabirds in the North Sea

Several authors indicate the presence of fish in the diet of gulls during chick rearing (*e.g.* Spaans 1971, Arbouw 1980, Keijl *et al.* 1986, Noordhuis 1987) and often claim that part of this fish was discharged from trawlers. In the above cases, fish species and length distributions of these fish, as calculated from indigestable remains found in pellets and faeces, were quite similar to what is commonly discarded in commercial fisheries off the Dutch coast (*cf.* Daan 1976, Lamp & Weber 1984, van Beek 1990). It might be expected that in such

case, the presence and relative abundance of these gulls increased behind trawlers in the vicinity of the colonies when large chicks were present (especially in July). However, from sightings data of trawlers and flocks of scavenging seabirds it can be deduced that this was not always the case. In case of the Herring and Lesser Black-backed Gull, numbers and frequency peaked in July and fell dramatically in August (table 4), a pattern well in accordance with growth and fledging of the chicks. Common Gulls, however, were absent or rare as scavengers between April and September, and there is no evidence from trawler sightings data that the fish delivered to the chick was obtained while scavenging at trawlers. In case of all three species of gulls, very large mass-feedings of actively fishing gulls are frequently seen in coastal waters. Prüter (1986) described the diet of wintering gulls at Helgoland and concludes that in most species, fish obtained at trawlers constituted a considerable part of the diet. However, the species composition of the diet was used to conclude whether or not fish was taken at trawlers or by fishing. When gadoid fish predominated, it was concluded that the fish was obtained at trawlers. When Eel *Anguilla anguilla*, sandeels Ammodytidae, and Hooknose *Agonus cataphractus* became more abundant, it was concluded that the gulls had taken the fish themselves in shallow water. The conclusion may be true, but the presence of sandeel and Hooknose in the diet does not exclude the possibility of taking discards, but might as well indicate a shift from one type of fishery vessel to the other. The relative importance of discarded fish in the diet of gulls should therefore not be deduced from dietary studies alone.

5.5 Observations of seabirds at trawlers

Scavenging seabirds compete for fishery waste at trawlers. This conclusion can be drawn from the facts that (1) most of the offal and a high proportion of discarded fish are eaten by seabirds (Hudson & Furness 1988, 1989, Berghahn & Rösner 1992, Furness *et al.* 1992, Garthe 1992, Camphuysen *in press*), (2) feeding success varies among species (Lockley & Marchant 1951, Boswall 1960, Hillis 1971, Boswall 1977, Dändliker & Mülhauser 1988, Furness *et al.* 1992, Garthe 1992, Camphuysen *in press*), (3) the presence of one species at a trawler clearly reduces the feeding success of another (Strann & Vader 1992, Furness *et al.* 1992), (4) adults generally have higher feeding success rates than immatures (Boswall 1960, Furness *et al.* 1988, Garthe 1992), (5) high rates of kleptoparasitism occur (Hudson & Furness 1988). Complex dominance hierarchies are found amongst seabirds at trawlers, often with Gannet, Fulmar and Great Black-backed Gull as most powerful, or aggressive scavengers (Hudson & Furness 1988, 1989, Garthe 1992). Kittiwake, Lesser Black-backed Gull and Sooty Shearwater are examples of more timid scavengers, often feeding at the periphery of feeding flocks (Hudson & Furness 1989, Van der Schot 1989, Camphuysen *in press*).

Scavenging seabirds tend to select fish they can handle easily and swallow without much delay (Furness *et al.* 1988, Hudson & Furness 1988, 1989, Garthe 1992). Most of the discarded roundfish are swallowed by seabirds while flatfish and benthos (which both sink faster) are more often ignored. Larger

flatfish are obviously not favoured because of their body shape. Furness *et al.* (1988) assessed the mean length of roundfish swallowed by the most numerous scavenging seabirds in the Clyde at (avg ± S.D.):

28.3 ± 3.6 cm for Gannets (n = 53)
21.9 ± 4.9 cm for Lesser Black-backed Gull (n = 11)
24.7 ± 3.2 cm for Herring Gull (n = 1147)
29.0 ± 3.4 cm for Great Black-backed Gulls (n = 35),
15.8 ± 2.9 cm for Kittiwake (n = 27)

