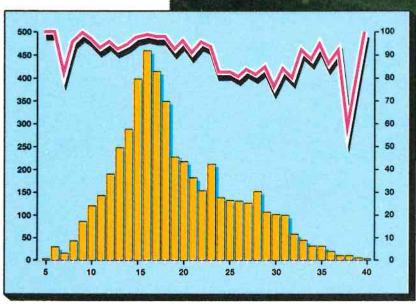
NIOZ-RAPPORT 1993 - 8

SEABIRDS FEEDING ON DISCARDS IN WINTER IN THE NORTH SEA

Final report to the European Commission

C.J. Camphuysen, K. Ensor, R.W. Furness, S. Garthe,
O. Hüppop, G. Leaper, H. Offringa, & M.L. Tasker



Nederlands Instituut voor Onderzoek der Zee

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

Applied Ornithology Unit, Zoology department,
Glasgow University G12 8QQ
Scotland U.K.

Institut für Vogelforschung 'Vogelwarte Helgoland',
Postfach 1220, D-2192 Helgoland
Germany

Offshore Animals Branch,
Joint Nature Conservation Committee (JNCC)
16-17 Rubislaw Terrace, AB1 1XE Aberdeen
Scotland U.K.

This report should be cited as follows: Camphuysen C.J., K. Ensor, R.W. Furness, S. Garthe, O. Hüppop, G. Leaper, H. Offringa & M.L. Tasker 1993. Seabirds feeding on discards in winter in the North Sea. EC DG XIV research contract 92/3505. NIOZ Rapport 1993 - 8, Netherlands Institute for Sea Research, Texel. 140pp.

Front cover: Fulmars *Fulmarus glacialis* competing for offal (photo M.F. Leopold) and Kittiwake *Rissa tridactyla* swallowing 22 cm Herring *Clupea harengus* (photo H. Offringa), diagram showing length distribution of roundfish discarded during experimental discarding (n= 5000, bars) and overall consumption rates of scavengers at the trawl (line).

Lay out: C.J. Camphuysen
Cover design: H. Hobbelink

ISSN 0923 - 3210

Seabirds feeding on discards in winter in the North Sea

Final report
EC DG XIV research contract 92/3505

C.J. Camphuysen, K. Ensor, R.W. Furness,
S. Garthe, O. Hüppop, G. Leaper, H. Offringa
& M.L. Tasker

Study contract no. 92/3505, DG XIV programme 'Protection of Marine Species, 1992/1993'

The study was undertaken by Netherlands Institute for Sea Research (Texel), Glasgow University, Institut für Vogelforschung "Vogelwarte Helgoland", Ornis Consult and the Joint Nature Conservation Committee.

This study has been carried out with financial assistance from the Commission of the European Communities.

Netherlands Institute for Sea Research
Zoology department, Glasgow University
Institut für Vogelforschung' Vogelwarte Helgoland'
Joint Nature Conservation Committee

SCIENTIFIC SUMMARY

The importance of discards and offal in seabird diets for seabirds wintering in the North Sea were studied and the implications of new regulations in commercial fisheries were assessed. Most fieldwork was carried out from the February 1993 International Bottom Trawl Survey (IBTS) fisheries research vessels.

The project provided information on a North Sea wide scale on the species, numbers and distribution of scavenging seabirds in winter, on co-occurrence of seabirds and commercial trawlers, on dominance hierarchies among scavengers in areas differing in species composition and relative abundance of seabirds, and provided quantifications of proportions of discarded biota which are consumed by seabirds by means of experimental discarding at trawling stations. Current knowledge on quantities of fish discarded from commercial fisheries in the North Sea are summarised and consumption rates of seabirds as found in this study throughout the North Sea were used to estimate total consumption by scavenging seabirds.

Fifteen species were observed as scavengers at the trawl. Of these only Fulmar, Gannet, Common Gull, Herring Gull, Great Black-backed Gull and Kittiwake occurred in substantial numbers. The total number of these six seabirds in the North Sea during the February 1993 study, was at least 1.62 million:

Fulmar	720,000
Gannet	70,000
Common Gull	57,500
Herring Gull	297,000
Great Black-backed Gull	175,000
Kittiwake	298,000

This is considered a minimum estimate, because some potentially important areas of the North Sea were not surveyed. Adults of Gannets and all gull species predominated. The largest total numbers of seabirds associated with the research ship were in descending order, during discarding while stationary, discarding while steaming, or when the net was lifted. Most birds were attracted from an area of 7-12 km around the ship.

It was estimated that *ca.* 1,500 fishing trawlers were present in those areas of the North Sea surveyed during this study. These comprised 650 (stern) trawlers in the northern North Sea, 550 beamtrawlers in the southern and central North Sea, and 100 'small trawlers' in the Skagerrak and 200 'other' trawlers spread out over the North Sea. The maximum recorded numbers of seabirds associated with commercial trawlers were higher than at the stern of research vessels, but there was considerable variation in the proportion of species at trawlers compared with that at research vessels. Of an estimated 460,000 scavengers associated with commercial trawlers in February 1993, 77% were associated with (stern) trawlers in the northern North Sea.

About 28% of the total number of scavengers in the North Sea were associated with a fishing commercial trawler. This suggests that these seabirds spend over a quarter of their time at these boats.

Lengths of discards tended to be largest in the northwest and were smaller to the east and south. For the whole North Sea sample, seabirds consumed 100% of offal discards (n = 605), 92.4% of roundfish discards (n = 5000), 35.5% of flatfish discards (n = 372) and 16.7% of benthic invertebrate or cephalopod discards (n = 54). However, a number of reservations have been expressed regarding the extrapolation of these data to commercial fishing vessels. For the purposes of further calculations we took the following figures for consumption of discards:

90% of offal
80% of roundfish,
20% of flatfish,
10% of benthic invertebrates.

In each subregion the largest number of items was swallowed by Kittiwakes, but the second and third most important consumers varied between subregions. Fulmars and Kittiwakes obtained considerably more offal than their numerical abundance predicted. The rank orders of major consumers of expe-

rimentally discarded gadids (Whiting, Haddock, Cod, Saithe, Norway Pout) were different among subregions. The major consumers of experimentally discarded clupeids (Herring and Sprat) were in most subregions Kittiwake and Herring Gull. Kittiwakes obtained more clupeids than expected in all subregions. The success indices for both adult and immature Great Black-backed Gulls, Herring Gulls were similar. Immature Kittiwakes were much more effective than adults. There was considerable competition for discards, and frequent robbery (kleptoparasitism, or piracy). Smaller scavenging seabirds tended to be robbed by larger species, Great Black-backed Gulls being the most successful at obtaining fish through robbery.

Median lengths of common roundfish offered and consumed by seabirds in the North Sea:

	gadids	*clupeids*
median offered:	21 cm	15 cm
median consumed:		
Fulmar	23 cm	15 cm
Gannet	28 cm	28 cm
Common Gull	-	14 cm
Herring Gull	23 cm	18 cm
Great Bb Gull	28 cm	20 cm
Kittiwake	17 cm	15 cm

We used a hypothetical 1000 g scavenging seabird, with a daily energy intake (3x Basal Metabolic Rate) of around 3 times 600 kJ/day, or 657,000 kJ/ year. The calorific value of fish offal is estimated at 10 kJ/g for offal, 5 kJ/g for roundfish, 4 kJ/g for flatfish, the calorific value of benthic invertebrates was assumed to be around 2.5 kJ/g. The average annual discard quantities in the North Sea as a whole (ICES IVabc), during the period 1985-92, were estimated at:

83,700 tonnes of offal,
146,000 tonnes of roundfish,
148,000 tonnes of flatfish, and
100,000 tonnes of benthic invertebrates.

These figures indicate that around 2 million 1000g scavenging seabirds may be supported by the offal and discards made available from North Sea fishing vessels in recent years (offal could support 1.1 million, roundfish 880,000, flatfish 180,000, and benthic invertebrates 38,000 1000g scavenging seabirds in the North Sea). Because of its high calorific value and high consumption rate, offal represents the most important portion of this waste, but is monopolised by only a few scavenging species, mostly Fulmars and Kittiwakes.

This study has shown that discards are a very important source of food for seabirds in winter throughout the North Sea. Reductions in the quantities of discards and offal which are released in the North Sea are likely to have a pronounced effect, not only on the reproduction of breeding seabirds in the North Sea, but also on the survival of wintering scavengers in the North Sea. Reductions through an increase of net mesh size are likely to mainly affect the smaller scavengers (*e.g.* Kittiwake, Common Gull), whereas a reduction through a decline in fishing effort would affect all species. Sudden declines in quantities of discards would disturb the ecological balance, because of reductions in the availability of this source of food for seabirds. Smaller seabirds may suffer from being outcompeted and increased predation. Measures to gradually reduce discards are therefore preferred, so that interspecific relationships among seabirds can gradually change. The results of this study can be used to estimate, in more detail, the effect of local measures to reduce discards or fishing effort for wintering scavengers.

ASFA key words:

Marine birds, census, diets, discards, ecological balance, feeding behaviour, feeding experiments, food preferences, interspecific relationships, nature conservation, marine fisheries, fishing effort, fishing gear, fishery management, discards, ANE, North Sea, Skagerrak, Kattegat

SUMMARY FOR NON-SPECIALISTS

The importance of discards and offal in seabird diets and the implications of new regulations in commercial fisheries for seabirds wintering in the North Sea were studied. Fieldwork was carried out during the February 1993 International Bottom Trawl Survey (IBTS). It was the first synoptic study of discard utilization by scavenging seabirds throughout the North Sea, and it was also one of the first studies of this subject in winter.

The project provided information on the species, numbers and distribution of scavenging seabirds in winter all over the North Sea, and the behaviour and prey selection of these birds at the trawl. The quantities of discards which were consumed by seabirds were assessed during experimental discarding of fish, benthic invertebrates and offal. Commercial trawlers were recorded on a North Sea wide scale, including type, activity and numbers of associated seabirds. Current knowledge on quantities of discarded fish in commercial fisheries in the North Sea is summarized. Consumption rates of seabirds as found in this study throughout the North Sea were used to estimate total consumption by scavenging seabirds.

Fifteen species were observed as scavengers at the trawl. Of these only Fulmar, Gannet, Common Gull, Herring Gull, Great Black-backed Gull and Kittiwake occurred in substantial numbers. The total number of these seabirds in the North Sea in February 1993 was at least 1.62 million:

Fulmar	720,000
Gannet	70,000
Common Gull	57,500
Herring Gull	297,000
Great Black-backed Gull	175,000
Kittiwake	298,000

This is considered a minimum estimate, because some potentially important areas of the North Sea were not surveyed.

Maximum numbers recorded at the stern of research vessels were 2000 Fulmars, 250 Gannets, 150 Common Gulls, 650 Herring Gulls, 250 Great Black-backed Gulls, and 452 Kittiwakes. Adults of Gannets and all gull species predominated.

Massive fluctuations in numbers at the stern occurred in response to changing activities of the ship, when commercial fishing boats were in the vicinity, when birds became satiated, and frequently for unknown reasons. Most birds were attracted from an area of 7-12 km around the ship. The largest total numbers of seabirds attending the ship were recorded when discards were released, but species composition varied with activity. Some species (*e.g.* Fulmar) appeared to be more numerous when discards were provided from a stationary vessel, whereas others (*e.g.* Kittiwake) increased in numbers when the vessel moved. It is concluded that more exact knowledge of discarding practices in commercial fisheries and a better understanding of feeding efficiency of scavengers attending moving or stationary vessels are needed.

It was estimated that *ca.* 1,500 fishing trawlers were present in those areas of the North Sea surveyed during this study. The maximum recorded numbers of seabirds associated with commercial trawlers were higher than at research vessels, but there was not one consistent tendency all over the North Sea with respect to one species being much more numerous or frequently recorded associated with trawlers or at the stern of research vessels.

Of an estimated 460,000 scavengers associated with commercial trawlers in February 1993, 77.2% were associated with trawlers in the northern North Sea. The ratio of numbers of seabirds at (28%) and away (72%) from fishing vessels led to the conclusion that the common scavengers spend over a quarter of their time at these boats.

Seabirds consumed 10% of discarded benthic invertebrates (*e.g.* starfish, crabs), 20% of flatfish, 80% of roundfish, and 90% of offal. The largest number of items was swallowed by Kittiwakes. Fulmars and Kittiwakes obtained most of the offal The major consumers of experimentally discarded Herring and Sprat were Kittiwake and Herring Gull. The feeding success of adult and imma-

ture Great Black-backed Gulls, Herring Gulls, was rather similar, but immature Kittiwakes were much more effective than adults.

There was considerable competition for discards, and frequent robbery (kleptoparasitism, or piracy). Smaller scavenging seabirds tended to be robbed by larger species, Great Black-backed Gulls being the most successful at obtaining fish through robbery. Generally, smaller seabirds selected small fish and larger seabirds took larger fish. This was not just because of the respective swallowing capacity of these birds. Birds that took discards of a size which were difficult to swallow suffered the greatest rates of robbery. So smaller birds, like Kittiwakes, were most likely to obtain high foraging success by selecting the smallest discards and swallowing these quickly.

Discard quantities in the North Sea as a whole during the period 1985-92, were estimated at:

83,700 tonnes of offal,
146,000 tonnes of roundfish,
148,000 tonnes of flatfish, and
100,000 tonnes of benthic invertebrates.

The conclusion was that around 2 million seabirds may be supported by the offal and discards made available from North Sea fishing vessels in recent years. Because of its high calorific value and high consumption rate, offal represents the most important portion of this waste, but offal is monopolised by only a few scavenging species, especially Fulmars and Kittiwakes.

This study has shown that discards are a very important source of food for seabirds in winter throughout the North Sea. Reductions in the quantities of discards and offal which are released in the North Sea are likely to have a pronounced effect, not only on the reproduction of breeding seabirds in the North Sea, but also on the survival of wintering scavengers in the North Sea. Sudden declines in quantities of discards would seriously disturb the ecological balance, because of reductions in the availability of this source of food for seabirds. Smaller seabirds will suffer from being outcompeted and increased predation. Measures to gradually reduce discards are therefore preferred, so that interspecific relationships among seabirds can gradually change. The results of this study can be used to estimate, in more detail, the effect of local measures to reduce discards or fishing effort for wintering scavengers.

SAMENVATTING

Het belang van '*discards*' (onverhandelbare vis) en snijafval voor zeevogels in de Noordzee in de winter waren onderwerp van studie. Vervolgens werden de gevolgen van maatregelen om het overboord zetten van discards en snijafval te beperken voor zeevogels ingeschat. Tijdens de 'International Bottom Trawl Survey' van februari 1993 werden gegevens verzameld aan boord van visserij-onderzoeksschepen.

Het project leverde informatie op over aantallen en verspreiding van zeevogels, over de verspreiding en aantallen vissersschepen en de aantallen daarmee geassocieerde zeevogels, over gedrag en fourageersucces van zeevogels bij het binnenhalen van het net en over de hoeveelheid discards die door zeevogels wordt geconsumeerd. Een onderdeel van dit project was het samenvatten van de beschikbare informatie over de hoeveelheden discards die er in de commerciële visserij in zee worden gedumpt. Aan de hand van de tijdens 'discard-experimenten' vastgestelde consumptie door zeevogels werd vervolgens berekend hoe groot de totale consumptie door zeevogels was en hoeveel zeevogels er alleen al van de geloosde discards in leven zouden kunnen blijven.

Vijftien soorten werden tot het schip aangetrokken tijdens het binnenhalen van de netten. Daarvan kwamen alleen de Noordse Stormvogel, Jan van Gent, Storm-, Zilver-, Grote Mantel- en Drieteenmeeuw in aantallen van betekenis voor. Het totaal aantal van deze soorten in februari in de Noordzee werd aan de hand van tijdens dit project verzamelde gegevens geschat op 1,62 miljoen:

Noordse Stormvogel	720.000
Jan van Gent	70.000
Stormmeeuw	57.500
Zilvermeeuw	297.000
Grote Mantelmeeuw	175.000
Drieteenmeeuw	298.000

Deze schatting wordt als een minimum beschouwd, omdat belangrijke zeevogelgebieden en grote delen van de kustzone niet (voldoende) werden onderzocht.

Bij zowel de Jan van Gent als alle soorten meeuwen was de meerderheid van de vogels volwassen. De meeste vogels werden tot het schip aangetrokken wanneer discards geproduceerd werden, maar de soortstamenstelling verschilde per activiteit van het schip. Noordse Stormvogels kwamen in de grootste aantallen bij het schip voor wanneer discards werden overboord gezet vanaf een stilliggend schip, terwijl Drieteenmeeuwen de grootste aantallen bereikten indien discards vanaf een varend schip in zee werden gezet. De meeste vogels werden aangetrokken uit een gebied met een straal van 7-12 km rond het schip.

Naar schatting 1500 vissende commerciele vissersschepen waren aanwezig in de onderzochte delen van de Noordzee. De aantallen zeevogels die geassocieerd met deze schepen werden gezien waren iets hoger dan die bij de onderzoeksschepen, maar er waren over de gehele Noordzee bezien geen soorten die achter vissersschepen altijd talrijker of schaarser waren dan achter onderzoeksschepen. Van de naar schatting 460.000 met commerciële vissersschepen geassocieerde zeevogels op de gehele Noordzee, werd 77.2% in het noordelijke deel vastgesteld. Op grond van het feit dat 28% van het totaal aantal zeevogels bij kotters werd gezien en de rest verspreid op zee, werd verondersteld dat deze vogels ruim een kwart van hun tijd bij deze schepen spenderen.

De lengte van de overboord gezette vis was groter in het noordwesten dan in het oosten en zuiden van de Noordzee. Globaal gezien, consumeerden zeevogels 100% van het overboord gezette snijafval (n= 605), 92.4% van de rondvis (n= 5000), 35.5% van de platvis (n= 372) en 16.7% van het benthos. Omdat de omstandigheden aan boord van onderzoeksschepen verschillen van die op commerciële vissersschepen werd deze schatting bijgesteld tot:

90% van het snijafval
80% van de rondvis
20% van de platvis
10% van het benthos

Drieteenmeeuwen pikten over het algemeen de meeste vissen en brokjes snijafval op,

maar de op één en twee na belangrijkste consumenten verschilden per deelgebied. Noordse Stormvogels en Drieteenmeeuwen waren de voornaamste consumenten van snijafval. De voornaamste consumenten van kabeljauwachtigen verschilden per deelgebied, maar Drieteenmeeuw en Zilvermeeuw waren meestal de belangrijkste consumenten van haringachtigen. Drieteenmeeuwen pikten aanzienlijk meer haringachtigen op dan kon worden verwacht op grond van de aantallen bij het schip. De competitie achter het schip was groot en veel vis ging verloren door kleptoparasitisme. Over het algemeen werden de kleine zeevogels daarbij het slachtoffer van de grotere en Grote Mantelmeeuwen bemachtigden op die manier de meeste vis van andere soorten.

De mediane lengte van de aangeboden en geconsumeerde rondvis in de Noordzee bedroeg:

	kabeljauw-achtigen	*haring-achtigen*
aangeboden:	21 cm	15 cm
geconsumeerd:		
Noordse Stormvogel	23 cm	15 cm
Jan van Gent	28 cm	28 cm
Stormmeeuw	-	14 cm
Zilvermeeuw	23 cm	18 cm
Grote Mantelm	28 cm	20 cm
Drieteenmeeuw	17 cm	15 cm

Uitgaande van een hypothetische zeevogel van 1000 gram, waarvan de dagelijkse energetische behoefte (3x Basaalmetabolisme) ongeveer 600 kJ bedraagt (657.000 kJ per jaar), werd berekend hoeveel zeevogels van de in de commerciële visserij overboord gezette vis in de Noordzee zouden kunnen leven. De energetische waarde van snijafval werd daarbij geschat op 10 kJ per gram, voor rondvis op 5 kJ per gram, voor platvis op 4 kJ per gram en voor benthos op 2.5 kJ per gram. De in de Noordzee overboord gezette hoeveelheden visafval bedroegen gedurende 1985-92 naar schatting:

83.700 ton snijafval,
146.000 ton rondvis,
148.000 platvis,
100.000 ton benthische invertebrata.

Geconcludeerd werd daarom dat daarvan naar schatting 2 miljoen zeevogels zouden kunnen leven: 1.1 miljoen van het snijafval, 880.000 van de rondvis, 180.000 van de platvis en 38.000 van het benthos. Snijafval, met zijn hoge energetische waarde en waarvan het merendeel door zeevogels wordt geconsumeerd, is de belangrijkste voedselbron. Van snijafval profiteert echter slechts een beperkt aantal specialisten (Noordse Stormvogel, Drieteenmeeuw).

Dit onderzoek heeft het belang van discards en snijafval voor overwinteraars in de gehele Noordzee aangetoond. Maatregelen ter vermindering van de hoeveelheden discards in de visserij zullen daarom niet alleen een negatief effect hebben op de reproductie van de in de Noordzee broedende zeevogels, maar ook op de overlevingskansen van overwinteraars. Het is te verkiezen dat dergelijke maatregelen niet plotseling maar geleidelijk worden ingevoerd, zodat de zeevogels de gelegenheid krijgen andere voedselbronnen te zoeken. De resultaten van dit onderzoek kunnen worden gebruikt om de te verwachten effecten van locale maatregelen ter vermindering van de hoeveelheden discards of van de vermindering van visserij-inspanning in te schatten.

ZUSAMMENFASSUNG

Die Bedeutung von Discards (wieder über Bord gegebene Teile des Fangs) und Schlachtabfällen (Eingeweide) aus der Fischerei für die Ernährung in der Nordsee überwinternder Seevögel wurde untersucht. Die meisten Freilandarbeiten erfolgten an Bord von Fischereiforschungsschiffen während des "International Bottom Trawl Survey" (IBTS) im Februar 1993.

Das Projekt lieferte für die gesamte Nordsee Informationen über Arten, Anzahl und Verbreitung von Seevögeln während des Winters sowie über ihr Vorkommen an kommerziellen Fischereifahrzeugen, Beschreibungen der Dominanzverhältnisse zwischen den Schiffsfolgern in Gebieten unterschiedlicher Artenzusammensetzung und relativer Häufigkeit sowie Quantifizierungen der von Vögeln genutzten Anteile experimentell über Bord gegebener Discards und Eingeweide an den Fangstationen der Forschungsschiffe. Der Nahrungsverbrauch aller Seevögel wurde anhand der in dieser Studie ermittelten Zahlen und der anfallenden Discard- und Eingeweidemengen abgeschätzt.

Bei 15 Arten wurde beobachtet, daß sie während des Netzeinholens Nahrung aufnahmen. Allein Eissturmvogel, Sturm-, Silber-, Mantel und Dreizehenmöwe traten in nennenswerten Zahlen auf. Die nordseeweite Gesamtzahl dieser Seevogelarten während des IBTS im Februar 1993 wird auf mindestens 1,62 Millionen geschätzt:

Eissturmvogel	720.000
Baßtölpel	70.000
Sturmmöwe	57.500
Silbermöwe	297.000
Mantelmöwe	175.000
Dreizehenmöwe	298.000

Beim Baßtölpel und bei allen Möwenarten überwogen Altvögel. Die meisten schiffsbegleitenden Vögel wurden beim Überbordgeben des Beifangs ohne Fahrt, beim Überbordgeben des Beifangs während der Fahrt und beim Hieven des Netzes an Deck (in abnehmender Reihenfolge) gezählt.

Schätzungsweise 1500 Fischereifahrzeuge waren während des IBTS im Februar 1993 anwesend: 650 Heckfänger in der nördlichen Nordsee, 550 Baumkurren in der südlichen und zentralen Nordsee, 100 "kleine trawler" im Skagerrak/Kattegat und 200 "andere" Schiffe über die gesamte Nordsee verteilt. Die Maximalzahlen schiffsbegleitender Vögel waren bei kommerziellen Fischereifahrzeugen höher als bei den Forschungsschiffen. Allerdings war keine Art gleichmäßig über die gesamte Nordsee besonders häufig oder regelmäßig anzutreffen. Von schätzungsweise 460,000 Schiffsfolgern, die im Februar 1993 an kommerziellen Fischereifahrzeugen gezählt wurden, wurden 77.2% an (Heck-)fänger in der nordlichen Nordsee angetroffen. Die Tatsache, daß 28% aller Vogelarten, die Discards und Eingeweide fressen, bei kommerziellen Fischereifahrzeugen angetroffen wurden, läßt vermuten, daß diese Seevögel etwa ein Vierteil ihrer Zeit in der Nähe solcher Schiffe verbringen.

Die Längen des Discards waren in der nordwestlichen Nordsee am größten. Sie nahmen nach Süden und Osten hin ab. Über die gesamte Nordsee nahmen Seevögel 100% der angebotenen Eingeweide (n= 605), 92.4% der angebotenen Rundfische (n= 5000), 35.5% der angebotenen Plattfische (n= 372) und 17% der angebotenen benthischen Wirbellosen und Cephalopoden (n= 54) auf. Hinsichtlich der Übertragbarkeit dieser Werte auf kommerziellen Fischereifahrzeuge bestehen jedoch einige Vorbehalte. Für weitergehende Berechnungen haben wir daher folgende Aufnahmeraten benutzt:

Eingeweide	90%
Rundfische	80%
Plattfische	20%
benthische Wirbellose	10%

In jeder Unterregion nahmen Dreizehenmöwen die meisten Objekte auf, während die nächstfolgenden Arten zwischen den Teilgebieten variierten. Eissturmvögel und Dreizehenmöwen nahmen deutlich mehr Abfall auf als aufgrund ihrer Häufigkeit zu erwarten war. Die Reihenfolge der Vogelarten war bei den angebotenen Dorschartigen (Wittling, Schellfisch, Kabeljau, Köhler, Stintdorsch) in

den einzelnen Unterregionen verschieden. Hingegen waren bei den angebotenen Heringsartigen (Hering und Sprott) Dreizehn- und Silbermöwe in den meisten Teilgebieten die wichtigsten Konsumenten. Dreizehenmöwen nahmen in allen Unterregionen mehr Heringsartige auf als aufgrund ihrer Häufigkeit zu erwarten war. Die Erfolgsraten bei der Aufnahme von Discards waren zwischen adulten und immaturen Mantel- und Silbermöwen jeweils ähnlich. Immature Dreizehenmöwen waren hingegen erheblich effektiver als adulte. Die Konkurrenz um die angebotenen Discards war bemerkenswert. Häufig wurde Kleptoparasitismus beobachtet, wobei in der Regel den kleinen Arten die Beute von den größeren abgejagt wurde, besonders erfolgreich von Mantelmöwen.

Mediane der Länge der am häufigsten angeboten und konsumierten Rundfischarten:

	Dorschartige	*Heringsartige*
angeboten:	21 cm	15 cm
aufgenommen:		
Eissturmvogel	23 cm	15 cm
Baßtölpel	28 cm	28 cm
Sturmmöwe	-	14 cm
Silbermöwe	23 cm	18 cm
Mantelmöwe	28 cm	20 cm
Dreizehenmöwe	17 cm	15 cm

Ausgehend von einem (theoretischen) 1000g schweren Vogel beträgt dessen täglicher Energiebedarf (= 3x Grundumsatz, BMR) dreimal 600 kJ, entsprechend 657,000 kJ pro Jahr. Der Energiegehalt von Fischeingeweiden wird auf 10 kJ/g, der von Rundfischen auf 5 kJ/g, der von Plattfischen auf 4 kJ/g und der von Invertebraten auf durchschnittlich 2.5 kJ/g Frischmasse geschätzt. Die Discard-Mengen von Fischereifahrzeugen betrugen für die gesamte Nordsee (ICES Gebiete IVa-c) in den Jahren 1985-92 etwa:

83,700 t Eingeweide,
146,000 t Rundfisch,
148,000 t Plattfisch,
100,000 t benthische Wirbellose.

Die Schlußfolgerung ist, daß hiervon rund zwei Millionen 1000g schwere Seevögel leben können (Eingeweide können 1.1 Millionen, Rundfische 880,000, Plattfische 180,000 und benthische Wirbellose 38,000 Vögel von jeweils 1000g Körpermasse ernähren). Wegen ihres hohen Energiegehalts und der hohen Aufnahmerate bilden Eingeweide den wichtigsten Teil der über Bord gegebenen Abfälle, doch werden sie fast ausschließlich von einigen wenigen Arten, vornehmlich Eissturmvogel und Dreizehenmöwe, gefressen.

Die Studie hat gezeigt, daß in der gesamten Nordsee Discards eine äußerst wichtige Nahrungsquelle für Seevögel während des Winters sind. Verringerungen der in die Nordsee gegebenen Discard- und Eingeweidemengen würden vermutlich gravierende Effekte nicht nur auf die Reproduktionsraten der Brutvögel sondern auch auf das Überleben während des Winters haben. Eine Reduktion der Discard- und Eingeweidemengen mittels vergrößerter Maschenweite der Netze würde wohl hauptsächlich die kleineren Arten (Dreizehn- und Sturmmöwe) betreffen, während eine Reduktion durch eine generelle Verringerung der Fischerei sich vermutlich auf alle Arten auswirken würde. Durch plötzliche Einbrüche in der Versorgung mit Discards und Eingeweiden sind nachhaltige Veränderungen in den ökologischen Beziehungen zu erwarten. Kleinere Seevogelarten wären durch Konkurrenzdruck und Prädation besonders betroffen. Es sollten daher Maßnahmen für eine schrittweise Reduzierung der Discardmengen bevorzugt werden. Die Ergebnisse dieser Studie können auch zur Abschätzung der Folgen lokaler Maßnahmen zur Verringerung der Discardmengen oder des Fischereiaufwandes für überwinternde Seevögel herangezogen werden.

RESUMÉ

Betydningen af fiskeriaffald, d.v.s. frasorterede ikkeilandbragte fisk og fiskeindmad, i havfugles føde og konsekvenserne af nye regler for kommercielt fiskeri for overvintrende havfugle i Nordsøen blev undersøgt. Hovedparten af feltarbejdet blev udført fra havforskningsskibe under det internationale bundtrawlsurvey (IBTS) i februar 1993.

Projektet gav information fra hele Nordsøen om arter, antal og udbredelse af '*scavengers*' (fuglearter der kan udnytte fiskeriaffald) om vinteren, information om korrelationer mellem havfugle og kommercielle trawlere, beskrivelse af dominans-hierakier blandt '*scavengers*' i områder med forskellig artssammensætning og relativ hyppighed af havfugle, og kvantifisering af andelen af de forskellige typer af fiskeriaffald, som konsumeres af havfugle v.h.a. eksperimenter med fiskeriaffald. Den nuværende viden om mængden af fisk, der smides ud fra det kommercielle fiskeri i Nordsøen, er opsummeret. Den totale konsumption af fiskeriaffald i Nordsøen blev estimeret udfra specifikke konsumptionsrater, der kunnen fastsættes udfra eksperimenterne med fiskeaffald.

