Scavenging seabirds at beamtrawlers in the southern North Sea

distribution, relative abundance, behaviour, prey selection, feeding efficiency, kleptoparasitism

and the possible effects of the establishment of 'protected areas'

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Summary

(1) At least 28 species of seabirds have been observed as scavengers associated with commercial trawlers in the southern North Sea.

(2) The most important consumers of discards and offal in the southern North Sea are Fulmar, Gannet, Black-headed Gull, Common Gull, Herring Gull, Lesser Black-backed Gull, Great Black-backed Gull and Kittiwake.

(3) In the breeding season, internationally important numbers of Herring Gulls (2.8% of the NE Atlantic population) and Lesser Black-backed Gulls (12.9%) were found in the Dutch sector of the North Sea. Of these, 23.9% and 41.9% respectively were found within the sector proposed for protection bordering the Wadden Sea islands.

(4) In Dutch beamtrawl fisheries, the most important fishery in the area, large amounts of discards, benthic invertebrates and offal are discharged. An estimated 5-10 kg of flatfish (45-50%), roundfish (1-5%) and benthic invertebrates (45-50%) were discarded per kg landed, marketable fish. All the offal and virtually all fish were suitable for consumption by seabirds.

(5) The proportion (%) of discards, offal and benthic invertebrates consumed by seabirds amounted to 87% in roundfish, 82% in offal, 28% in flatfish and less than 1% in benthic invertebrates.

(6) Of seabirds breeding in the Netherlands, only Herring Gull and Lesser Black-backed Gull profited from discards and offal to a large extent. The first was only found at inshore trawlers, the latter had a larger feeding range at sea.

(7) The establishment of 'protected areas', closed for fisheries, off the Dutch Wadden Sea islands (as proposed in Bergman *et al.* 1991) will probably only negatively affect the foraging possibilities of Lesser Black-backed Gulls, particularly the breeding population on Texel, Vlieland and Terschelling (*ca.* 50% of the Dutch population).

(8) Reductions in the amount of discards and offal produced in commercial fisheries will affect the feeding possibilities of seabirds in different ways, depending on the way in which reductions are achieved. Increased mesh size, less fishing days or fleet reduction, reductions of fisheries in the coastal zone or a total ban of fishing in certain areas will have effects that can roughly be predicted from data derived from this study.

(9) Future research will have to focus on the relative importance of pelagic fish for breeding birds feeding in the coastal zone, particularly on the relationship between breeding success and the provision of chicks with discards and/or pelagic fish.

Samenvatting

(1) In de zuidelijke Noordzee komen tenminste 28 zeevogelsoorten voor die een deel van hun voedsel achter vissersschepen bemachtigen.

(2) De talrijkste consumenten van bijvangst en snijafval in dit gebied zijn Noordse Stormvogel, Jan van Gent, Kokmeeuw, Stormmeeuw, Zilvermeeuw, Kleine Mantelmeeuw, Grote Mantelmeeuw en Drieteenmeeuw.

(3) In de broedtijd komen op het Nederlands deel van de Noordzee internationaal belangrijke hoeveelheden Zilvermeeuwen (2.8% van de Noordoostatlantische populatie) en Kleine Mantelmeeuwen (12.9%) voor. Hiervan werden respectievelijk 23.9% en 41.4% aangetroffen binnen de voorgestelde 'beschermde gebieden' grenzend aan de Waddeneilanden.

(4) In de boomkorvisserij, de meest voorkomende visserij in de zuidelijke Noordzee, worden grote hoeveelheden ondermaatse vis, benthische ongewervelden en snijafval overboord gezet. Naar schatting 5-10 kg platvis (variërend 45-50%), rondvis (1-5%) en bentische ongewervelden (45-50%) worden per kg aangelande vis overboord gezet. Alle snijafval en vrijwel alle vis is geschikt voor consumptie door zeevogels.

(5) Het aandeel (%) door zeevogels geconsumeerde ondermaatse vis, snijafval en bentische ongewervelden bedroeg gemiddeld: 87% van de rondvis, 82% van het snijafval, 28% van de platvis en minder dan 1% van de ongewervelden.

(6) Van de in Nederland broedende zeevogels profiteren alleen de Zilvermeeuw en Kleine Mantelmeeuw op grote schaal van *discards* en snijafval. De eerstgenoemde soort bezoekt alleen vissersvaartuigen in de kustzone, de tweede soort heeft een groot verspreidingsgebied op zee.

(7) Het instellen van voor de visserij afgesloten gebieden (zoals voorgesteld in Bergman *et al.* 1991), heeft vermoedelijk alleen negatieve gevolgen voor de fourageermogelijkheden van de Kleine Mantelmeeuw, speciaal de broedvogels van Texel, Vlieland en Terschelling (bijna 50% van de Nederlandse populatie).

(8) Een vermindering van de hoeveelheden overboord gezette bijvangst en snijafval kan allerlei effecten hebben op zeevogels, afhankelijk van de manier waarop die verandering wordt bereikt. Het vergroten van mazen, het verminderen van visserij-intensiteit of vlootomvang, het verminderen van visserij in de kustzone of het totaal verbieden van visserij in bepaalde gebieden leidt tot allerlei verschillende aanpassingen van zeevogels, die grotendeels kunnen worden voorspeld met de in dit rapport gepresenteerde gegevens.

(9) Toekomstig onderzoek zal zich vooral moeten richten op het belang van pelagische schoolvis voor broedvogels van de kustzone, met name de relatie tussen broedsucces en de aanvoer van discards en/of pelagische vis.

1. Introduction

The southern North Sea is of international importance for its seabirds. Numbers of breeding scavenging seabirds in the North Sea have increased by at least ten-fold from 1900 to the early 1990s (Lloyd *et al.* 1991). In coastal colonies in the southern North Sea, some 480,000 pairs of gulls, Gannets *Sula bassana* and Fulmars *Fulmarus glacialis* were breeding in 1990 (Camphuysen 1993a). Assuming an equal number of immatures and non-breeding adults of each of these species, this would lead to an estimate of some 2 million seabirds of these in the area. Discards (unmarketable fish or bycatch) and offal (*i.e.* entrails of gutted fish) are an important source of food many seabirds. Recent proposals to the designation of protected areas in the Dutch sector of the North Sea, which will be closed for all types of fisheries throughout the year (Bergman *et al.* 1991) are currently under study. Fishery waste as a food supply is likely to change as a consequence of the establishment of protected areas in the southern North Sea, and this may cause changes in the size of populations and/or breeding success of seabirds.

This project aimed to assess the influence of current fisheries on seabirds in the southern North Sea. Species of scavenging seabirds were identified, the distribution of scavengers and trawlers in the southern North Sea were evaluated, the composition of discards in commercial fisheries, consumption rates of discards, feeding strategies, prey selection at trawlers and intra- and interspecific behaviour of scavengers were studied and described. The use of such data is twofold: (1) as a prediction of effects on scavenging seabirds of the establishment of protected areas in the Dutch sector of the North Sea, and (2) as baseline data to be able to evaluate such effects in future when such protected areas have been established. The information collected can also be used to predict the effects of other measures to reduce fisheries or to reduce the provision of discards. In this report, attention is focussed on Lesser Black-backed Gulls and Herring Gull; two species breeding in large numbers in the Netherlands and important scavengers at trawlers. Most of the information presented in this final report was either published in papers or reports during the project, or is currently under preparation for publication (Camphuysen 1992ab, Camphuysen 1993abcd, Camphuysen & Offringa 1993, Camphuysen 1994, Camphuysen C.J. *in prep.*; see separate list of references)

2. Background

The affinity between several species of seabirds and trawlers and the use of discards by seabirds has been described for several parts of the NE Atlantic (*e.g.* Manikowski 1971, Tasker *et al.* 1987, Dändliker & Mülhauser 1988, Hudson & Furness 1988, 1989, Berghahn & Rösner 1992, Garthe 1992, Camphuysen 1993a, Camphuysen *et al.* 1993). At least 32 species of seabirds have been observed as scavengers at trawlers in this region, 28 of which were also observed at trawlers in the southern North Sea (Camphuysen 1993a, this report). Within the southern North Sea, however, only nine species are commonly observed as ship-followers at trawlers: Fulmar, Gannet, Great Skua *Catharacta skua*, Black-headed Gull *Larus ridibundus*, Common Gull *L. canus*, Lesser Black-backed Gull, Herring Gull, Great Black-backed Gull *L. marinus* and Kittiwake *Rissa tridactyla*. Most species breed in the southern North Sea, although Great Black-backed Gulls only very recently and in very small numbers (Dierschke *et al.* 1988, Vercruijsse & Spaans 1994). Recent breeding population estimates were (after Camphuysen 1993a):

Fulmar 3500 p (mainly E England),
Gannet 800 p (Bempton Cliffs, E England),
Black-headed Gull 200,000 p (widespread),
Common Gull 10,500 p (mainly Germany and The Netherlands),
Lesser Black-backed Gull 32,000 p (mainly The Netherlands),
Herring Gull 115,000 p (widespread),
Great Black-backed Gull 1-2 p,
Kittiwake 125,000 p (E England and Helgoland).

From diet studies of breeding seabirds in the southern North Sea it was concluded that Common Gulls, Herring Gulls, Lesser Black-backed Gulls and Kittiwakes obtain at least part of the food brought in for the chicks at trawlers (*e.g.* Pearson 1968, Spaans 1971, Noordhuis 1987, Prüter 1986). From diet studies and offshore observations in winter it was obvious that all species obtained a significant part of their food at sea at trawlers

(Vauk & Jokele 1975, Prüter 1986, Camphuysen 1993a).

Furness (1992) evaluated the effects of increased net-mesh size, reduced fishing effort and reduced discarding regimes in commercial fisheries for scavenging seabirds. It was concluded that on a North Sea scale these measures could make that 0.5 million scavenging seabirds might lose their food supply (of about 2 million birds that could presently be supported), and that these measures would particularly affect the food supply of species relying on smaller sizes of discards. Few studies have evaluated the effects on scavenging seabirds of a fishing moratorium. Paterson *et al.* (1992), however, described the effect on breeding Audouin's Gulls *Larus audouinii* of a voluntary moratorium on inshore fishing in the waters of Tarragona and Castellón (Spanish Mediterranean). The moratorium led to very low breeding success or even total breeding failure in coastal colonies of Audouin's Gulls in the area.

For Herring Gulls and Lesser Black-backed Gulls breeding around the southern North Sea, much of the fish brought to the chicks must be obtained at beamtrawlers, which carry out the most prominent fishery in the area. An analysis of the remains of marine fish in pellets of adults and regurgitated food of chicks of gulls on Terschelling in the late 1960s and mid-1980s (Spaans (1971), Noordhuis (1987) Noordhuis & Spaans 1992) showed that Herring Gulls consumed relatively fewer marine fish in recent years than in the 1960s. It was suggested that Herring Gulls had changed their resource exploitation pattern as a consequence of increased interspecific competition with Lesser Black-backed Gulls. It was assumed that the first were forced by the latter to feed on less favourite food (Noordhuis & Spaans 1992).

Two areas within the Dutch sector are proposed for a protected status (Bergman *et al.* 1991). In a first alternative, the area northwest of the Frisian islands includes coastal waters of Texel, Vlieland and Terschelling (figure 1). In a second alternative this area also includes coastal waters of Ameland. Both alternatives may have consequences for the colonies of Herring Gulls and Lesser Black-backed Gulls of the Wadden Sea islands.

3. Study area and methods

The area under study for this project, the southern North Sea, is defined as all North Sea waters between 51°N and 57°N. Much effort was directed towards the areas proposed as 'protected areas' off the Dutch Wadden Sea islands (figure 1; Bergman *et al.* 1991).

Most fieldwork at sea was carried out onboard research vessels *Tridens* (Directorate of Fisheries, Ministry of Agriculture, Nature and Fisheries) and *Pelagia* (Netherlands Institute for Sea Research), and onboard the 2000 Hp commercial beamtrawler *HD 7*. The work onboard research vessels offered excellent opportunities to achieve thorough coverage of large parts of the southern North Sea in a relatively short period of time. Field work onboard commercial trawlers was essential to fully appreciate the attractions and opportunities for scavenging seabirds in beamtrawl fisheries. Additional field-work was performed from the coast (counting birds associated with inshore trawlers). Aerial surveys for trawlers and birds by Orion on the Royal Navy fisheries patrol flight proved unsuccesful and were cancelled after a first trial.

Seabirds associated with commercial trawlers and fishing research vessels were recorded by means of *'stern counts'*. Stern counts were designed to assess the numbers of seabirds associated with the ship at a given moment and were performed from the position onboard which offered the best view (either top deck, bridge-wing or stern). Species, age, plumage and numbers associated with the ship were recorded. At first, the aim was to 'monitor' the seabirds associated with the ship during the various fishing activities (*i.e.* steaming with and without discarding, shooting net, towing net with and without discarding, hauling net, lifting net, cleaning net, stationary ship and discarding). Hence, seabirds at the stern were initially counted whenever activity changed and at regular intervals during steaming. Later, only 'maximum counts' at each haul were obtained. When the project was designed, it was hoped that associated seabird counts and discard sessions would continue both day and night. However, despite powerful lights on the vessels, night time observations proved impossible. Obviously, scavengers attended our vessels at night, but counts were never accurate enough.

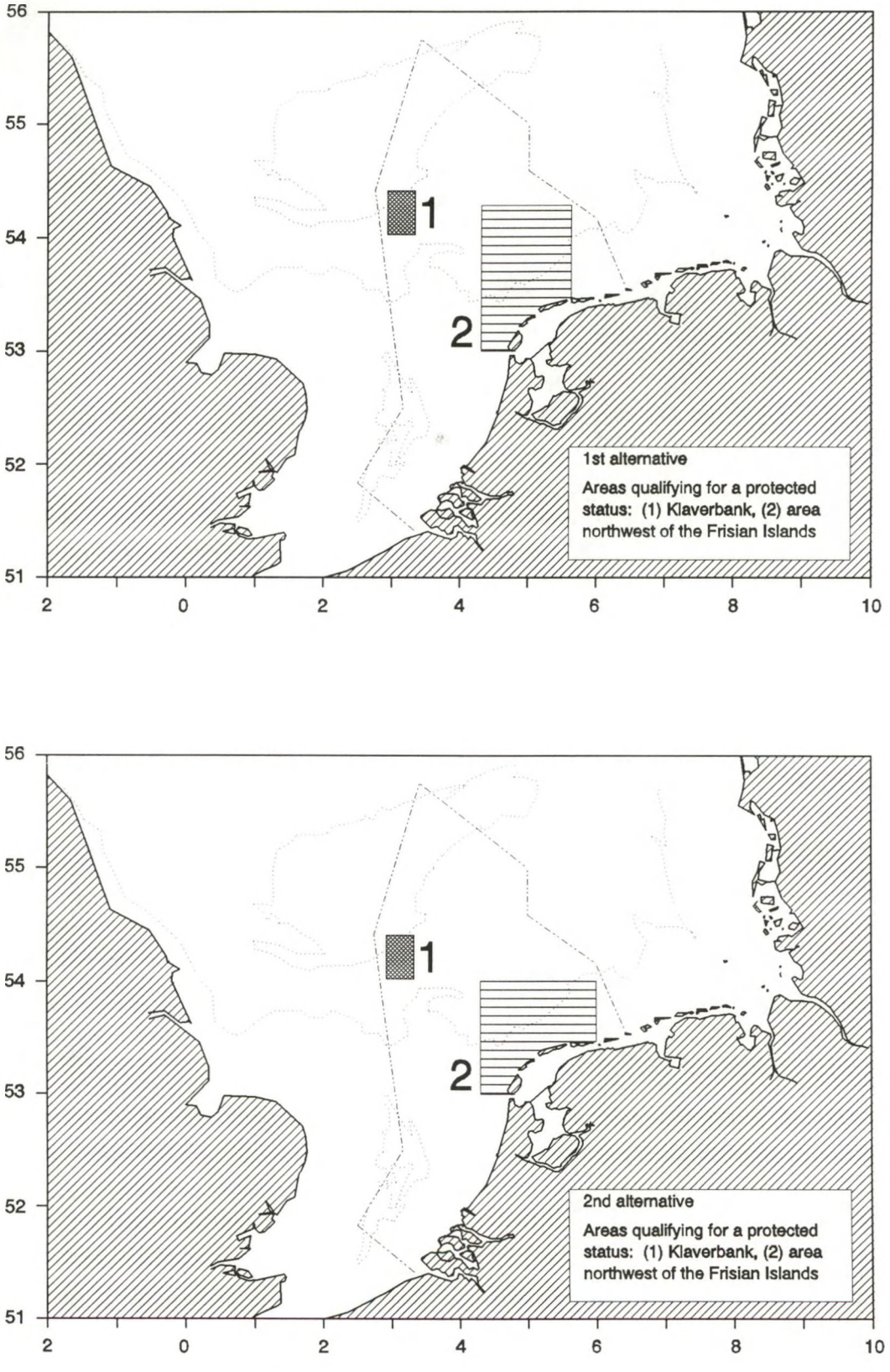

Figure 1. Areas within the Dutch sector qualifying for a protected status, 1st and 2nd alternatives (cf. Bergman et al. 1991).