Similarly, Camphuysen (*in press*), discarding Whiting experimentally, found:

25.8 ± 4.9 cm for Gannets (n = 13)
26.0 ± 2.5 for Lesser Black-backed Gulls (n = 4)
24.2 ± 2.1 for Herring Gulls (n = 48)
25.6 ± 3.1 cm for Great Black-backed Gulls (n = 40),
17.1 ± 3.0 cm for Kittiwakes (n = 37)

Garthe (1992) listed mean lengths for Whiting (n = 417) and Herring (n = 324) in spring and summer taken by scavengers:

Fulmar 22.1 cm for Whiting (n = 70), 24.1 cm for Herring (n = 73)
Gannet 23.9 cm for Whiting (n = 61), 27.4 cm for Herring (n = 161)
Great Skua 21.4 cm for Whiting (n = 34), 26.2 cm for Herring (n = 12)
Lesser Black-backed Gull 23.8 cm for Whiting (n = 46), 22.3 cm for Herring (n = 25)
Herring Gull 23.2 cm for Whiting (n = 50), 26.9 cm for Herring (n = 8)
Great Black-backed Gull 21.8 cm for Whiting (n = 89), 27.4 cm for Herring (n = 23)
Kittiwake 18.7 cm for Whiting (n = 5), 15.5 cm for Herring (n = 2)

In all three studies, Kittiwakes selected the smaller fish, whereas the other scavengers sort of 'shared' the rest of the discards with relatively minor differences between selected prey. Offal, with its high calorific value, is a popular item in fishery waste, particularly among Fulmars and Kittiwakes (Hudson & Furness 1989, Garthe 1992, Camphuysen *in press*).

A fish which is not swallowed instantly forms a reason for other birds to attack and try and steal the fish. Kleptoparasitism is an important reason why fish get lost for seabirds lower in the dominance hierarchy (Hudson & Furness 1989, Camphuysen *in press*). More powerful birds simply join the scrumble and fight for discards and offal. More timid birds, lower in the dominance hierarchy, tend to feed at the periphery of feeding flocks, dive deeper to pick up fish which were in fact lost (shearwaters; Lockley & Marchant 1951), pick up nearer the ship and act faster and select smaller prey (Kittiwakes; Camphuysen *in press*) or otherwise try to reach food outside the centre of activity associated with the trawler (Dändliker & Mülhauser 1988, Hudson & Furness 1989, Strann & Vader 1992, Camphuysen *in prep.*).

Feeding efficiency at trawlers is very much dependent on species composition and on the manner in which discards and/or offal are released. The constant release of small quantities of offal and single fish from a moving trawler offered excellent feeding opportunities for Kittiwakes, which were feeding close to the stern of the ship, away from the general scrumble for discards in the

wake of the vessel. The release of larger quantities at once reduced the feeding possibilities from this and other rather 'timid' species, while the more aggressive species obtained most of the fishery waste in a massive fight behind the ship (Camphuysen *in press*). Furness *et al.* 1992 showed that the presence of increasing numbers of Gannets in some months reduced the feeding efficiency of Herring Gulls to such an extent that the species simply moved away from the Clyde Sea.

5.6 The relative importance of discards and offal in the diet of scavenging seabirds

For some species, regarding the number of birds seen on fishing grounds, this source of food is very important, at least during part of the year: *e.g.* Fulmar, Gannet, several of the common *Larus*-gulls, and Kittiwake. For many others, this appears to be an additional source of food of lesser importance, used only opportunistically, or when more natural sources of food become depleted (*e.g.* Guillemots in the Irish Sea, *cf.* Hillis 1971; Great Skua on Shetland, *cf.* Furness 1992). It seems likely that the offal and discards thrown overboard by fishermen are more important to seabirds than the fish that fisheries take, but any effect is masked by the slow rate of change of bird populations (Bourne 1983). Scavenging should not be overestimated in the absence of less easily gathered data on natural feeding (*cf.* Watson 1981), but the released quantities of fishery waste are huge. Rees (1963) estimated that the offal produced in October-November from the cod and redfish fishery off Belle Isle, Newfoundland, is capable of supporting 120,000 scavenging seabirds. Furness *et al.* (1988) calculated that in theory, if all the offal and discards were taken, some 2.8 million '1000 gram' seabirds might be supported by this food supply around the British Isles. Hüppop (1992) suggested that the daily discharge of discards in the German Sole fishery (a fraction of the total fishery for Sole in the southern North Sea) in the German Bight was sufficient to feed 100,000 seabirds of Herring Gull size.