Femten fuglearter blev observeret som '*scavengers*' ved travlet. Af disse var det dog kun Mallemuk, Sule, Stormmåge, Sølvmåge, Svartbag og Ride, der forekom i større antal. Det totale antal af disse arter i Nordsen under februar 1993 IBTS var ca. 1.62 millioner:

Mallemuk	720.000
Sule	70.000
Stormmåge	57.500
Sølvmåge	297.000
Svartbag	175.000
Ride	298.000

Udfarvede fugle dominerede hos Sule og alle mågearterne. Under trawling blev maksimumregistreringer af fugle generelt optalt (efter betydning) når fiskeriaffald blev smidt overbord mens skibet var i ro, når fiskeriaffald blev smidt overbord mens skibet var under transport mellem trawlstationer eller når trawlet blev løftet.

Det totale antal trawlere i Nordsøen under februar 1993 IBTS blev estimeret til ca. 1500, heraf 650 i den nordlige Nordsø, 550 bomtrawlere i den sydlige og centrale Nordsø og 100 mindere trawlere i Skagerrak og Kattegat samt 200 'andre' trawlere spredt over Nordsøen.

Maksimumregistreringerne af havfugle ved kommercielle trawlere var højere end ved IBTS forskningsskibene, men generelt var forskellen ikke signifikant. Ud af estimeret 460.000 '*scavengers*' ved kommercielle trawlere i februar 1993, var 77.2% associeret med trawlere i den nordlige Nordsø. På baggrund af at 28% af det totale antal af '*scavengers*' i Nordsøen var relaterede til fiskende trawlere konkluderes, at disse havfugle bruger omkring 1/4 af deres tid ved disse skibe.

Længden af fisk, der blev smidt overbord, syntes at være størst i den nordvestlige del og mindst i den østlige og sydlige del. Ud af undersøgelsesmaterialet fra eksperimenterne for hele Nordsøen konsumerede havfuglene 100% af indmad smidt overbord (n= 605), 92.4% af ikke-fladfisk (n= 5000), 35.5% af fladfisk (n= 372) og 16.7% af bentiske invertebrater og blæksprutter (n= 54). På grund af usikkerheder m.h.t. at ekstrapolere disse høje værdier til kommercielle trawlere, blev følgende mere konservative værdier anvendt for konsumption af fiskeriaffald:

indmad	90%
ikke-fladfisk	80%
fladfisk	20%
bentiske invertebrater	10%

I alle sektorer blev det største antal emner spist af Ride, hvorimod den anden- og tredjevigtigste konsument af fiskeriaffald vekselde imellem sektorer. Mallemuk og Ride tog mere fiskeriaffald end forventet udfra deres antal ved trawlet. Rækkefølgen af vigtige konsumenter af torskefisk (Hvilling, Kuller, Sej, Sperling) var forskellig fra sektor til sektor. Ride og Sølvmåge var generelt de vigtigste konsumenter af sildefisk (Sild og Brisling). I alle regioner tog Riderne flere sildefisk and forventet udfra deres antal ved trawlet. Succes-indexer for adulte og immature Sølvmåge

og Svartbag var ret ens, mens immature Ride var længt mere effektive end adulte. Konkurrence om fiskeriaffald forekom meget ofte og kleptoparasitisme var temmelig udbredt. Mindre arter fik ofte stjålet deres bytte af de sørre arter, hvoraf Svartbag var den mest succesfulde kleptoparasit.

Median længden af de almindeligste ikke-fladfisk, som blev tildbudt og spist af fuglene under eksperimenterne i Nordsøen var:

	torskefisk	*sildefisk*
tilbudt:	21 cm	15 cm
spist:		
Mallemuk	23 cm	15 cm
Sule	28 cm	28 cm
Stormmåge	-	14 cm
Sølvmåge	23 cm	18 cm
Svartbag	28 cm	20 cm
Ride	17 cm	15 cm

Det daglige energi forbrug (3x BMR) for en hypotetisk 1000g havfugl svarer til 3 gange 600kJ/dag, eller 657.000kJ/år. Kalorieværdien af fiskeriaffald er estimeret til 10 kJ/g for indmad, 5kJ/g for ikke-fladfisk og 4 kJ/g for fladfisk. Kalorieværdien af bebtiske invertebrater formodes at være ca. 2.5 kJ/g. Estimater af den samlede mængde fiskeriaffald i Nordsøen (ICES IVabc) for perioden 1985-92 vistes:

83.700 tons indmad,
146.000 tons ikke-fladfisk,
148.000 tons fladfisk,
100.000 tons bentiske invertebrater.

Konklusion var, at omkring 2 millioner 1000g havfugle i de senere år potentielt har kunnet ernære sig af fiskeriaffaldet fra Nordsøfiskeflåden. Mængden af indmad kunnen således potentielt udgøre fødegrundlaget for 1.1 mio 1000g havfugle, ikke-fladfisk kunnen føden for 880.000 fugle, fladfisk kunnen udgøre føden for 180.000 og bentiske invertebrater kunne udgøre føden for 38.000 fugle. Fiskeindmaden udgør p.g.a. dets høje kalorieværdi den vigtigste type af affald, med den monopoliseres af få arter, især af Mallemuk og Ride.

Dette studie har vist, at fiskeriaffald udgør en vigtig føderessource for overvintrende havfugle i hele Nordsøen. Reduktion i mængden af fiskeriaffald i Nordsøen formodes at ville få en tydelig effekt, ikke bare på reproduktionen hos de ynglende havfugle i Nordsøen, men også på overlevelsen af de overvintrende *'scavengers'* i Nordsøen. Reduktioner i fiskeriaffaldet ved øgede maskestørrelser formodes hovedsageligt at ramme de mindre arter (f. eks. Ride, Stormmåge), hvorimod reduktioner ved en general nedgang i fiskeriaktiviteten vil ramme flere arter. Pludselige reduktioner i mængden af fiskeriaffald vil skabe økologisk ubalance, p.g.a. nedgang i den tilgængelige mængde af denne føderessource for havfuglene. Mindre havfuglearter vil lide under øget konkurrence- og prædationspres. Det rekommanderes derfor at gennemføre foranstaltninger, der gradvis vil nedbringe mængden af fiskeriaffald. Resultaterne af dette studie kan anvendes til mere detaljerede estimater af effekterne af lokale/regionale initiativer til reduktion af fiskeriaffald for overvintrende havfugle.

1. INTRODUCTION

The North Sea is of great international importance for its seabirds, not only during the breeding season, but also in winter. Breeding numbers of scavenging seabirds on North Sea coasts have increased by at least tenfold from 1900-1990 (Dunnet *et al.* 1990, Lloyd *et al.* 1991), and it is generally held that seabird numbers are most often limited by food. Discards (unmarketable fish or bycatch) and offal (*i.e.* entrails of gutted fish) are an important source of food for scavenging species of seabirds. Fishery waste as a food supply is likely to change as a consequence of changes in the Common Fisheries Policy of the European Community and this may cause massive changes in populations and or breeding success of quite a number of species of seabirds (*e.g.* Furness 1992).

Seabirds at sea studies showed strong correlations between at sea distribution of scavenging seabirds and fishing boats in winter (Tasker *et al.* 1987). Information on the dietary importance of discards for scavenging seabirds is limited (Furness & Hislop 1981, Noordhuis 1987, Noordhuis & Spaans 1992), particularly outside the breeding season and away from colonies (Prüter 1986, Furness 1992), but indicate that fishery waste can be very important in winter. Comprehensive reviews of current knowledge of scavenging seabirds in the North Sea (Furness 1992, Camphuysen 1993b), identified the areas where further research is needed. Unfortunately, most earlier studies on discard utilization by seabirds were undertaken in the breeding season or early autumn and base line data on a North Sea scale were largely unavailable (Camphuysen 1993b).

OBJECTIVES The study was meant to further investigate the importance of discards in seabird diets and the implications of new regulations in commercial fisheries for seabirds wintering in the North Sea. It is the first synoptic study of discard utilization by scavenging seabirds throughout the North Sea, and it is also one of the first studies of this subject in winter. Basic questions were:

- *Which seabirds are common scavengers at trawlers in the North Sea in winter?*
- *How are these seabirds distributed and what numbers occur in the North Sea in winter?*
- *How are North Sea fisheries distributed and which fisheries attract most seabirds?*
- *Which part of discards is utilized by seabirds and how do scavenging seabirds interact at the trawl?*
- *How large a proportion of discards and offal is consumed by scavenging seabirds?*
- *How large a number of scavenging seabirds can potentially be supported by fishery waste in commercial fisheries in the North Sea?*
- *What effect will measures to reduce discards in commercial fisheries have on seabirds?*

Anticipated results from this project included an overview (maps) of spatial distribution and relative abundance of scavenging seabirds in winter all over the North Sea, information on co-occurrence of seabirds and (different types of) fishing vessels on a North Sea wide scale, descriptions of dominance hierarchies in areas differing in species composition and relative abundance of scavenging seabirds, and quantifications of proportions of discarded biota which are consumed by seabirds in winter.

Distribution patterns, numbers (relative abundance and estimates of total numbers in the North Sea), species composition and age composition of scavenging seabirds in winter in the North Sea are described using the results of strip-transect counts, stern counts and counts of birds associated with nearby trawlers. It was attempted to identify the types of fisheries which occurred in different parts of the North Sea and which species of scavenging seabirds were attracted to these fisheries. An assessment of the proportion of discarded biota which is consumed by seabirds was made by means of discard experiments at trawling stations. The quantitative study of discard and offal consumption broadly followed the methodology developed by Hudson & Furness (1988), studying scavenging seabirds at trawlers around Shetland in summer. As a result of the experimental discarding the following are described: differences between subregions in the species composition of scavenging seabirds consuming discarded material from boats, the proportions of discards being consumed, and selectivity and competitive abilities of different species and age groups of scavenging seabirds. Current knowledge on quantities of discarded fish in commercial fisheries in the North Sea is summarized and consumption rates of seabirds as found in this study throughout the North Sea were used to estimate total consumption by scavenging seabirds.

FIELDWORK The work was carried out during the February 1993 International Bottom Trawl Survey (IBTS), on board the research vessels *Argos*, *Dana*, *Scotia*, *Tridens* and *Walter Herwig*, and on board RV *Pelagia*, in January/February 1993. The fact that the work was carried out from research vessels rather than from commercial fishing vessels was a limitation, but this was offset by the opportunity to achieve thorough coverage of the whole North Sea in a short period of time. The project was concluded by a workshop (April, Texel) on which results were amply discussed while evaluating the project.

AUTHORS This report, being the final report to the European Commission, is written as a joint effort by the main subcontractors in the project *'Seabirds feeding on discards in winter in the North Sea'*. The report provides a consensus view from the group attending the workshop mentioned above. Seabird distribution and relative abundance from strip transect counts were described by Henk Offringa (NIOZ) and seabird associations at the stern and at nearby trawlers are described by Kees Camphuysen (NIOZ) and Genevieve Leaper (JNCC/NIOZ). Bob Furness, Kenny Ensor (both Glasgow University) and Stefan Garthe (Vogelwarte Helgoland), dealt with results of discard experiments. Kees Camphuysen summarized all these chapters in a section with species accounts and Bob Furness prepared a chapter on the consumption of discards and quantities of discards in commercial fisheries. Kees Camphuysen prepared the remaining sections and edited the entire report, while Genevieve Leaper has checked all the English.

ACKNOWLEDGEMENTS We would like to thank Captains P.O. Bengston and L. Hansson and crew and cruise leaders O. Hagström and N. Håkonsson (RV *Argos*), cruise leader Dr H. Degel and Captain F.R. Larsen and crew (RV *Dana*), Captain A. Souwer and crew (RV *Pelagia*), cruise leader Dr A. Newton and Captain Ramsay and crew (RV *Scotia*), cruise leaders A. Corten, Dr H. Heessen and Captain Krijgsman and crew (RV *Tridens*), and cruise leader Dr H. Dornheim and Captain I. Seelmann and crew (RV *Walter Herwig*) for their co-operation onboard. We would like to thank Frank Albers, Uwe Walter, Stefan Groenewold and Olaf Zeiske for their co-operation during the inter-callibration cruise onboard RV *Pelagia*. Genevieve Leaper (Joint Nature Conservation Committee), Max Nitske Colin Barton, Olaf Flore, Jens Lund Hansen, and Max Nitske are thanked for their effort at sea. Mardik Leopold, Henrik Skov, Uwe Walter and Stefan Groenewold helped to make the Texel workshop a success. Furthermore we would like to thank Mardik Leopold for permission to use data collected on board RV *Navicula* and reading earlier drafts of this report, Maarten van Arkel and Dr Han Lindeboom (NIOZ) for their advice, assistance and encouragement during all phases of the project, from proposal to final report. David W. Armstrong (EC) kindly commented on the final draft of this report.

2. METHODS

The standardisation of methods was an important aspect of this project. Co-operation between different researchers in the North Sea is important to widen the scale of this sort of work, but is particularly valuable if methods used are fully compatible. During a week of training on board RV *Pelagia*, seabird counts and discard sessions were held in teams of varying composition, while methods of data processing were practised, discussed and standardised. The methods and standards for data processing were discussed further after the survey at the workshop in April at NIOZ, Texel, and are described in this section.

2.1 SUBREGIONS

On the basis of ICES areas IVa-c and IIIa, the North Sea and Skagerrak/Kattegat, (51-62° N, 4°W to 13°E), were divided into 7 subregions (figure 2.1). ICES area IVa, the northern part of the North Sea, was cut in two halves (NW and NE), the central North Sea, ICES area IVb, was divided in three parts (CW, C, and CE respectively), ICES area IVc, the Southern Bight, and IIIa, the Skagerrak/Kattegat area, were named S and Sk respectively. The total surface area for these subregions was estimated at 643,053 km²:

NW	156,906 km²
NE	97,271 km²
Sk	58,972 km²
CW	69,447 km²
C	140,933 km²
CE	62.781 km²
S	56,763 km²

2.2 FIELD METHODS

STRIP-TRANSECT COUNTS When steaming between trawling stations, observers counted seabirds within a strip-transect (90° forward and on one side of the ship, usually 300m wide) from which seabird densities (n/km²) were calculated. Species, age, plumage, number, behaviour (*e.g.* swimming or flying), distance to the ship, direction of flight, presence in transect and associations between different species were recorded as a routine. Strip-transect counts included a snapshot count for flying birds (Tasker *et al.* 1984). However, most scavenging seabirds spend much time on the wing and the strip-transect method, despite the snapshot count, does not always provide satisfactory results for flying birds when assessing relative abundance at sea (distribution patterns). Therefore, a scan of all birds seen ahead of the ship was performed in addition to the strip-transect. This was used to calculate the number of birds per unit distance travelled (birds per km) to provide additional information on seabird distribution. Unfortunately, the 180° scan, was not subsequently used by all observers: some did not record birds outside the transect at all, while others used only a 90° scan. As a result, some of the data could not be used when plotting distribution patterns based on the scan.

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 which offered the best view (either top deck, bridge-wing or stern). Species, age, plumage and numbers associated with the ship were recorded. 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, observers were asked to count seabirds at the stern whenever activity changed, and at regular intervals during steaming. On board RVs *Dana, Pelagia, Tridens* and *Scotia*, this procedure was indeed followed. On board RVs *Walter Herwig*, and *Argos* only 'maximum counts' at each haul were obtained. Stern counts were performed most frequently on board RV *Tridens*, and these data provide good examples demonstrating fluctuations in numbers at the stern during the day. 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. It was obvious that scavengers attended our vessels at night, but counts were never accurate enough and most trawling was during daylight anyway.

RECORDS OF COMMERCIAL TRAWLERS Records were made of nearby commercial trawlers. At each trawler, type of vessel, name, code, activity, distance, and numbers and species of associated seabirds was recorded. These observations were usually made from the top

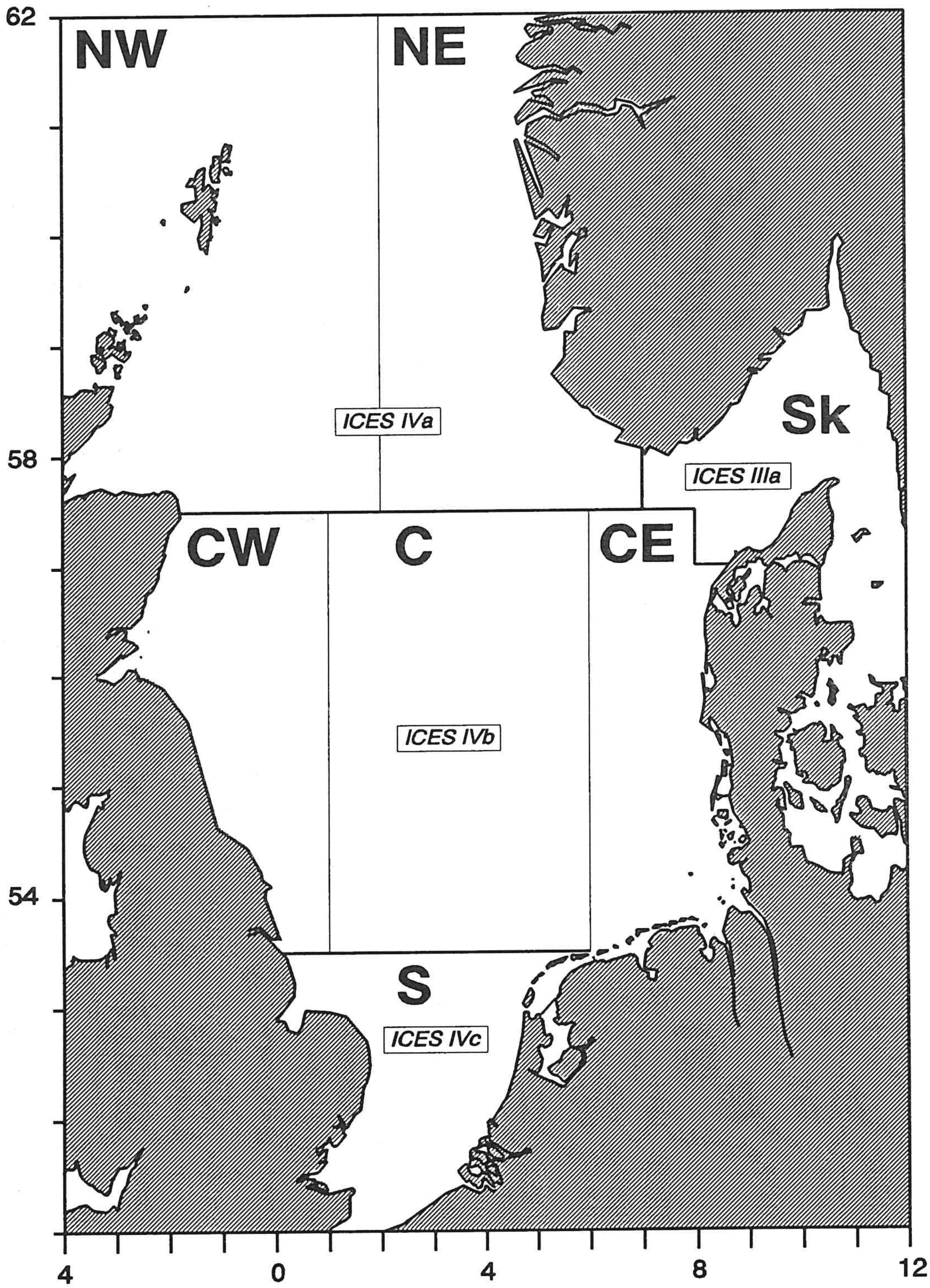


Figure 2.1 *Subregions in the North Sea used for this project, as based on ICES fishing areas IVa-c and IIIa.*

deck during steaming, but records were kept separately from the strip-transect data.

DISCARD-EXPERIMENTS When the working programme of the vessel permitted, a sample was taken from each haul. The items were identified, length measured to the nearest cm, and discarded into the sea. Wherever possible, discard experiments were held during routine discarding from the vessel after fish sampling work, so that scavenging seabirds were already feeding on a stream of discards. In our opinion, this came closest to a natural situation that can occur on a fishing vessel. 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 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. RVs *Dana* and *Scotia* discharged waste fish by mincing the fish and discharging into the sea through the hull. At these vessels in particular it was often necessary to discard quantities of whole fish from the deck to attract scavenging birds before experimental discarding began. In many experiments fish were being routinely discarded from the vessel by fishery biologists while experimental discarding was being performed, a situation similar to that at many small fishing boats in the North Sea. However, for some experiments the discarding rate was much less than would occur at commercial vessels, and so the research results cannot be considered a reliable model of events at commercial boats. Any differences between the research vessels should have minimal effects on comparisons between areas of the North Sea since each vessel performed experiments in at least three of the six subregions of the North Sea. No experimental discarding was performed in the Skaggerak/Kattegat (Sk).

During discarding experiments the numbers and age classes of scavenging seabirds of each species were recorded so that fish consumption could be related to scavenging flock composition. The items discarded were not necessarily a random selection of the catch, since they were obtained after fishery biologists had selected samples. It was intended that discards would include benthos and fish offal as well as whole roundfish and flatfish. In practice, offal was not available on some vessels and discarding concentrated on roundfish since much of the benthos and flatfish discarded was not taken.

EQUIPMENT AND FACILITIES ON BOARD Equipment and consumables used at sea consisted of (1) pre-printed data sheets for all counts and for discard experiment results, (2) a small tape recorder, or dictaphone, suitable for one-handed use) for discard experiments and (3) fish measuring ruler (at least 50 cm). Pairs of powerful but small binoculars (*e.g.* 10x40) were used during all seabird counts and during experimental discarding. Most data were put onto computer while onboard.

Facilities on board the research vessel were: use of the top deck, access to of navigation equipment and charts (for reading positions), permission to sample fish out of the discard fraction of the catch, permission to work at the stern of the ship to conduct discard experiments.

For future studies, the following equipment is recommended: pre-printed data sheets, (2) a well prepared tape recorder, and (3) a fish measuring ruler as indicated above. Powerful notebook computers to process data on board the ship, capable of running a database programme and working files of several hundreds of kilobytes at reasonable speed (recommended type is a notebook 386 DX, 2-4MB RAM, 50-100MB harddisk), and plenty of HD diskettes for backups. Very warm cloths (strip-transect counts) as well as rubber boots, waterproofs and fishermens gloves (discard experiments, fish sampling) are needed during fieldwork. Observation posts on the top-deck should be prepared so that at least some shelter is given to the observer plus a reasonably confortable position with good views.

2.3 DATA ANALYSIS

STRIP-TRANSECT COUNTS Observer effort from the scan and the strip-transect were expressed as distance travelled (km) and surface area surveyed (km²) respectively. Birds were either plotted as number per linear distance (n/km) or according to densities (n/km²). The distribution of counts per subregion was approximately random and, hence, multiplying the densities with the surface area of a subregion will be sufficient to estimate the total number of scavengers wintering in the North Sea from transect data. However, transect counts in the vicinity of fishing boats were excluded from this routine, as numbers of birds associated with fishing vessels were analysed separately (see below).

Some of the strip-transect counts were during bad weather, and were considered of poor quality. Conditions that have a negative effect on the quality are visibility and wave height. It was decided to reject counts conducted when the visibility was less than 1 km and when waves were more than 3 meters high. Since birds are apparently more attracted to slow moving vessels (O. Hüppop and S. Garthe *pers. comm.*), all counts when the ship travelled with a speed of less than 5 knots were omitted.

STERN COUNTS Maximum counts for each haul were used to compare seabird numbers at the stern at the 188 different hauls which were studied. Counts were also analysed in each subregion. Abundance estimates of ship-followers comprised *frequency* (number of counts at which present), *total number seen* (sum of all hauls), maximum number present, *presence* (% of all stern counts at which species was present), *average* number at the stern (total number observed divided by total number of stern counts), *standard error*, *proportion adults* (%), and *sample* over which the age composition was calculated. The 'mean' was chosen rather than the 'median', although the latter would be more appropriate statistically. However, the median would be 0, and not very informative, in all cases where birds were present at <50% of the counts. It has to be kept in mind, that the information provided from the mean over a non-normal distribution, although satisfactory for our purposes here, is limited in statistical terms.

Fluctuations in numbers at the stern were studied using data collected on board RV *Tridens*. The presence of birds at different types of activities was ranked to work out the most attractive 'state' of a fishing vessel. The speed at which numbers at the stern build-up is demonstrated and, based on flying speeds and densities at sea, calculations were made to estimate the range from which seabirds were attracted.

RECORDS OF COMMERCIAL TRAWLERS The distribution of commercial trawlers during February 1993 IBTS surveys is described in section 4.3, but the total numbers of birds associated with these vessels were used in section 4.1 to produce estimates of total numbers of seabirds in the North Sea during the February 1993 IBTS. Birds associated with trawlers were excluded from the analysis of strip-transect counts. All records of fishing vessels and their associate birds within 2 km of the ship (*i.e.* a 4 km transect) were used to calculate total numbers associated with trawlers per subregion. This figure was added to numbers calculated from strip-transect counts, to give total number of birds.

DISCUSSION Despite agreements on the intercallibration trip, complete standardization was not achieved. Note that some of the deviations from the standard methods were caused by differences between vessels. Discard and fishing practices (including gear, timing, and planning of the cruise) were different and conditions on board did not always allow field work exactly in the way we had planned it. Minor differences in methods, mainly the result of (mis-) interpretation of agreements and because some of the observers were unable to be present on the *Pelagia* cruise, did cause some problems in the analysis of data. The lesson for any subsequent exercise of this sort is that written manuals should be prepared in advance and that the guidelines in these manuals should be followed strictly by participants. In this report, deviations of the standard method are identified while assessing the effect on data analysis.

2.4 SPECIES SELECTION

Some 32 species of seabirds have been recorded scavenging at trawlers in the NE Atlantic regions (Camphuysen 1993b). Many of these occur only occasionally and in small numbers. In this report data were analysed in detail only for numerous scavengers as found during the February 1993 IBTS:

Fulmar *Fulmarus glacialis*
Gannet *Sula bassana*
Common Gull *Larus canus*
Herring Gull *Larus argentatus*
Great Black-backed Gull *Larus marinus*
Kittiwake *Rissa tridactyla*

In addition, for comparison with these scavenging species, distribution maps were prepared for the Little Auk *Alle alle*, as an example of a species in which distribution is not influenced by fisheries.

During discard experiments a variety of fish, benthic animals, cephalopods, and items classified as 'offal' were thrown over the side. Only eleven taxa were discarded in large enough numbers to warrant analysis individually:

offal
Herring *Clupea harengus*
Sprat *Sprattus sprattus*
Saithe *Pollachius virens*
Cod *Gadus morhua*
Haddock *Melanogrammus aeglefinus*
Whiting *Merlangius merlangus*
Norway Pout *Trisopterus esmarckii*
Grey Gurnard *Eutrigla gurnardus*
Dab *Limanda limanda*
Long rough Dab *Hippogloss. platessoides*

3. CRUISE REPORTS

In this section, cruises of the research vessels engaged in the IBTS programme and of RV *Pelagia*, used for the intercallibration of methods at sea, are described. Routes are plotted for each ship, and the vessels are briefly described, focussing on length, gear used, activity and methods of discarding.

RV ARGOS

Fisheries research vessel, Insitute of Marine Research, Lysekil, Sweden, length 62 m
Cruise dates: 8-25 February 1993
Observer: Jens Lund Hansen (Ornis Consult)
Subregions visited: Sk

RV *Argos* worked in the Skagerrak/Kattegat area (figure 3.1) and an area of 197 km² was

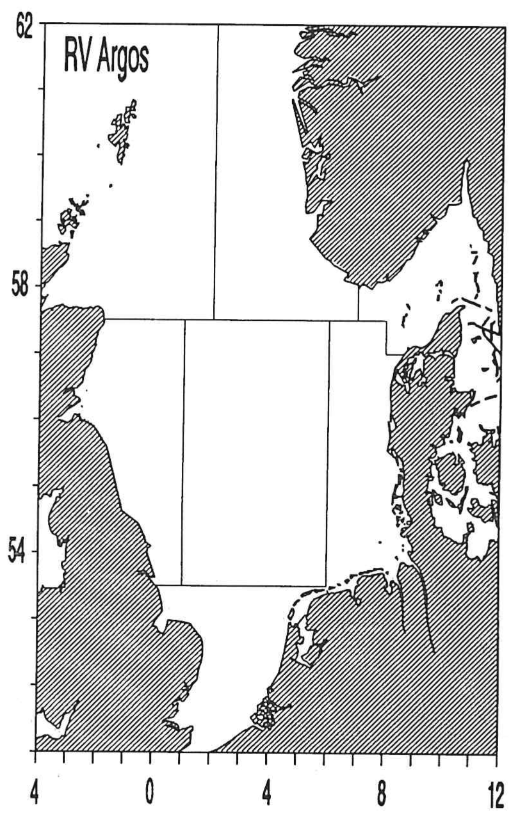


Figure 3.1 Strip-transect counts on board RV Argos, 8-25 February 1993.

surveyed by the strip-transect method (table 3.1). The 180° scan method was not used following methods described by Tasker *et al.* (1984), but some birds outside the transect were recorded. All work was carried out by the same observer. Observations were usually from the top-deck (height 8 m), but occasionally from inside the bridge (5 m). The large shallow areas of Jammerbugt and western Kattegat were not trawled and trawling stations west of Skagen were clumped. GOV-trawl was used. Maximum numbers of associated birds were assessed at every haul during daylight but separate counts were not made for different activities. Details of 43 stern counts were received (table 6.2.1). The weather was generally calm, except for force 6 winds on 22 February, and visibility was moderate to good.