Stern counts were derived from three more sources. During ship-based surveys, organised by NIOZ, the Dutch Seabird Group (NZG) and the Institute for Forestry and Nature research (IBN-DLO) from 1987 to 1994, records were made of nearby commercial trawlers. Initially, trawlers were only recorded if a flock of birds was feeding around it, without notes being made on the type of boat or its activity. In later years, type of vessel, name, code, activity, distance, and numbers and species of associated seabirds were recorded. In a later phase, counts of flocks of birds at trawlers were derived from the European Seabird At Sea database (ESAS database), in which ship-based surveys from a number of North Sea countries were combined over from 1980 to 1993. Finally, seawatchers working at coastal sites in The Netherlands were asked in 1992 and 1993 to keep an eye on inshore trawlers and count associated birds whenever possible. All four sets of data (NIOZ/NZG/IBN-DLO stern counts during ship-based surveys, ESAS data, trawler observations from coastal sites, and stern counts onboard fishing research vessels and commercial trawlers), were used to assess distribution patterns of scavengers at boats in the southern North Sea (533 stern counts during the breeding season, 1399 stern counts in winter). Trawler distribution was analysed by using only stern counts of nearby trawlers during ship-based surveys in the southern North Sea (ESAS database and NIOZ/NZG/ RWS/IBN-DLO data). This set of data, as an image of trawler distribution in the southern North Sea, is heavily biased towards trawlers with associated birds. Obviously, most of these boats were attracting scavengers because of fishing activities onboard. However, towing trawlers which did not produce discards at the time, and therefore had no scavengers around the boat, were not recorded. Moreover, inshore waters were relatively poorly covered because ship-based surveys were usually conducted at rather large vessels, working at least several kilometres from the coast. Distribution patterns of trawlers were compared with patterns described in literature.

The distribution and abundance (densities) of scavenging seabirds in the southern North Sea was derived from ship-based surveys compiled by Camphuysen & Leopold (1994). Ship-based surveys between 1985 and 1993 have produced distribution patterns and abundance estimates for an area in the southern North Sea bordered by 51°N and 56°N, 2°E and 7°E (indicated as 'the southern North Sea' in the text), and for the Dutch sector of the North Sea. Abundance estimates were prepared of numbers of scavenging seabirds at sea within sectors proposed for protection and these were compared with abundance estimates for the Dutch sector. Comparisons of total numbers of birds were made with the NE Atlantic population (*cf.* Rose & Scott 1994, Camphuysen & Leopold 1994). Descriptions of the relative distribution of Lesser Black-backed Gulls and Herring Gulls in distance zones around the breeding colonies on Terschelling were taken from Camphuysen (*in prep.*).

Onboard fisheries research vessels and the commercial trawler, samples of discards were taken from each haul. Wherever possible, *'discard experiments'* were held during routine discarding from the vessel, so that scavenging seabirds were already feeding on a stream of discards. The items were identified, length measured to the nearest cm, and discarded into the sea. Attempts by seabirds to pick up and swallow the item were recorded into a tape recorder, noting the species and age class of the bird taking the item, whether the item was eaten, dropped or stolen. If it was stolen, the same notes were made for the second and subsequent birds, until the item was finally lost (sunk) or swallowed. Experimental discarding onboard research vessels was carried out while vessels were stationary, trawling, or steaming between sampling sites, as it was impossible to standardize vessel activity for all discarding experiments. During discarding experiments the maximum numbers and age classes of scavenging seabirds of each species were recorded so that fish consumption could be related to scavenging flock composition ('maximum stern count'). Onboard research vessels, the items discarded were not necessarily a random selection of the catch since they were obtained after fishery biologists and others had selected samples. Experimental discards included benthos and fish offal as well as whole roundfish and flatfish. Success indices (S.I.) were calculated (number of fish swallowed by a species, divided by the expected number of fish swallowed on the basis of its relative abundance at the trawl), and a vulnerability to robbery index (number of experi-

mental discards stolen from a species or age group divided by the number of experimental discards stolen by this species).

The composition of the catch onboard the trawlers was assessed in terms of portion landed/portion discharged and discard rates were compared with similar data in literature. Consumption rates (proportion of fish swallowed by seabirds) and the discarded amounts in the southern North Sea (from landings data and information on quantities of discards) were used to estimate the relative importance of discards for seabirds. Finally, for each of the common scavengers in the southern North Sea, the available information on prey selection, feeding success, feeding strategy, and vulnerability to robbery at trawlers, its relative abundance at sea and diet during the breeding season and in winter is summarized.

4. Distribution and relative abundance of scavenging seabirds at sea

SEABIRDS IN THE SOUTHERN NORTH SEA (51-56°N, 2-7°E) In the southern North Sea internationally important numbers of Great Skuas, Lesser Black-backed Gulls, Herring Gulls, and Great Black-backed Gulls were found (>10% of the NE Atlantic population present in this area). Besides, important numbers of Fulmars, Gannets, Common Gulls and Kittiwakes were located (1-5% of the NE Atlantic population). The distribution of scavenging seabirds in the southern North Sea can be summarized as follows.

The southern North Sea is an area with a large number of **Fulmars**, of which highest densities occur in relatively clear Central North Sea water, north of 53°N and west of 6°E. Peak numbers are in the range of 230,000 individuals (2.3% of the NE Atlantic population, Camphuysen & Leopold 1994). High numbers were seen in patches, often in association with fishing vessels. The distribution and abundance of Fulmars were in fact quite unpredictable. At times, large areas appeared totally deserted whereas Fulmars could stream into the region without any obvious underlying reason. Observations on gas production platforms in winter 1984/85 demonstrated massive differences between consecutive days in the same area (Platteeuw *et al.* 1985). The southern North Sea is important for **Gannets** during southward migration in autumn, and as a wintering area for adults. The age composition of Gannets in Dutch waters agreed well with results obtained at seawatching sites in the 1970s (Camphuysen & Van Dijk 1983). A numerical predominance of adults in winter (Nov-Apr) and large numbers of immatures in the rest of the year were major aspects of this seasonal pattern. In autumn, when peak numbers of Gannets were found in the southern North Sea (estimated 35,900 individuals, Oct-Nov, or 4.0% of the NE Atlantic population (*cf.* Lloyd *et al.* 1991), nearly 65% (*i.e.* 23,500 individuals) were adults. **Great Skuas** were widespread and comparatively numerous, particularly in August-September. Low densities were found offshore in the Southern Bight, around the Frisian Front (an enriched zone, approximately between 53°30'N, 4°E and 54°N, 5°E) and scattered further to the north. It was estimated that around 2900 Great Skuas occurred in the entire study area in early autumn (*ca.* 10.7% of the NE Atlantic population). Great Skuas were particularly numerous in 1987 and this coincided with exceptionally high numbers at coastal sites that year (Platteeuw *et al.* 1994). Results from ship-based surveys indicated that Great Skuas tend to avoid the coastal strip. **Black-headed Gulls** were common as migrants in the southern North Sea, both during spring and autumn migration, but were otherwise restricted to the coastal strip (mainly within 5 km from the nearest shore). The southern North Sea appeared to be a very important wintering area for **Common Gulls**. Peak numbers observed in December-January, an estimated 80,400 individuals, formed around 5.0% of the NE Atlantic population (Camphuysen & Leopold 1994). In summer, however, Common Gulls were comparatively scarce at sea and restricted to the coastal strip. **Lesser Black-backed Gulls** were the only species of gull breeding in the Netherlands that used the marine environment to a great extent. High densities occurred around colonies in the breeding season, but adults were found venturing out to sea over large distances (>100 km). Peak numbers were found in April-July (over 80,000 individuals in the southern North Sea), when the majority of these gulls were adults. Considering the current size of the Dutch breeding population (*ca.* 30,000 pairs; Spaans *et al.* 1994), it is obvious that many of these birds feed at sea. In April-May, over 18% of the NE Atlantic population was esti-

mated to occur in the southern North Sea (Camphuysen & Leopold 1994), indicating the international importance of this area for this species. Densities of adult Lesser Black-backed Gulls at sea during ship-based strip-transect counts (n/km²) declined with a rate of 2.9% per km away from the coast from a mean density of 1.74/km² within 1 km from the coast (Poisson regression; $y = 1.737 * e^{(-0.029 * dc)}$; where d_c = distance to the nearest coast in km). In contrast to Herring Gulls, this species occurred frequently beyond the shipping lanes and in the Frisian Front area. Around 90% of the Lesser Black-backed Gulls at sea during the breeding season were adults, except at great distances from the coast. By far the largest colony of Lesser Black-backed Gulls within the study area is found on Terschelling (*ca.* 83% of the breeding numbers in this area). Densities (y) at sea around Terschelling dropped gradually, from 3.7/km² within 2 km from the colony with a rate of 3.5% per km away from the colony perpendicular to the coast and 2.1% per km away from the colony along the coast ($y = 3.706 * e^{(-(0.029 * dcol) - (0.014 * dcst))}$; where d_{col} = distance to the Terschelling colony in km and d_{cst} = distance to the nearest coast in km. **Herring Gulls** were strictly confined to coastal waters during the breeding season and probably obtained most of their food in these months in the coastal zone, the littoral zone, on land or in the Wadden Sea (*cf.* Spaans 1971). Most gulls were found within 5 km of the nearest coast. Numbers of adult Herring Gulls at sea during ship-based strip-transect counts (n/km²) declined with a rate of 8.2% per km away from the coast within the study area from a mean density of 1.74/km² within 1 km from the coast (Poisson regression; $y = 1.735 * e^{(-0.082 * dc)}$; where d_c = distance to nearest coast in km). Beyond the shipping lanes, Herring Gulls were quite rare during most of the summer. Adult gulls predominated in most areas, but immatures were relatively numerous at over 100 km from the coast. Comparatively large numbers were seen at over 50 km from the shore to the northwest of Texel and Vlieland, an area very rich in offshore installations (Placid Field and associated installations). Large gulls are known to roost on platforms in considerable numbers during most of the year (Tasker *et al.* 1986), but those associated with offshore installations during the breeding season are probably non-breeding birds. Substantial colonies of Herring Gulls occur on most Wadden Sea islands. Modelling the densities of adult Herring Gulls at sea in 1 km strata around the nearest colonies resulted in similar patterns as described for densities with increasing distance to the nearest coast ($y = 2.591 * e^{(-0.086 * dcol)}$; where d_{col} = distance to the nearest colony in km). Around Terschelling, distance to the coast was of greater importance than distance to the colony, as can be concluded from a decline of 8.4% per km away from the colony perpendicular to the coast and 0.4% per km away from the colony along the coast ($y = 2.07 * e^{(-(0.004 * dcol) - (0.084 * dcst))}$; where d_{col} = distance to the Terschelling colony in km and d_{cst} = distance to the nearest coast in km). Immediately after fledging of the young, the numbers of Herring Gulls at sea (and associated with commercial trawlers near the coast; Camphuysen 1993a), fell dramatically, indicating that the post-nuptial wing moult was spent on, or at least very much near, land. In autumn, a rapid increase in numbers was witnessed leading to very high numbers at sea in winter. Peak numbers were observed in winter (estimated over 170,000 individuals, or 12.2% of the NE Atlantic population; Camphuysen & Leopold 1994). In winter, Herring Gulls were more widespread and occurred scattered over the offshore zone. Substantial concentrations could be observed at trawlers or associated with offshore installations. The southern North Sea is a very important wintering area for **Great Black-backed Gulls**, considering the peak estimate of 63,500 individuals in late autumn (13.2% of the NE Atlantic population; Camphuysen & Leopold 1994). Most Great Black-backed Gulls occurred in the coastal zone, but less concentrated than most other gulls. Offshore sightings were common and total numbers away from the coast were usually considerably larger than inshore. **Kittiwakes** were mainly winter visitors in the southern North Sea of which substantial numbers were found between October and April. Peak numbers occurred in autumn (nearly 150,000 individuals).

SEABIRDS IN THE DUTCH SECTOR OF THE NORTH SEA From estimates of total numbers of seabirds in the southern North Sea, derived from mean densities in ICES squares (0.5°latitude x 1°longitude rectangles), an assessment was

Table 1. Estimates of (average) total numbers of scavenging seabirds in the Dutch sector of the North Sea (after Camphuysen & Leopold 1994).

	Jun-Jul	Aug-Sep	Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	max
Fulmar	58,600	114,100	43,400	15,300	110,800	44,300	Aug-Sep
Gannet	2,700	9,500	19,900	1,600	12,300	3,600	Oct-Nov
Great Skua	400	2,000	800	200	200	100	Aug-Sep
Little Gull	0	50	10,700	3,800	2,200	4,900	Oct-Nov
Bl-h Gull	800	1,100	21,900	10,300	10,000	3,100	Oct-Nov
Common Gull	1,700	400	29,900	60,800	29,100	3,400	Dec-Jan
L Bl-b Gull	36,800	24,600	15,300	800	9,300	57,900	Apr-May
Herring Gull	14,700	5,000	51,900	117,700	101,300	39,700	Dec-Jan
G Bl-b Gull	700	6,900	35,300	71,500	32,800	5,600	Dec-Jan
Kittiwake	7,100	6,400	53,100	32,900	74,600	16,900	Feb-Mar

*) Due to poor coverage north of 54°N in mid-winter, the offshore area for which the number of birds was calculated in December-January was only *ca.* 70% of the total area.

Table 2. Estimates of total numbers of scavenging seabirds birds in the sector proposed for protection (upper part of table) and their proportion (%) as compared to the numbers in the Dutch sector of the North Sea (lower portion of table; after Camphuysen & Leopold 1994).

	Jun-Jul	Aug-Sep	Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	max
Fulmar	7000	4000	8000	5700	32000	5800	Feb-Mar
Gannet	500	2300	4400	200	900	500	Oct-Nov
Great Skua	100	500	200	5	0	20	Aug-Sep
Little Gull	0	30	1700	40	700	300	Oct-Nov
Bl-h Gull	40	50	200	20	150	60	Oct-Nov
Common Gull	700	200	3700	7400	9700	200	Feb-Mar
L Bl-b Gull	14300	7200	200	200	3600	24000	Apr-May
Herring Gull	8400	600	5400	13200	20800	9500	Feb-Mar
G Bbl-b Gull	200	2500	13600	47100	6200	1200	Dec-Jan
Kittiwake	1800	2900	13300	6700	8700	900	Oct-Nov
Fulmar	11.9	3.5	18.4	37.2	28.9	13.1	
Gannet	18.5	24.3	22.1	12.4	7.3	13.9	
Great Skua	25.6	24.7	26.6	3.0	0.0	21.0	
Little Gull	0.0	62.2	15.9	1.1	31.3	6.1	
Bl-h Gull	52.2	29.3	12.8	1.4	9.3	66.2	
Common Gull	41.1	45.6	12.4	12.2	33.3	6.0	
LBl-b Gull	38.9	29.3	1.3	24.0	38.6	41.4	
Herring Gull	57.3	12.0	10.4	11.2	20.5	23.9	
Gr Bl-b Gull	30.2	36.0	38.5	65.9	18.9	21.5	
Kittiwake	25.3	45.3	25.1	20.3	11.7	5.3	

made of total numbers in the Dutch sector of the North Sea (table 1; *cf.* Camphuysen & Leopold 1994). The next step was to estimate total numbers of scavenging seabirds, in the sector that was proposed by Bergman *et al.* (1991) to qualify for protection (total number within 53°-54°N, 4°-6°E, an area roughly equalling alternatives 1 and 2; figure 1, table 2).