Obviously, despite the enormous quantities of fishery waste discharged in commercial fisheries, this source of food is not unlimited. The change of diet and connected breeding failures and population decline of Herring Gulls at Terschelling, which were formerly mainly dependent on discards during chick rearing, indicates that this source of food is currently less plentiful available despite an overall increase in fishing effort (Noordhuis & Spaans 1992). There are indications that recent measures to remove fisheries from the coastal zone (12 miles zone for larger trawlers) and shipping regulations off the Wadden Sea islands were responsible for a reduction in the availability of discards near the colonies of these gulls (Camphuysen *in prep.*). Similarly, Paterson *et al.* (1992) described the effect on Audouin's Gulls of a voluntary moratorium on inshore fishing in the waters of Tarragona and Castellón (Spanish Mediterranean).

5.7 Suggestions for future research

Information on the quantity and composition of discards and offal in different fisheries is not readily available and needs to be collected on board commercial trawlers. In the Netherlands, the beamtrawl fishery is the major fishery in terms of tonnes of fish landed. Therefore, the quantity of offal and discards which is put overboard in this fishery in the southern North Sea, the proportion of discarded biota which is consumed by seabirds, and the (possible) effects on seabird populations should be studied. Basic questions are:

(1) how much biota are discarded by the Dutch beamtrawl fishery (species composition, quantity, spatial and temporal distribution),
(2) which are the birds scavenging in the southern North sea (species composition, relative abundance, diet, spatial and temporal distribution),
(3) what proportion of the discarded biota are consumed by seabirds, and
(4) what is the effect of discards/offal provision to populations and breeding success of scavenging seabirds in the southern North Sea.
(5) is the beamtrawl fishery the most important fishery in terms of food provisioning to scavenging seabirds

Counts of seabirds associated with commercial trawlers are needed and these can be obtained during dedicated aerial surveys (while circling around the vessel), opportunistically during ship-based surveys while counting seabirds at sea, and during seawatching from coastal sites.

The turnover rate of scavengers at a trawler deserves much more study. Individually identifiable birds (peculiar stage of moult or slightly damaged feathers, colour phase, plumage) should be observed in more detail (recording arrival and departure from the associated flock in relation to discard provision), or individuals should be dye-marked and recorded conform Erikstad *et al.* (1988).

The status of Fulmars scavenging at trawlers in summer in the southern North Sea is not clear. A study of the state of primary moult during April-August is important to assess whether these birds are immatures (or rather non-breeding birds) or succesful breeders.

Herring Gulls and Lesser Black-backed Gulls, assumed to compete at trawlers during the breeding season in the coastal zone, should be studied in particular detail. The suggestion that Lesser Black-backed Gulls, being more efficient feeders at trawlers, have forced away Herring Gulls from this attractive source of food (*cf.* Spaans & Noordhuis 1989, Noordhuis & Spaans 1992) is not supported by the sightings data as provided in this report. Both species are common scavengers at trawlers and the on average greater distance to the nearest coast of Lesser Black-backed Gulls could indicate that these avoid competition with Herring Gulls. Field observations at sea from commercial trawlers off the Wadden Sea islands, most notably in June and July, are required. It would be very useful if a number of gulls from colonies at Texel, Vlieland, or Terschelling could be dye-marked to assess the origin of scavengers at trawlers at sea.

Diet studies in gull colonies at the Waddensea islands could be coupled with the discharge of large quantities of tagged fish at sea at various distances off these coast, in areas where these birds are presumed to feed at trawlers.