RV DANA

Fisheries research vessel, Danish Institute for Fisheries, length 78m
Cruise dates: 3-18 February 1993
Observers: Genevieve Leaper (Joint Nature Conservation Committee) & Max Nitske (Ornis Consult)
Subregions visited: Sk, CW, C, CE

The *Dana* worked mainly in the central North Sea, between Denmark and the east coast of England (figure 3.2). An area of 360 km² was surveyed by transect counts. Transect counts were made from the top deck, a good, high observation position but scan counts (carried out about half the time) were limited to 90°. Visibility for counting associated birds was less good, with large areas obscured by the ship's superstructure from any position. Counts of associated birds were made from the afterdeck. One observer did transect counts and recorded birds associated with fishing vessels while the other carried out discard experiments and counted birds associated with the ship. The two observers performed both roles on alternate days. Except when leaving port, the *Dana* trawled on all days, 14 in total, with usually three or four hauls a day. Discarding practices on board *Dana* were different from most fishing vessels. After a sample had been taken by fisheries scientists, the rest of the catch was macerated and discarded beneath the hull. Discards were randomly sampled off the conveyor belt, but then more of the preferred items were selected for experimental discarding. The macerated discards sometimes became available to the birds, but on other occasions apparently sank. Because of the discarding procedure, it was impossible to carry out discard experiments during discarding. The experiments were instead carried out whenever associated birds were numerous, usually during or just after lifting the net. Weather conditions were generally quite good, with winds of force 3 or less for much of the time. Strong winds were only encountered at the very beginning and end of the cruise. Visibility, however, was moderate to

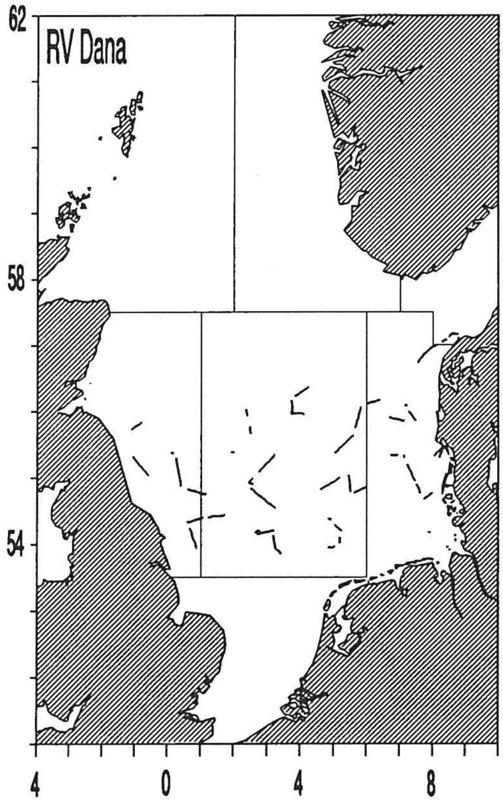


Figure 3.2 Strip-transect counts on board RV Dana, 3-18 February 1993.

poor and on one occasion transect counts had to be discontinued due to thick fog.

RV Pelagia

Research vessel, NIOZ, length 66m
Cruise dates: 27-28 January 1993
Observers: Frank Albers, Ommo Hüppop & Uwe Walter (Vogelwarte Helgoland), Kees Camphuysen and Henk Offringa, (Netherlands Institute for Sea Research), Kenny Ensor (Glasgow University), Stefan Groenewold and Olaf Zeiske (Hamburg University), Genevieve Leaper (Joint Nature Conservation Committee), Max Nitske (Ornis Consult)
Subregions visited: C, S

To standardise methods to be used during the February 1993 IBTS, a 4 day cruise was scheduled on RV *Pelagia*, from 25-28 January 1993. Unfortunately departure was delayed two days due to bad weather but the ship sailed two transects perpendicular to the Dutch coast on 27 and 28 January (figure 3.3, table 3.1) at an average cruising speed of 10 knots. The strip transect method for assessing densities, discard experiments and counts of birds associated with own vessel and commercial fishing vessels were practiced and discussed. Transect counts were made from a specially designed bird-watching position on the top deck (13m high). The number of observers varied to train those unfamiliar with the method. Three trawling stations were worked on each transect, trawling for 30 minutes each time with a small (5m) beamtrawl. Discard experiments were limited as the catches were small and consisted mainly of flatfish. Unlike the fisheries research vessels, the *Pelagia* has no facilities for processing catches so there was no discarding from the ship during experimental discarding. Weather conditions were moderate to good with winds not more than force 5 and low waves (< 2 m). Visibility was good (>10 km), but counts were stopped early on the second day due to heavy rain. The *Pelagia* cruise was not part of the IBTS, but the data were included in the database and are evaluated in this report.

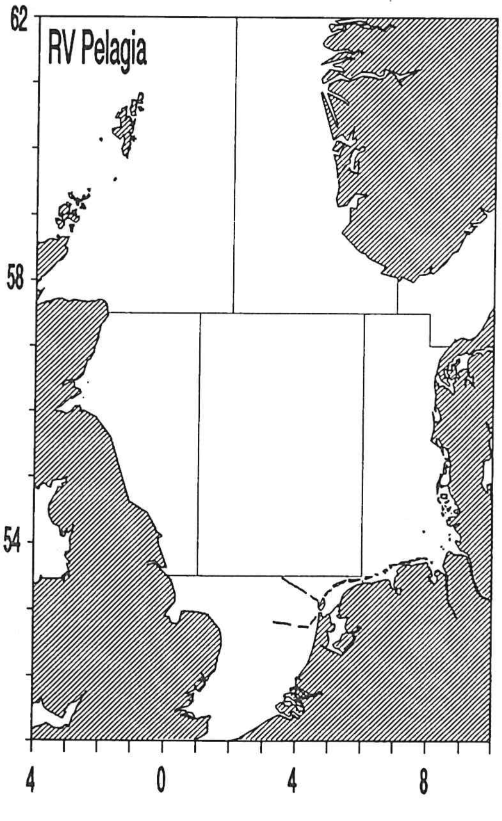


Figure 3.3 Strip-transect counts on board RV Pelagia, 27-28 January 1993.

RV Scotia

Fisheries research vessel, Scottish Office Agriculture & Fisheries Dept., length 69 m
Cruise dates: 1-19 February 1993
Observers: Kenny Ensor (Glasgow University) and Colin Barton (Joint Nature Conservation Committee)
Subregions visited: NW, NE, CW, C

The *Scotia* was diverted because of the *Braer* oilspill and much time was spent in activities other than fishing. Birds were counted in the strip-transect over an area of 316.6 km² (table 3.1, figure 3.4). Transect counts and 180° scan were carried-out by one observer (Colin Barton). *Scotia* trawled from an 'A' frame at the stern, using GOV-trawl. Trawling took place on only 10 out of 19 days. The fish were sorted below decks and discards were liquidised and pumped out through the hull below the water. When ex-

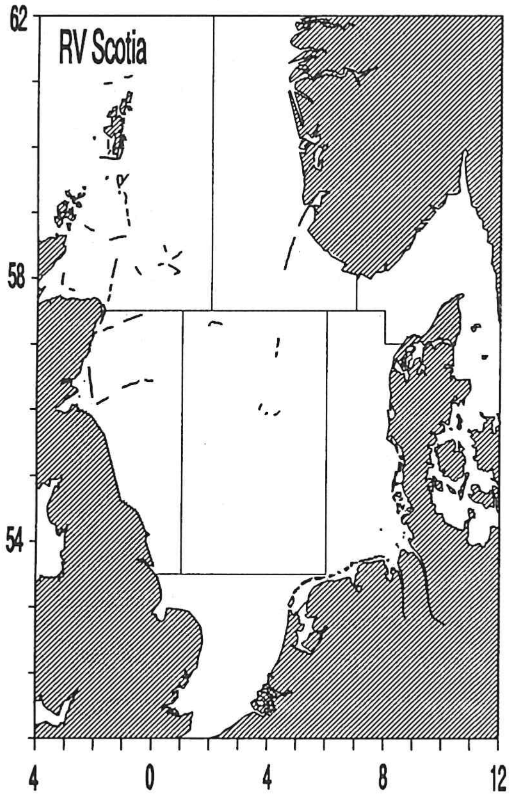


Figure 3.4 Strip-transect counts on board RV Scotia, 1-19 February 1993.

tremely large catches were made, only a sample of the catch was taken below and the rest of the fish were discarded whole down a chute at the stern, one basket at a time. The discarded fish were difficult to see in the wake and the majority presumably sank. Counts of associated birds and discard experiments were made by the same observer throughout (Kenny Ensor). An attempt to count associated birds and discard fish after dark was unsuccessful so thereafter counts were only made during daylight. The weather was often quite calm with moderate wind and waves of 1-2m but occasional strong winds up to force 12 and high encountered.

RV TRIDENS

Fisheries research vessel, Directorate of Fisheries, length 73.5m
Cruise dates: 2-25 February 1993
Observers: Kees Camphuysen & Henk Offringa (Netherlands Institute for Sea Research)
Subregions visited: NW, CW, C, CE, S

RV *Tridens* visited several subregions with highest effort in subregions S, CW and NW (figure 3.5). During steaming (average speed 13 knots) transect counts and 180° scan were carried out over an area of 538km² (table 3.1). The transect width occasionally had to be reduced to 200m. Transect counts were made from the top deck with two observers. Stern counts were hampered by the ship's superstructure, and were often made from the top deck, occasionally from the bridge wings or from the stern. Both obser-

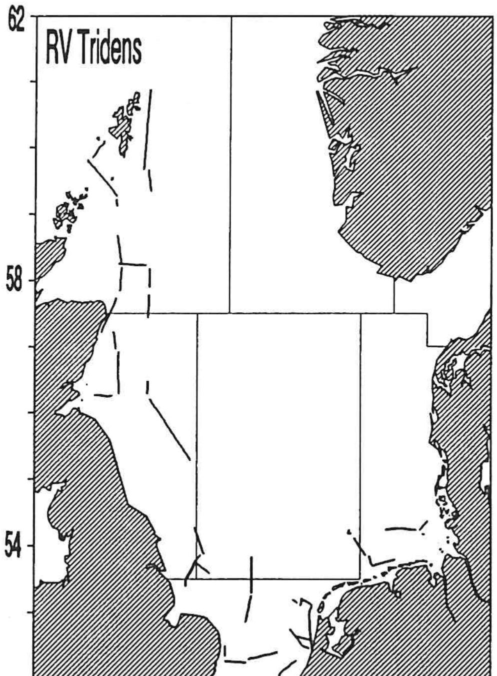


Figure 3.5 Strip-transect counts on board RV Tridens, 2-25 February 1993.

vers also worked together during fishing activities, which was found to be very effective. One counted associated birds at the stern while the other was experimentally discarding fish. On average 3 to 4 hauls were worked per day (41 hauls total), using standard fishing methods and gear (GOV trawl). Stern counts were made during all fishing activities and were also performed at intervals during steaming. Discarding practices on board *Tridens* were similar to many fishing vessels. After a sample had been taken by the fisheries scientists, the rest of the catch was discarded, usually shortly after hauling, but sometimes fish were also discarded just prior to or during the next haul. The best times for discard experiments were found to be during stationary activities. Experimental discarding was carried out from the stern, close to the hatch where the ship's discards came out. Fish were thrown one by one, or small handfuls at a time between fish discharged by the ship's normal practice or during hauling. Weather conditions were moderate to excellent; winds varied from force 0 to force 7 and wave height from 0 to 3m.

RV Walter Herwig

Fisheries research vessel, Bundesforschungsanstalt für Fischerei (Hamburg), length 80 m.
Cruise dates: 23 January-12 February 1993
Observers: Stefan Garthe & Olaf Flore (Institut für Vogelforschung "Vogelwarte Helgoland")
Subregions visited: NW, NE, CW, C, CE

RV Walter Herwig is the largest vessel involved in the survey and resembles commercial stern trawlers operating in the northwestern North Sea in appearance. Large areas of the central and northern North sea were surveyed up to the north of Shetland (figure 3.6) with highest effort in subregion NW. Strip-transect counts were mostly conducted from the bridge (10 m high), on a few occcasions from the top deck (12m) and usually by two observers. The scan method was not practiced. Due to high waves, the transect width had to be reduced to 200m for much of the time but a total area of 290km² was surveyed (table 3.1). Counts of birds associated with the ship were not recorded separately for different fishing activities but maximum numbers for each species and age group were recorded for all hauls (44) during daylight. The counts were made during the period from shooting the net until steaming was resumed, usually by one observer from a platform at the stern. Trawling took place on every day except 24 January. with normally 3 to 4 hauls per day. Practice of discarding differed from commercial trawlers and varied according to the size of catch and time of day. Sometimes the largest part of the catch was discarded immediately after sorting, but on other occasions the catch was not sorted for three quarters of an hour after hauling and no discarding occurred for some time. Discards experiments were carried out within the period from hauling the net until the beginning of steaming from a platform 8 m

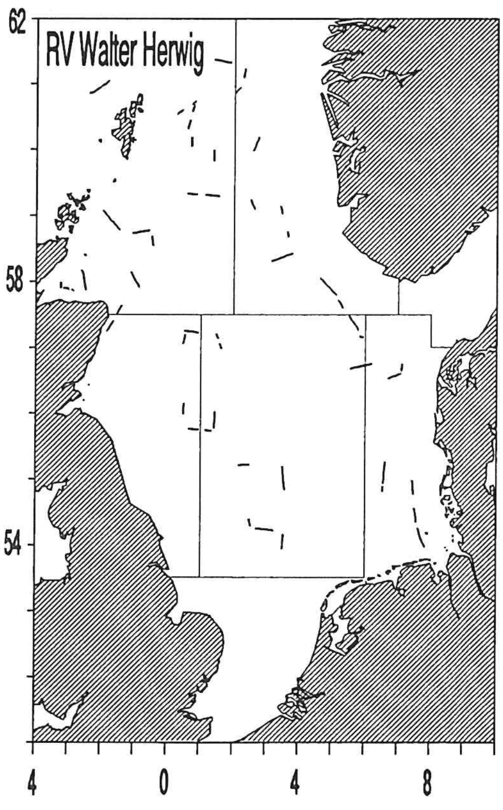


Figure 3.6 Strip-transect counts on board RV Walter Herwig, 23 January-12 February 1993.

high at the stern. One person measured total length, (at most hauls also standard length, height and circumference) and discarded the fish. The other observed the fate of the fish. The cruise was characterized by bad weather, especially at the beginning. Winds up to force 12 and waves up to 14 m high severely restricted work in the first few days.

4. RESULTS

4.1 NUMBERS OF SEABIRDS AT SEA: RESULTS OF STRIP-TRANSECT COUNTS

The overall distribution of seabirds at sea in the North Sea changes from year to year and between seasons (Tasker *et al.* 1987). These changes are probably mainly caused by spatial fluctuations in food supply. Scavenging seabirds are obviously attracted by fishing fleets (Wahl & Heinemann 1979) and the distribution of scavengers at sea may partly reflect the spread of fishing activities over the area. This section deals with results of counts of seabirds at sea during steaming (assumed not to be influenced by the research vessel) and provides distribution patterns and abundance estimates of scavengers at the time of our surveys. Birds were counted between trawling stations within a 200 or 300m wide strip-transect on one side and in front of the ship.

Distribution maps of the common scavengers were drawn from both strip-transect counts (densities) and scan counts (numbers per km). Densities were used to estimate total numbers present in each of the subregions and in the North Sea and Skagerrak as a whole (extrapolation of results to total surface area). The distribution maps and abundance estimates were compared with results of similar surveys in the North Sea undertaken during 1978-86 (Tasker *et al.* 1987), and European database, a compilation of surveys from 1980-90 (ESASD, unpubl. data). Densities and numbers per linear distance are given per 15x30 minute-square (quarter ICES squares), with legend keys similar to those used by Tasker *et al.* (1987) to allow direct comparisons.

During the April workshop, it was decided for reasons of comparison to produce maps of a species which is unlikely to be influenced by fisheries. Distribution maps are presented for the Little Auk *Alle alle*, a plankton-feeding seabird from the high arctic, which uses the North Sea only as a wintering area.

COVERAGE Strip-transect counts have been conducted since the late 1970s in the North Sea (Blake *et al.* 1984), but this was the first time that the entire North Sea was synoptically covered in one month. Some subregions were surveyed more thoroughly than others, but the overall coverage in terms of km² surveyed was 0.27% (table 3.1, figures 4.1.1):

	Area surveyed	*coverage*
NW	430.09 km²	0.27 %
NE	81.67 km²	0.08 %
Sk	207.33 km²	0.35 %
CW	293.46 km²	0.42 %
C	338.84 km²	0.24 %
CE	174.22 km²	0.28 %
S	224.61 km²	0.40 %

Observer effort for this IBTS February survey, in terms of km² surveyed, amounted to the equivalent of one quarter of all February data currently available in the ESAS database (ESASD, unpubl. data). In terms of number of quarter ICES squares visited (figures 4.1.2-3), some 36.2% of the North Sea and Skagerrak were covered:

	Quarter ICES squares visited	*coverage*
NW	68	32.9%
NE	20	15.9%
Sk	31	37.8%
CW	44	51.1%
C	63	39.4%
CE	32	42.7%
S	33	48.5%

AT SEA DISTRIBUTION During the February 1993 IBTS, 26 species of seabirds and waterfowl were seen during transect counts, including 8 species of gulls, 5 species of

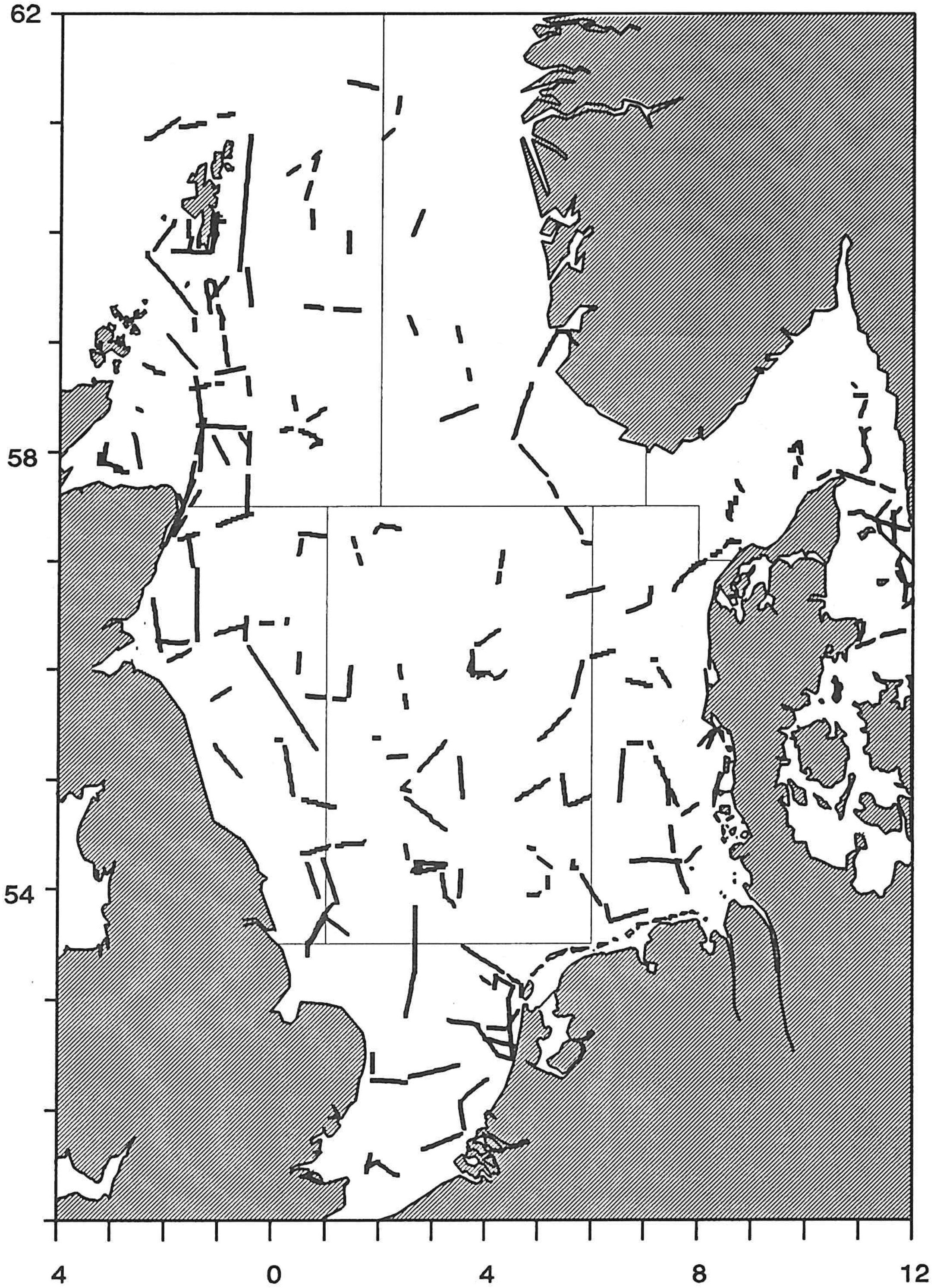


Figure 4.1.1 *Total coverage (1): routes of transect counts of all ships, IBTS 1993*

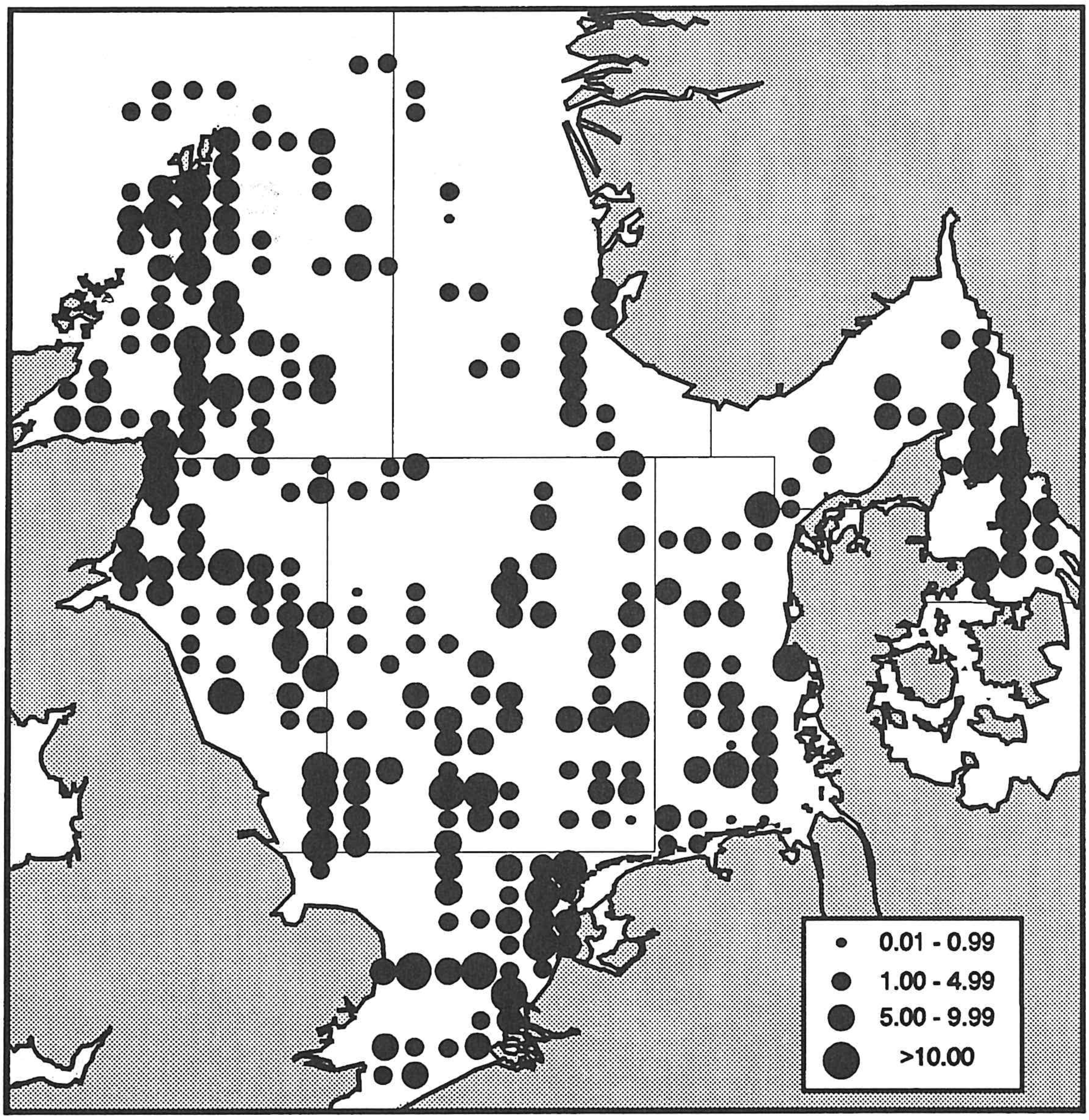


Figure 4.1.2 *Total coverage (2): coverage of the North Sea using strip-transect counts. Dot size represents km² surveyed per quarter ICES-square.*

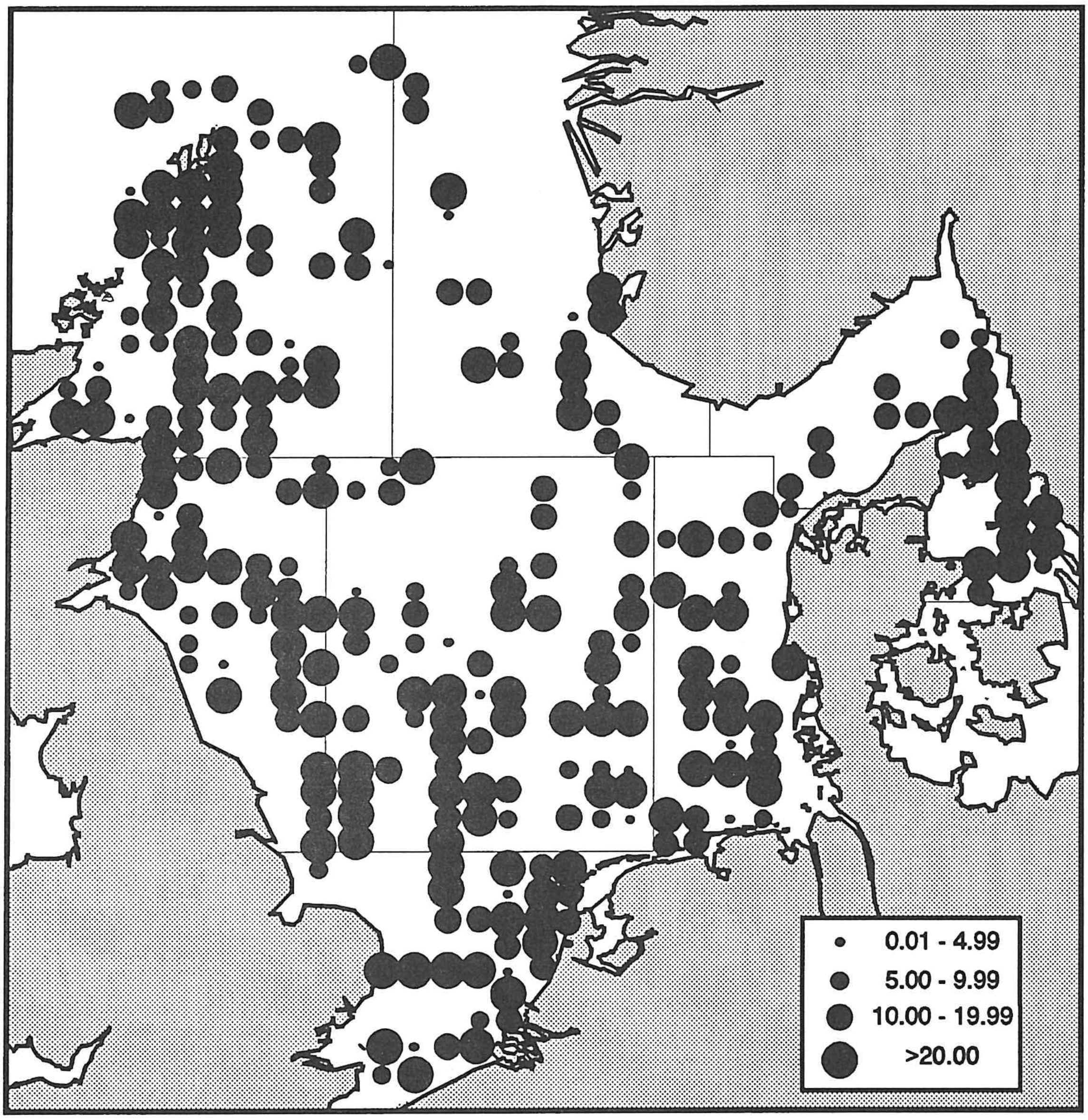


Figure 4.1.3 *Total coverage (3): coverage of the North Sea using scan method. Dot size represents distance travelled (km) per quarter ICES-square.*

auks, Fulmar *Fulmarus glacialis*, Gannet *Sula bassana*, and Great Skua *Catharacta skua* (table 4.1.1). Common scavengers at the trawl, including Fulmar, Gannet, Common Gull *Larus canus*, Herring Gull *Larus argentatus*, Great Black-backed Gull *Larus marinus*, and Kittiwake *Rissa tridactyla*, were widespread and often numerous at sea (figures 4.1.4-15). The Lesser Black-backed Gull *Larus fuscus* and Black-headed Gull *Larus ridibundus*, well known as scavengers from earlier studies (Camphuysen 1993b), were scarce. The former occurs in substantial numbers in the North Sea only during summer, while the latter species only occurs in numbers close inshore, a zone which was inadequately covered during the present IBTS survey. These two species are not considered in any detail here. Guillemots and Razorbills were numerous, but rarely recorded as scavengers.

Densities of Fulmars were high around Shetland, off the Moray Firth and in the Southern Bight (figures 4.1.4-5). Gannets were only found in numbers to the west of 6°E, with high numbers off the Firth of Forth, off the Moray Firth and southeast of Shetland, all close to important colonies (figures 4.1.6-7). Common Gulls were mainly encountered in the Southern Bight, the German Bight and in the Skagerrak/Kattegat (figures 4.1.8-9). Herring Gulls were widespread but usually occurred in low densities. Most were found in the Kattegat and off the Moray Firth (figures 4.1.10-11). Great Black-backed Gulls were most numerous around Shetland and in the Southern Bight (figures 4.1.12-13). Kittiwakes, the most widespread of all species, were encountered in the highest densities off northeast Scotland and in the southern Bight (figures 4.1.14-15). Little Auks were found in the northern half of the North Sea only, with concentrations off SW Norway, in the western part of the Skagerrak and off northeast England and East Scotland (figures 4.1.16-17).

Distribution patterns as derived from strip-transect counts are slightly different from those plotted from scan data (see discussion). The presence of seabirds in each of the subregions by quarter ICES squares (comparing data derived from scan and strip-transect), is given in table 4.1.2.

DIFFERENCES BETWEEN OBSERVERS Every ship has its own limitations for observers. The height of the top deck varies, and the view from the observation position is often partially obscured by superstructure. In order to check the variation between results on different vessels in the same area, a comparison was made between results obtained in the southern part of subregion NW; the only area which was visited by three research vessels at roughly the same time (between 2 and 21 February). RV *Tridens* covered 84.2km², *Scotia* 93.1km² and *Walter Herwig* 57.3km². The densities of scavengers and Little Auks found are listed in table 4.1.3. A Friedman test did not show significant differences between the three vessels ($t = 3$, $b = 6$, $p > 0.1$), even when compared two by two (paired t-test, $p > 0.5$).