Fulmars peaked in late winter, when an estimated 32,000 individuals occurred in the suggested protected zone (table 2). The significance of this zone was greatest in winter, when 28.9% (February-March) to 37.2%

(December-January) of all Fulmars present in the Dutch sector of the North Sea occurred. **Gannets** were most numerous in autumn (August-September 2300 individuals, October-November 4400 individuals), when over 20% of all Gannets in the Dutch sector were found in the protected zone. **Great Skuas** peaked in early autumn and the 500 individuals found in the protected zone in August-Sepember (a quarter of all Great Skuas in the Dutch sector), accounted for at least 1.8% of the world population of this species (Camphuysen & Leopold 1994). **Little Gulls** were particularly important as migrants in the southern North Sea. Peak numbers within the protected zone were found in autumn, when 1700 Little Gulls were estimated to occur (15.9% of total numbers in the Dutch sector). **Black-headed Gulls** occurred only in very small numbers in the protected zone (200 or less). **Common Gulls** were numerous as winter visitors and numbers in the protected zone peaked in February-March (*ca.* 9700 individuals). **Lesser Black-backed Gulls** occurred in significant numbers in summer in the protected zone, with an estimated 24,000 individuals in April-May (41.4% of total numbers in the Dutch sector) and 14,300 in June-July (38.9%). **Herring Gulls** peaked in winter, with 20,800 individuals in the protected zone during February-March (20.5% of total numbers in the Dutch sector. **Great Black-backed Gulls** apparently peaked in December-January, but the estimate of total numbers in the protected zone was unreliable (*cf.* Camphuysen & Leopold 1994). Therefore, the estimate of October-November (13,600 individuals) was taken as maximum (38.5% of all Great Black-backed Gulls within the Dutch sector). **Kittiwakes** were numerous throughout the year, but particularly so in October-November (13,300 individuals in the protected zone, 25.1% of all Kittiwakes within the Dutch sector).

5. Relative abundance of scavengers at trawlers in the southern North Sea

BREEDING SEASON During the breeding season (April-August), 17 species of seabirds were observed associated with fishing vessels in the southern North Sea of which only 7 occurred in substantial numbers (table 3). Of these, Fulmar, Gannet, Great Skua, and Kittiwake were typically offshore species, whereas Lesser Black-backed Gull, Herring Gull, and Great Black-backed Gull occurred mainly at trawlers near the coast (Camphuysen 1993a). Black-headed Gulls and Common Gulls rarely occurred at trawlers and those that were seen scavenging were found near the coast in the southeastern half of the study area. **Fulmars** were recorded in 51.4% of all flocks of seabirds associated with commercial trawlers in the southern North Sea (n= 605), with a maximum of 505 individuals at one boat. Fulmars occurred widespread, but both those observed at trawlers off the Frisian islands (German Bight) and in the Southern Bight were mainly moulting birds and, hence, non-breeders (Camphuysen 1993b). Larger numbers of **Gannets** were only observed off the coast of NE Britain, and these were probably mainly birds associated with the Bass Rock colony in Firth of Forth. Gannets were recorded in 14.5% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 145 individuals at one boat. **Great Skuas** were widespread, but occurred only in small numbers. Most sightings were in August, when the southern North Sea rapidly gained importance as a feeding area for this species. **Black-headed Gulls** were recorded in 6.3% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 15 individuals at one boat. Scavenging Black-headed Gulls occurred exclusively close to the shore, except a few odd immatures seen at the trawl on greater distances from land. In June and July **Common Gulls** became progressively more numerous in the coastal zone and could be observed in mass-feedings of gulls (plunge diving) or associated with inshore shrimptrawlers (Platteeuw 1986a, Keijl *et al.* 1989). Common Gulls were recorded in 10.4% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 270 gulls at one boat. **Lesser Black-backed Gulls** were recorded in 59.5% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of *ca.* 1000 individuals at one boat. Scavenging adult Lesser Black-backed Gulls occurred in substantial numbers at over 100 km from the coast and moderate to high densities at sea between Terschelling and the Frisian Front could indicate that breeding gulls frequently ventured over 100 km away from the colony. Lesser Black-backed Gulls were abundant at

Table 3. Relative abundance of scavengers at commercial trawlers and fishing research vessels in the southern North Sea in summer (April-August, n = 605 stern counts; ESAS database and NIOZ unpubl. data): Frequency (number of records), total number observed, maximum at a boat and presence (%).

Species	Frequency	Total	Maximum	Presence %
Fulmarus glacialis	311	13451	505	51.4
Puffinus griseus	10	14	3	1.7
Hydrobates pelagicus	1	1	1	0.2
Sula bassana	88	745	145	14.5
Phalacrocorax carbo	3	4	2	0.5
Stercorarius parasiticus	6	9	3	1.0
Stercorarius skua	45	88	10	7.4
Stercorarius spec.	2	7	5	0.3
Larus minutus	5	16	5	0.8
Larus ridibundus	38	137	15	6.3
Larus canus	63	513	270	10.4
Larus fuscus	360	35915	1000	59.5
L. fuscus / L. argentatus	1	8	8	0.2
large *Larus* spec.	24	769	230	4.0
Larus argentatus	255	17382	900	42.1
Larus marinus	192	1870	130	31.7
L. fuscus / L. marinus	1	200	200	0.2
Rissa tridactyla	217	4686	300	35.9
Larus spec.	32	5493	1200	5.3
Sterna sandvicensis	4	5	2	0.7
Sterna hirundo	24	82	27	4.0
Sterna paradisaea	1	50	50	0.2
S. hirundo / S. paradisaea	4	166	100	0.7
Chlidonias niger	1	1	1	0.2

inshore trawlers in the German Bight and off the Dutch coast and larger groups at trawlers occurred at distinctly larger distances than Herring Gulls, which were mainly restricted to the first 5 kilometres from the coast (Camphuysen *in prep*). Large numbers of both species were observed attending commercial beamtrawlers west of Helgoland in June/July. Most were adults in summer plumage, but numbers were too large and too far away from the nearest breeding colonies to be breeding birds. **Herring Gulls** occurred exclusively near the shore, with small numbers of, mainly immature, at offshore trawlers. Herring Gulls were recorded in 42.1% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 900 individuals at one boat. In August, Herring Gulls were virtually absent at sea and as scavengers at trawlers and Lesser Black-backed Gulls numerically dominated at all inshore trawlers. **Great Black-backed Gulls** were rather scarce in summer, but small numbers were recorded in 31.7% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 130 individuals at one boat. Most larger flocks of **Kittiwakes** were seen well offshore off NE England. Besides, scavenging Kittiwakes occurred in substantial numbers to the west of Helgoland and this could indicate that the local breeding population relied on discards to a considerable extent. Kittiwakes were recorded in 35.9% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 300 individuals at one boat. Species which were recorded in summer in more than 1% of all flocks of seabirds associated with commercial trawlers in the southern North Sea were Sooty Shearwater (10 records; maximum 3 birds at a boat), Arctic Skua (6 records, maximum 3), Great Skua (45 records, maximum 10), and Common/Arctic Tern (29 records, maximum 100).

NON-BREEDING SEASON The spectrum of species at trawlers in winter (September-March) was larger than in summer. Some 24 species of seabirds were observed at fishing research vessels and commercial trawlers in winter. Of these, 9 species occurred in large numbers (table 4). Fulmar, Gannet, Great Skua, Great Black-backed Gull, and Kittiwake were widespread, pelagic species at trawlers. Black-headed Gulls and Common Gulls occurred in large numbers at inshore trawlers, whereas Herring Gulls occurred both offshore and inshore (Camphuysen 1993a, Camphuysen *et al.* 1993). Most Lesser Black-backed Gulls were found to have left the (southern) North Sea and only scattered records at nearshore trawlers in the southern Bight occurred.

Fulmars were recorded in 40.7% of all flocks of seabirds associated with commercial trawlers in the southern North Sea (n= 1408), with a maximum of 2033 individuals at one boat. Larger numbers had penetrated into the Southern Bight in these months and many hundreds were sometimes observed associated with trawlers in Belgian waters and the Voordelta. **Gannets** were clearly more numerous at trawlers in autumn, and of the few Gannets observed in winter, a large fraction was seen near fishing vessels. Gannets were recorded in 21.9% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 450 individuals at one boat. The coastal zone had gained importance for scavenging **Black-headed Gulls**, of which substantial numbers could be seen very closely inshore. Black-headed Gulls were recorded in 7.3% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of *ca.* 1000 individuals at one boat. **Common Gulls** were recorded in 29.2% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 500 gulls at one boat. As in Black-headed Gulls, most sightings were closely inshore. **Lesser Black-backed Gulls** were recorded in only 13.1% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 250 individuals at one boat. Most records were in autumn, whereas the southern North Sea was virtually abandoned between December and early March. In winter, **Herring Gulls** became much more widespread as scavengers than in summer, both inshore and offshore, and numerically dominated at many occasions. Herring Gulls were recorded in 53.0% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 3720 individuals at one boat. **Great Black-backed Gulls** were another species which was clearly more abundant as a scavenger in winter than in summer. Great Black-backed Gulls were recorded in 45.7% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 1150 individuals at one boat. Inshore and offshore records were equally common. **Kittiwakes** were recorded in 59.9% of all flocks of seabirds associated with commercial trawlers in the southern North Sea, with a maximum of 700 individuals at one boat. Sightings of scavenging Kittiwakes were widespread over the entire southern North Sea. Species which were recorded in winter in more than 1% of all flocks of seabirds associated with commercial trawlers in the southern North Sea were Great Skua (57 records; maximum 48 birds at a boat), Little Gull (26 records, maximum 20), and Guillemot (17 records, maximum 4).

6. Discards in beamtrawl fisheries

Catches in beamtrawl fisheries north of the Wadden Sea islands in summer comprised mainly flatfish (nearly 50%), benthic invertebrates (nearly 50%) small quantities of roundfish (1-2%) and rubbish (not quantified; Camphuysen 1993b). There were some day by day fluctuations in these proportions. Certain areas produced huge quantities of starfish *Asterias rubens* or *Ophiura* spp., others appeared rich in (broken) sea-potatoes *Echinocardium cordatum*, Ocean Quahog *Arctica islandica* were numerous in places. Occasionally, large Cod *Gadus morhua* were more frequently caught, leading to a higher proportion of roundfish in terms of tonnes brought on deck. It was estimated that around 5-10 kg of discards (including fish and benthic invertebrates) were produced for each kg landed, marketable fish. With 7 tonnes of fish landed after one week (47 hauls), this would lead to an estimate of 750-1000 kg discards per haul, or 30-60 kg roundfish, 350-700 kg flatfish and 350-700 kg benthic invertebreates (*cf.* Camphuysen 1993b). Other weeks at sea resulted in similar data, except that the landed catch was sometimes two

Table 4. Relative abundance of scavengers at commercial trawlers and fishing research vessels in the southern North Sea in winter (September-March, n = 1408 stern counts; ESAS database and NIOZ unpubl. data): Frequency (number of records), total number, maximum at a boat and presence (%).

Species	Frequency	Total	Maximum	Presence %
Fulmarus glacialis	573	24359	2033	40.7
Puffinus griseus	8	11	4	0.6
Puffinus puffinus	2	2	1	0.1
Hydrobates pelagicus	1	1	1	0.1
Sula bassana	308	3598	450	21.9
Phalacrocorax aristotelis	1	1	1	0.1
Stercorarius pomarinus	2	2	1	0.1
Stercorarius parasiticus	11	12	2	0.8
Stercorarius longicaudus	1	1	1	0.1
Stercorarius skua	57	131	48	4.0
Larus melanocephalus	1	1	1	0.1
Larus minutus	26	82	20	1.8
Larus ridibundus	103	6312	1000	7.3
Larus canus	411	11077	500	29.2
Larus / Rissa spec.	1	10	10	0.1
Larus fuscus	184	2879	250	13.1
L. fuscus / L. argentatus	2	170	140	0.1
Larus argentatus	746	50288	3720	53.0
Larus cachinnans	1	1	1	0.1
Larus glaucoides	1	1	1	0.1
Larus hyperboreus	5	5	1	0.4
Larus marinus	644	21242	1150	45.7
large *Larus* spec.	45	8341	2200	3.2
L. fuscus / L. marinus	2	60	50	0.1
Rissa tridactyla	843	31368	700	59.9
Larus spec.	84	15220	1150	6.0
Sterna hirundo	5	10	5	0.4
Sterna spec.	1	2	2	0.1
Uria aalge	17	24	4	1.2
Alca torda	3	3	1	0.2
patterned dolphin	1	2	2	0.1

times higher. The discards fraction was estimated at 4-8 kg discards per kg of fish landed. Besides discards, a steady trickle of offal was produced for half an hour after each haul (estimated at 10-12 kg per haul; using estimates provided by Boswall 1960, Bailey & Hislop 1978, Furness *et al.* 1988).

Van Beek (1990) sampled the catch and discards fractions onboard beamtrawlers in the southern North Sea and found that volume of the debris fraction (*i.e.* anything but discarded fish) varied between 37% and 75% of the catch. The landings fraction in the catch varied between 5% and 43% between the trips, and the discard fraction varied between 13% and 37%. Most (>75%) Dab of less than 24 cm total length were discarded, most Plaice of less than 26 cm length, most Sole of less than 22 cm length. About 8% in numbers and weight of the discards fraction comprised Sole, Cod, Scaldfish, Solenette, Dragonet, Hooknose, Grey Gurnard, Tub Gurnard, Mackerel, Scad, Herring, Flounder, Poor Cod, Bib, and eels. Most discarded roundfish were less than 40 cm total length.

7. Consumption of discards and prey selection by scavenging seabirds

During experimental discarding in winter (September-March; n= 92 experiments) in the southern North Sea, the following scavengers were represented:

Kittiwake	5581	46.7	%
Fulmar	1915	16.0	
Herring Gull	1863	15.6	
Great Black-backed Gull	1168	9.8	
Lesser Black-backed Gull	570	4.8	
Common Gull	345	2.9	
Gannet	307	2.6	
unidentified gulls	150	1.3	
Great Skua	20	0.2	
Black-headed Gull	12	0.1	
Others	17		

In summer, April-August (breeding season; n= 72 experiments) the following scavengers were observed during experimental discarding:

Lesser Black-backed Gull	22635	76.4	%
Herring Gull	3592	12.1	
Fulmar	1306	4.4	
Kittiwake	1151	3.9	
Great Black-backed Gull	847	2.9	
Gannet	38	0.1	
Black-headed Gull	22	0.1	
Common Tern	16	0.1	
Common Gull	16	0.1	
Great Skua	15	0.1	

Within the sector proposed for protection, 16 discard experiments were performed during the breeding season, with Lesser Black-backed Gulls numerically dominating even stronger than in the entire southern North Sea:

Lesser Black-backed Gull	3039	94.2	%
Fulmar	55	1.7	
Kittiwake	50	1.6	
Great Black-backed Gull	35	1.1	
Herring Gull	30	0.9	
Others	16		

FEEDING STRATEGIES At trawlers off the Wadden Sea Islands during the breeding season, either Herring Gulls, or Lesser Black-backed Gulls were the numerically dominating species. The more powerful Great Black-backed Gulls formed a small minority and Kittiwakes occurred in numbers only near Helgoland. Fulmars were usually scarce and the individuals that turned up at boats were usually moulting individuals in poor physical condition. Skuas were absent or occurred in very small numbers. As a result, most fights for scraps were between Herring Gulls and Lesser Black-backed Gulls. Feeding started when the trawler resumed towing after having brought a catch on deck. Sorting and gutting marketable fish took place at a speed of 5-7 knots. Herring Gulls and Lesser Black-backed Gulls took discards mainly very near the ship, constantly being on the wing and making shallow plunge-dives into the water. Most gulls consumed fish which they picked up themselves, but kleptoparasitism occurred frequently (see below). The more agile Kittiwakes were feeding on small fish and small particles of offal near the ship, avoiding fights with the larger and more powerful gulls further back in the wake. Great Black-backed Gulls were mainly feeding in the rear end of the associated flock of birds, stealing fish from other gulls or picking up large fish which were ignored by the smaller species (from Camphuysen 1993bc, Camphuysen *in prep*).