The effect of the establishment of a 'protected area' off Texel and Vlieland, from which all fishing activities are removed, should be investigated. Base-line data should becollected, now that such an area is only planned. The effects of other meauseres which resulted into a decline of fishing effort on breeding performance of gulls and other scavenging seabirds should be studied in detail.

The scavenging habits of Common Gulls and Black-headed Gulls (in winter) have not sufficiently been studied. In fact, these species are often ignored. Coastal observations from trawlers will have to provide information on numbers taking profit of coastal fisheries in The Netherlands, while observations on board coastal fishing vessels are required to assess their status in the dominance hierarchy at trawlers.

When Little Gulls or terns are present in the flock of birds at a trawler, it should be tried to observe whether these birds are actually feeding on fishery waste. The chance for these scarce species to pick up offal or fish during experimental discarding is rather small, so some extra time may be spent on these birds.

5.8 Conclusions

(1) The most important scavengers in the Northeast Atlantic region, of a total of 32 recorded species, are Fulmar, Great Shearwater, Sooty Shearwater, Gannet, Great Skua, Black-headed Gull, Common Gull, Herring Gull, Lesser Black-backed Gull, Great Black-backed Gull, Kittiwake.

(2) The most important scavengers in the southern North Sea (51°-56°N), of a total of 16 recorded species, are Fulmar, Gannet, Black-headed Gull, Common Gull, Herring Gull, Lesser Black-backed Gull, Great Black-backed Gull, Kittiwake. Of these, seven species breed in substantial numbers in the area, while one (Great Black-backed Gull) is mainly winter visitor.

(3) Breeding populations of all seabirds in the North Sea which are known to obtain a substantial part of their food at trawlers have increased during most of this century. The increase was most pronounced in the 1970s and early 1980s.

(4) The total number of potentially scavenging seabirds in the southern North Sea during the breeding season is estimated at 1,000,000 individuals. Recent estimates of numbers of breeding pairs were *ca.* 3500 Fulmar, 800 Gannet, 195,000 Black-headed Gull, 10,500 Common Gull, 32,500 Lesser Black-backed Gull, and 125,000 Kittiwake.

(5) Reliable estimates of numbers of wintering seabirds in the southern North Sea are currently unavailable.

(6) The relative importance of discarded fish in the diet of gulls should not be deduced from dietary studies alone.

(7) Only sightings from fishing vessels can be used to demonstrate the use, and the scale of use of fishery waste by different species of seabirds. Direct observations from some distance are second best when assessing species composition and relative abundance at trawlers.

(8) Scavenging seabirds compete for fishery waste at trawlers and tend to select fish they can handle easily and swallow without much delay. Feeding efficiency, or feeding success of scavengers behind trawlers is mainly dependent on species composition and relative abundance in the scramble for discards and offal, the movements of the trawler during hauling, sorting and gutting, and the amount of discards and offal discharged at once.

(9) Kittiwakes selected the smaller fish, whereas the other scavengers 'shared' the rest of the discards with minor differences between selected prey. Offal, with its high calorific value, is a popular item in fishery waste, particularly among Fulmars and Kittiwakes. Information on the scavenging habits of Common Gulls and Black-headed Gulls, which probably also select smaller fish, is lacking.

(10) Relatively powerful or aggressive seabirds join the scrumble and fight for discards and offal. More timid birds, lower in the dominance hierarchy, tend to feed at the periphery of feeding flocks, some dive deeper to pick up fishery waste which was in fact lost (*e.g.* shearwaters, Kittiwake), pick up nearer the ship and act faster and select smaller prey (Kittiwake), or otherwise try to reach food outside the centre of activity associated with the trawler (*e.g.* Sooty Shearwater, Lesser Black-backed Gull).

(11) Massive quantities of fishery waste are discharged in commercial fisheries. From recent estimates it can be deduced that at least several millions of seabirds might be supported by this food source.

(12) There are several indications that local changes in fishing effort, and, hence, discard provision, can cause declines in reproductive output of nearby gull colonies.

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