ABUNDANCE ESTIMATES The detection of flying birds is generally not much of a problem for observers. Swimming birds, however, are more easily overlooked (*cf.* Dixon 1977). To correct for birds in the strip-transect which were missed, the perpendicular distance to the ship was recorded for each sighting on the water (in strata (A) 0-50m, (B) 51-100m, (C) 101-200m, and (D) 201-300m). Assuming that densities are similar in each of these strata, numbers of birds which were missed can be calculated (correction to densities found in the nearest stratum; figure 4.1.18). Two separate correction factors were calculated (1) for birds which spend a considerable amount of time flying (*e.g.* petrels, gannets, gulls) and (2) for species which mostly spend more time on the water and are therefore more easily overlooked (*e.g.* auks). Calculated factors, derived from numbers observed in each of the strata, used to correct densities of on-water birds from strip-transect counts in the February 1993 IBTS were used to estimate total numbers of birds in the North Sea from strip-transect counts (table 4.1.4). The total number of scavengers in the North Sea (excluding those associated with fishing vessels) in February

1993, as calculated from transect counts and corrected for birds which were missed, was approximately 1.16 million (table 4.1.4). Most abundant were:

Fulmar	466,500
Herring Gull	215,000
Kittiwake	226,000

To assess the importance of commercial trawlers with respect to seabird distribution, trawler sightings were analysed separately, considering a 2 km wide strip transect on both sides of the ship, assuming that all trawlers were counted within this area. For all trawlers, type of ship, activity and numbers and species of associated seabirds were recorded separately (see also section 4.3). A total of nearly 18,000 seabirds were recorded in association with 72 fishing trawlers (table 4.1.4). When extrapolated using total surface area in each subregion, some 460,000 birds may be associated with commercial trawlers in the North Sea. Added to numbers recorded in transect, a total of about 1.62 million scavenging seabirds were estimated in the North Sea in February 1993, comprising:

Fulmar	720,000
Gannet	70,000
Common Gull	57,500
Herring Gull	297,000
Great Black-backed Gull	175,000
Kittiwake	298,000

AGE COMPOSITION The ages of Gannets and gulls were routinely recorded during strip-transect counts, using plumage characteristics. In most areas and for most species, adults predominated (table 4.1.5). Immature Gannets were virtually absent in the North Sea (97.2% adult, n= 776). Most Common Gulls were adults (85.5%, n= 325), particularly so in Sk (95.2% adult, n= 21), and least so in NE where small numbers occurred near Stavanger (74.7% adult, n= 91). Over two thirds of all Herring Gulls were identified as adults (71.1%, n= 1,642), but in the central North Sea (subregions CW-CE) nearly half the Herring Gulls were immatures (54.3% adult, n= 398). Adults clearly predominated in Sk (83.2% adult, n= 600). Some 58% of all Great Black-backed Gulls were adults, but this ratio differed a lot between subregions (range 37.5-79.2% adult, table 4.1.5). Adult Kittiwakes predominated in all subregions (92.0% adult, n= 3,122), with the highest proportion of immatures in CE (73.6% adult, n= 182).

DISCUSSION The two methods used to map distribution patterns based on transect counts or the scan are similar in most cases, although according to the first method, several species seem less widespread than according to the latter. The main advantage of the densities derived from strip-transects is that they represent the 'true' number of birds and can be used to calculate total numbers present in an area. Scan results give a better impression of the distribution of a species. Obviously, the frequency of records found using the scan exceeds that found in transect. Theoretically, the probability to record a blank in strip-transect counts would be $e^{-\lambda}$ and the probability to record a blank in the scan for birds ahead of the ship is $e^{-b\lambda}$ (where λ= number of birds in transect per quarter ICES square). Discrepancies between distribution patterns would than mainly occur in areas with moderate densities, whereas the difference would be small when densities are either very low or high. Some of the differences found in distribution patterns of scavenging seabirds were rather large, even in areas where densities were comparatively high. Great Black-backed Gulls in subregion NW were not recorded in 49 out of 68 quarter ICES squares in transect-transect counts (presence 28.1%; table 4.1.2), while the species was found in 70.8% squares using the scan (*cf.* figures 4.1.10-11). Substantial differences were also found in Fulmars in the central North Sea (subregion C; 55.3% in transect, 82.6% in scan, n= 53 quarter ICES squares), Herring Gulls in the northwestern (NW; 29.7% in transect, 52.3% in scan, n= 68) and central North Sea (C; 17.0% in transect, 41.3% in scan, n= 53).

Distribution patterns and abundance estimates show some striking differences from

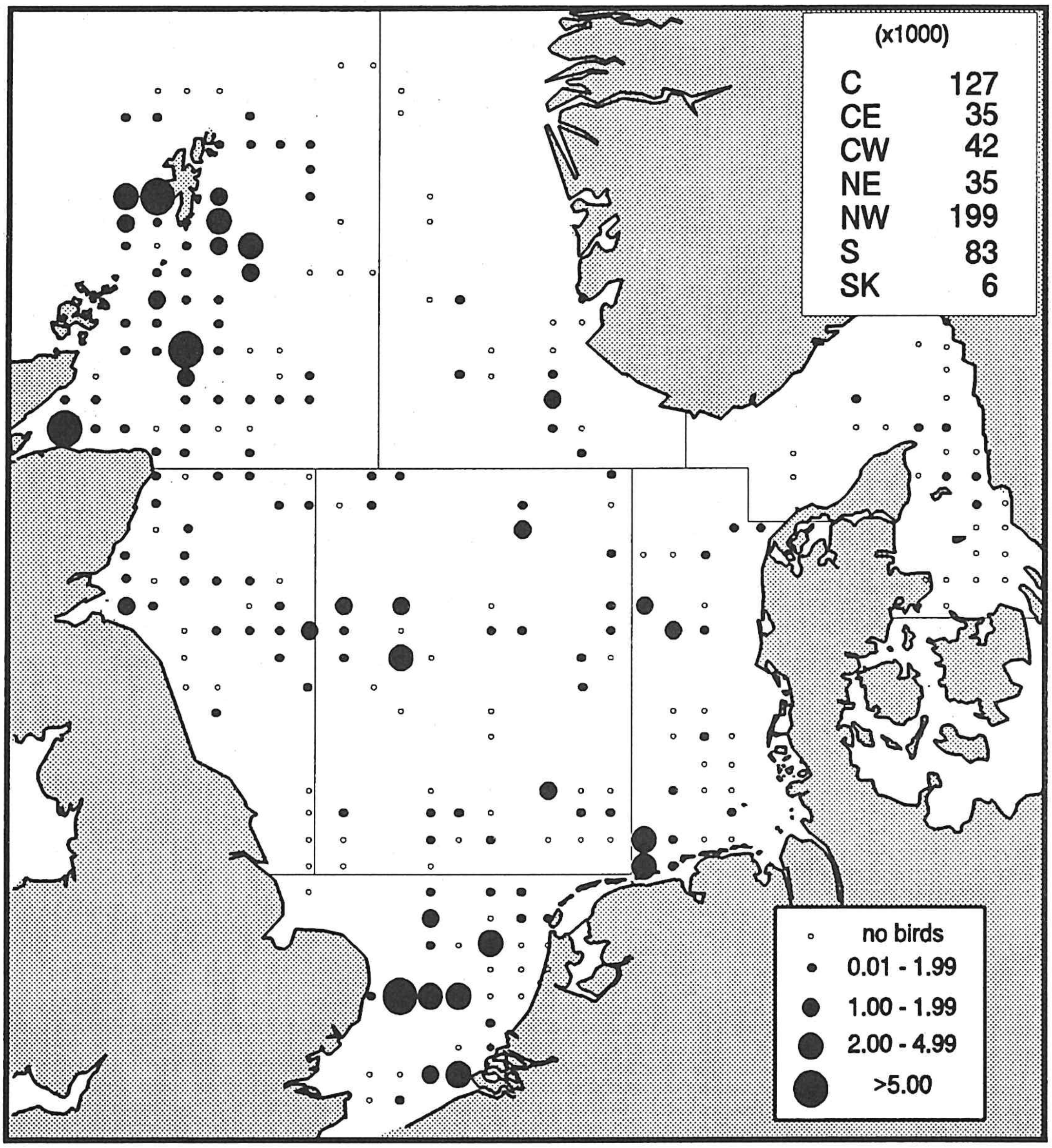


Figure 4.1.4 *Distribution of Fulmars Fulmarus glacialis in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

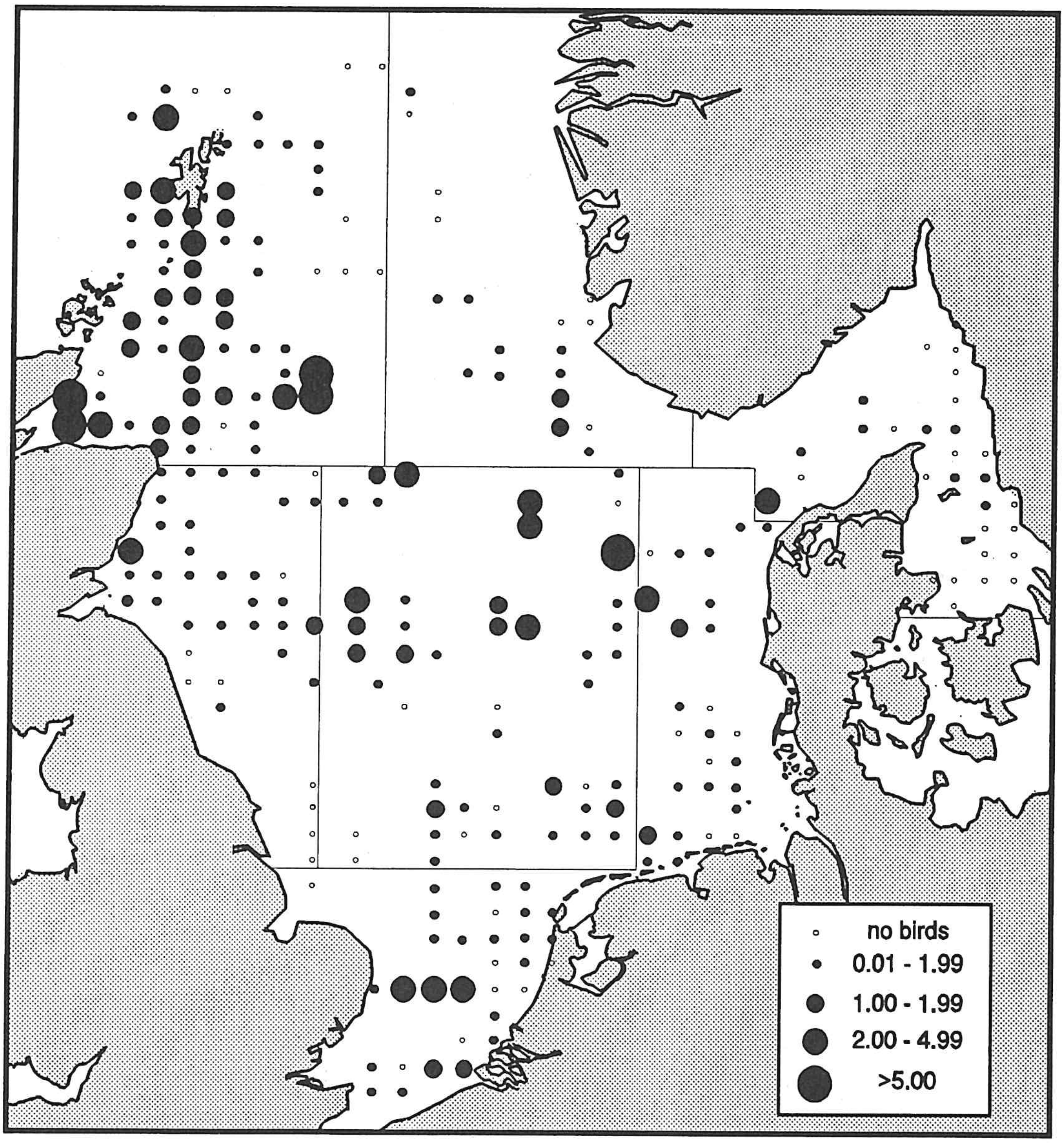


Figure 4.1.5 *Distribution of Fulmars Fulmarus glacialis in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

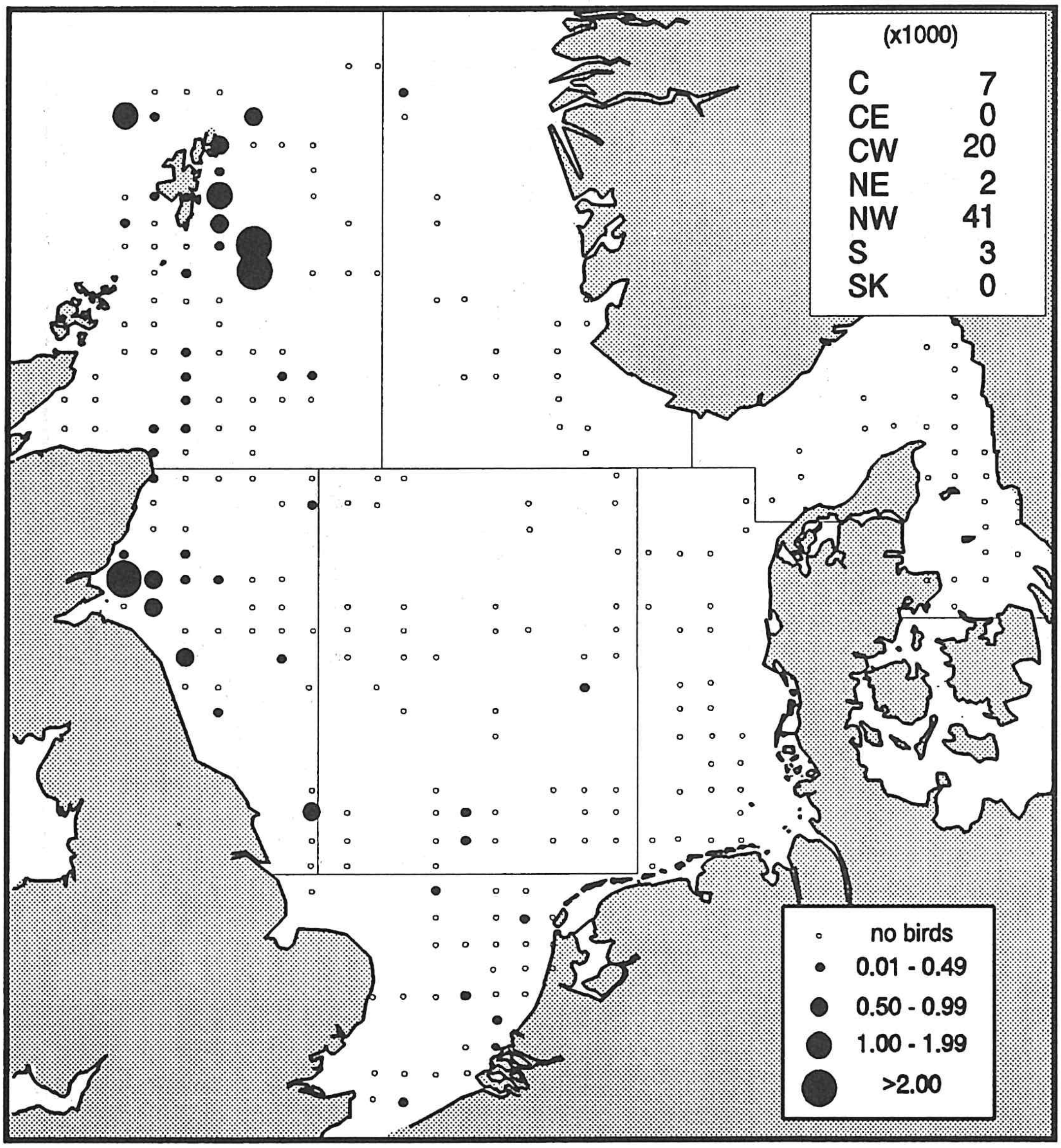


Figure 4.1.6 *Distribution of Gannets Sula bassana in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

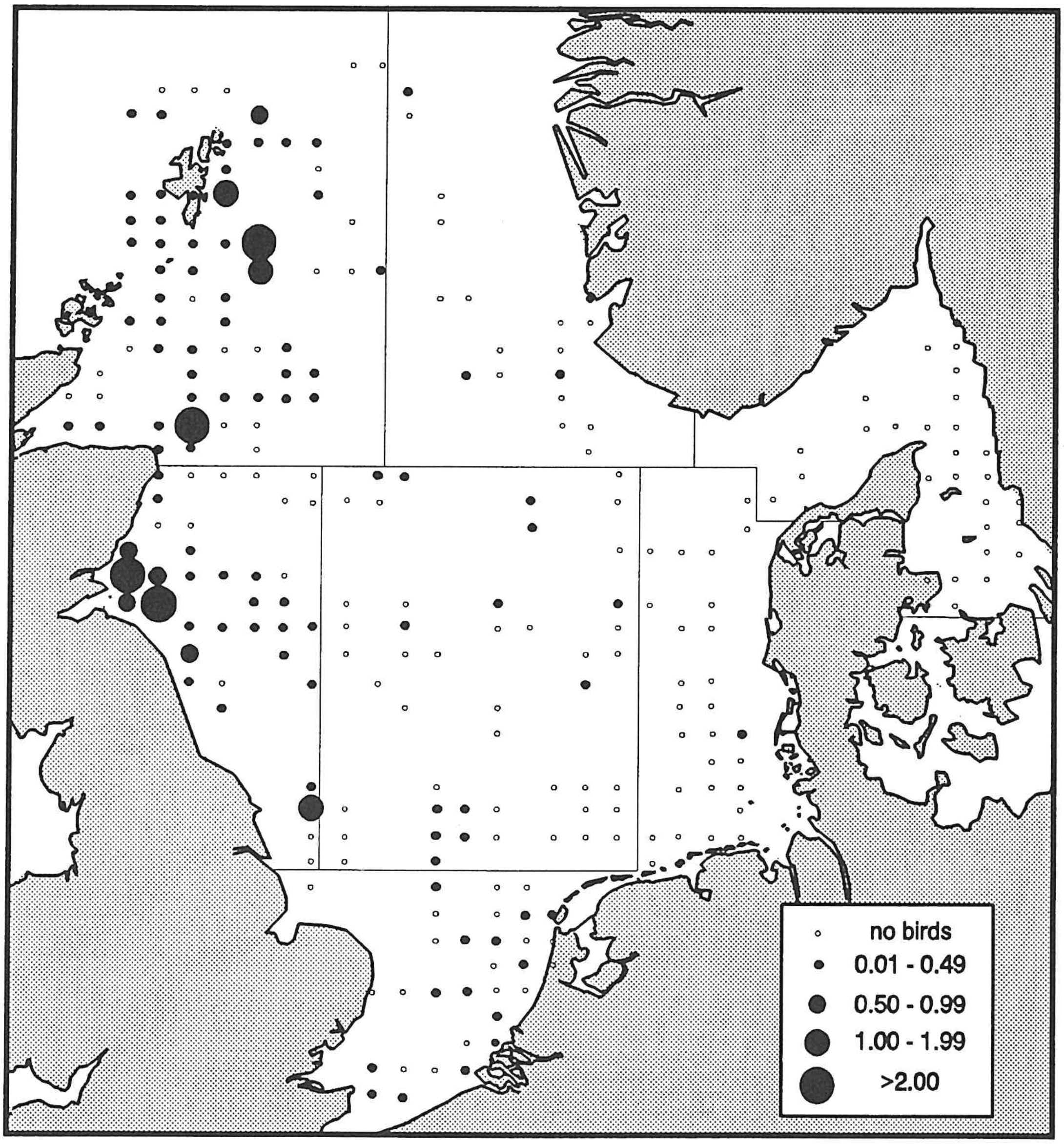


Figure 4.1.7 *Distribution of Gannets Sula bassana in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

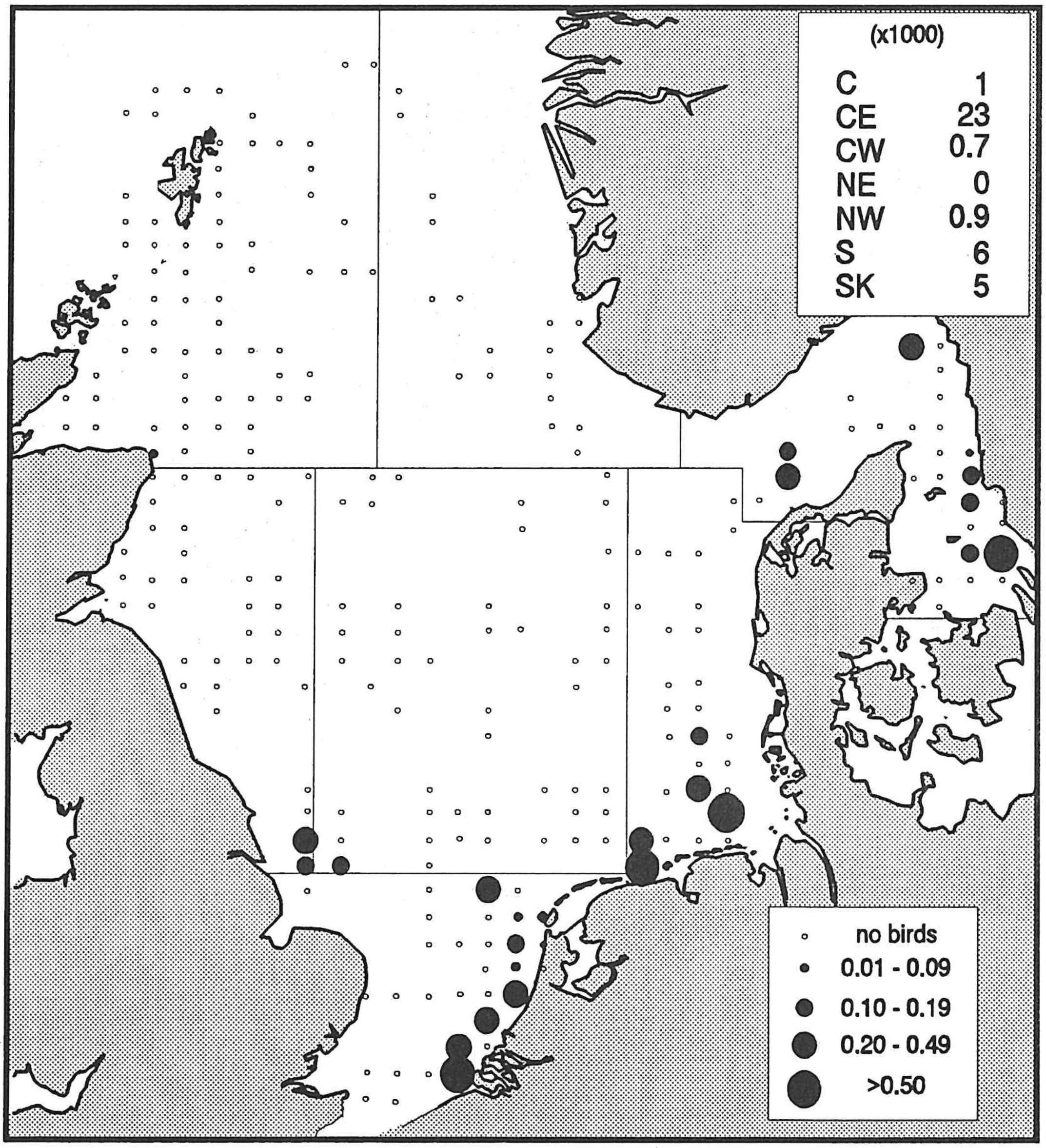


Figure 4.1.8 *Distribution of Common Gulls Larus canus in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

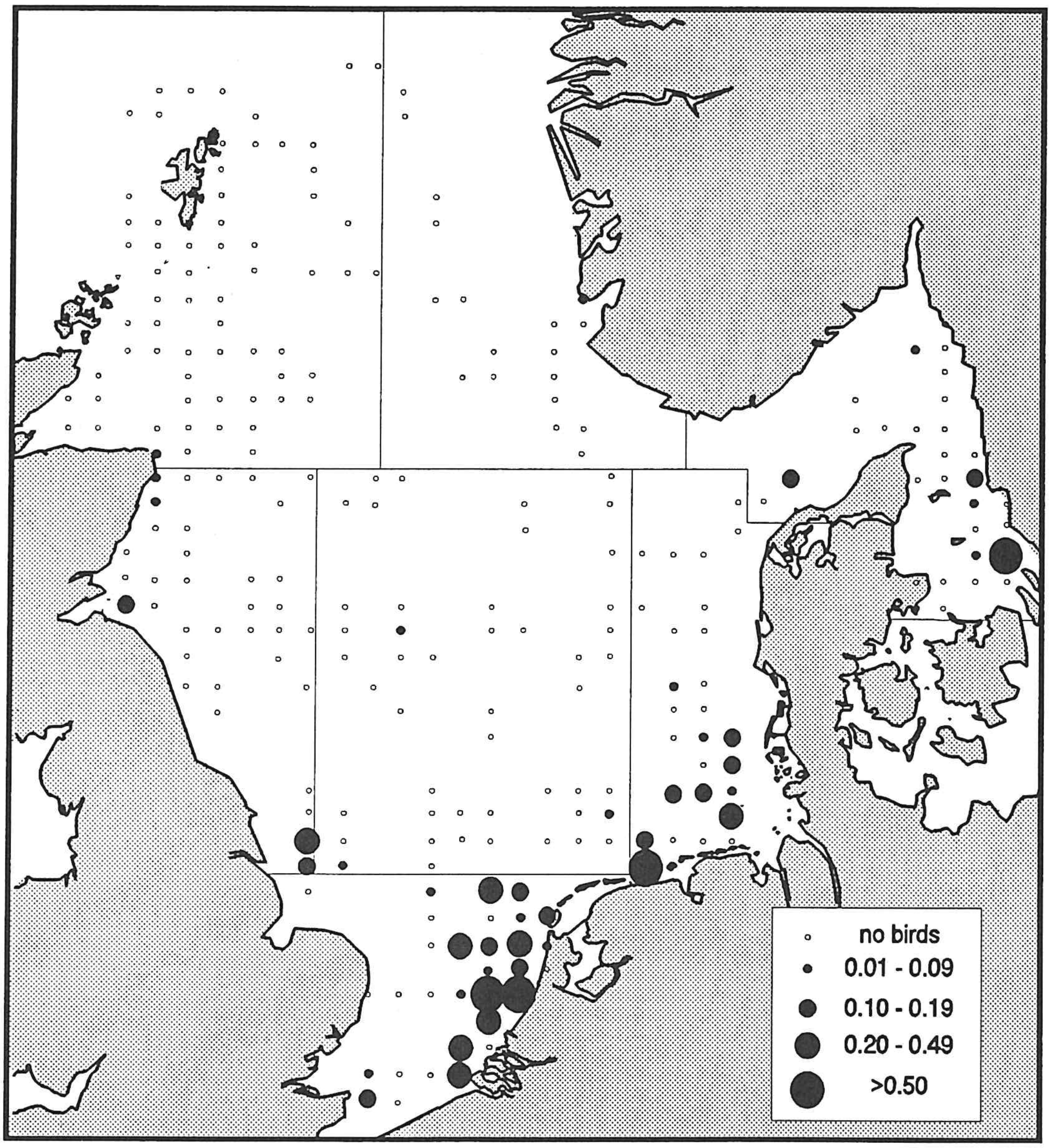


Figure 4.1.9 *Distribution of Common Gulls Larus canus in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

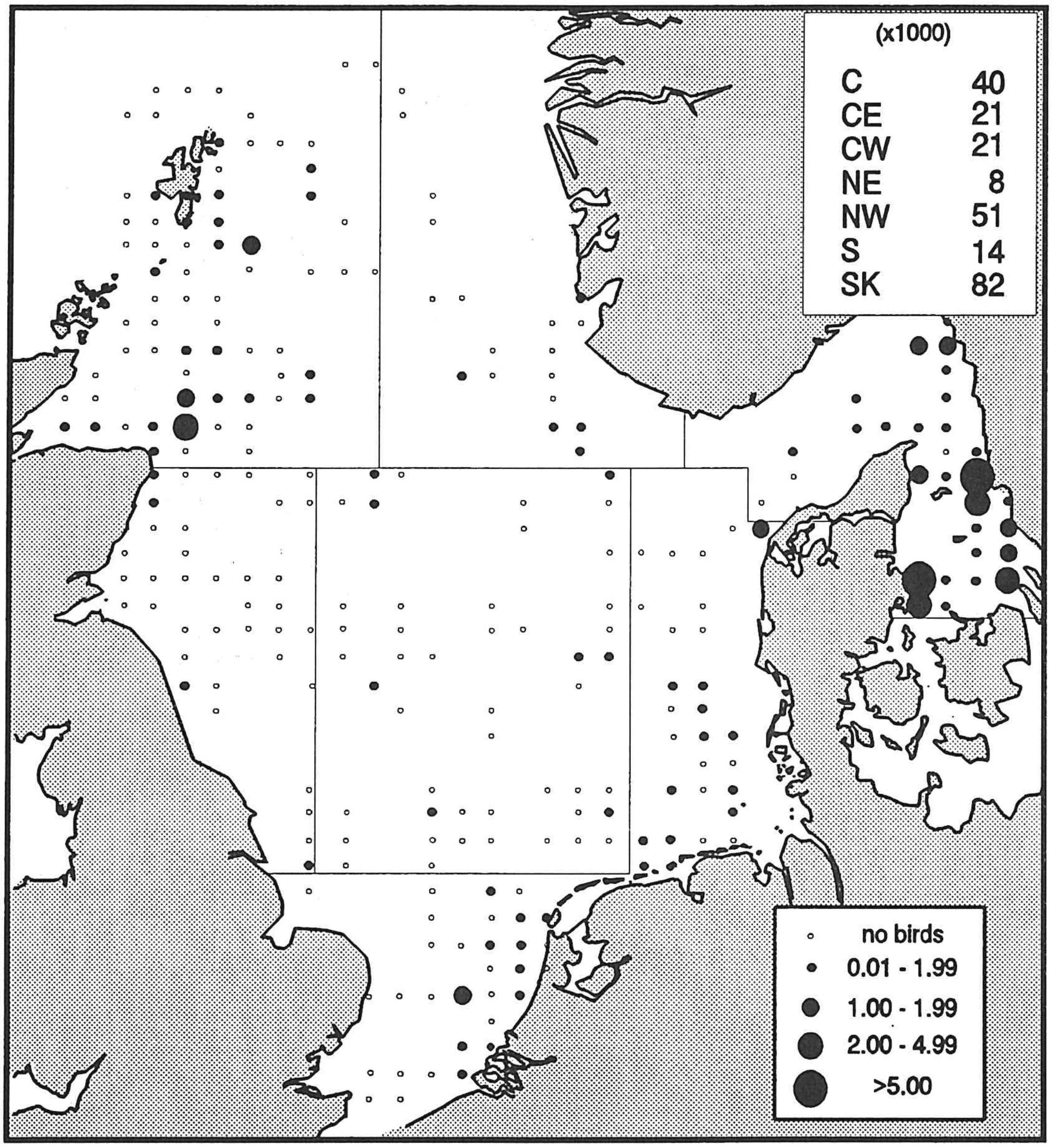


Figure 4.1.10 *Distribution of Herring Gulls Larus argentatus in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