DISCARDS CONSUMPTION For common fish in the discards fraction, offered during discard experiments onboard commercial trawlers and research vessels in the southern North Sea (Appendix 2), prey choices (species and fish size) were assessed. For each species of scavenger, all fish species which were offered at least 100 times during its presence at a boat are used for size preferences. It was demonstrated earlier, that flatfish were mainly selected on the basis of width rather than on length (Camphuysen 1994). Because it was not practical to measure width under field conditions, total lengths were used to calculate the width of flatfish before the analysis of size preferences commenced. Although circumference and spinyness of roundfish may be important factors in the preferences of certain species of roundfish (*cf.* Swennen & Duiven 1977), total length was a good indicator of fish size.

Consumption rates during experimental discarding in winter in the southern North Sea ranged from 1.8% in benthic invertebrates (111 offered in which fate is known) and 90.7% in roundfish (3684 offered in which fate is known; table 5). Of offal, 79.0% was consumed (n= 852), whereas 23.9% of 816 flatfish were taken by scavengers. In summer,

Table 5. Consumption rates in winter (September-March) and summer (April-August) in the southern North Sea during experimental discarding onboard commercial trawlers and research vessels.

September-March	offered (n)	sunk (n)	(%)	consumed (n)	(%)	unknown (n)
Offal	880	179	21.0	673	79.0	28
Roundfish	3877	344	9.3	3340	90.7	193
Flatfish	891	621	76.1	195	23.9	75
Benthic invertebrates	117	109	98.2	2	1.8	6
April-August	**offered (n)**	**sunk (n)**	**(%)**	**consumed (n)**	**(%)**	**unknown (n)**
Offal	1244	203	16.5	1027	83.5	14
Roundfish	1291	293	24.3	912	75.7	86
Flatfish	1097	726	68.4	335	31.6	36
Benthic invertebrates	2542	2533	99.7	7	0.3	2

consumption rates ranged from 0.3% in benthic invertebrates (n= 2540 items offered of which fate is known) to 83.5% in offal (n= 1230). Consumption rates in roundfish (n= 1205) and flatfish (n= 1061) amounted to 75.7% and 31.6% respectively. The overall consumption rates of roundfish, offal, flatfish and benthic invertebrates during these studies were respectively 87.0% (n= 4891), 81.7% (n= 2082), 28.2% (n= 1877) and 0.3% (n= 2651).

SPECIALIZATION OF SCAVENGERS Most scavengers overlapped with respect to species and size selection of fish at the trawl. The relative abundance at the trawl, but also specific preferences and abilities of different species of seabirds led to major differences in feeding success (table 6, *pers. obs.*). **Benthic invertebrates** were virtually always ignored by scavengers and will therefore not be discussed here. In winter, success indices (S.I.) for **flatfish** were particularly high in Gannet (S.I. 8.8, *i.e.* 8.8x more taken than was expected from numbers at the trawl), Lesser Black-backed Gull (S.I. 5.2), and Great Black-backed Gull (S.I. 3.5). Fulmar, Common Gull and Kittiwake ignored most flatfish. In summer, flatfish were most successfully preyed on by Great Black-backed Gull (S.I. 1.6) and Lesser Black-backed Gull (S.I. 1.1). All other species took less flatfish than expected from their abundance at the trawl.

Feeding efficiency in winter for **roundfish** was highest in Gannets (S.I. 2.0), Kittiwakes (S.I. 1.3) and Herring Gulls (S.I. 1.1). Interestingly, these species can be classified as specialists in respectively the larger fish in the discards fraction, the smaller fish and intermediate sized fish. Hence, all these species occupied a separate 'niche' in size classes taken most. Gannets were efficient scavengers which were not easily outcompeted by other species. Gannets took fish whether or not fighting seabirds were around and obtained these fish by diving deep, robbing other birds, or by seizing floating fish while swimming. In summer, success rates were highest in Gannet (S.I. 2.6), Fulmar (S.I. 2.1) and Great Black-backed Gull (S.I. 1.3). At the commercial breamtrawler, Herring Gulls obtained more gadids than expected only of numbers present at the trawl. Lesser Black-backed Gulls were remarkably keen at gurnards, equalled only by Great Black-backed Gulls which tended to obtain the larger individuals through robbery from the smaller species (Camphuysen *in prep*).

Fulmars are known as **offal** specialists (*e.g.* Hudson & Furness 1988, 1989). However, this species is only successful when a sufficient number of other Fulmars are around and when offal can be taken near a stationary or very slow moving vessel. In the southern North Sea, Fulmars were not found to be offal consumers number one! Success indices in winter were highest for Lesser Black-backed Gull (S.I. 2.0) and Kittiwake (S.I. 1.5), while

Table 6. Relative abundance of scavenging seabirds during experimental discar-ding in the southern North Sea in winter (top, September-March) and summer (bottom, April-August) and observed and expected frequencies of consumption of discarded benthic invertebrates, flatfish, roundfish and offal. S.I. = Success Index (observed frequencies divided by expected frequencies, which were calculated on the basis of relative abundances of seabird species at the trawl during experimental discarding).

Southern North Sea	(Sep-Mar)		Discards consumed									Offal consumed		
			Benthos			Flatfish			Roundfish			Offal		
Species	Number	%	obs	exp	S.I.	obs	exp	S.I.	obs	exp	S.I.	obs	exp	S.I.
Rissa tridactyla	5581	46.7	3	2.3	1.3	11	91.1	0.1	2105	1560.1	1.3	479	314.4	1.5
Fulmarus glacialis	1915	16.0	1	0.8	1.2	2	31.3	0.1	95	535.3	0.2	54	107.9	0.5
Larus argentatus	1863	15.6		0.8	0.0	23	30.4	0.8	561	520.8	1.1	49	104.9	0.5
Larus marinus	1168	9.8	1	0.5	2.0	67	19.1	3.5	286	326.5	0.9	9	65.8	0.1
Larus fuscus	570	4.8		0.2	0.0	48	9.3	5.2	60	159.3	0.4	63	32.1	2.0
Larus canus	345	2.9		0.1	0.0		5.6	0.0	63	96.4	0.7	14	19.4	0.7
Sula bassana	307	2.6		0.1	0.0	44	5.0	8.8	168	85.8	2.0	5	17.3	0.3
Larus spec.	150	1.3		0.1	0.0		2.4	0.0		41.9	0.0			
Stercorarius skua	20	0.2					0.3	0.0		5.6	0.0			
Larus ridibundus	12	0.1					0.2	0.0	1	3.4	0.3			
Uria aalge	5	0.0					0.1	0.0		1.4	0.0			
Larus minutus	3	0.0								0.8	0.0			
Stercorarius parasiticus	3	0.0								0.8	0.0			
Puffinus griseus	2	0.0								0.6	0.0			
Larus cachinnans	1	0.0								0.3	0.0			
Puffinus puffinus	1	0.0								0.3	0.0			
Sterna hirundo	1	0.0								0.3	0.0			
Larus hyperboreus	1	0.0							1	0.3	3.6			
Totals	11948		5			195			3340			673		

Southern North Sea	(Apr-Aug)		Discards consumed									Offal consumed		
			Benthos			Flatfish			Roundfish			Offal		
Species	Number	%	obs	exp	S.I.	obs	exp	S.I.	obs	exp	S.I.	obs	exp	S.I.
Larus fuscus	22635	76.4	7	5.3	1.3	288	255.8	1.1	712	696.5	1.0	627	784.3	0.8
Larus argentatus	3592	12.1		0.8	0.0	30	40.6	0.7	66	110.5	0.6	175	124.5	1.4
Fulmarus glacialis	1306	4.4		0.3	0.0	1	14.8	0.1	86	40.2	2.1	87	45.3	1.9
Rissa tridactyla	1151	3.9		0.3	0.0	1	13.0	0.1	9	35.4	0.3	128	39.9	3.2
Larus marinus	847	2.9		0.2	0.0	15	9.6	1.6	34	26.1	1.3	2	29.3	0.1
Sula bassana	38	0.1					0.4	0.0	3	1.2	2.6		1.3	0.0
Larus ridibundus	22	0.1					0.2	0.0		0.7	0.0	8	0.8	10.5
Sterna hirundo	16	0.1					0.2	0.0		0.5	0.0		0.6	0.0
Larus canus	16	0.1					0.2	0.0	1	0.5	2.0		0.6	0.0
Stercorarius skua	15	0.1					0.2	0.0	1	0.5	2.2		0.5	0.0
Stercorarius parasiticus	1	0.0												
Totals	29639		7			335			912			1027		

Fulmars took only half the amount of offal as was expected from its relative abundance at the trawl. In summer, Kittiwakes were specialized feeders on offal, feeding very close at the stern of research vessels and very near the outlet of discards and offal in commercial beamtrawlers (S.I. 3.2). Other successful offal feeders were Fulmar (S.I. 1.9) and Herring Gull (S.I. 1.4). At the trawl of the beamtrawler in summer 1993, Herring Gulls could be classified as offal specialists, second only to the highly manoeuvrable Kittiwakes (Camphuysen 1993b). In areas where Fulmars occurred abundantly, other seabirds were scared away and most offal was consumed by this highly aggressive species. This situation did not frequently occur in the southern North Sea, but was commonly observed further to the north (Camphuysen *et al.* 1993). Large flocks of fighting Fulmars were avoided by Kittiwakes, Lesser Black-backed Gulls, and most Herring Gulls. Great Black-backed Gulls were specialized on robbing other seabirds. Fish was stolen from easily, even from a large group of Fulmars fighting for a single fish.

In winter, substantial numbers of Sprat were sticking out the meshes of the beamtrawl net in each haul, which formed an important source of food for the scavenging Kittiwakes. Unfortunately, this source was difficult to quantify, but it was estimated that between 100 and 500 of Sprat were sticking out each net in each haul and most of these fish were successfully consumed before the net was brought on deck.

SIZE SELECTION Gape limited piscivorous seabirds have obvious preferences with respect to the size of fish taken. The competition at trawlers is intense and scavenging seabirds

have a tendency to select fish which can be swallowed easily and fast. Feeding efficiency declines when fish are more difficult to handle, because fish that are not instantly swallowed are often stolen by other birds (Furness *et al.* 1988, Hudson & Furness 1988, 1989). Generally, the handling time of consumed discarded fish increases with fish length, but is also affected by the shape of fish: seabirds take longer to swallow flatfish than roundfish (Hudson 1989). Smooth, slender bodied species of fish, like clupeids and gadids are most profitable prey, whereas consumption rates of certain spiny roundfish (*e.g.* Dragonet *Callionymus lyra*, Lesser Weever *Trachinus vipera*) of otherwise suitable size are significantly below those of gadids and clupeids, also because swallowing these fish is dangerous (Forbes 1989, Camphuysen 1993b). Not surprisingly, in earlier studies at trawlers in the North Sea it was found that for scavenging seabirds, flatfish are among the least preferred fish discards (Hudson & Furness 1988, Garthe 1993, Camphuysen *et al.* 1993, Camphuysen 1994). In appendix 2, for common scavengers and frequently offered fish during experimental discarding, size selection is illustrated. Shown are frequencies of fish per length class in cm (or width in flatfish; *cf.* Camphuysen 1994) offered and the frequencies consumed. Minimum, median and maximum length/width of offered and consumed discards are indicated.

Fulmars were frequently observed not to swallow fish, but to rip the belly open to consume intestines, especially the liver. The median length of swallowed roundfish was 19 cm (range 7-29 cm), while the median length of roundfish from which intestines were consumed was 26 cm (range 17-32 cm). Herring, Sprat and smaller Whiting were usually swallowed whole, wheres most other fish were pecked open. Fulmars rarely took flatfish and swallowed only very small specimens (maximum width of flatfish swallowed 5 cm). **Gannets** had a strong preference for the larger fraction of roundfish discards. The median length of consumed roundfish was 26 cm (range 14-40 cm), whereas the median of offered roundfish in the presence of Gannets was 17 cm (range 5-40 cm). Even in certain spiny or bony fish such as Grey Gurnard, Gannets selected rather large specimens (median offered 19 cm, median consumed 27 cm). Of flatfish, only Dab were frequently offered in the presence of Gannets and the median width of Dab offered (6 cm) was only slightly smaller than the consumed fish (7 cm, range 4-9 cm). **Common Gulls** selected roundfish of a median length of 13 cm (range 6-21 cm), which is slightly less than the median length of roundfish offered in the presence of these gulls (14 cm). Flatfish were not offered in sufficient quantities in the presence of scavenging Common Gulls to allow further analysis. The median length of roundfish consumed by **Lesser Black-backed Gulls** was 18 cm (range 9-31 cm), which is slightly below the median length of roundfish offered in the presence of this species (19 cm). The median length of consumed Whiting (23 cm, range 9-31 cm) was just above what had been offered (median 22 cm). Of the much preferred Grey Gurnard, a median of 18 cm was offered and consumed (range of consumed gurnards 11-28 cm). Of flatfish, comparatively small specimens were usually selected, with a median width of 6 cm (range 3-9 cm width, median offered 7 cm, range 3-14 cm width). The median length of roundfish consumed by **Herring Gulls** was 20 cm (range 7-35 cm), while a median of 17 cm was offered in the presence of this species. In Haddock, Herring, Sprat and Whiting, Herring Gulls selected slightly larger fish than were offered, whereas comparatively small Dragonets were taken. The median length of consumed Grey Gurnards (median 18 cm, range 8-31) equalled that of offered fish, of which only large individuals were rejected. In flatfish, the median width consumed was 7 cm (range 5-9 cm), which is similar to what was offered. **Great Black-backed Gulls** took larger roundfish (median length 23 cm, range 11-35 cm) than what was offered in the presence of this species (median 17 cm, range 5-38 cm). Only in Red Gurnard, this species consumed slightly smaller fish (median length 20 cm) than what was offered (median 21 cm). The median width of flatfish consumed by Great Black-backed Gulls was 6 cm (range 3-11 cm), similar to what was offered. **Kittiwakes** selected rather smaller roundfish (median 14 cm, range 5-27 cm) than what was offered (median 16 cm, range 5-40 cm). Flatfish were scarcely taken by this species, of a maximum width of 5 cm. Arranged by mass of the scavenging seabirds, it is obvious that the smaller species tend to select smaller fish, and larger birds take larger fish (table 7). The range of discards taken by

Table 7. Roundfish and flatfish selection by scavenging seabirds, arranged by body mass. Shown are mass of bird, median length of roundfish consumed (total length in cm), range of length of roundfish consumed, median width of flatfish consumed (cm), range of width of flatfish consumed, from experimental discarding in the southern North Sea onboard commercial trawlers and research vessels.

Species	body mass (g)	Roundfish median	Roundfish range	Flatfish median	Flatfish range
Kittiwake	300-500	13	5-27	-	4-5
Common Gull	300-500	13	6-21	-	-
Fulmar	700-900	19	7-29	-	3-5
Lesser Bl-b Gull	700-1000	18	9-31	6	3-9
Herring Gull	800-1200	20	7-35	7	5-9
Great Bl-b Gull	1100-2000	23	11-35	6	3-11
Gannet	2800-3200	26	14-40	7	4-9
Total range			5-40		3-11

scavengers in the southern North Sea indicates that virtually all discards produced in commercial fisheries are exploited by seabirds, except some of the larger flatfish.

8. Inter- and intra-specific competition of scavengers at trawlers

With differences in preferred prey and different strategies to feed at the trawl, much of the potential competition between different species of scavengers was avoided. All species which were the first to handle a particular item in the trickle of discards and offal were equally capable of swallowing (82.4-89.0% of all fish handled for the first time were successfully consumed), except in Fulmars which were found to fight for fish rather than to simply pick one up (table 8). In Gannets and gulls, 6.9% of discards handled for the first time were dropped, 7.0% were stolen by another scavenger (n= 6748). Only 2.3% of the discards were missed in the first attempt. From these figures can be concluded that all scavengers aimed for fish which could be swallowed easily, of preferred species.

In the fight for scraps following first attempts that failed, discards were picked up after simply being dropped, or were stolen (kleptoparasitism). The first category comprises 522 records of discards which were dropped and subsequently picked up. Most retrials were within the same species, probably because species shared the same position at the trawl and were therefore the most likely candidate to try again. Otherwise, small species were seen to pick up items dropped by large birds and vice versa.

A very obvious dominance hierarchy appeared in the registrations of discards that were stolen. Including interactions within the same species, 806 cases of kleptoparasitism were recorded. Great Black-backed Gulls and Gannets were the most successful kleptoparasites, obtaining five times more discards by robbing other birds than they lost by being robbed (table 9). Kittiwakes were the most vulnerable species, being robbed 2.4x more frequently than being successful as a kleptoparasite. A *vulnerability to robbery index* was calculated by dividing the number of fish stolen **from** a species by the number of fish stolen **by** that species. Including intraspecific competition, robbery indices ranged from 2.4 (Kittiwake) to 0.2 (Great Black-backed Gull). When selecting for interspecific competition, the vulnerability of Kittiwakes was even more obvious, whereas Great Black-backed Gulls were found to be superior over all other species (robbery indices ranged from 21.9 (Kittiwake) to 0.0 (Great Black-backed Gull; table 9). Herring Gulls and Lesser Black-backed Gulls, with greatly overlapping interests at the trawl, were not equally successful as kleptoparasites. Lesser Black-backed Gulls suffered considerably more losses through robbery than Herring Gulls (vulnerability to robbery index 2.2 versus 0.6, excluding robberies within species).

Table 8. Fate of discards taken by the first bird (C= consumed, D= dropped, K= stolen, M= missed, P= not swallowed but pecked), during experimental discarding in the southern North Sea, 1992-94. (A) total numbers observed, (B) proportions (%).

	Fate of discards					A
First to pick up	C	D	K	M	P	Totals
Fulmar	234	16	59	6	33	348
Gannet	159	15	6	2		182
Black-h Gull	8	1				9
Common Gull	73	6	3			82
Lesser Bl-b Gull	1617	134	108	97		1956
Herring Gull	699	63	69	17		848
Great Bl-b Gull	202	22	5	5	1	235
Kittiwake	2623	211	224	29	1	3088
Totals	5615	468	474	156	35	6748

%%	Fate of discards					B
First to pick up	C	D	K	M	P	Totals
Fulmar	67.2	4.6	17.0	1.7	9.5	348
Gannet	87.4	8.2	3.3	1.1	0.0	182
Black-h Gull	88.9	11.1	0.0	0.0	0.0	9
Common Gull	89.0	7.3	3.7	0.0	0.0	82
Lesser Bl-b Gull	82.7	6.9	5.5	5.0	0.0	1956
Herring Gull	82.4	7.4	8.1	2.0	0.0	848
Great Bl-b Gull	86.0	9.4	2.1	2.1	0.4	235
Kittiwake	84.9	6.8	7.3	0.9	0.0	3088
Totals	83.2	6.9	7.0	2.3	0.5	

Table 9. Vulnerability to robbery index calculated from the number of kleptoparasitic incidents for each species (number of discards stolen from a species divided by number of discards stolen by that species; see text).

Fish stolen from	Fish stolen by								
		Kitt	Fulm	LBbG	HerG	Gann	GBbG	other	Totals
Kittiwake		112	19	5	93	5	48	5	287
Fulmar	3	80	2	4	17	33	2	141	
L Blb Gull			4	126	38		26		194
Herring Gull		5		23	66	9	40		143
Gannet						3	4		7
Gr Blb Gull			1	1	3	1	23		29
others		1		1		3		5	
Totals	120	105	157	205	35	177	7	806	
Vulnerability to robbery index									interactions:
		2.4	1.3	1.2	0.7	0.2	0.2		incl. own species
		21.9	2.4	2.2	0.6	0.1	0.0		excl. own species

9. The importance of discards in seabird diets

The relative importance of discards in seabird diets in the southern North Sea is evaluated in this chapter on the basis of (1) the presence of demersal (marine) fish in the diet, (2) the presence of pelagic (marine) fish in the diet (both from literature sources), and (3) the presence at trawlers at sea (this report and Camphuysen 1993a).

Fulmars feed on the surface and have only very limited diving capacity (probably less than a few metres depth). Most of the food is obtained when swimming, pecking up small

particles from the surface. The main prey of Fulmars is zooplankton and small fish occurring near the surface. Their feeding range is considerable and their diet is extremely varied. In literature the following is mentioned: fish offal, fish (Gadidae, Clupeidae, Stomiatoidei, and Ammodytidae), Mollusca (Gastropoda, Pteropoda, Cephalopoda), Chaetognatha, Crustacea (Schizopoda, Isopoda, Copepoda, Cumacea, Decapoda), Annelida, Coelenterata, carrion (meat and blubber of whales, walrus, seals, Polar Bear, and several species of birds, vegetable matter, grit, plastics, and finally Fulmars have been seen drinking floating whale- or fish-oil at sea (see Camphuysen 1990). In winter, Fulmars feed extensively on fish offal. Behind trawlers Fulmars are mainly interested in offal. Discarded fish were only swallowed whole when very small. Alternatively, when there was a lull in the discharge of offal, Fulmars ripped open the bellies of discarded whole fish to feed on the liver and guts (Hudson & Furness 1989). The median length of experimentally discarded fish in a study in Shetland in summer 1985 was 28 cm for Haddock and 29 cm for Whiting. The mean length of these fish known to have been swallowed whole by Fulmars was 23.0 cm for Haddock (range 15-30cm) and 24.1 for Whiting (range 14-29cm; Hudson & Furness 1988). Hudson & Furness (1988) described which discarded fish were selected (species and size preferences). Few flatfish were taken and Red Gurnards proved to be less popular than Grey Gurnards, Whiting, Haddock and Norway Pout. To these consumers of discards, the size of fish is of limited importance. Fulmars are known to rip larger prey and carrion apart into pieces they can manage. From British breeding locations it is known that Fulmars can rely on sandeels and clupeoids. Self-captured fish are rather small, probably less than 20 cm long, shoaling species occurring near the surface. Gadoids and clupeoids are preferred from discards above flatfish and gurnards.

Gannets are plunge divers which perform dives from various heights (sometimes from over 50m heigth) and angles, and immediately before entry they fold their wings back, entering the water like an arrow. The maximum depth reached with this method is probably no more than 10 or 15 metres, either or not aided by swimming with half-open wings in pursuit or search for prey. Gannets dive at random when fish are spotted from the air, and strike or follow fish when under water. The impact of the plunge dive may well dazzle and disorientate the shoals of fish for a while. The fish is usually swallowed under water, only large individuals are brought to the surface, and Gannets rarely take wing with their prey still in the beak. Gannets often dive solitarily, but the bright white plumage of the Gannets, together with its spectacular diving performance, are effective social signals, attracting other Gannets and other seabirds to the fishing area. Scores of a number of tens of Gannets, or even many hundreds, may assemble in areas with good fishing (mainly from Nelson 1978, 1980). Recorded prey species in the East Atlantic Ocean are (from Martin 1989, Nelson 1978, Reinsch 1969) Herring, Sprat, Pilchard, Shad, Anchovy, salmonids, Smelt, Capelin, Argentine, Greater Argentine, Cod, Haddock, Whiting, Blue Whiting, Poor Cod, Norway Pout, Bib, Pollack, Saithe, Ling, Hake, Eelpout, Garfish, Red-fish, gurnards, Scad, sea-breams, mullets, Catfish, sandeels, Mackerel, Plaice, Dab, Lemon Sole, and Long Rough Dab. Gannets are well known as trawler attendants and readily take discarded fish. Part of their success in obtaining discards is due to their ability to dive deep for fish that had already sunk (Hudson & Furness 1989). Gannets are rarely observed to take offal.

The maximum fishing range during the breeding season is estimated to be at least 170 nautical miles (320 km; Nelson 1978). Tasker *et al.* (1985), however, found that fishing trips of North Sea Gannets rarely exceed 80 nm (150 km) and that most trips are below one-third of that distance. Martin described the changing diet in Gannets breeding on Hermaness, Unst, Shetlands, during 1981-88 and found that sandeels was the only species in respectively 90%, 62%, 37%, 15%, 14%, and 6% of the 1981, 83, 84, 86, 87, and 88 identifiable bolus samples (regurgitated matter). Herring, and to a lesser extent gadoids and Mackerel, gained importance in the Gannet diet, particularly after 1986. In Gannet chick regurgitates on Sula Sgeir in June 1986 sandeels predominated (percentage of occurrence 75.6%), with occasionally Blue Whiting (8.9%), Herring (4.4%), Argentines (2.2%), Redfish (2.2%) and unidentified fish (Benn *et al.* 1987). Winter life of Gannets is nomadic. Adults and immatures have been

observed attending the North Sea Herring fleets in October and November and wherever they find large shoals of Sprat (from the English Channel to beyond the Moray Firth), feeding flocks of several hundreds strong may be seen during winter (Nelson 1978). In a mild winter, when fish was abundant, many Gannets were found not even to leave the Bass Rock (Robinson 1935). Nearly all common North Sea fish have been recorded at some time, but pelagic shoaling fish as Herring and Mackerel are the Gannet's main food fish, with Sprat, Saithe and sandeels being also important (Nelson 1978). Gannets can handle rather large fish and may utilize older age-groups of gadoids and Herring than other seabirds can possibly do; fish of over 30 cm length are easily swallowed (Hudson & Furness 1989).

Literature on feeding habits and diet of **Black-headed Gulls** is readily available for many parts of its range, but the marine feeding of this species was seldom very prominently represented (*e.g.* Vernon 1970, Hartwig 1971, Vernon 1971, Lebret 1976, Fuchs 1977, Schlegel 1977, Hanssen 1982, Schrey 1984, Christmas *et al.* 1986, Gorke 1990, Hartwig *et al.* 1990). The wealth of information can be summarized as follows: marine fish formed only a minor part of the diet in coastal colonies of Black-headed Gulls and these fish were partly obtained by robbing other birds (*e.g.* terns), by surface feeding in tidal fronts and patches with turbulent water near the coast, and by scavenging at inshore trawlers and at fishing boats in the Wadden Sea. Even on Helgoland formed marine fish not the predominating aspect in the diet of this species (Prüter 1986).

Of **Common Gulls** nesting on Texel and in Noord-Holland, a substantial part of the food was obtained on land (Arbouw 1980, Arbouw & Swennen 1985, Keijl *et al.* 1986, Platteeuw 1986b). However, in June and July Common Gulls became progressively more numerous in the coastal zone and could be observed in mass-feedings of gulls (plunge diving) or associated with inshore shrimptrawlers (scavenging; Arbouw 1980, Arbouw & Swennen 1985, Platteeuw 1986a, Keijl *et al.* 1986, 1989). Marine fish formed a minor part of the diet on Texel (11% of pellets studied; Arbouw & Swennen 1985) and in Noord-Holland (5% of pellets; Keijl *et al.* 1986), but was relatively important during chick raising. The most important marine fish were (in descending order) Gadidae (Whiting, Bib), Ammoditydae, flatfish (Plaice, Dab), Osmeridae, and Clupeidae. Roundfish ranged from 6.5-20 cm total length, flatfish ranged from 4-7 cm width (calculated from Arbouw & Swennen 1985, see Camphuysen 1994). Common Gulls wintering at Helgoland were mainly feeding on marine fish (75.8% of 33 stomachs), plants (54.5%), rubbish (48.5%), Nereidae (27.3%), and Mollusca (18.2%; Prüter 1986). The most important marine fish were (in descending order) Gadidae (Whiting, Poor Cod), Ammoditydae, Clupeidae (Sprat), Sygnathidae, Gobiidae, and Agonidae (Hooknose).

Lesser Black-backed Gulls breeding on the Farne Islands (NE England) were mainly feeding on marine fish (74% in numbers, 77% in weight; Pearson 1968). Main prey were sandeel (55/14%), Clupeidae (6/11%), and Gadidae (13/52%). Breeding coincided with the period of greatest abundance of sandeel and Clupeidae in the area. On the basis of flying speed and the length of time away on feeding flights, the average potential feeding range of Lesser Black-backed Gulls breed on the Farne Islands was assessed at approximately 45 km. Lesser Black-backed Gulls in the Netherlands primarily feed on marine fish (Noordhuis & Spaans 1992), whereas the diet of **Herring Gulls** is more divergent and includes many kinds of marine organisms (from small crustaceans and molluscs to large fish), terrestrial animals, carrion and refuse, grains and berries (Spaans 1971, Noordhuis 1987, Noordhuis & Spaans 1992). The presence of marine fish in the diet of Herring Gulls during 1985-1987 has declined to 14% of levels found in 1966-68. The diet of both gulls includes several demersal fish which are difficult to catch by plunge diving seabirds. These fish commonly occur in the bycatch of beamtrawlers and it is therefore concluded that at least part of the fish brought ashore by these gulls must have been obtained at fishing vessels in the North Sea. Lesser Black-backed Gulls were reported to be more manoeuvrable and efficient scavengers at trawlers than Herring Gulls (Verbeek 1977, Strann & Vader 1992). The increase in numbers of breeding Lesser Black-backed Gulls on Terschelling were therefore assumed to have forced Herring Gulls to concentrate on other food resources (Noordhuis & Spaans 1992). This change in feeding habits

of the Herring Gull, may have contributed to the decline in breeding success which has taken place since the late 1960s (Noordhuis & Spaans 1992). From diet studies in the late 1960s, Spaans (1971) concluded that the total contribution of discards in the marine fish part of the diet of Herring Gull chicks was *ca.* 27% (assuming that Gadidae, flatfish and unidentified fish with white flesh were discards, while pelagic fish such as Clupeidae, Ammodytidae and Scombridae were obtained by plunge diving). Fish was particularly important for the chicks, while the diet of full grown Herring Gulls comprised mainly invertebrates from the littoral and sub-littoral zone (compiled after Pearson 1968, Noordhuis 1987, Spaans & Noordhuis 1989, Noordhuis & Spaans 1992, Meijering 1954, Ehlert 1957, Focke 1959, Ehlert 1961, Löhmer & Vauk 1969, Vauk & Löhmer 1969, Löhmer & Vauk 1970, Wietfeld 1977, Prüter 1986, Noordhuis 1987, Prüter *et al.* 1988, Spaans & Noordhuis 1989, Noordhuis & Spaans 1992).

In summer 1993, over 75% of the roundfish picked up by Lesser Black-backed Gulls during experimental discarding were gurnards, but in terms of fish mass gadids accounted for nearly half (46.4%) of the consumption (table 10). Scavenging Herring Gulls took mainly gadids (55.6% of all roundfish taken, 88.3% in terms of fish mass). Flatfish discards comprised 6 species, but were numerically dominated by Dab (61.5%), Plaice (21.3%) and Sole (11.7%). Since discarded Plaice and Sole were on average larger than Dab (Camphuysen 1994), the discards fraction of flatfish comprised an important quantity of these two flatfish in terms of fish mass (table 10). The flatfish choice of Lesser Black-backed Gulls and Herring Gulls was dominated by Dab in terms of numbers of fish and fish mass (table 10), with Sole ranking second and Plaice as a relatively unimportant species. Size selection of discarded flatfish in Herring Gulls and Lesser Black-backed Gulls was similar (median width 6 cm), and both species tended to ignore flatfish of over 8 cm in body width (see Camphuysen 1994). Compared with other scavengers at the trawl, Herring Gulls could be classified as offal specialists, second only to the highly manoeuvrable Kittiwakes. Also, Herring Gulls obtained more gadids than expected only from numbers present at the trawl. Lesser Black-backed Gulls were remarkably keen at gurnards, equalled only by Great Black-backed Gulls which tended to obtain the larger individuals through robbery from the smaller species.