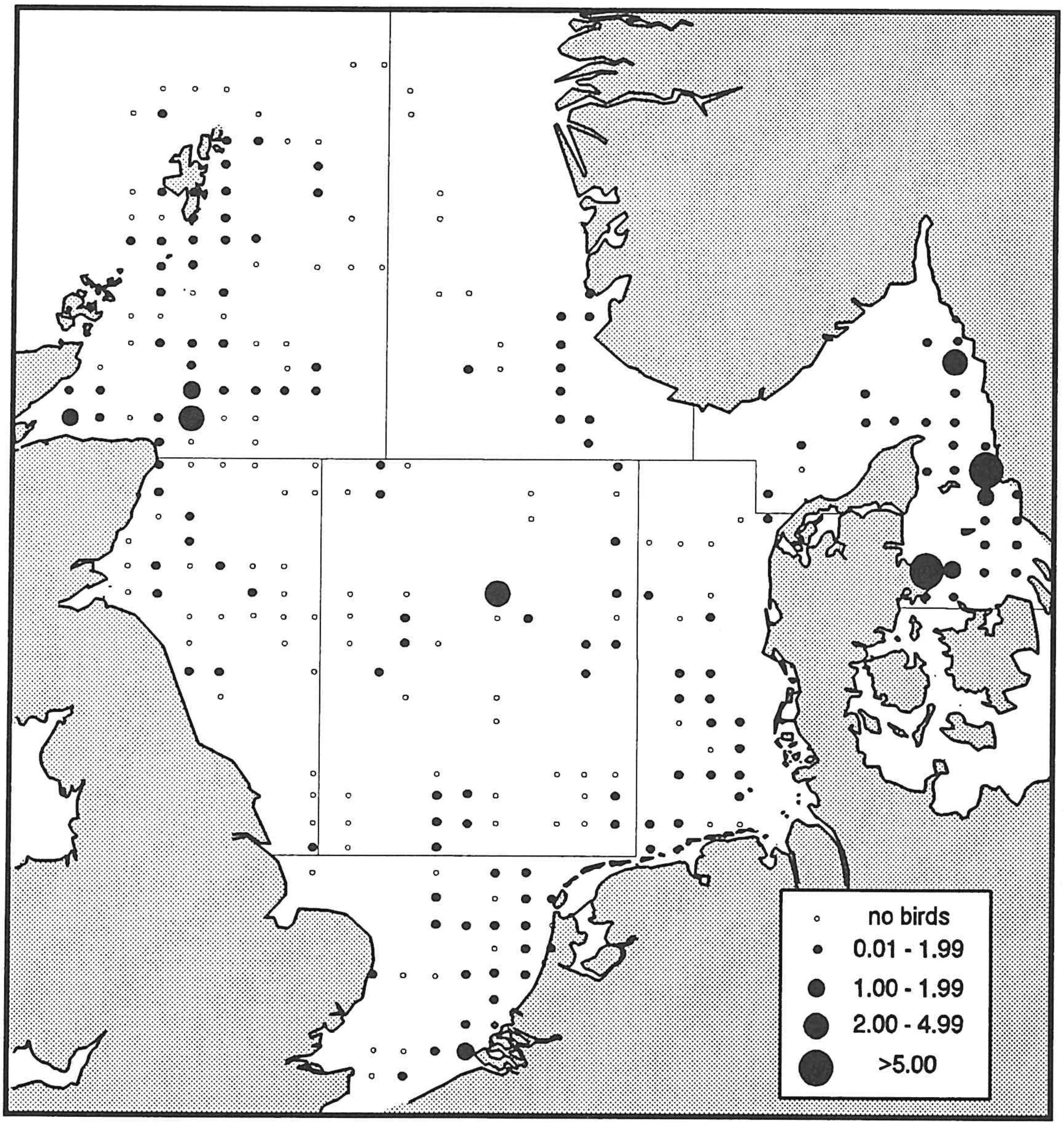


Figure 4.1.11 *Distribution of Herring Gulls Larus argentatus in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

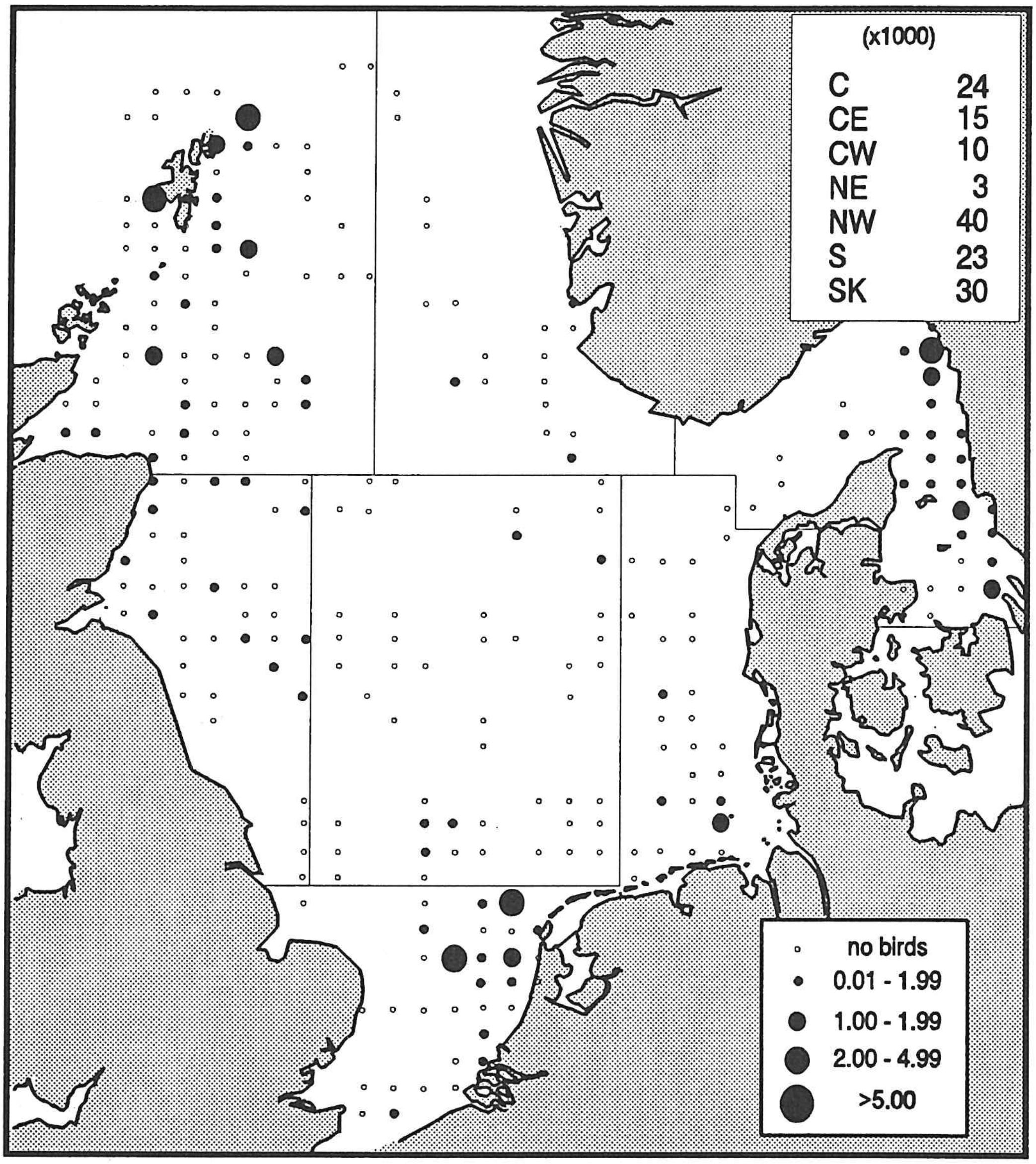


Figure 4.1.12 *Distribution of Great Black-backed Gulls Larus marinus in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

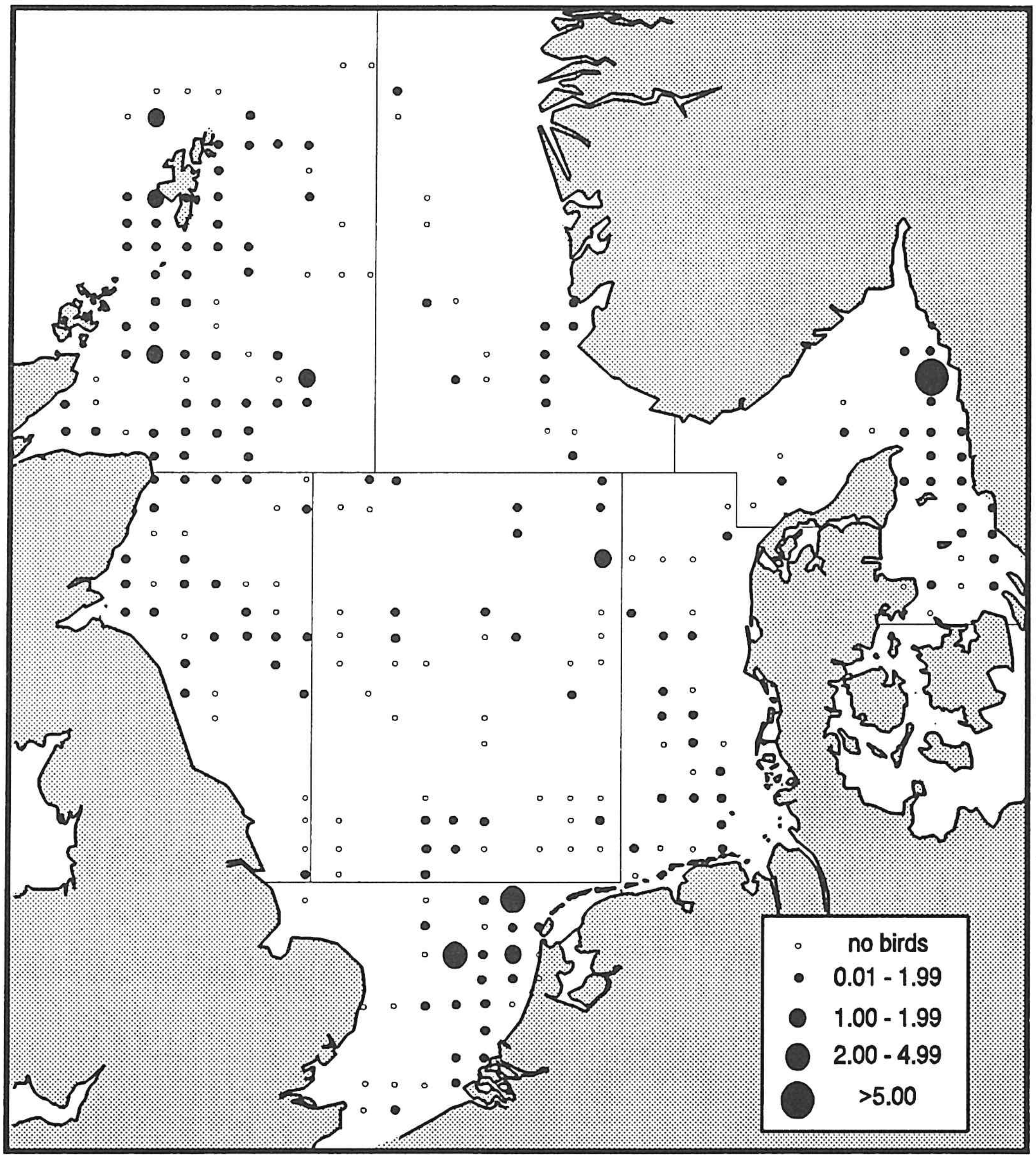


Figure 4.1.13 *Distribution of Great Black-backed Gulls Larus marinus in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

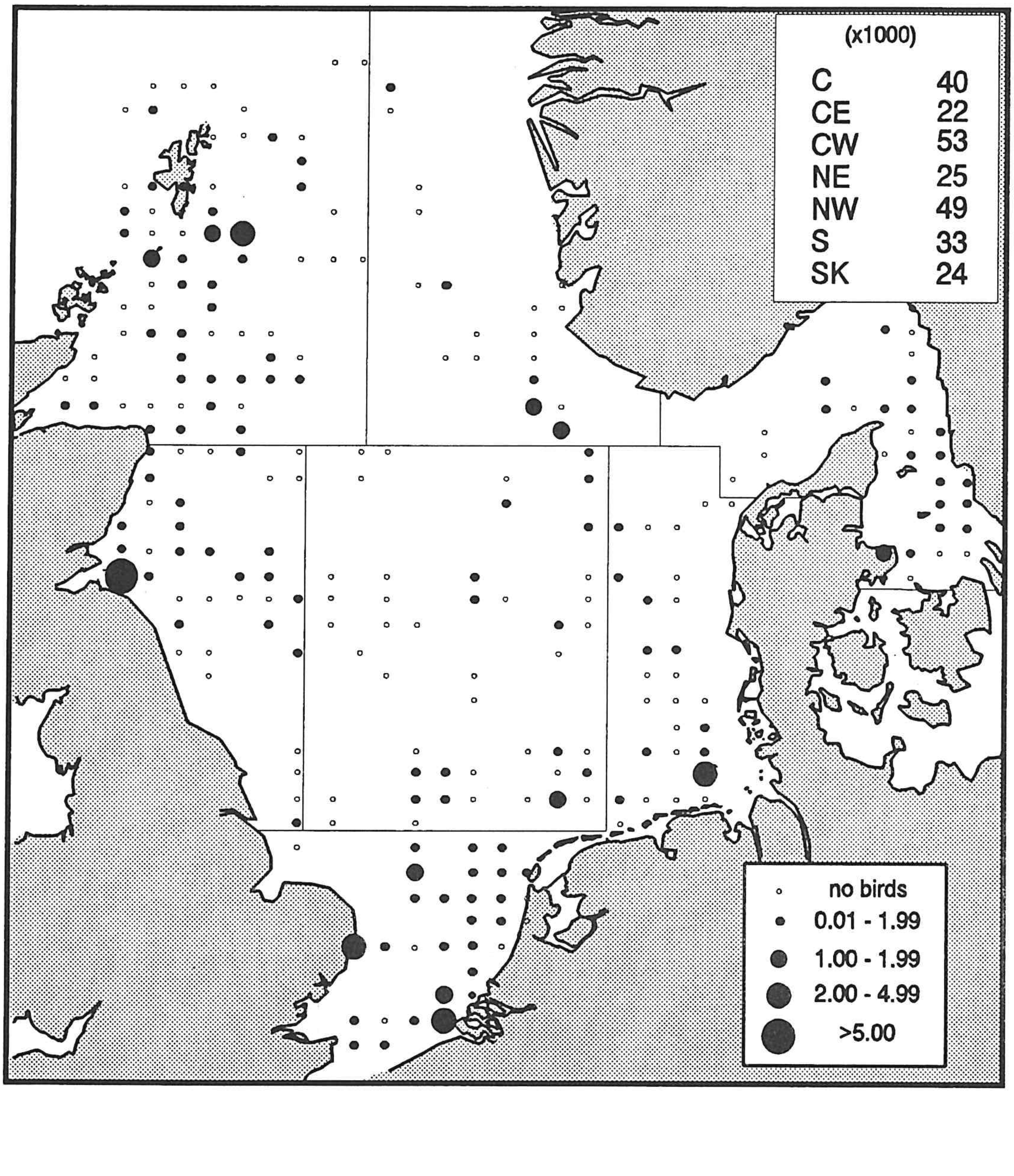


Figure 4.1.14 *Distribution of Kittiwakes Rissa tridactyla in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

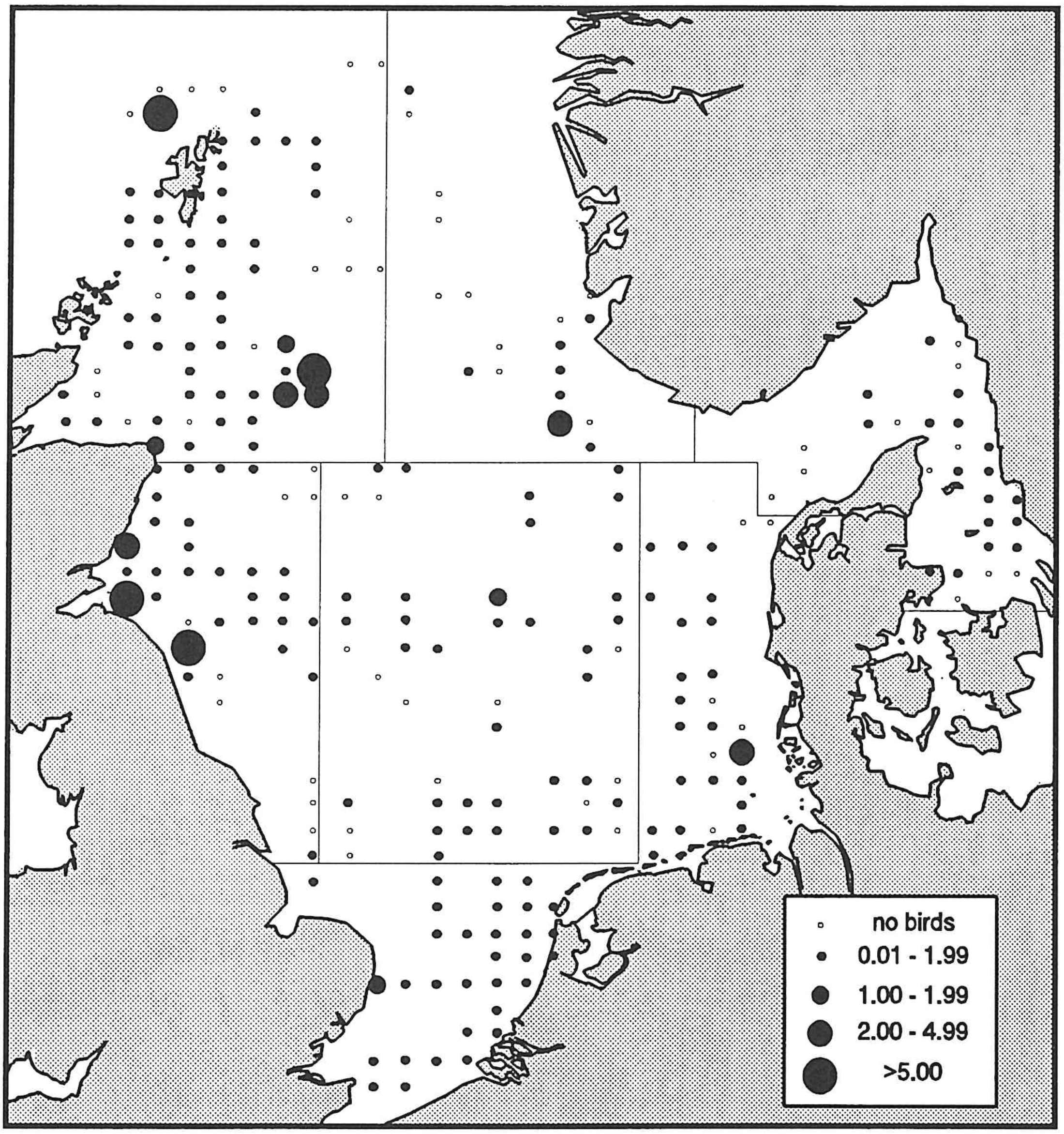


Figure 4.1.15 *Distribution of Kittiwakes Rissa tridactyla in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

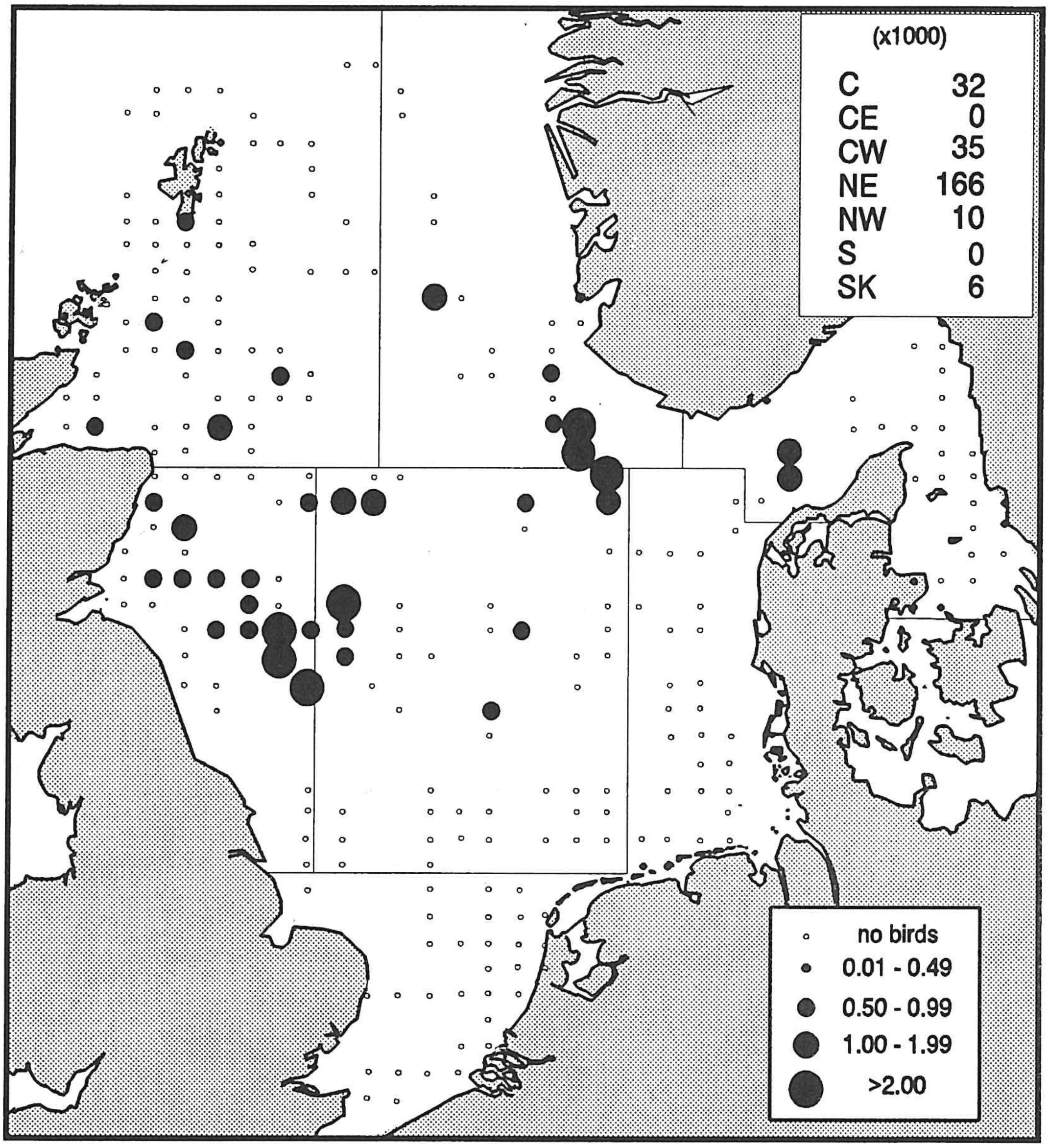


Figure 4.1.16 *Distribution of Little Auks Alle alle in the North Sea, February 1993, and abundance estimates per subregion (inset). Dot size represents density of birds per km².*

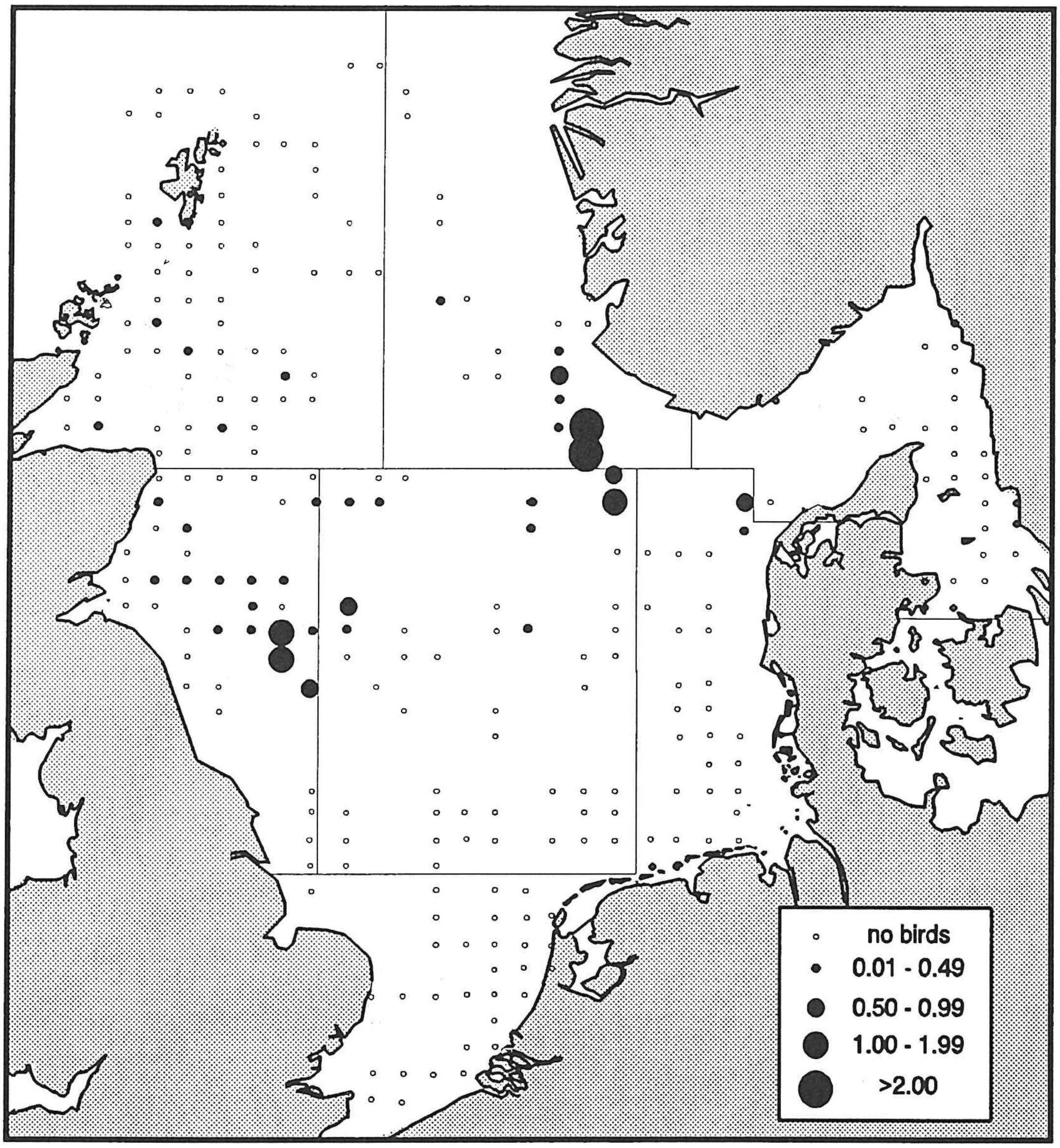


Figure 4.1.17 *Distribution of Little Auks Alle alle in the North Sea, February 1993, based on the scan method. Dot size represents number of birds per kilometre travelled.*

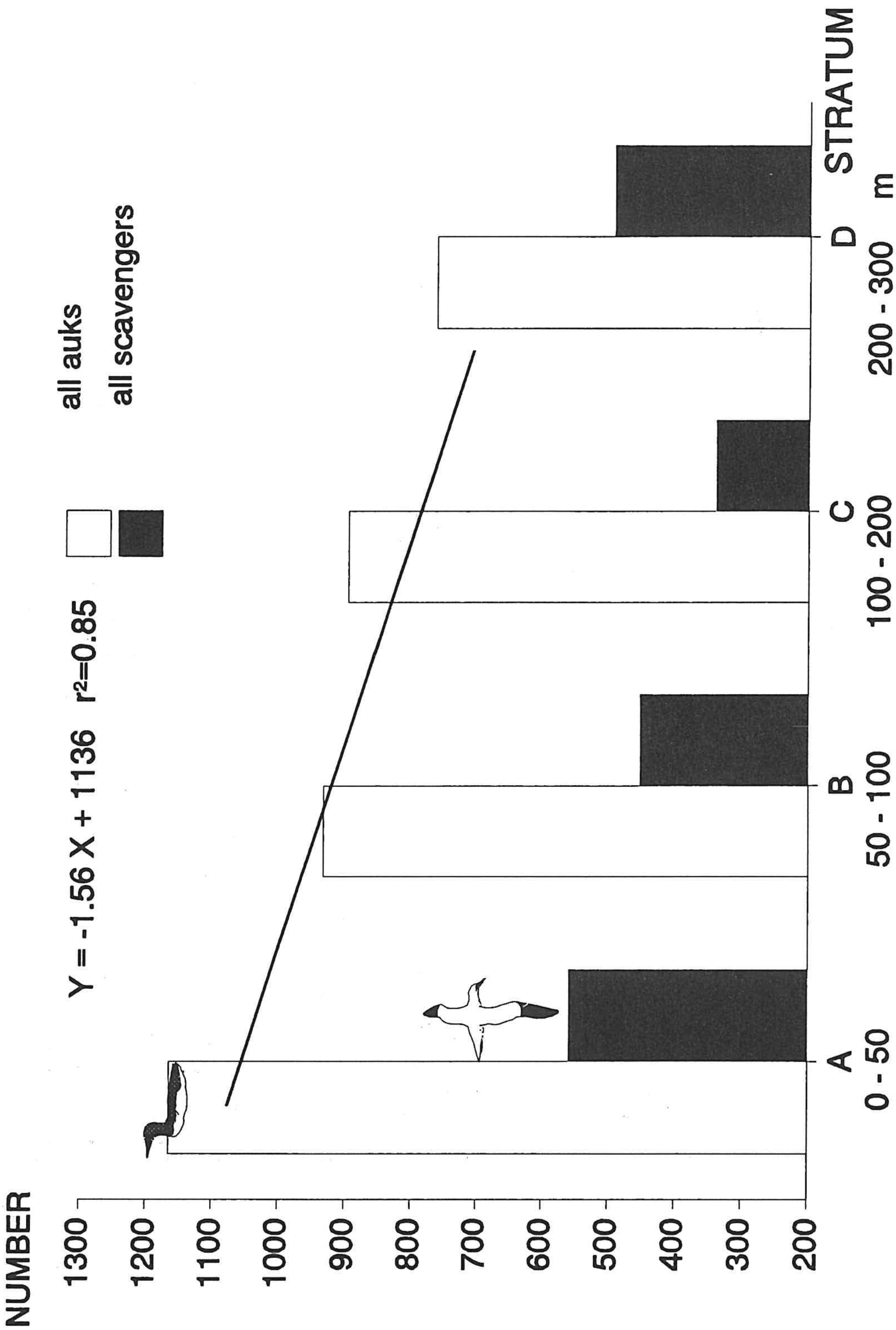


Figure 4.1.18 *Mean number of birds per distance stratum perpendicular to the ship, IBTS 1993.*

the winter period in previous years (Tasker *et al.* 1987 and ESASD unpubl. data). The February 1993 IBTS revealed rather low densities for scavenging seabirds in most areas (table 4.1.4). This leads to rather low estimates of total numbers for the seven species dealt with here, most of which are substantially below previous estimates. Numbers of birds found at sea in February 1993 are also low compared with the breeding population of at least 1.1 million pairs in the North Sea, many of which are thought to remain in the area in winter (Tasker *et al.* 1987, Dunnet *et al.* 1990). Assuming that and an equal number of immatures and immigrants from other breeding areas use the North Sea as their wintering area, it has been estimated that between 4 and 6 million scavengers could be present in the North Sea in winter (Furness 1992). From European database (ESASD unpubl. data), however, it was estimated that on average 2.9 million scavenging seabirds occur in the North Sea in February, or 1.8x more than found in the 1993 survey. A comparison of distribution patterns and abundance estimates for the commoner species with previous studies is given below.