Great Black-backed Gulls are powerful, large gulls which obtain a substantial part of their food in winter by robbing other seabirds. Marine fish formed an important part of the diet of these gulls, part of which was obtained by feeding in shallow water and at the surface, part of which was obtained by robbing other birds and part of which was obtained as a scavenger at trawler (either by robbing or by picking up discards) (Boddington 1959, Belopol'skii 1957, Bergman 1960, Kock 1974, Verbeek 1979, Tayler 1985, Hudson & Furness 1988, 1989, Sueur 1989, Cairns *et al.* 1991, Shillcock 1991, Walker 1991, Furness *et al.* 1992, Strann & Vader 1992). Prüter (1986) described a shift in the diet of Great Black-backed Gulls wintering on Helgoland from a 100% reliance on discards (October-February, diet 75% fish, 100% from discarded bycatch) to own catches (March-April). Obviously, the littoral zone was also of great significance for Great Black-backed Gulls on this island. As a scavenger at trawlers, Great Black-backed Gulls were high positioned in the dominance hierarchy in Scotland and Norway and obtained a substantial part of their share at boats through robbery (Hudson & Furness 1988, 1989, Furness *et al.* 1992, Strann & Vader 1992).

Kittiwakes feed exclusively on the surface and have a very limited (plunge-) diving capacity (Belopol'skii 1961, Burtt 1974). Feeding occurs when settled on the water, but most often the Kittiwakes continue flying around and around, pecking small particles from the surface (Cramp & Simmons 1983, Hartley & Fisher 1936, Nelson 1980, Vauk & Jokele 1975). In local upwellings Kittiwakes can be seen feeding on zooplankton, either by swimming and dipping or by flying around and (shallow) plunge diving, in vast numbers (Hartley & Fisher 1936, pers. obs.). Pearson (1968) lists offal from fishing boats, surface living crustaceans and fish (post-larval and juvenile Gadidae, Ammodytidae, and Clupeidae) as most important food items. Over 21 species of fish were listed in literature to feature in the Kittiwake's diet, including Herring, Sprat, Capelin, Cod, Arctic Cod, Haddock, Whiting, Blue Whiting, Poor Cod, Bib, Saithe, Viviparous Blenny, Stickleback, Nilsson's Pipefish, unident. pipefish, Hooknose,

Table 10. Fish species dominating the discards fraction (%) at a commercial beamtrawler, June-August 1993, in terms of number of fish and fish mass, and the relative importance of these fish for scavenging Lesser Black-backed Gulls and Herring Gulls (Camphuysen in prep).

Species	Offered		Less. Bl.b. Gull		Herring Gull	
	numbers	mass	numbers	mass	numbers	mass
Flatfish						
Limanda limanda	61.5	47.1	75.3	66.2	86.7	76.1
Pleuronectus platessa	21.3	35.3	3.5	4.8	3.3	7.4
Solea solea	11.7	17.0	13.6	27.9	10.0	16.5
Buglossidium luteum	5.5	0.6	7.7	1.1	0.0	0.0
Roundfish						
Gadus morhua	5.1	18.5	2.1	8.6	12.7	22.0
Merlangius merlangus	16.5	38.0	13.9	37.8	42.9	66.3
Callionymus lyra	15.2	7.2	8.6	4.8	9.5	1.7
Eutrigla gurnardus	52.5	27.0	65.2	40.4	34.9	10.1
Trigla lucerna	10.7	9.4	10.2	8.4	0.0	0.0

Lumpsucker, Butterfish, sandeels, Greater Sandeel, Sand Goby (Belopol'skii 1961, Galbraith 1983, Vauk & Jokele 1975, Vauk-Hentzelt & Bachmann 1983, Camphuysen 1990). Invertebrates are reported frequently, but in smaller quantities by weight, including Chaetognaths, Mollusca, Crustacea, Polychaetes and Echinoderms. Plastics, grid, vegetable matter, insects and all sorts of litter are frequently encountered in Kittiwakes stomachs (Belopol'skii 1961, Vauk & Jokele 1975, Vauk-Hentzelt & Bachmann 1983, Camphuysen 1989b, *pers. obs.*). Kittiwakes are often seen to follow trawlers in large numbers and several reports indicate their preference for both discarded fish (up to 15 cm; Watson 1981) and offal (Watson 1978, 1981, Benn *et al.* 1988, Hudson 1988). Kittiwakes are seen to feed on offal and discards during towing and sorting, but they also take all sorts of small particles, dipping, when the net is being lifted (Watson 1981). Harvey *et al.* (1989) found trawler waste in 27% of the food samples of Kittiwakes breeding at Fair Isle in 1989; nothing other than sandeel had figured prominently in their diet before that year. The diet and feeding habits of Kittiwakes are less catholic than that of other gulls. Kleptoparasitism by Kittiwakes received little attention in literature, probably because Kittiwakes are so often the victim of Great and Arctic Skuas chasing them for food. Kleptoparasitism by Kittiwakes themselves is described by Harkness (1959) and Moritz (1986).

10. Discussion

THE USE OF DISCARDS IN THE SOUTHERN NORTH SEA Beamtrawl fisheries in the southern North Sea produce a large amount of offal and discards which is exploited by a variety of seabirds. All size classes of fish normally represented in the discards fraction, except some of the larger Plaice and Flounder (Van Beek 1990, Garthe 1993, Camphuysen 1994, this report), were suitable for consumption for the combination of these species (table 7). Consumption rates of benthic invertebrates were invariably very low. Special conditions, such as prolonged periods of poor weather, may elevate consumption rates off less preferable items in the discards fraction, as a result of increased competition at the trawl (Garthe pers. comm., Camphuysen 1993b). Consumption rates of roundfish (87%), flatfish (28%), and offal (82%) were roughly in agreement with earlier findings, elsewhere and in the southern North Sea (Berghahn & Rösner 1992, Camphuysen *et al.* 1993, Garthe 1993). In summer, scavengers at trawlers were numerically dominated by Lesser Black-backed Gulls, and most of these birds were probably breeding birds. Many Fulmars (wing moult) and Gannets (immature plumage) were non-breeders or immatures. Herring Gulls occurred concentrated near the coast (and near breeding colonies), and these were probably mainly breeding birds. High numbers of Herring Gulls at trawlers to the west and

northwest of Helgoland were, although classified as adults, probably mainly non-breeders. Common Gulls and Black-headed Gulls were scarce at offshore trawlers in the breeding season, but several scavenging flocks were seen closely inshore. In winter, Lesser Black-backed Gulls abandoned the southern North Sea, whereas several other *Larus*-gulls increase in numbers at sea (Camphuysen & Leopold 1994). In conclusion, discards produced in the offshore zone of the southern North Sea are of particular importance for breeding Lesser Black-backed Gulls and for non-breeding individuals of a variety of other species.

THE IMPORTANCE OF DISCARDS IN SEABIRD DIETS Most of the scavenging seabirds described in this report have a varied diet, comprising a great variety of prey from oceanic zooplankton to chicken bones on rubbish tips and from pelagic fish to french fries on city streets. It is important to realize that most studies of seabird diets were during the breeding season, whereas winter feeding remained fairly unsurveyed. In breeding Fulmars, a species which is famous as a scavenger at trawlers, dietary studies in colonies showed that prey are dominated by zooplankton, pelagic fish and sandeel rather than by offal and discards. Similarly, Spaans *et al.* (1994) found that although diets of Lesser Black-backed Gulls comprised substantial amounts of discards, high breeding success occurred in years that Herring features prominently in chick regurgitations (Herring is sparsely discarded in beamtrawl fisheries). As a result, there appears to be a discrepancy between findings in dietary studies (use of discards frequent, but as an additional source of food) and sightings at sea (large flocks of eagerly scavenging birds at boats). Estimates on the basis of known quantities of discards in commercial fisheries in the North Sea indicated that over 2 million seabirds may be supported by discards (Furness *et al.* 1988, Camphuysen *et al.* 1993). However, this does not necessarily mean that 2 million seabirds would suffer from significant food shortages, when discards are suddenly no longer supplied! Scavenging should not be overestimated in the absence of less easily gathered data on natural feeding. Distribution patterns of seabirds in the North Sea, as recently prepared from large, joint databases, indicate that the spatial distribution of the main fisheries and seabirds only partly overlap (ESAS Database, unpubl. data). The number of seabirds at sea, even in the case of notorious scavengers as Fulmars and Kittiwakes, is certainly not simply a function of the numbers of commercial trawlers available in that area. Considering the specializations and dominance hierarchies of scavengers observed at trawlers in the southern North Sea, the following effects of changes in fishing effort, discard practices or catch composition (mesh size) can be expected. An increase in mesh size, *i.e.* a decline in numbers of small fish caught, would mainly affect the feeding opportunities of Kittiwakes and Common Gulls (table 7). From increased competition at trawlers, resulting from a smaller amount of discards per haul or a reduction in fishing effort in the southern North Sea, it is likely that Kittiwake, Fulmar and Lesser Black-backed Gull suffer most (species with high vulnerability to robbery indices), whereas Gannet and Great Black-backed Gull are probably unaffected (table 9; insufficient data for Common Gulls). When fishing effort would be further reduced in the coastal zone, it is likely that feeding possibilities at sea of Common Gull, Black-headed Gull and Herring Gull are also severely affected. A reduction in the amount of offal produced in beamtrawl fisheries would mainly influence scavenging efficieny of Kittiwake, Fulmar and Herring Gull in summer, and Kittiwake in winter (table 6). Serious reductions in the amount of benthic invertebrates set over the side in beamtrawl fisheries will not have any effect on scavenging seabirds. 'Affecting' a species could mean that other food resources need to be exploited at sea (Fulmar, Gannet, Kittiwake), or that other feeding areas are to be used (*Larus*-gulls). Extra mortality as a result of starvation is possible, but not to be directly expected. Considering recent findings in changes in the diet of Herring Gulls on Terschelling (Spaans 1971, Noordhuis 1987, Noordhuis & Spaans 1992), a measurable effect would be greater annual fluctuations in breeding success when discards are less available, because 'poor years' in terms of available pelagic fish will have more pronounced negative effects on chick provision.

THE RELATIVE IMPORTANCE OF SECTORS PROPOSED FOR PROTECTION FOR SCAVENGING SEABIRDS The proposed protected areas off the Wadden Sea islands (the area at Klaverbank is too small to

be considered in terms of numbers of seabirds using that part of the North Sea), are of particular significance for Lesser Black-backed Gulls and Herring Gulls breeding on Texel, Vlieland and Terschelling. Breeding Common Gulls and Black-headed Gulls hardly occurred in these waters in summer. A reduction in fishing effort (and, hence, discards provision) is most likely to affect Lesser Black-backed Gulls. Not only is the diet of this species less varied than that of Herring Gulls, but also is the North Sea the prime feeding habitat of birds breeding on these islands with only two options: fishing or scavenging. The littoral zone and feeding areas on land, although extensively used by this species elsewhere, are currently of minor importance for Lesser Black-backed Gulls. A sudden change of feeding habits and the increased use of food resources on land or in the littoral zone will probably lead to increased competition with Herring Gulls and probably also with Common Gulls. Reductions in breeding success and population declines are the most probable results of such changes. Wintering and/or migratory seabirds, some of which were found in (inter-) nationally important numbers in these sectors, are probably adaptable enough to follow the fishing fleet if fishing were to be banned completely from these areas.

FURTHER STUDIES Information on the quantity and composition of discards and offal in different fisheries is not sufficiently available, and more information needs to be collected on board commercial trawlers. Basic questions are: (1) How much biota are discarded (species composition, quantity, size, spatial and temporal distribution). (2) The turnover rate of scavengers at a trawler deserves much more study. (3) Diet studies in gull colonies at the Wadden Sea islands should 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, to assess feeding ranges more precisely. (4) The scavenging habits of Common Gulls and Black-headed Gulls (in winter) have not sufficiently been studied. 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 prey selection and their status in the dominance hierarchy at trawlers. Future research on diets of breeding gulls should focus on the relationship between breeding success and the proportions of discards as opposed to pelagic fish in meals fed to the chicks, on breeding numbers and breeding success.

11. Conclusions

(1) The most important scavengers in the southern North Sea (between 51° and 56°N), of a total of 28 recorded species, are 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*, Great Black-backed Gull *Larus marinus*, and Kittiwake *Rissa tridactyla*.

(2) 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.

(3) Important scavengers breeding in substantial numbers in the Netherlands are Black-headed Gull, Common Gull, Lesser Black-backed Gull and Herring Gull. (Inter-) nationally important colonies of Lesser Black-backed Gull and Herring are found on Texel, Vlieland, and Terschelling. Birds from these colonies were found distributed at sea in waters that are completely or partly overlapping sectors proposed for a protected status.

(4) Peak numbers at sea during the breeding season (April-July) of Herring Gull and Lesser Black-backed Gull within the Dutch sector of the North Sea were estimated at 39,700 and 57,900 individuals respectively, or 2.8% and 12.9% of their respective NE Atlantic populations (Camphuysen & Leopold 1994, Rose & Scott 1994).

(5) Within the sector proposed for a protected status (53-54°N, 4-6°E), maxima of 9500 Herring Gulls (23.9% of total numbers at sea within the Dutch sector) and 24,000 Lesser Black-backed Gulls (41.4% of numbers in the Dutch sector) were found in April-May. Over 90% of these gulls were classified as adults, and were potentially breeding birds.

(6) Peak numbers at sea during the breeding season (April-July) of Black-headed Gull and Common Gull within the Dutch sector of the North Sea were estimated at 3100 and 3400 individuals respectively, or 0.1% and 0.2% of their respective NE Atlantic population (Camphuysen & Leopold 1994, Rose & Scott 1994).

(7) Within the sector proposed for a protected status (53-54°N, 4-6°E), maxima of 60 Black-headed Gulls in April-May and 700 Common Gulls were found in June-July.

(8) Peak numbers of other scavenging seabirds within the sector proposed for protection were 32,000 Fulmars (February-March), 4400 Gannets (October-November), 500 Great Skuas (August-September), 1700 Little Gulls (October-November), 13,600 Great Black-backed Gulls (October-January), and 13,300 Kittiwakes (October-November).

(9) An increase in mesh size would mainly affect the feeding opportunities of Kittiwakes and Common Gulls.

(10) Reductions in the amount of discards and offal discharged in commercial fisheries as a whole, would lead to increased competition at trawlers, from which Kittiwake, Fulmar and Lesser Black-backed Gull will suffer most, whereas Gannet and Great Black-backed Gull are probably largely unaffected.

(11) Reductions of fishing effort in the coastal zone, would mainly affect the possibilities to feed for Common Gull, Black-headed Gull and Herring Gull.

(12) Reductions in the amount of offal produced in beamtrawl fisheries would mainly affect feeding opportunities of Kittiwake, Fulmar and Herring Gull in summer, and Kittiwake and Lesser Black-backed Gull in winter.

(13) Serious reductions in the amount of benthic invertebrates set over the side in beamtrawl fisheries will not have any effect on scavenging seabirds.

(14) Measurable effects of declines in amounts of discards provided at sea for gulls breeding in the Netherlands would be greater annual fluctuations in breeding success, because 'poor years' in terms of the availability of pelagic fish will have more pronounced negative effects on chick provision.

(15) The proposed protected areas off the Wadden Sea islands are of particular significance for Lesser Black-backed Gulls and Herring Gulls breeding on Texel, Vlieland and Terschelling.

(16) The establishment of 'protected areas', closed for fisheries, off the Dutch Wadden Sea islands (as proposed in Bergman *et al.* 1991) will probably only negatively affect the foraging possibilities of Lesser Black-backed Gulls to a measurable extent, particularly affecting the breeding population on Texel, Vlieland and Terschelling (*ca.* 50% of the Dutch population).

(17) A sudden change of feeding habits of Lesser Black-backed Gulls and increased use of food resources on land or in the littoral zone will lead to increased competition with Herring Gulls and Common Gulls. Reductions in breeding success and population declines are the most probable results of such changes.

(18) Wintering and/or migratory seabirds will probably follow the fishing fleet if fishing were to be banned completely from these protected areas.

(19) Future studies should focus on (1) the quantity and composition of discards and offal in different fisheries in the southern North Sea, (2) the turnover rate of scavengers at trawlers, (3) diets of gulls breeding on the Wadden Sea islands, and particularly the relationship between breeding success and the provision of chicks with discards and/or pelagic fish.

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Camphuysen C.J. *in prep.* Herring Gull *Larus argentatus* and Lesser Black-backed Gull *L. fuscus* feeding at trawlers in the breeding season: competitive scavenging versus efficient flying. Manuscript.
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Appendix 1. Definitions, terms and bird names used in this report

Benthic invertebrates - bottom fauna, including Brittle Star, Starfish, shellfish, Astropecten, Echinocardium, Aphrodite, and crustaceans.

Breeding season - Nesting period for seabirds in the southern North Sea (April-August), also referred to as 'summer'.

Consumption rate - Percentage of discarded fish and particles of offal consumed by seabirds of total amount discharged during experimental discarding.

Discards - unmarketable fish or bycatch.

Discard experiment - experimental discarding of fish, benthic invertabrates or offal from a ship, recording fate and consumer.

Flatfish - fish families including Plaice, Turbot, Brill, Dab, Sole, Solenette, Flounder, and Lemon Sole.

Maximum stern count - maximum of each seabird species attending a trawler during a particular haul.

Non-breeding season - outside the nesting period for seabirds in the southern North Sea (September-March), also referred to as 'winter'.

Offal - entrails of gutted (marketable) fish.

Protected areas - Proposed areas in the Dutch sector of the North Sea, which may be closed for all types of fisheries throughout the year (see Bergman *et al.* 1991; figure 1).

Roundfish - fish families including Herring, Sprat, Cod, Whiting, Haddock, Bib, Poor Cod, sandeels, Mackerel, Scad, and gurnards.

Scavenging - feeding on dead or weakened prey, discarded from trawlers.

Stern count - assessment of numbers of seabirds associated with a ship.

Success index - (S.I.) Percent of all fish swallowed by a seabird species or age group, divided by percent of all birds present that were this species or age group at the vessel during experimental discarding.

Summer - See: 'Breeding season'.

Vulnerability to robbery index - Number of experimental discards stolen from a seabird species or age group divided by the number of experimental discards stolen by this species.

Winter - See: 'Non-breeding season'.

Scientific name	English name	Nederlandse naam	
Fulmarus glacialis	Fulmar	Noordse Stormvogel	
Puffinus griseus	Sooty Shearwater	Grauwe Pijlstormvogel	
Puffinus puffinus	Manx Shearwater	Noordse Pijlstormvogel	
Hydrobates pelagicus	Storm Petrel	Stormvogeltje	
Sula bassana	Gannet	Jan van Gent	
Phalacrocorax carbo	Cormorant	Aalscholver	*) ●
Phalacrocorax aristotelis	Shag	Kuifaalscholver	
Stercorarius pomarinus	Pomarine Skua	Middelste Jager	
Stercorarius parasiticus	Arctic Skua	Kleine Jager	
Stercorarius longicaudus	Long-tailed Skua	Kleinste Jager	
Stercorarius skua	Great Skua	Grote Jager	
Larus melanocephalus	Mediterranean Gull	Zwartkopmeeuw	○
Larus minutus	Little Gull	Dwergmeeuw	○
Larus ridibundus	Black-headed Gull	Kokmeeuw	●
Larus canus	Common Gull	Stormmeeuw	●
Larus fuscus	Lesser Black-backed Gull	Kleine Mantelmeeuw	●
Larus argentatus	Herring Gull	Zilvermeeuw	●
Larus cachinnans	Yellow-legged Gull	Geelpootmeeuw	○
Larus glaucoides	Iceland Gull	Kleine Burgemeester	
Larus hyperboreus	Glaucous Gull	Grote Burgemeester	
Larus marinus	Great Black-backed Gull	Grote Mantelmeeuw	○
Rissa tridactyla	Kittiwake	Drieteenmeeuw	
Sterna sandvicensis	Sandwich Tern	Grote Stern	●
Sterna hirundo	Common Tern	Visdiefje	●
Sterna paradisaea	Arctic Tern	Noordse Stern	●
Chlidonias niger	Black Tern	Zwarte Stern	●
Uria aalge	Guillemot	Zeekoet	
Alca torda	Razorbill	Alk	

**) Common (●) and rare (○) breeding species in The Netherlands are indicated.*

Appendix 2. Discards offered during experimental discarding, southern North Sea, 1992-94.

G	Scientific name	Nederlandse naam	Offered
B	unident. anemone	anemoon	1
B	Acanthocardia echinata	Gedoornde Hartschelp	3
B	Arctica islandica	Noordkromp	4
B	Aphrodite aculeata	Zeemuis	71
B	Nereis spec.	ongedet. borstelworm	3
B	Corystes cassivelaunus	Helmkrab	193
B	Liocarcinus holsatus	Gewone zwemkrab	63
B	Nephrops norvegicus	Noorse Kreeft	2
B	Pagurus bernhardus	Heremietkreeft	39
B	Buccinum undatum	Wulk	1
B	Echinocardium cordatum	Hartegel	65
B	Psammechinus miliaris	Zeeappel	30
B	Asterias rubens	Gewone zeester	1171
B	Astropecten irregularis	Kamster	568
B	Ophiura spec.	Slangster	440
C	Loligo spec.	pijlinktvis	9
C	Octopus vulgaris	Octopus	1
F	Raja radiata	Sterrog	2
F	Lophius piscatorius	Zeeduivel	1
F	Platichthys flesus	Bot	5
F	Limanda limanda	Schar	1352
F	Glyptocephalus cynoglossus	Hondstong	1
F	Hippoglossoides platessoides	Lange schar	9
F	Solea solea	Tong	157
F	Buglossidium luteum	Dwergtong	73
F	unidentified flatfish	ongedet. platvis	2
F	Scophthalmus rhombus	Griet	4
F	Phrynorhombus norvegicus	Dwerg-tarbot	1
F	Arnoglossus laterna	Schurftvis	9
F	Pleuronectes platessa	Schol	372
O	offal	Snijafval	2124
R	Scyliorhinus canicula	Hondshaai	17
R	Squalus acanthias	Doornhaai	1
R	Clupea harengus	Haring	1538
R	Sprattus sprattus	Sprot	646
R	Enchelyopus cimbrius	Vierdradige meun	14
R	Gadus morhua	Kabeljauw	82
R	Merlangius merlangus	Wijting	1352
R	Melanogrammus aeglefinus	Schelvis	195
R	Trisopterus minutus	Dwergbolk	10
R	Trisopterus esmarkii	Kever	106
R	Trisopterus luscus	Steenbolk	16
R	Molva molva	Leng	5
R	Merluccius merluccius	Heek	1
R	Belone belone	Geep	4
R	Syngnathus acus	Grote zeenaald	1
R	Eutrigla spec.	ongedet. poon	8
R	Trigla lucerna	Rode poon	180
R	Eutrigla gurnardus	Grauwe poon	660
R	Myoxocephalus scorpius	Zeedonderpad	1
R	Agonus cataphractus	Harnasmannetje	43
R	Trachurus trachurus	Horsmakreel	29
R	Echiichtys vipera	Kleine Pieterman	20
R	Hyperoplus lanceolatus	Smelt	6
R	Callionymus lyra	Pitvis	224
R	Callionymus maculatus	Gevlekte Pitvis	4
R	Pomatoschistus minutus	Dikkopje	3
R	Scomber scombrus	Makreel	2
Total number			11944

Appendix 3.

Prey selection at the trawl during experimental discarding, southern North Sea, 1992-94. Shown are for each of the important scavengers in the southern North Sea, the number of fish offered per cm width (flatfish) or total length (roundfish), median width/length of fish offered (*), number of fish consumed and median consumed (*). Samples were only shown if more than 100 fish of a certain species were offered in the presence of the scavenger.

Fulmar *Fulmarus glacialis* — Flatfish consumption

Total Width	Dab Offered	Dab Picked	Dab Swallowed	Sole Offered	Sole Picked	Sole Swallowed	Total numbers Offered	Total numbers Picked	Total numbers Swallowed	Total Width
2	1						1			2
3	12		1				12		1	3
4	64						64			4
5	170		1	2			172		1	5
6	270 *			27 *			297 *			6
7	463	1		86	1		549	2		7
8	118			11			129			8
9	47			3			50			9
10	7						7			10
11	2			1			3			11
12										12
13										13
14										14
15										15
16										16
17										17
18										18
19										19
20										20
Total	1154	1	2	130	1		1284	2	2	
min	2	7	3	5	7		2	7	3	
median	6			6			6			
max	11	7	5	11	7		11	7	5	

Total length	Grey Gurnard Offered	Picked	Swallowed	Haddock Offered	Picked	Swallowed	Herring Offered	Picked	Swallowed	Red Gurnard Offered	Picked	Swallowed	Sprat Offered	Picked	Swallowed	Total length
5													5			5
6							1						28			6
7							1			1			20			7
8	1						3						32			8
9							4			1			48 *			9
10	1						30			1	1		87			10
11	6						33			3			63		1	11
12	10						81			3	2		39		1	12
13	12			2			100			2	3		19		1	13
14	16			3			116			2	4		6			14
15	28			7			163				4		5		1	15
16	45			7			201 *			7	9					16
17	75			4			119			8 *	8	1	1			17
18	89 *			20			78			8	9		1			18
19	87	1		32			48			7	14		2			19
20	62			25 *			60			3	11					20
21	38	1		18			41			1	15 *					21
22	34			5			50			1	16					22
23	36	1		8			64			4	12					23
24	11	1 *		2			18			3	10					24
25	19	1		2			2			1	11					25
26	10	2		4	1	1	4	2			6					26
27	9		1	4			1				9					27
28	9			3	1		2	1			8					28
29	5			4			3			1	4	4 *				29
30				3			3	1			4	1				30
31	3			4												31
32	4	1		4							1					32
33	2			9												33
34				7												34
35				5												35
36	2			2												36
37																37
38	1															38
39				1												39
40				1												40
Total	615	8	1	186	2	1	1226	4	57	161	6		356		4	
min	8	19	27	13	26	26	5	4	6	10	17		5		10	
median	18	24		20			16		17	21	29		9			
max	38	32	27	40	28	26	30	30	29	32	29		19		14	

Total length	Whiting			Total numbers			Total length
	Offered	Picked	Swallowed	Offered	Picked	Swallowed	
5				5			5
6				29			6
7				21		1	7
8				36			8
9	1			53		1	9
10	4			123		1	10
11	5			107		4	11
12	16			148		4	12
13	17			153		3	13
14	41		2	186		4	14
15	55			262		1	15
16	75		2	337		9	16
17	80		4	287 *	1	12	17
18	63		5	260		13	18
19	49		8	232	1	15 *	19
20	51		8	209		11	20
21	68		5 *	180	1	6	21
22	104 *		4	209		5	22
23	105		2	225	1	6	23
24	84	10	11	125	11	14	24
25	62	2	8	96	3	9	25
26	66	1 *	3	90	6 *	4	26
27	68	6	4	91	6	5	27
28	55	2	3	77	4	3	28
29	45	5		61	9	1	29
30	26			36	2		30
31	17	1		24	1		31
32	9	1		18	2		32
33	5			16			33
34	3			10			34
35	2			7			35
36	3			7			36
37							37
38				1			38
39				1			39
40				1			40
Total	1179	28	69	3723	48	132	
min	9	24	13	5	17	7	
median	22	26	21	17	26	19	
max	36	32	28	40	32	29	

Total Width	Dab Offered		Consumed		Total Width
2					2
3	4				3
4	25		1		4
5	54				5
6	95	*	6		6
7	208		21	*	7
8	61		8		8
9	18		1		9
10	3				10
11					11
12					12
13					13
14					14
15					15
16					16
17					17
18					18
19					19
20					20
	468		37		
min	3		4		
median	6		7		
max	10		9		

Total length	Grey Gurnard offered	Grey Gurnard consumed	Haddock offered	Haddock consumed	Herring offered	Herring consumed	Norway Pout offered	Norway Pout consumed	Sprat offered	Sprat consumed	Whiting offered	Whiting consumed	Total numbers offered	Total numbers consumed	Total length
5									2				2		5
6					1				3				4		6
7					1				13				14		7
8					1				19				20		8
9									29				29		9
10	1				11				69 *		3		84		10
11	3				23				48		2		76		11
12	3				43		4		25		11		86		12
13	1		2		66		4		15		10		98		13
14	2		3		61	1	12	1	5		30	2	113	4	14
15	5		7		97 *		25	4 *	5		34	1	173	5	15
16	13		7		73	2 *	6 *				48	2	147	4	16
17	14		3		52		31	4	1		57	2	158 *	6	17
18	21		14	1	36		12	2	1	1	50	2	134	6	18
19	22 *	1	23	1	19	1	1		2		32	2	99	5	19
20	12	1	19 *		25						44	2	100	3	20
21	9		13	3	15		1	1			52 *	4	90	8	21
22	11		4		17						65	5	97	5	22
23	16	1	4		23						76	9	119	10	23
24	7	2	2		11						66	6	86	8	24
25	6		2		1						43	7 *	52	7	25
26	2		3		3						34	9	42	9 *	26
27	3	1 *	2		1						37	5	43	6	27
28	4	2	3		2	1					24	7	33	10	28
29	3		2	1	3						16	1	24	2	29
30			3	2	3						12	5	18	7	30
31	2	1	5	4							12	4	19	9	31
32	4	1	3	3 *							4	3	11	7	32
33			11	8							1	1	12	9	33
34			6	5							2	1	8	6	34
35			6	5							2	1	8	6	35
36	1	1	2	2							3	3	6	6	36
37															37
38															38
39			1	1									1	1	39
40			1	1									1	1	40
	165	11	151	37	588	5	96	12	237	1	770	84	2007	150	
	165	11	151	37	588	5	96	12	237	1	770	84	2007	150	
min	10	19	13	18	6	14	12	14	5	18	10	14	5	14	
median	19	27	20	32	15	16	16	15	10		21	25	17	26	
max	36	36	40	40	30	28	21	21	18	18	36	36	40	40	

Total length	Herring offered	consumed	Sprat offered	consumed	Whiting offered	consumed	Total numbers Offered	Consumed	Total length
5			5				5		5
6			32	2			32	2	6
7	1		13				14		7
8	2		39	1	1		42	1	8
9	2		71	3 *	3		76	3	9
10	25		86 *	2	1		112	2	10
11	27	1	86	1	5		118	2	11
12	40	3	68	1	8		116	4	12
13	66	13	56	1	9		131	14 *	13
14	87 *	8 *	31		25		143 *	8	14
15	57	11	5		21		83	11	15
16	69	9	1		29		99	9	16
17	26	1			28		54	1	17
18	10		1		24	1	35	1	18
19	10		2		17		29		19
20	21	2			37	1	58	3	20
21	7	1			34		41	1	21
22	4				43 *		47		22
23	12				54		66		23
24	8				49		57		24
25	1				37		38		25
26	2				36		38		26
27	1				33		34		27
28	1				26		27		28
29	3				15		18		29
30	2				16		18		30
31					10		10		31
32					6		6		32
33					2		2		33
34					1		1		34
35					1		1		35
36					1		1		36
37									37
38									38
39									39
40									40
Total	484	49	496	11	572	2	776	31	
min	7	11	5	6	8	18	5	6	
median	14	14	10	9	22		14	13	
max	30	21	19	13	36	20	36	21	

Lesser Black-backed Gull *Larus fuscus*

Flatfish consumption

Total width	Dab		Plaice		Sole		Total numbers		Total width
	Offered	Consumed	Offered	Consumed	Offered	Consumed	Offered	Consumed	
2									2
3	7	1			2		9	1	3
4	60	20			1		61	20	4
5	170	74	2		2	1	174	75	5
6	232	77 *	3		29	6	264	83 *	6
7	420 *	71	15	4	93 *	28 *	528 *	103	7
8	95	9	39	6 *	15	7	149	22	8
9	46	4	118 *	2	3		167	6	9
10	4		93				97		10
11	2		52		1		55		11
12			7				7		12
13			4				4		13
14			1				1		14
15									15
16									16
17									17
18									18
19									19
20									20
	1036	256	334	12	146	42	758	155	
min	3	3	5	7	3	5	3	3	
median	7	6	9	8	7	7	7	6	
max	11	9	14	9	11	8	14	9	