Generally, the distribution of Fulmars was similar to previous studies, but the densities in the Southern Bight were higher in the 1993 survey (table 4.1.4). The total of 725,000 Fulmars estimated from the 1993 survey is much lower than previous estimates of 1.35 million (Dunnet *et al.* 1990, 1.9x higher) and 1.22 million (ESASD, unpubl. data; 1.7x higher).

As shown previously (*e.g.* Tasker *et al.* 1987), Gannets were nearly absent from the eastern part of the study area and were found in substantial numbers only near the colonies on the British Isles. Dunnet *et al.* estimated that nearly 100,000 Gannets were in the North Sea in February and from the European database it was estimated that some 106,000 individuals were present (table 4.1.4). These estimates are respectively 1.4 and 1.5x the figure found in this study.

Common Gulls were restricted to the inshore areas in the Southern and German Bights and Skagerrak/Kattegat. In earlier surveys, nearly 2.9x more Common Gulls were estimated to be present in the North Sea in February (ESASD unpubl. data, table 4.1.4), and numbers found in 1993 were particularly low in subregions Sk, CW, and S. The difference was probably mainly caused by the planning of surveys rather far from the coast and so the data are not entirely comparable.

Herring Gull distribution appeared to be rather different from that described by Tasker *et al.* (1987). In February 1993, densities were very low in the whole North Sea except in the Moray Firth and in the Kattegat. Tasker *et al.* (1987) found high densities of Herring Gulls in winter close to the English east coast and near the Dogger Bank. Herring Gulls were rather scarce in these latter waters in February 1993, although coverage was poor. Compared with earlier surveys numbers of Herring Gulls were rather small this year. From previous February surveys it was estimated that nearly half a million Herring Gulls can be found in the North Sea in February, approximately 1.7x more than found in 1993 (ESASD unpubl. data). Since coastal areas were poorly covered during the 1993 surveys, the difference was probably mainly an artefact, similar to that reported for Common Gulls. However, from data collected by Tasker *et al.* (1987), Furness (1992) estimated that in February 1 million Herring Gulls were at sea in the North Sea. It is beyond the scope of this project to try and explain a difference like this.

Similar differences in distribution patterns were found in Great Black-backed Gulls. The overall estimate of numbers present in the North Sea, approximately 180,000 individuals, was similar to that from previous February surveys (ESASD unpubl. data), but considerably below that derived from densities published by Tasker *et al.* (1987; 600,000 individuals early winter, *cf.* Furness 1992). Considering that the world population of Great Black-backed Gulls is estimated at 120,000-240,000 pairs (the majority breeds in NW Europe and W Russia; Lloyd *et al.* 1991), it can be concluded, even from the most conservative estimate of numbers in the North Sea, that the North Sea is a major wintering area for this species.

Densities of Kittiwakes in the North Sea were very low compared to earlier surveys (Tasker *et al.* 1987, ESASD unpubl. data). Compared to the European database, Kittiwakes were comparatively numerous in subregions CW and S, but remarkably scarce in Sk and C. Tasker *et al.* (1987) found Kittiwakes mainly in the western half of the North Sea in winter, and also that numbers peaked in February at over 2 million individuals present in the North Sea (see Dunnet *et al.* 1990), 6.7x more than found in this study. Estimates of total numbers in February from the European database are considerably lower (690,000 individuals, 2.3x IBTS 1993; table 4.1.4).

The Little Auk was selected as an example of a non-scavenging species. The distribution pattern was quite different from those of the scavenging species mentioned above. Main concentrations of Little Auks were found off Farne Deep and on the Great Fisher Bank and overall numbers were 2.3x lower than estimates from earlier surveys (ESASD unpubl. data). Important differences in abundance estimates occurred in NE (35x more common in 1993 compared to earlier surveys) and Sk (98x more common during previous surveys compared to 1993 IBTS; table 4.1.4). The reason for these differences is probably that important concentrations occur in comparatively small areas and that these areas are easily missed during large scale surveys (H. Skov *pers. comm.*).

In general, the distribution maps show that the Dogger Bank area and the east coast of England held only small numbers of scavenging birds during the IBTS-survey in February 1993. The areas with highest concentrations of scavengers were in the northwest and the Southern Bight. Some shifts in the distribution of the most common gull species compared to previous surveys may have been caused by a change in the distribution of fishing vessels over the years. Another reason for changes in distribution patterns could be the weather in January 1993. Violent storms were a constant factor during most of this month and a wreck of Guillemots *Uria aalge* in the German and Southern Bights late January 1993 was an indication of poor feeding conditions for piscivorous seabirds. These storms may have influenced the distribution and behaviour of seabirds in the North Sea.

4.2 SEABIRDS AT THE STERN

The attraction of scavenging seabirds to fishing vessels was studied by means of 'stern counts'. The aim of stern counts was to assess species and age composition of scavengers at the trawl and how this varied between subregions, to determine which of the ship's activities were most attractive to different species of scavenging seabirds and how numbers associated with the ship were related to densities of seabirds at sea. All seabirds associated with the ship were recorded during steaming, during all fishing activities, and when discard experiments were performed. Only birds which were obviously associated with the ship were included, but not those which only altered course briefly to investigate the ship.

In total, from all research vessels, 863 stern counts were collated (figure 4.2.1, table 4.2.1), covering 188 hauls of the net (numbered 1-188; figure 4.2.2), and including 101 counts of birds associated with the ship during discard experiments (numbered 1-101; figure 4.4.1). Maximum counts at each haul, normally while the net was at the surface after hauling or just pulled onto deck, were selected for further analysis. For each count, the following was recorded: date, time, position, weather conditions, activity of the ship, numbers, age and species of associated birds.

SPECIES COMPOSITION Fifteen species were observed as scavengers at the trawl:

Fulmar *Fulmarus glacialis*,
Gannet *Sula bassana*,
Great Skua *Catharacta skua*,
Little Gull *Larus minutus*,
Black-headed Gull *Larus ridibundus*,
Mediterranean Gull *Larus melanocephalus*,
Common Gull *Larus canus*,

Iceland Gull *Larus glaucoides*,
Herring Gull *Larus argentatus*,
Lesser Black-backed Gull *Larus fuscus*,
Glaucous Gull *Larus hyperboreus*,
Great Black-backed Gull *Larus marinus*,
Kittiwake *Rissa tridactyla*,
Razorbill *Alca torda*,
Guillemot *Uria aalge*

Of these only Fulmar, Gannet, Common Gull, Herring Gull, Great Black-backed Gull and Kittiwake occurred in substantial numbers. Maximum numbers recorded (during 'maximum counts') at the stern were 2000 Fulmars, 250 Gannets, 150 Common Gulls, 650 Herring Gulls, 250 Great Black-backed Gulls, and 450 Kittiwakes (table 4.2.2). Species composition (maximum counts) varied. The five most numerous scavengers in each subregion were:

NW	NE	Sk
Fulmar	Fulmar	Herring G
Kittiwake	Kittiwake	Great BbG
Herring G	Herring G	Kittiwake
Great BbG	Great BbG	Common G
Gannet	Gannet	Fulmar

CW	C	CE
Kittiwake	Kittiwake	Kittiwake
Fulmar	Fulmar	Herring G
Herring G	Herring G	Fulmar
Gannet	Great BbG	Great BbG
Great BbG	Gannet	Common G

S
Kittiwake
Herring G
Fulmar
Common G
Great BbG

Obviously, Kittiwake and Fulmar predominated in most of the North Sea. Species composition varied little across the northern North Sea (Norway-Shetland), with Fulmar and Kittiwake accounting for 68.6% of all scavengers at the trawl (n= 22,328). Besides the five commonest species, only Glaucous Gulls *Larus hyperboreus*, and an occasional Iceland Gull *Larus glaucoides* or Guillemot were seen at the stern (table 4.2.3). The Skagerrak/Kattegat area was quite different from most of the North Sea, with *Larus*-gulls predominating (92.2% of all scavengers at the trawl; n= 5,846). Other species besides those listed above were Black-headed Gull (rare), remarkable numbers of auks (16 Guillemots, 13 Razorbills *Alca torda*), and a Manx Shearwater *Puffinus puffinus* (1, during hydrographic observations, not while trawling, 12 February 1993). In the central North Sea (CW, C, CE), Kittiwakes were the most numerous scavengers in all subregions. Species composition changed gradually from west to east. Gannets and Fulmars, common in CW, became progressively less numerous in Danish waters and the German Bight (CE). Common Gulls, however, occurred in numbers only in CE. Species diversity of scavengers was highest in the Southern Bight (S). *Larus*-gulls and Kittiwake predominated at the trawl (79.5% of all scavengers, n= 2,605). Besides the common species listed above, Great Skua, Little Gull *Larus minutus*, Mediterranean Gull *Larus melanocephalus*, Black-headed Gull, Lesser Black-backed Gull, Razorbill and Guillemot were recorded (table 4.2.3). Variations in species composition during different activities of the research vessels are considered in a later section ('Fluctuations in numbers').

RELATIVE ABUNDANCE AND GEOGRAPHICAL DISTRIBUTION In table 4.2.2, a number of abundance estimates are given for all scavengers at the stern. Fulmar, Herring Gull, Great Black-backed Gull, and Kittiwake were widespread and often numerous. Fulmars were abundant in the northern North Sea, and occurred in smaller numbers further to the south (figure 4.2.3). Gannets occurred in large numbers around Shetland and in small numbers further to the south, mainly to the west of 6°E (figure 4.2.4). Common Gulls were virtually restricted to the southern and eastern parts of the North Sea and Skagerrak (figure 4.2.5). Herring Gulls were most numerous at the trawl off NE Scotland and east of Shetland, in the Skagerrak/Kattegat area and in the German Bight (figure 4.2.6). High numbers were recorded at trawl stations in the

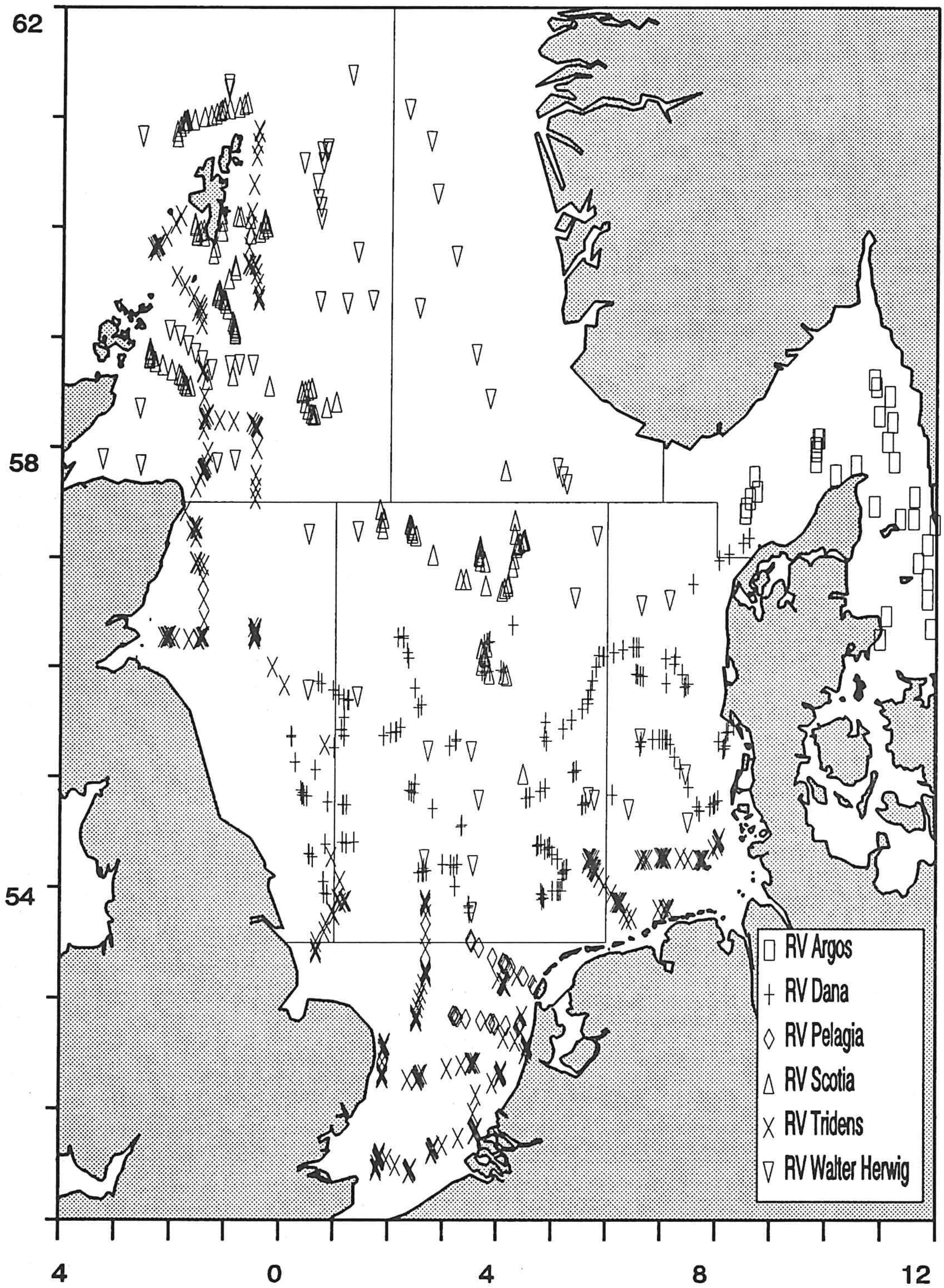


Figure 4.2.1 *Distribution of stern counts for each of the research vessels (n= 863), IBTS 1993.*

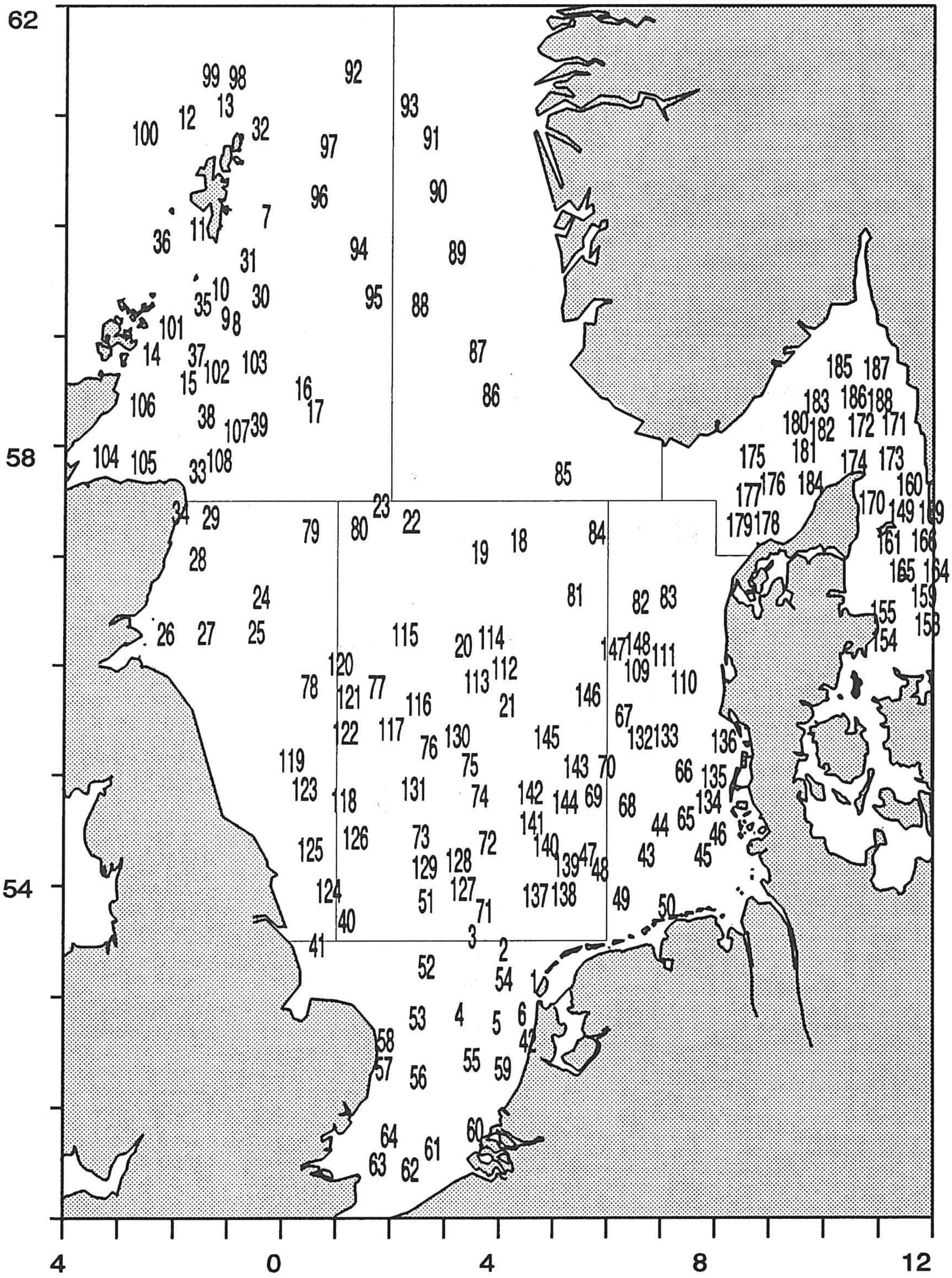


Figure 4.2.2 *Numbered 'maximum stern counts' for each haul (nos. 1-188), all research vessels combined, IBTS 1993.*

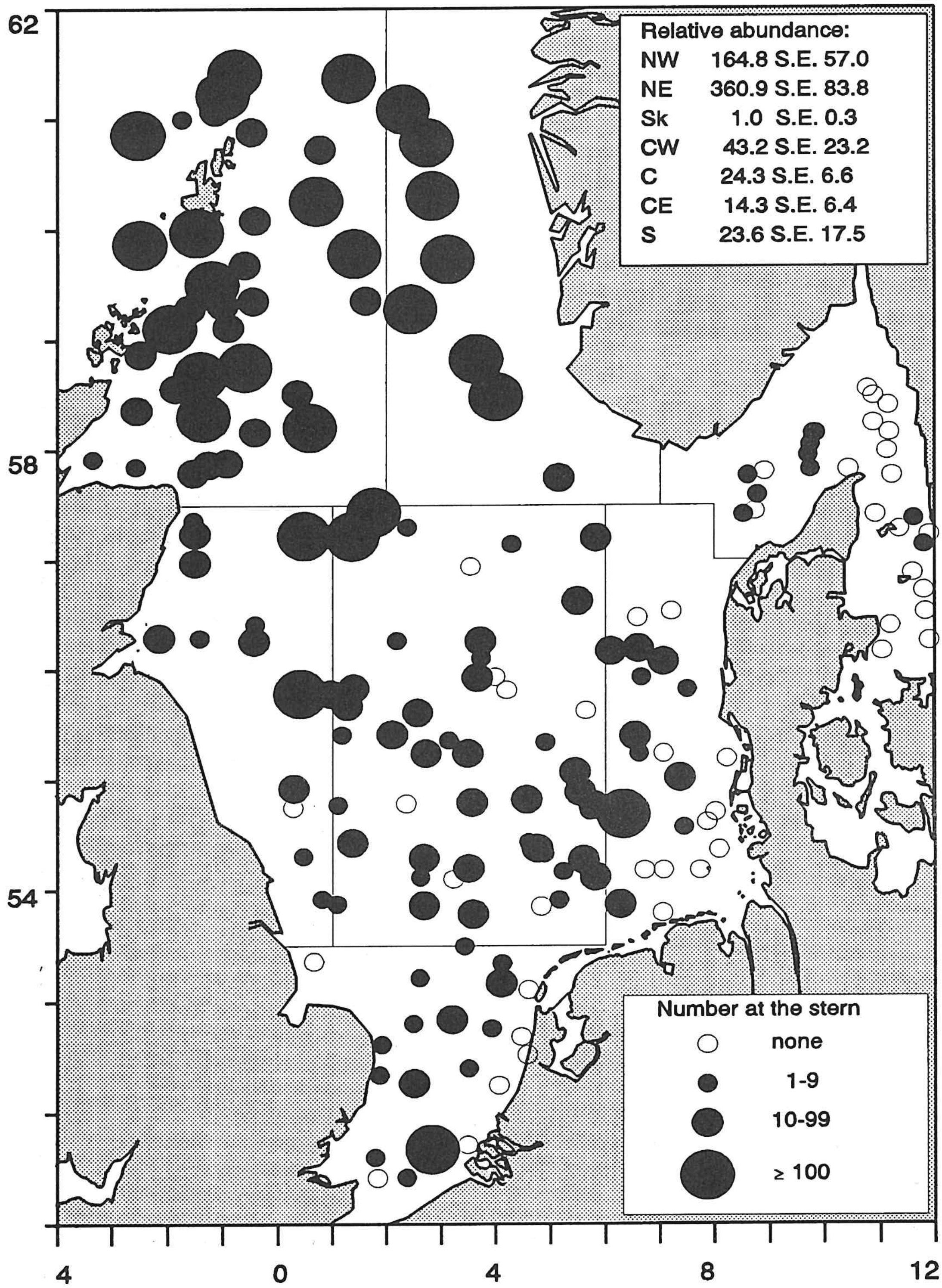


Figure 4.2.3 *Relative abundance of Fulmar Fulmarus glacialis at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

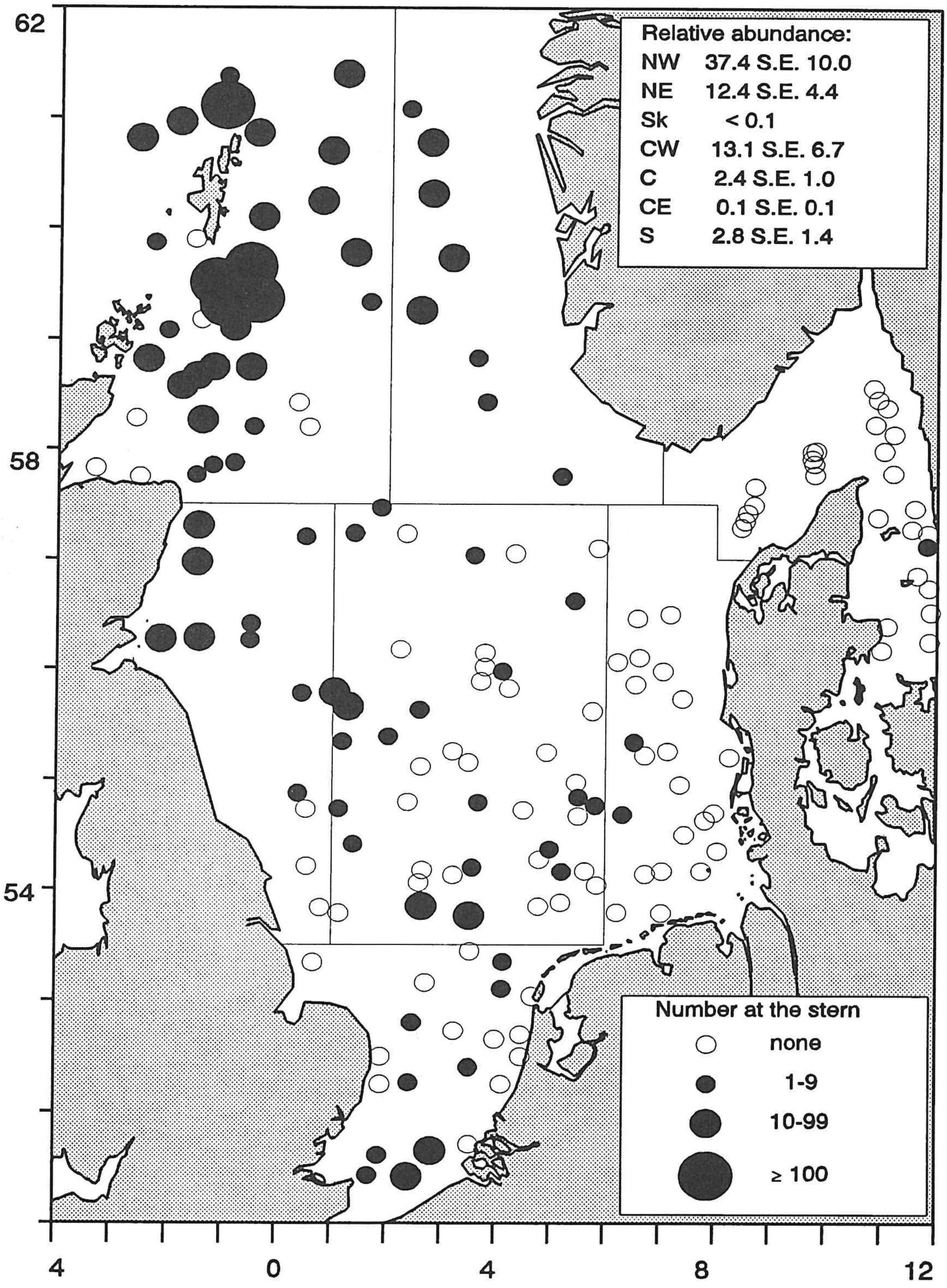


Figure 4.2.4 *Relative abundance of Gannet Sula bassana at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

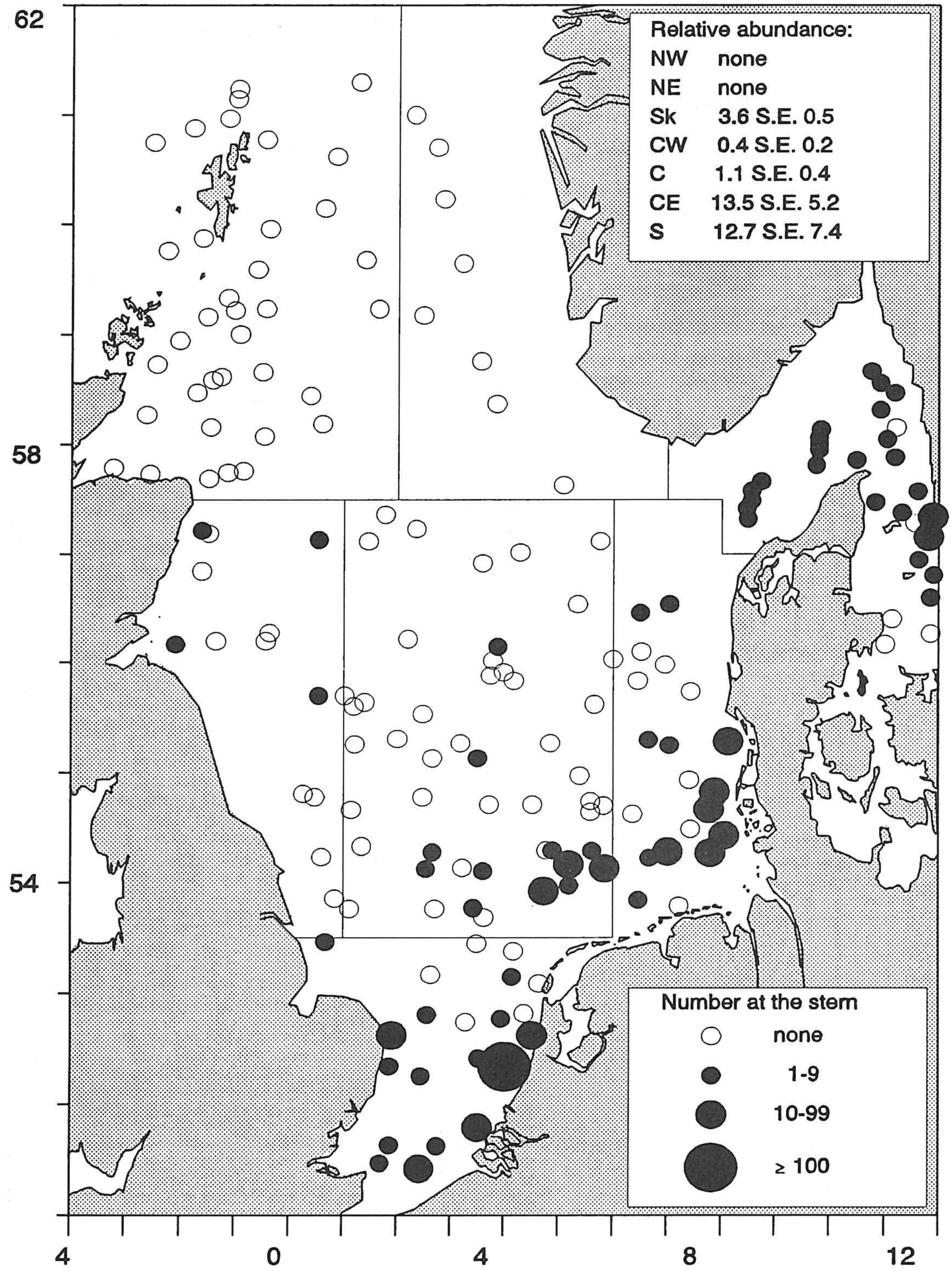


Figure 4.2.5 *Relative abundance of Common Gull Larus canus at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