Total length	Dragonet Offered	Dragonet Consumed	Grey Gurnard Offered	Grey Gurnard Consumed	Herring Offered	Herring Consumed	Whiting Offered	Whiting Consumed	Total numbers Offered	Total numbers Consumed	Total length
5											5
6											6
7											7
8			1				1		2		8
9							4	1	4	1	9
10	1		1		3		3	1	8	1	10
11	1	1	4	1	4		7		16	2	11
12	9	3	7	5	11	1	7	1	34	10	12
13	9	2	14	10	30		8		61	12	13
14	15	9	17	12	29		23		84	21	14
15	30	15 *	30	24	16		15	1	91	40	15
16	20 *	7	44	35	17 *		28	2	109	44	16
17	30	9	80	71	2		18	1	130	81	17
18	29	6	89 *	71 *	2		23	4	143	81 *	18
19	15	4	86	69			22	8	123 *	81	19
20	14	2	57	47			29	5	100	54	20
21	11	2	33	22	1		34	7	79	31	21
22	6		32	24	3		56 *	23	97	47	22
23	7		29	26	9		56	10 *	101	36	23
24	1		8	6	20	2	55	16	84	24	24
25			22	15	17		34	6	73	21	25
26			12	5	13		45	10	70	15	26
27			5	1	8		42	13	55	14	27
28			5	1	13		29	9	47	10	28
29			3		6		36	8	45	8	29
30			1		6		8	3	15	3	30
31							11	1	11	1	31
32			1				4		5		32
33			1				2		3		33
34							3		3		34
35							1		1		35
36			1				2		3		36
37											37
38							1		1		38
39											39
40											40
Totaal	198	60	583	445	210	3	607	130	1598	638	
min	10	11	8	11	10	12	8	9	8	9	
median	16	15	18	18	16		22	23	19	18	
max	24	21	36	28	30	24	38	31	38	31	

Total width	Dab Offered	Dab Consumed	Plaice Offered	Plaice Consumed	Total numbers Offered	Total numbers Consumed	Total width
2	1				1		2
3	10	3			10	3	3
4	48				48		4
5	117	5	2		119	5	5
6	216 *	15	3		219	15	6
7	401	18 *	5		406 *	18 *	7
8	104	2	25	1	129	3	8
9	42	2	74 *	2	116	4	9
10	6		53		59		10
11	2		27		29		11
12			6		6		12
13			5		5		13
14			1		1		14
15							15
16							16
17							17
18							18
19							19
20							20
	947	45	201	3	1148	48	
min	2	3	5	8	2	5	
median	6	7	11		7	7	
max	11	9	14	9	14	9	

Total length	Dragonet Offered	Dragonet Consumed	Grey Gurnard Offered	Grey Gurnard Consumed	Haddock Offered	Haddock Consumed	Herring Offered	Herring Consumed	Red Gurnard Offered	Red Gurnard Consumed	Sprat Offered	Sprat Consumed	Whiting Offered	Whiting Consumed	Total numbers Offered	Total numbers Consumed	Total length
5											5				5	0	5
6							1				32				33	0	6
7											17	2			17	2	7
8			1	1			3				45	4	1		50	5	8
9							2				83	7	4		89	7	9
10	1	1	1				15	1	1		107 *	3	3		128	5	10
11			6	1			21	3			102	4 *	8	1	137	9	11
12	5	1	7				64	5	3		80	5	16	1	175	12	12
13	3		4		2		117	3	3		66	8	18	1	213	12	13
14	8	1	8	3	3		164	17	2	1	35	3	40	3	260	28	14
15	12		12	1	7	1	217 *	24	4		6	1	55	3	313	30	15
16	11	2 *	28	1	7		218	32	5		1		76	7	346	42	16
17	17	1	50	5	4		121	21	8	1 *	1		78	6	279 *	34	17
18	20 *	2	68 *	8 *	19	2	72	14 *	7		1		67	8	254	34	18
19	13		67	5	33	4	44	19	12	1	2		49	12	220	41	19
20	11		49	5	26 *	2	66	17	7				58	12	217	36 *	20
21	14	1	26	2	18	1	47	12	9 *				60	14	174	30	21
22	9	1	25	3	5	2 *	46	23	10				95 *	23	190	52	22
23	10		24	2	5	5	72	23	6				96	30 *	213	60	23
24	1		8				35	8	9				87	17	140	25	24
25	1		13	1			18	6	5				67	33	104	40	25
26			8	1	1	1	12	1	4				68	17	93	20	26
27			5	1	4	2	8	3	8				72	18	97	24	27
28			6		2	2	12	5	5				56	18	81	25	28
29			4		4		6	2	2				46	9	62	11	29
30					2		5		3				28	4	38	4	30
31			3	1	5	1							23	7	31	9	31
32			4		4				1				10	2	19	2	32
33			2		11	1							6		19	1	33
34					7	1							4		11	1	34
35					6	1							2		8	1	35
36			2		2								3		7	0	36
37															0	0	37
38			1										1		2	0	38
39					1										1	0	39
40					1										1	0	40
Totaal	136	10	432	41	179	26	1386	239	114	3	583	37	1197	246	4027	602	
min	10	10	8	8	13	15	6	10	10	14	5	7	8	11	5	7	
median	18	16	18	18	20	22	15	18	21	17	10	11	22	23	17	20	
max	23	22	38	31	40	35	30	29	32	19	19	15	38	32	40	35	

Total width	Dab		Plaice		Sole		Total numbers		Total width
	Offered	Consumed	Offered	Consumed	Offered	Consumed	Offered	Consumed	
2	1						1		2
3	11	1			2		13	1	3
4	70	5			1		71	5	4
5	198	4	2		4		204	4	5
6	292 *	17 *	3	1	29		324 *	18 *	6
7	485	28	14	1	89 *	4	588	33	7
8	132	9	43	3 *	12		187	12	8
9	55	2	123 *	1	3		181	3	9
10	8		85	3			93	3	10
11	3		51	1	1		55	1	11
12			7				7		12
13			5				5		13
14			1				1		14
15									15
16									16
17									17
18									18
19									19
20									20
	1255	66	334	10	141	4	865	40	
min	2	3	5	6	3	7	2	3	
median	6	6	9	8	7		6	6	
max	11	9	14	11	11	7	14	11	

Great Black-backed Gull *Larus marinus*

Roundfish consumption

Total length	Dragonet Offered	Dragonet Consumed	Grey Gurnard Offered	Grey Gurnard Consumed	Haddock Offered	Haddock Consumed	Herring Offered	Herring Consumed	Red Gurnard Offered	Red Gurnard Consumed	Sprat Offered	Sprat Consumed	Whiting Offered	Whiting Consumed	Total numbers Offered	Total numbers Consumed	Total length
5											6				6		5
6							1				34				35		6
7							1				21				22		7
8			2				3				47		1		53		8
9							2				82		4		88		9
10	1		1				25		1		107 *		6		142		10
11	1		7				36				101	1	9		154	1	11
12	9		11	1			75	3	3	1	78		16	1	195	7	12
13	8		12		2		124		3		65		18		235		13
14	15		15		3		148	3	3		33		43	1	263	4	14
15	29		25		6		181 *	4	5	1	6		54	1	311	7	15
16	19		45	3	6		211	6	9	1	1		74	2	374	13	16
17	28 *		76	1	4		110	6	12	3	1		81	2	324 *	15	17
18	27	1	92 *		20	1	61	2	10	2	1		68	5	289	13	18
19	16		80	2	33 *	2	42	6	15		2		50		253	10	19
20	15		58	4	25	5 *	66	6 *	11	1 *			57	3	243	20	20
21	15		38	2 *	17	4	41	6	8 *	2			65	4	192	20	21
22	8	2 *	31	3	4		45	5	13	2			99 *	18	213	32	22
23	12		30	2	6		69	10	13				98	18	241	30 *	23
24	1		12	1			35	5	11	2			90	22	160	32	24
25	1		21	2			19	1	13	2			67	9 *	134	16	25
26			11	1	1		11	1	6				68	16	103	18	26
27			8	2	4	1	9	1	8	1			69	18	106	24	27
28			9	2	2		13	1	8				57	14	97	17	28
29			5	1	4	1	8	1	4				48	13	73	16	29
30					2		6		4				28	7	44	7	30
31			3		1								22	4	26	4	31
32			5		1				1				11	3	19	3	32
33			2		1								6	3	9	3	33
34					2								4	1	6	1	34
35					1								2	1	3	1	35
36			1										3		4		36
37																	37
38			1										1		2		38
39																	39
40																	40
	205	3	601	27	145	14	1342	67	161	18	585	1	1219	166	2209.5	157	
min	10	18	8	12	13	18	6	12	10	12	5	11	8	12	5	11	
median	17	22	18	21	19	20	15	20	21	20	10		22	25	17	23	
max	25	22	38	29	35	29	30	29	32	27	19	11	38	35	38	35	

Total width	Dab Offered	Dab Consumed	Plaice Offered	Plaice Consumed	Total numbers Offered	Total numbers Consumed	Total width
2	1				1		2
3	10				10		3
4	49	1			49	1	4
5	144	1	2	1	146	2	5
6	233 *		4		237 *		6
7	418		10		428		7
8	109		24		133		8
9	44		80 *		124		9
10	6		58		64		10
11	2		34		36		11
12			6		6		12
13			5		5		13
14			1		1		14
15							15
16							16
17							17
18							18
19							19
20							20
	1016	2	224	1	1240	3	
min	2	4	5	5	4	4	
median	6		9		6		
max	11	5	14	5	14	5	

Total length	Dragonet Offered	Dragonet Consumed	Grey Gurnard Offered	Grey Gurnard Consumed	Haddock Offered	Haddock Consumed	Herring Offered	Herring Consumed	Norway Pout Offered	Norway Pout Consumed	Red Gurnard Offered	Red Gurnard Consumed	Sprat Offered	Sprat Consumed	Whiting Offered	Whiting Consumed	Total numbers Offered	Total numbers Consumed	Total length
5													6	5			6	5	5
6							1						35	32			36	32	6
7							1						24	19			25	19	7
8			1				3	1					48	39	1	1	53	41	8
9							4	3					87	74	4	3	95	80	9
10	1		1	1			31	27	1	1	1		123 *	115 *	5	2	163	146	10
11			6	1			38	28	3	2			119	105	8	5	174	141	11
12	6		8	4 *			90	70	5	4	3		89	76	17	14	218	168	12
13	2		6		2	2	134	103	5	4	3		69	53	19	16	240	178	13
14	11	1	10		3	3	168	118 *	14	12	1		35	30	47	36	289	200 *	14
15	14	2 *	17		7	5	218 *	169	26 *	20 *	5	1	6	4	59	50	352	251	15
16	17		33		7	5	225	165	6	4	8		1	1	83	63 *	380 *	238	16
17	21 *		62		4	4	131	88	31	22	10		1	1	89	71	349	186	17
18	26	1	74 *	1	20	15 *	84	54	12	7	9		1		72	44	298	122	18
19	14	1	68	1	33	25	57	21	1	1	15		2	1	57	26	247	76	19
20	11		56		26 *	11	71	33			9 *				69	24	242	68	20
21	14		30		20	8	48	24	1		11				73	25	197	57	21
22	8		22		6	2	50	17			8				102 *	19	196	38	22
23	12		24		8		73	25			9				109	17	235	42	23
24	1		10		2		38	4			6				95	3	152	7	24
25	1		13		2		19				7				73	2	115	2	25
26			9		4		15	1			3				76		107	1	26
27			7		4		9				9				76	1	105	1	27
28			5		3		14				7				60		89		28
29			4		4		8				2				49		67		29
30					3		7				3				29		42		30
31			3		5										23		31		31
32			5		4						1				11		21		32
33			1		11										6		18		33
34					7										4		11		34
35					6										2		8		35
36			2		2										3		7		36
37																			37
38			1												1		2		38
39					1												1		39
40					1												1		40
	159	5	478	8	195	80	1537	951	105	77	130	1	646	555	1322	422	4572	2099	
min	10	14	8	10	13	13	6	8	10	10	10	15	5	5	8	8	5	5	
median	17	15	18	12	20	18	15	14	15	15	20		10	10	22	16	16	13	
max	25	19	38	19	40	22	30	26	21	19	32	15	19	19	38	27	40	27	

Flatfish consumption

Total length	Fulmar Offered	Picked	Swallowed	Gannet Offered	Picked	Lesser Bl-b Gull Offered	Picked	Herring Gull Offered	Picked	Great Bl-b Gull Offered	Picked	Kittiwake Offered	Picked	Total length
2	1							1		1		1		2
3	12		1	4		9	1	10	3	13	1	10		3
4	64			25	1	61	20	48		71	5	49	1	4
5	172		1	54		174	75	119	5	204	4	146	2	5
6	297 *			95 *	6	264	83 *	219	15	324 *	18 *	237 *		6
7	549	2		208	21 *	528 *	103	406 *	18 *	588	33	428		7
8	129			61	8	149	22	129	3	187	12	133		8
9	50			18	1	167	6	116	4	181	3	124		9
10	7			3		97		59		93	3	64		10
11	3					55		29		55	1	36		11
12						7		6		7		6		12
13						4		5		5		5		13
14						1		1		1		1		14
15														15
16														16
17														17
18														18
19														19
20														20
Total	1284	2	2	468	37	758	155	1148	48	865	40	1240	3	
min	2	7	3	3	4	3	3	2	5	2	3	4	4	
median	6			6	7	7	6	7	6	6	6	6		
max	11	7	5	10	9	14	9	14	9	14	11	14	5	

Roundfish consumption

Total length	Fulmar Offered	Picked	Swallowed	Gannet Offered	Swallowed	Common Gull Offered	Swallowed	Lesser Bl-b Gull Offered	Swallowed	Herring Gull Offered	Swallowed	Great Bl-b Gull Offered	Swallowed	Kittiwake Offered	Swallowed	Total length
5	5			2		5				5		6		6	5	5
6	29			4		32	2			33		35		36	32	6
7	21		1	14		14				17	2	22		25	19	7
8	36			20		42	1	2		50	5	53		53	41	8
9	53		1	29		76	3	4	1	89	7	88		95	80	9
10	123		1	84		112	2	8	1	128	5	142		163	146	10
11	107		4	76		118	2	16	2	137	9	154	1	174	141	11
12	148		4	86		116	4	34	10	175	12	195	7	218	168	12
13	153		3	98		131	14 *	61	12	213	12	235		240	178	13
14	186		4	113	4	143 *	8	84	21	260	28	263	4	289	200 *	14
15	262		1	173	5	83	11	91	40	313	30	311	7	352	251	15
16	337		9	147	4	99	9	109	44	346	42	374	13	380 *	238	16
17	287 *	1	12	158 *	6	54	1	130	81	279 *	34	324 *	15	349	186	17
18	260		13	134	6	35	1	143	81 *	254	34	289	13	298	122	18
19	232	1	15 *	99	5	29		123 *	81	220	41	253	10	247	76	19
20	209		11	100	3	58	3	100	54	217	36 *	243	20	242	68	20
21	180	1	6	90	8	41	1	79	31	174	30	192	20	197	57	21
22	209		5	97	5	47		97	47	190	52	213	32	196	38	22
23	225	1	6	119	10	66		101	36	213	60	241	30	235	42	23
24	125	11	14	86	8	57		84	24	140	25	160	32	152	7	24
25	96	3	9	52	7	38		73	21	104	40	134	16 *	115	2	25
26	90	6 *	4	42	9 *	38		70	15	93	20	103	18	107	1	26
27	91	6	5	43	6	34		55	14	97	24	106	24	105	1	27
28	77	4	3	33	10	27		47	10	81	25	97	17	90		28
29	61	9	1	24	2	18		45	8	62	11	73	16	67	1	29
30	36	2		18	7	18		15	3	38	4	44	7	42		30
31	24	1		19	9	10		11	1	31	9	26	4	31		31
32	18	2		11	7	6		5		19	2	19	3	21		32
33	16			12	9	2		3		19	1	9	3	18		33
34	10			8	6	1		3		11	1	6	1	11		34
35	7			8	6	1		1		8	1	3	1	8		35
36	7			6	6	1		3		7		4		7		36
37																37
38	1							1		2		2		2		38
39	1			1	1					1				1		39
40	1			1	1					1				1		40
Total	3723	48	132	1003.5	75	776	31	1598	638	4027	602	2209.5	157	4573	2100	
min	5	17	7			5	18	8	9	5	7	5	11	5	5	
median	17	26	19	4	13	14	13	19	18	17	20	17	23	16	13	
max	40	32	29	20	26	36	40	38	31	40	35	38	35	40	29	

CONTENTS