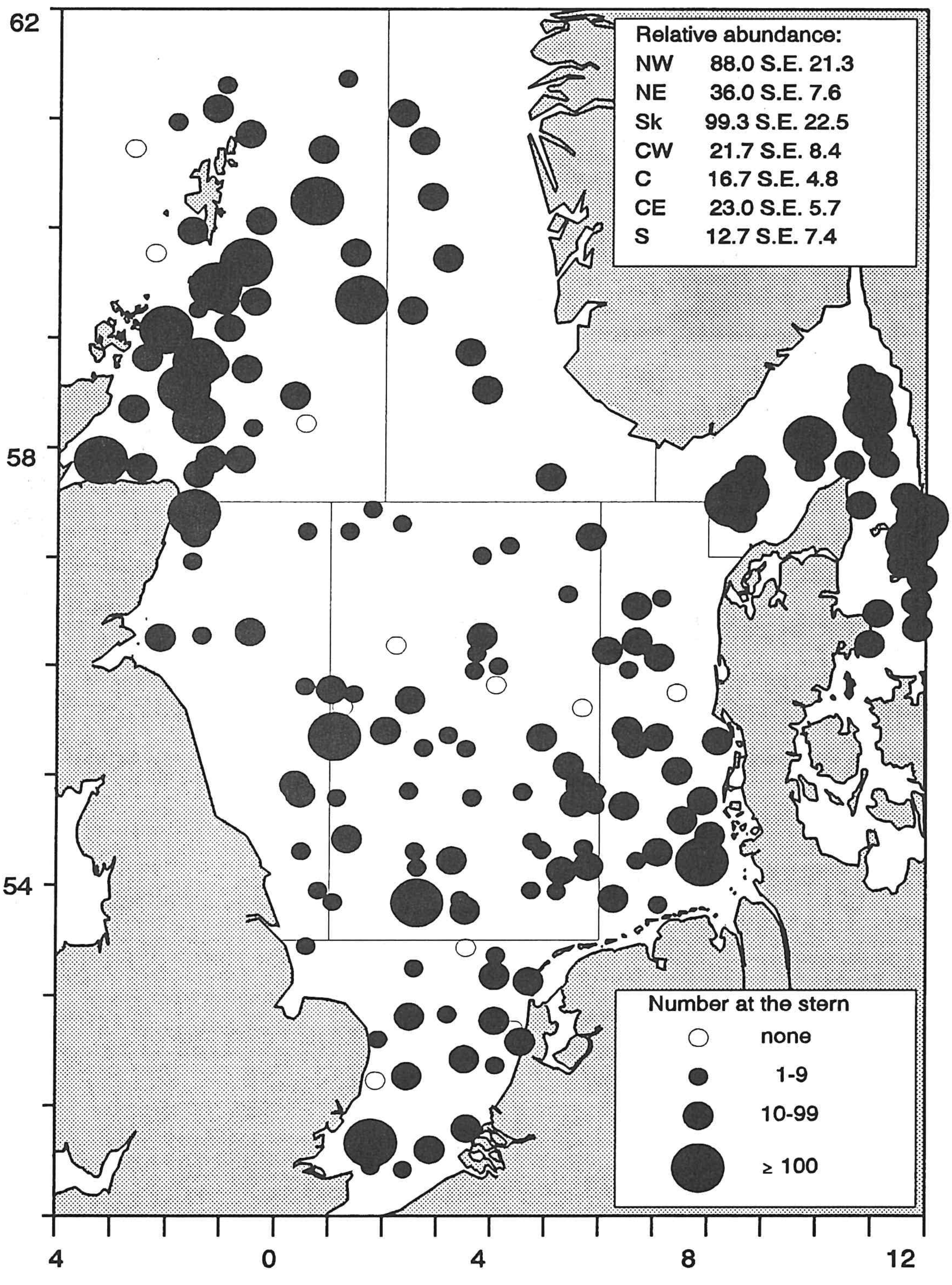


Figure 4.2.6 *Relative abundance of Herring Gull Larus argentatus at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

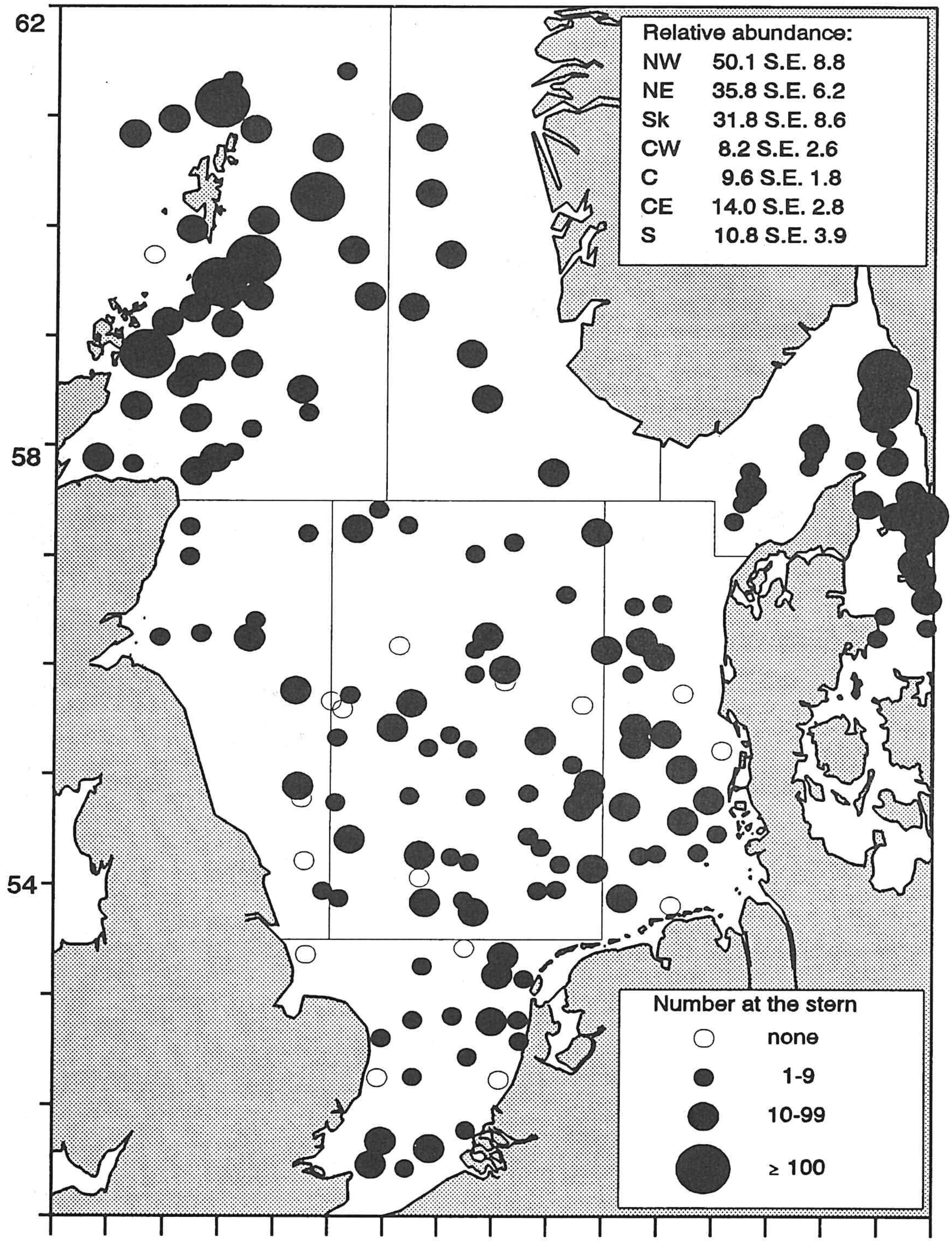


Figure 4.2.7 *Relative abundance of Great Black-backed Gull Larus marinus at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

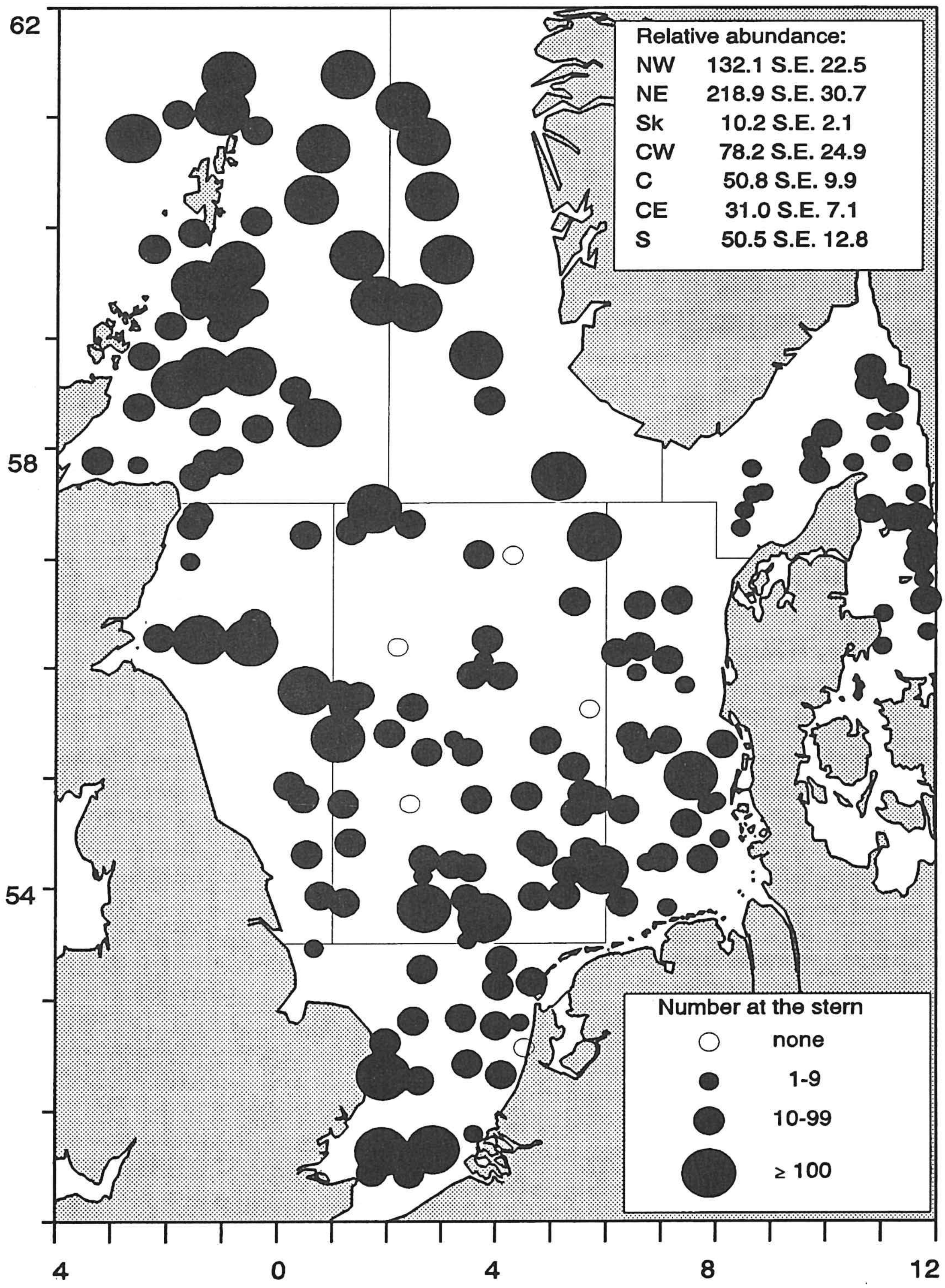


Figure 4.2.8 *Relative abundance of Kittiwake Rissa tridactyla at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

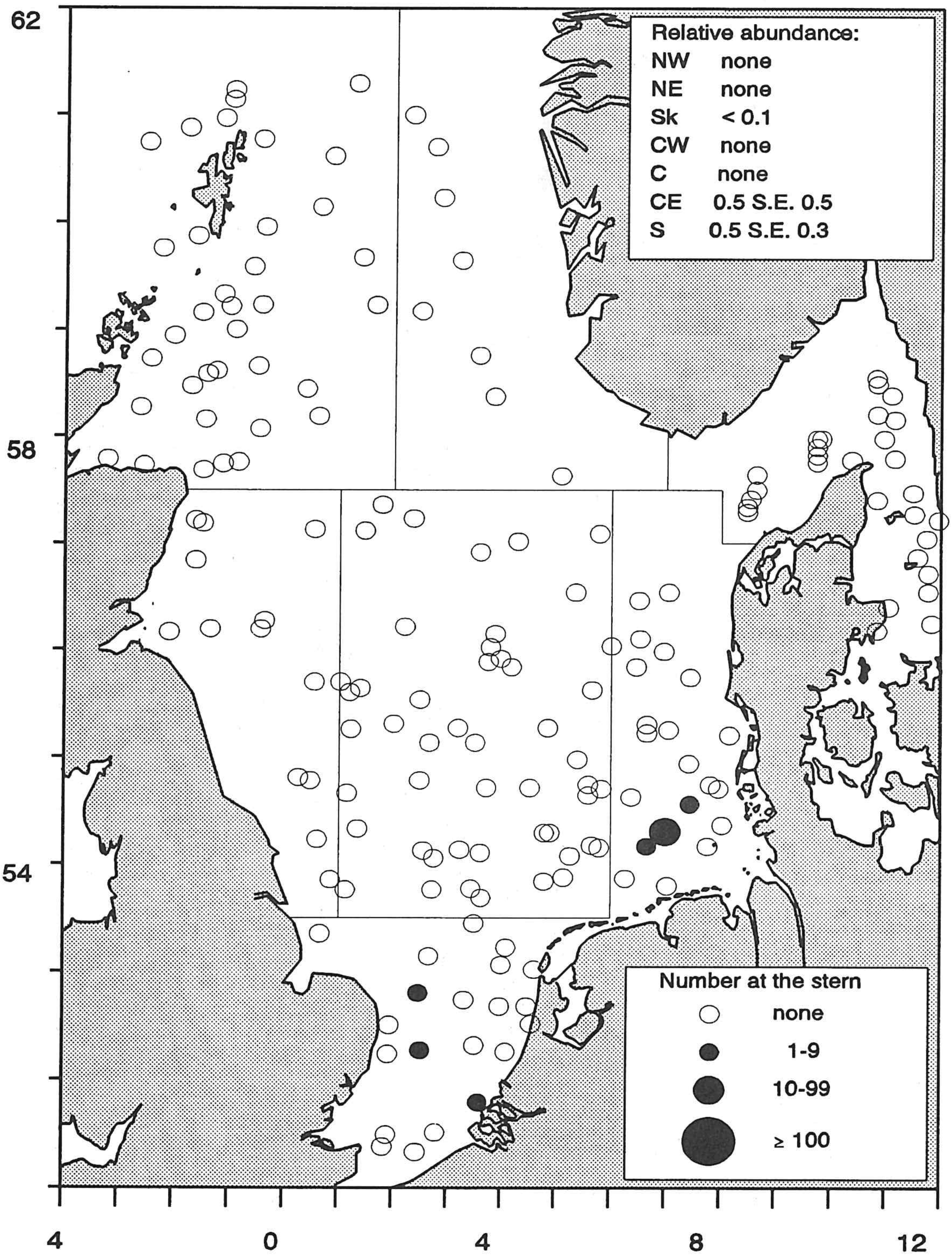


Figure 4.2.9 *Relative abundance of Black-headed Gull Larus ridibundus at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

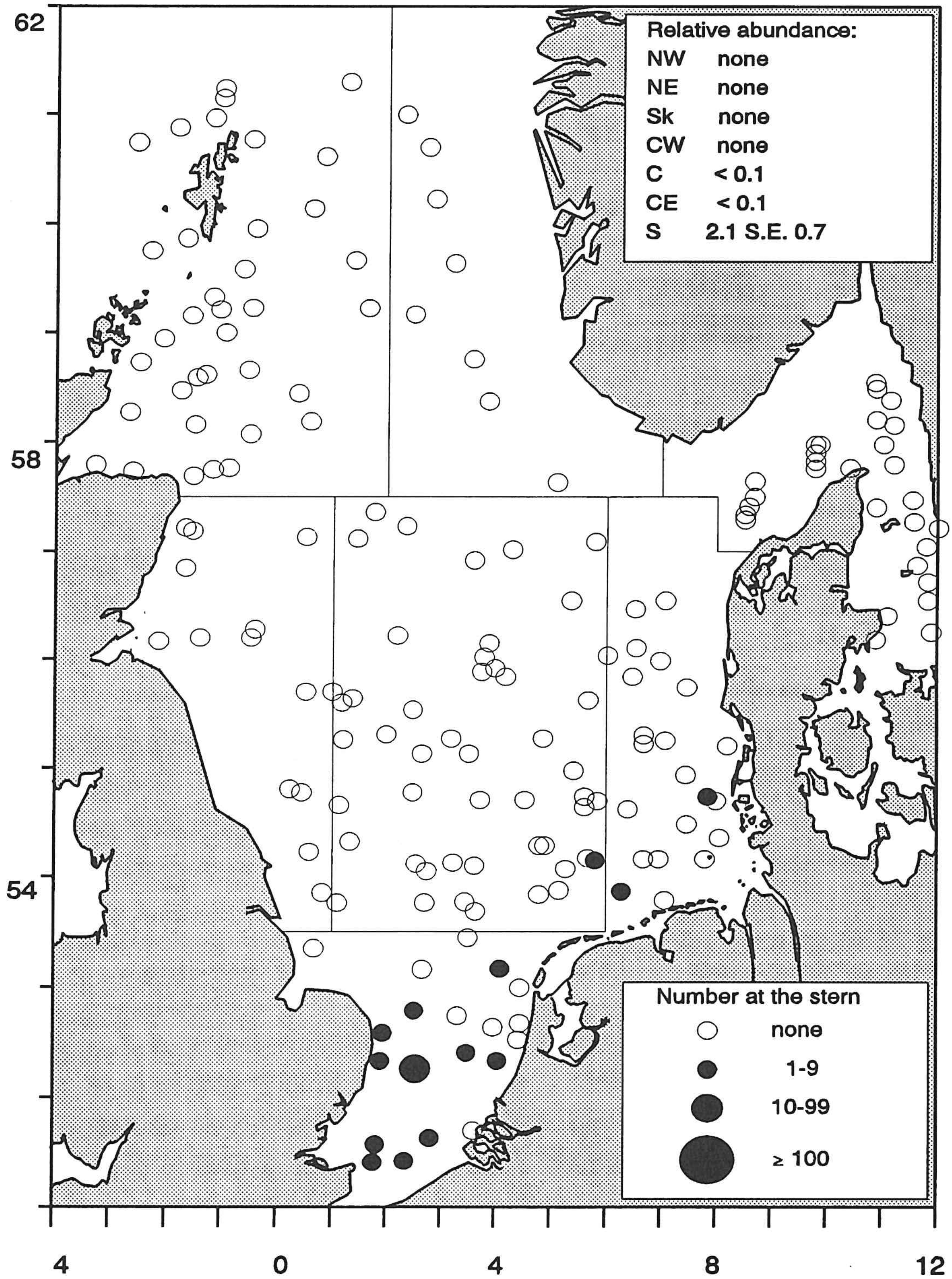


Figure 4.2.10 *Relative abundance of Lesser Black-backed Gulls at the stern, from maximum counts at each haul, IBTS 1993. Inset: mean ± S.E. per subregion.*

mouth of the Thames estuary and occasionally in the central North Sea. Great Black-backed Gulls had a similar distribution pattern, but generally occurred in lower numbers (figure 4.2.7). Comparatively large numbers were found near Orkney and Shetland and in the Kattegat. The Kittiwake was prominently represented at trawl stations in all areas (figure 4.2.8). Large numbers were encountered both inshore and offshore, but most notably in the northern North Sea.

Figures 6.2.9 and 10 show distribution patterns of Black-headed Gull and Lesser Black-backed Gull, two much scarcer species. The first species is known to occur in large numbers at trawlers in February, but only very near the coast (see section 4.3), beyond the areas sampled by this survey. Lesser Black-backed Gulls were only just returning from more southerly wintering areas and, not surprisingly, were mainly seen in the Southern Bight.

RANGE FROM WHICH BIRDS WERE ATTRACTED Estimates of the range from which scavengers were attracted to the research vessels were based on densities of seabirds at sea (n/km²) on the same day. Hence, each maximum count at the stern was compared with the density found that day. The sea area from which the birds were attracted to the ship was calculated by dividing the associated number at the stern by the density at sea for each species. Assuming that birds were attracted from all directions, the radius (km) was calculated (radius= $\sqrt{area/\pi}$). From regular stern counts at the Tridens it could be demonstrated that very few birds followed the ship during steaming and that a build-up in numbers at the stern occurred from shooting the net onwards. Hence, all birds found at the stern were 'new' and probably attracted by the activity of the ship in combination with numbers and types of birds already present (advertisement and interference, *cf.* Wahl & Heinemann 1979). On average, scavengers were probably attracted from an area around the ship of 150-420 km² (radius 7-12 km; table 4.2.4). Assuming a flying speed of 40 km/h, associated birds could have reached the ship on average within approximately quarter of an hour. The maximum area around the ship from which birds were attracted, comparing densities at sea and numbers turning up at the stern, ranged from 900 km² (Great Black-backed Gull) to 4500 km² (Kittiwake).

AGE COMPOSITION The age of Gannets and gulls can be deduced from plumage characteristics. In most areas, adults of all species predominated (table 4.2.2). Immature Gannets were virtually absent in the North Sea (98.8% adult, n= 1,752). Most Common Gulls were adults (86.0%, n= 708), particularly where only small numbers were present (Sk and C: >90% adult). Two thirds of all Herring Gulls were identified as adults (65.7%, n= 9,312). The highest proportion of immatures was found in subregions C and S (60.0% adult, n= 527, and 54.6% adult, n= 370 respectively). A similar proportion of Great Black-backed Gulls were adults, but with little variation between subregions (range 65.7-79.0% adult). Adult Kittiwakes predominated in all North Sea subregions (at least 95% adult). A high proportion of immatures was found in Sk (63.1% adult, n= 407). Most immature Kittiwakes were juveniles (2nd calendar year birds), while subadults (3rd calendar year birds) were scarce.

FLUCTUATIONS IN NUMBERS (FISHING ACTIVITIES) Massive fluctuations in numbers at the stern occurred in response to changing activities of the ship, when commercial fishing boats were in the vicinity (either attracting birds away from the research vessel or by providing an incoming stream of scavengers to the ship), when birds became satiated, and frequently for unknown reasons. Onboard RV *Tridens*, an attempt was made to monitor ship-followers during all activities of the ship. In this section, the fishing activities which attracted most birds are described. The different fishing activities were categorised as follows:

STE	steaming, no fishing activities
SHO	shooting net
TOW	towing net, no discards or offal produced

HAU hauling net, not at surface
LIF lifting net, at surface
STAT stationary vessel, no discards or offal produced
DIS stationary vessel, discarding fish
SOR steaming or towing, while gutting or discarding

All categories were frequent onboard *Tridens* (tables 4.2.5). Four activities (HAU, LIF, DIS and SOR) provide feeding opportunities (stealing from net or discards), while STE, SHO, TOW, and STAT are probably comparatively unattractive for seabirds, because little or no discards are produced. Two activities need further explanation. After a haul, just after the net was taken onboard, the *Tridens* stopped moving for some time to collect some hydrographical data. After a large catch, the ship usually produced discards while stationary (DIS), but after a small catch nothing was released (STAT). The standard fishing procedure on board *Tridens* was (abbreviated):

STE - SHO - TOW - HAU - LIF -
STAT/DIS - SOR/STE - STE

The time from shooting to lifting was normally about an hour (towing the net in the right position for approximately 30 minutes).

The largest total numbers of seabirds attending, in descending order, were during DIS, SOR, LIF, HAU, STAT, SHO, TOW, and STE (table 4.2.5), but species composition varied with activity. Fulmars were comparatively numerous when the ship was stationary and discarding (DIS), but rather scarce when the ship discarded while steaming (SOR; figure 4.2.11), indicating that this species is most successful at feeding beside a stationary boat. Gannet numbers (same figure) fluctuated considerably, being much more numerous when discards were produced and scarce when the ship did not provide much. Gannets were observed 'streaming in' when the associated flock of scavengers was behaving eagerly and leaving the ship immediately if nothing became available (*cf.* Reinsch 1969). This species had a rapid build-up of numbers compared to other species, and probably the greatest turnover at the stern. Common Gulls (figure 4.2.12) were scarce as ship-followers of steaming vessels. Numbers at the stationary ship when discards were produced (DIS) were remarkably low compared to numbers when the ship just stopped moving (STAT). Possibly this species was outcompeted when the fight for scraps was most intense during discarding. Herring Gull (figure 4.2.12), Great Black-backed Gull, and Kittiwake (both figure 4.2.13) were attracted to much the same activities, with highest numbers occurring during discarding (DIS). While numbers of most species were higher when discarding took place while stationary, Kittiwake numbers were higher when the vessel was steaming during discarding (SOR). This indicates perhaps that this species' manoeuvrability on the wing is advantageous under these conditions. The Fulmar, which is much less agile, showed the largest drop in numbers when the ship moved. Generally, most scavengers were attracted when discards became available (DIS, SOR; figure 4.2.14), but shooting and towing a net was apparently attractive enough to at least double the numbers of seabirds following the vessel.

FLUCTUATIONS IN NUMBERS (EXTERNAL FACTORS)
Fluctuations in numbers did not always correspond to changing activities of the ship and were often difficult to explain. Figures 4.2.15-18 show examples of hauls recorded on board RV *Tridens* in various parts of the North Sea. Numbers could suddenly rise during steaming, when apparently nothing had changed, nor were there any trawlers nearby. Proximity to land seemed to affect the rate of build-up of numbers with birds arriving directly from land.

A nice example of a gradual build-up of numbers at the stern is shown in figure 4.2.15 (haul 27). Within an hour from shooting, nearly 400 scavengers were attracted which disappeared immediately as soon as the vessel set off for the next trawling station. When large quantities of Herring were discarded after haul 38 (figure 4.2.16), with over 600 scavengers around, the birds appeared satiated and few were willing to take any fish. One hour earlier the boat was in an area with a pair trawling fleet of at least 8 vessels. Two hours later, in an area where 6 trawlers were visible on radar within 6 km of the vessel, and despite substantial discards, hardly any birds turned up at the stern. The rapid increase at the stern during shooting and towing on 16 February around 12:35 GMT (figure 4.2.17) was caused by the fact that the trawling station was right at the spot where a considerable concentration of scavengers was resting (probably a flock resting from feeding at a comercial trawler). At the end of that day, while numbers increased rapidly at the stern during hauling and lifting, there were very few feeding attempts (the birds were apparently satiated). On 24 February, working trawling stations off the Dutch coast, few scavengers turned up during most of the day (figure 4.2.18), while in contrast to other trawling stations visited late in the afternoon, high numbers were attracted just before sunset.

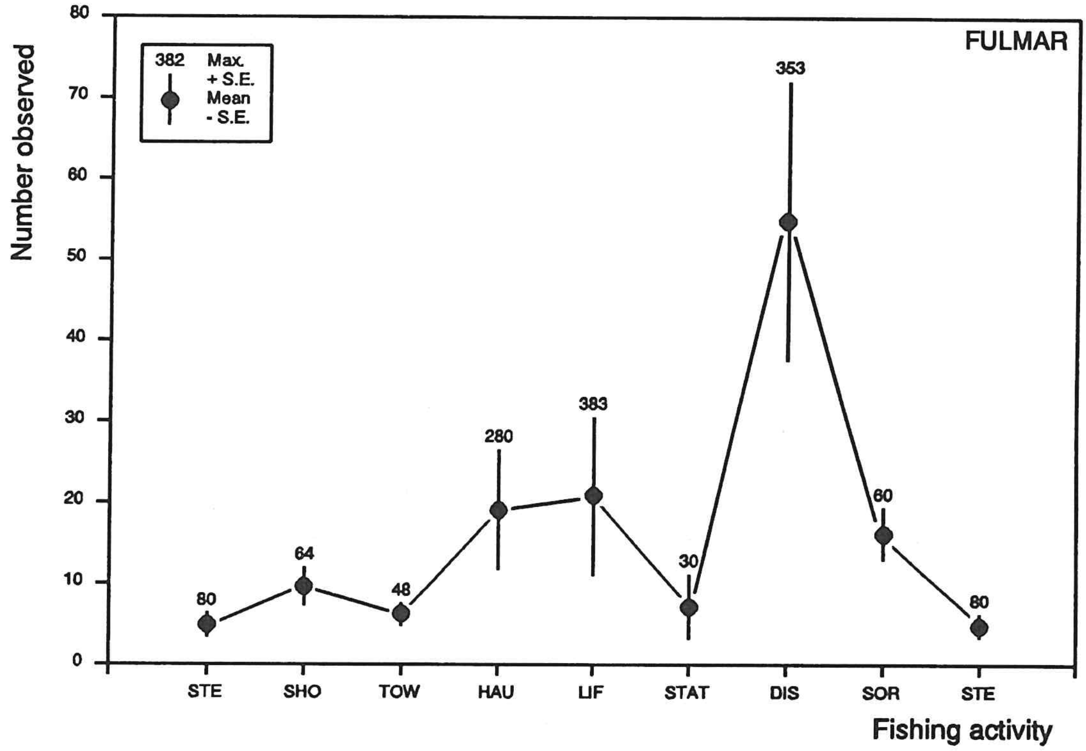
TURNOVER The turnover at the stern was not studied in any detail. It appeared that for some species (*e.g.* Gannet and Fulmar) the stay at the stern was relatively short, while several species of gulls stayed longer periods and sometimes followed the ship for quite a while when it steamed away after trawling. It seemed, but this was not demonstrated by firm data, that Gannets tended to leave the ship when satiated, whereas many gulls stayed even after they stopped attempting to feed. Prolonged periods of steaming without discarding usually discouraged birds from staying with the ship any longer.

DISCUSSION The most numerous and widespread scavengers in winter in the North Sea, as deduced from maximum stern counts at 188 hauls from fisheries research vessels, were Kittiwake, Fulmar, Herring Gull and Great Black-backed Gull (93.1% of all scavengers at the stern, n= 40,350; table 4.2.2). Gannet and Common Gull were scarce overall but locally numerous; 75% of all Gannets were recorded in NW, while Common Gulls were most abundant in the southeastern North Sea and Skagerrak/Kattegat. Another 9 species were observed in very small numbers. However, shallow inshore waters were largely unsurveyed during IBTS. Observations from coastal sites, in the Netherlands and Germany, indicate that other species such as the Black-headed Gull can be numerous as scavengers at commercial trawlers in inshore waters (Camphuysen 1993b).

Wahl & Heinemann (1979) concluded that scavenging seabirds were attracted to fishing vessels from at least 12 km away, and that rates of attraction (and departure) should depend on amount and type of discards available, number and species of birds present, the size and visibility of the trawlers and the periods of time spent fishing. IBTS research vessels are much larger than most commercial trawlers, produce less discards and offal, and do trawl for only short periods with long periods of steaming between trawling stations. Data collected on board of research vessels indicate that a radius of 12 km is just above the mean for most species (table 4.2.4). Perhaps birds from a larger area would appear at the stern if the time of trawling was prolonged or if the vessel continued to fish the same area, but from these calculations it is assumed that most birds are attracted from a distance of 7-12 km around the ship. This radius is based on the assumption that áll birds at sea were attracted to the ship (given the fact that species and age composition of the associated flock of birds and seabirds at sea were different this is not always the case) and that attracted birds did stay associated with the ship until the maximum number of birds was reached (ignoring possible turnover at the stern). If only part of the seabirds at sea were actually attracted and if turnover is rapid, some birds must come from further afield than a comparison of densities at sea and numbers at the stern would indicate.

Most scavenging Gannets and gulls were adults:

Gannet	98.8%	(n= 1,751)
Common Gull	87.4%	(n= 697)
Herring Gull	71.8%	(n= 8,519)
Great Bl.-b. Gull	72.4%	(n= 3,870)
Kittiwake	96.6%	(n= 10,922)



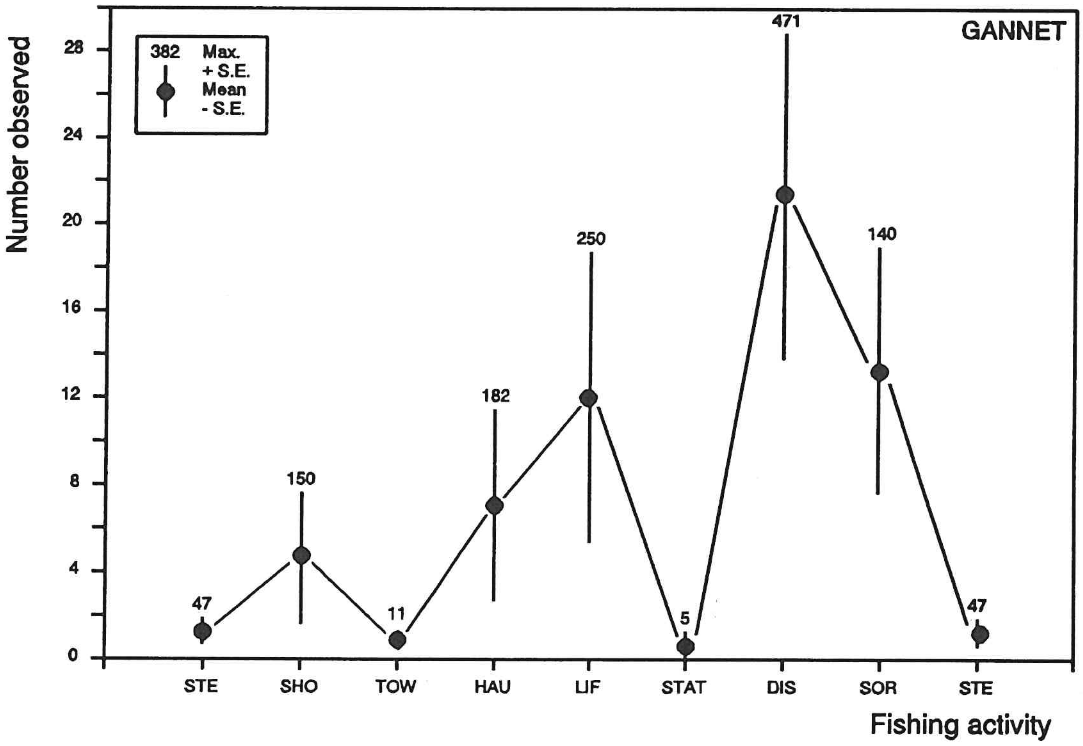
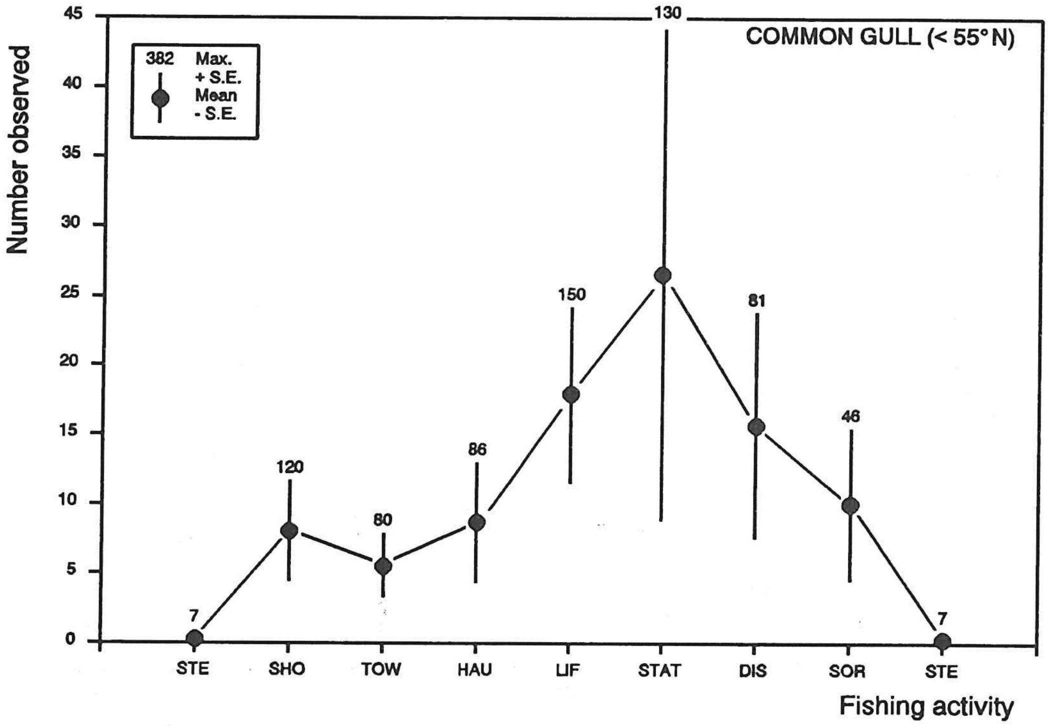


Figure 4.2.11 *Relative abundance (mean ± S.E. and maximum observed) of Fulmar (top) and Gannet (bottom) at the stern during different activities of RV Tridens, IBTS 1993 (n= 343 counts).*



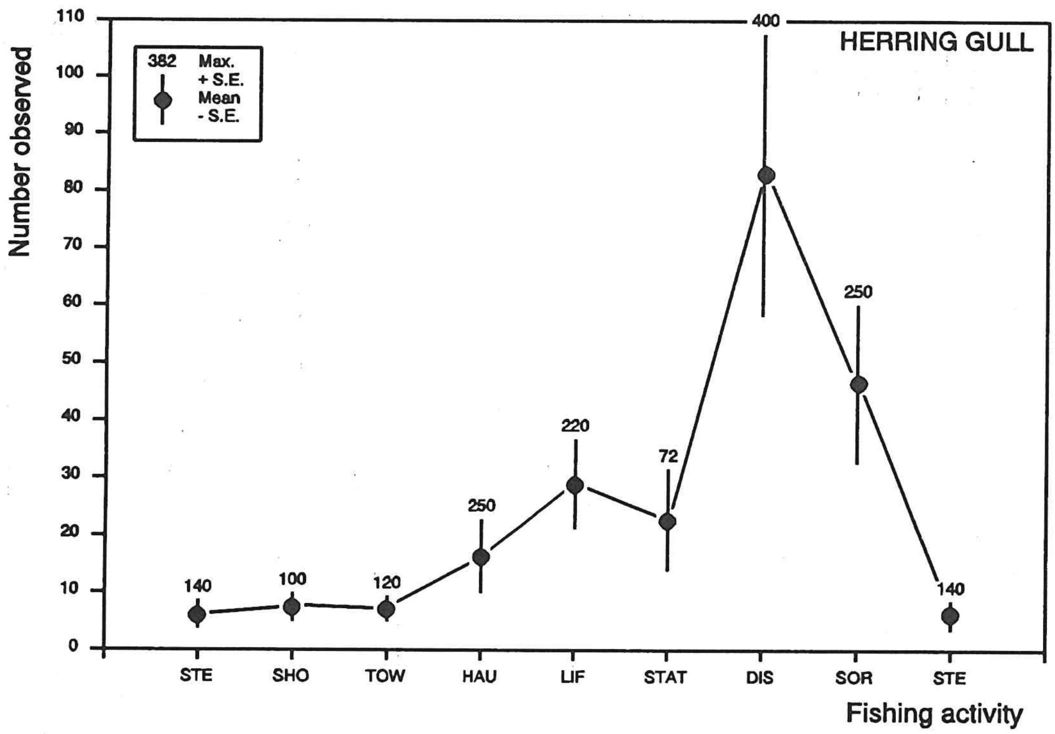
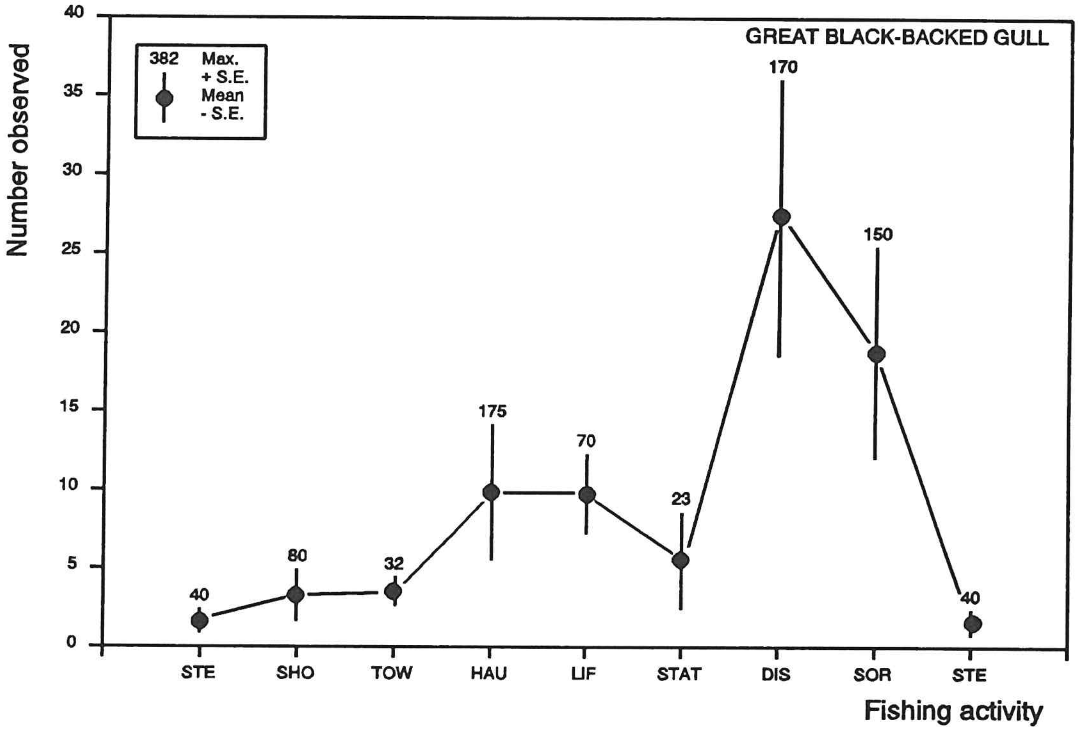


Figure 4.2.12 *Relative abundance (mean ± S.E. and maximum observed) of Common Gull (top) and Herring Gull (bottom) at the stern during different activities of RV Tridens, IBTS 1993 (n = 343 counts).*



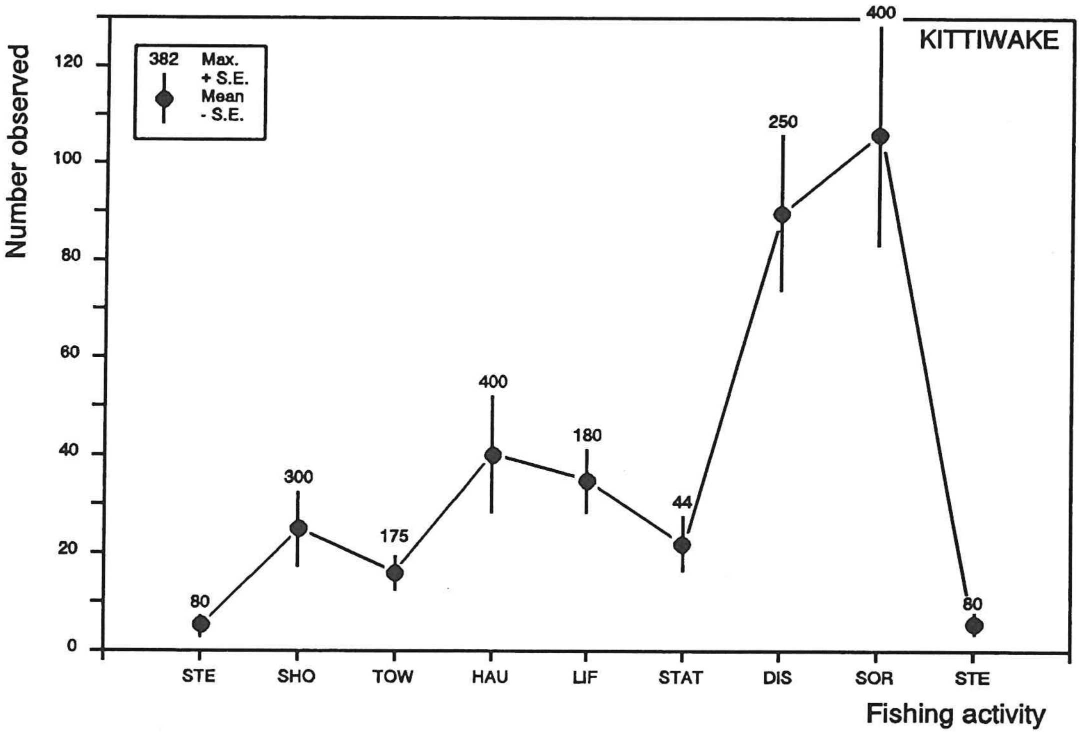


Figure 4.2.13 *Relative abundance (mean ± S.E. and maximum observed) of Great Black-backed Gull (top) and Kittiwake (bottom) at the stern during different activities of RV Tridens, IBTS 1993 (n = 343 counts).*

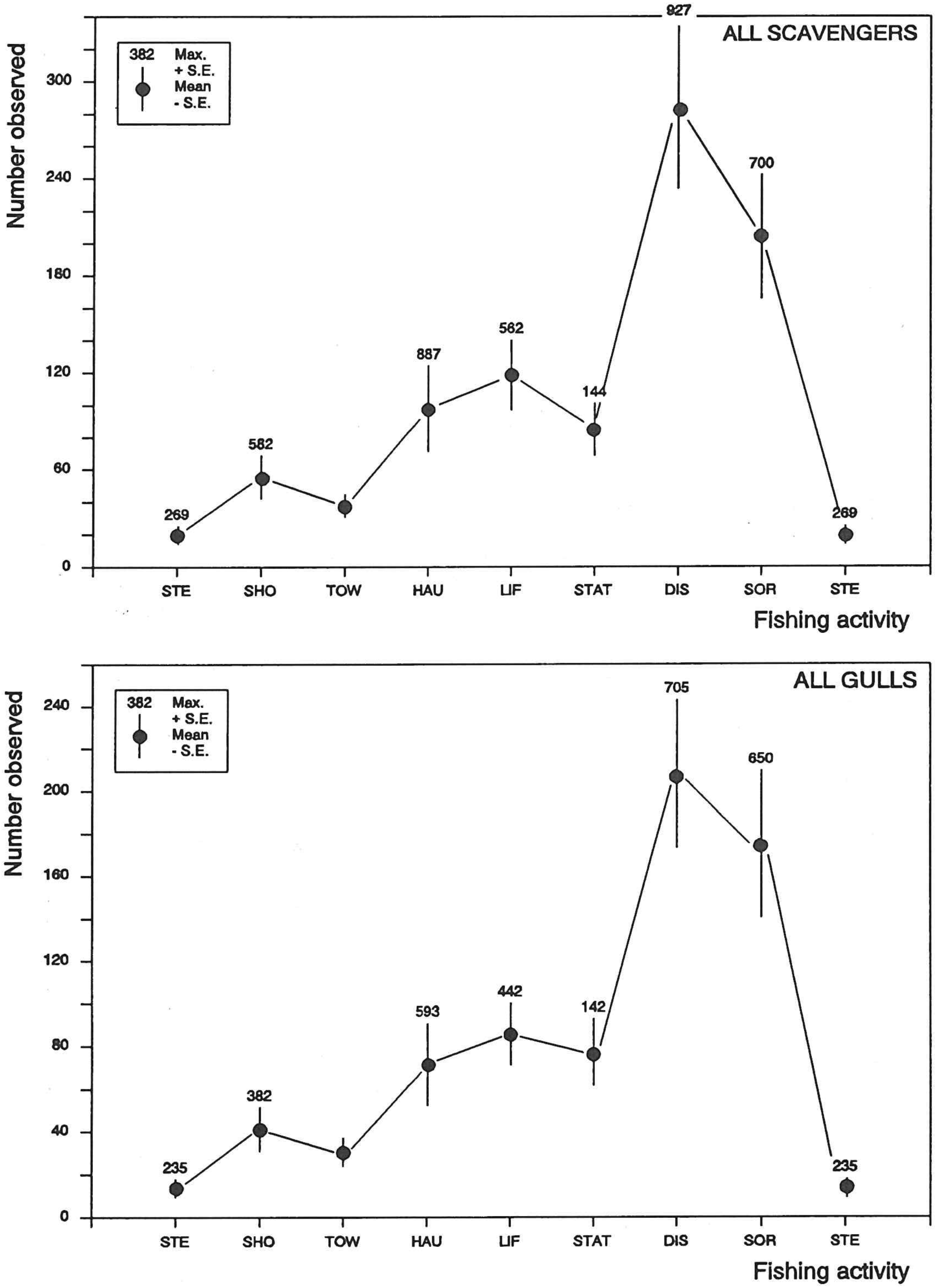


Figure 4.2.14 *Relative abundance (mean ± S.E. and maximum observed) of all scavengers (top) and all gulls (bottom) at the stern during different activities of RV Tridens, IBTS 1993 (n= 343 counts).*

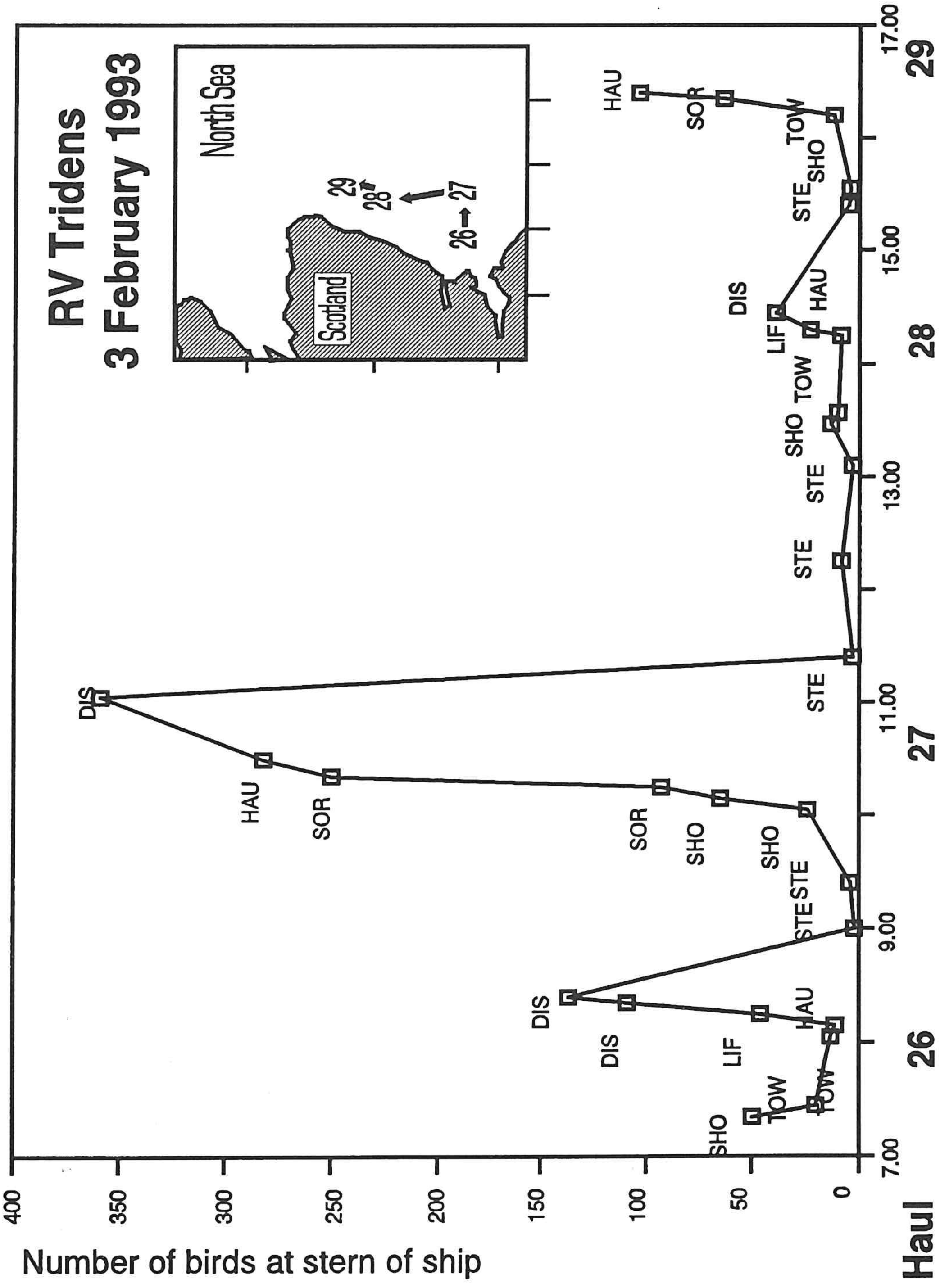


Figure 4.2.15 *Fluctuations in numbers at the stern off E Scotland (hauls 26-29), 3 February 1993, RV Tridens.*

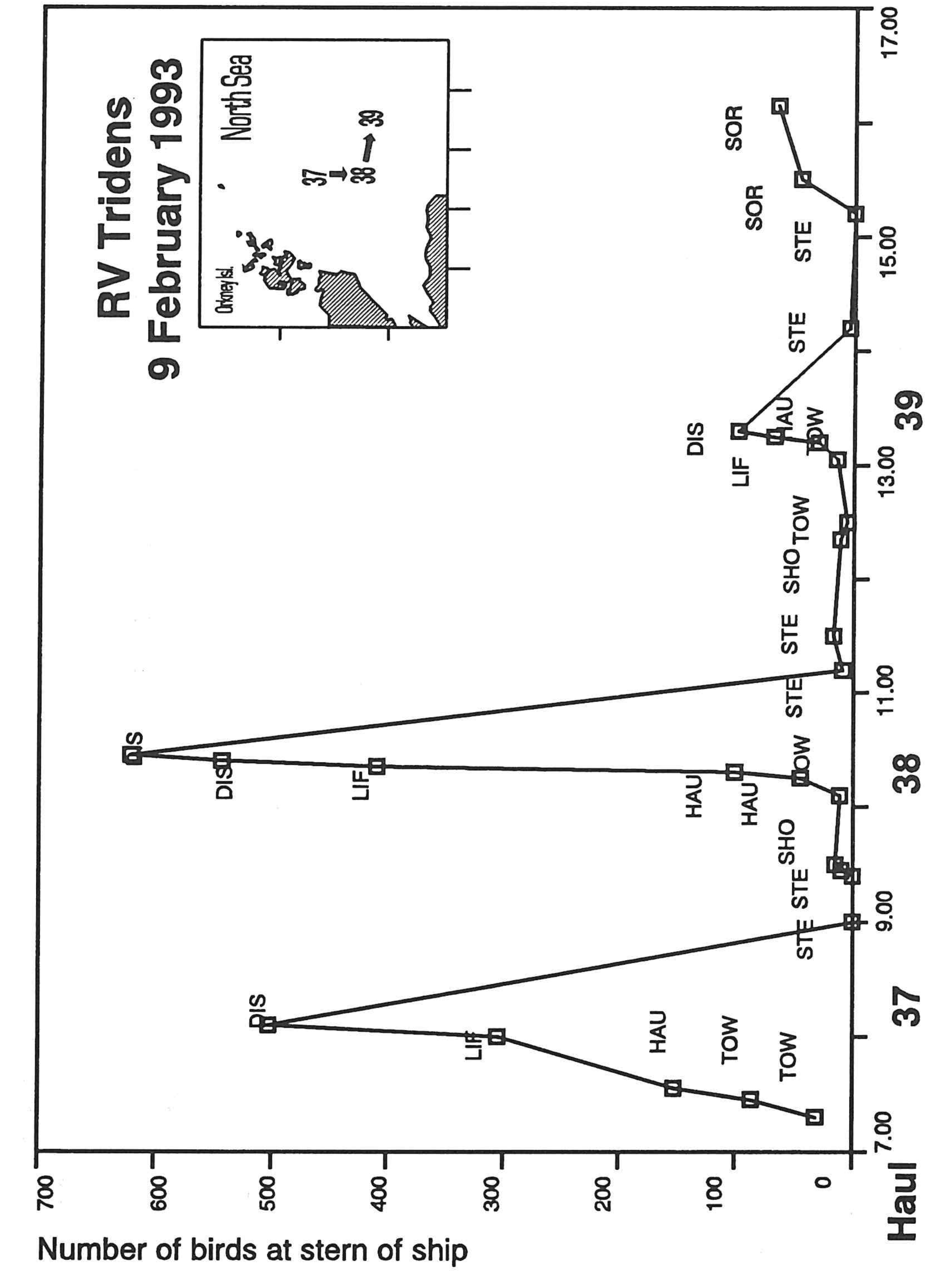


Figure 4.2.16 *Fluctuations in numbers at the stern in the northern North Sea (hauls 37-39), 9 February 1993, RV Tridens.*

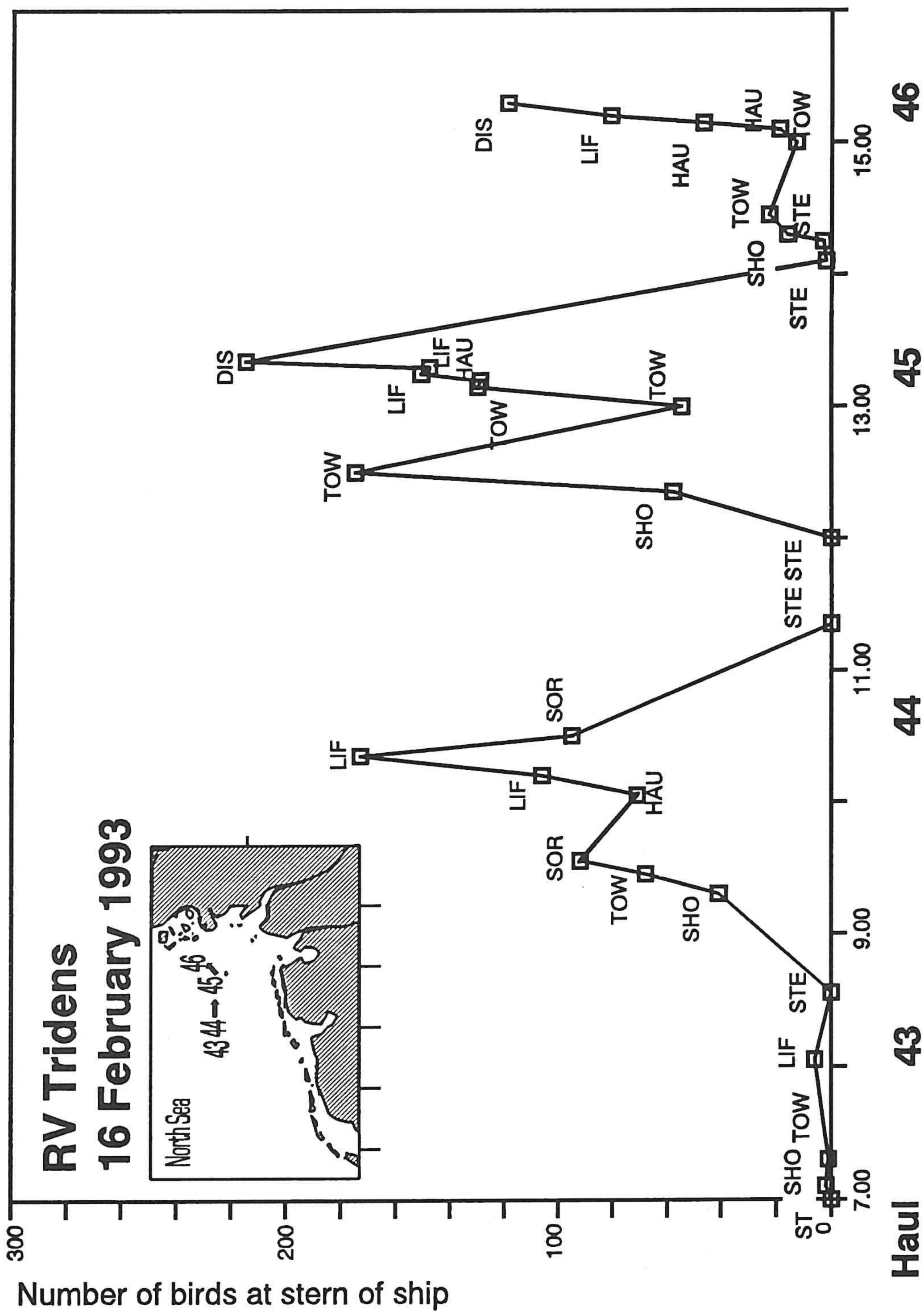


Figure 4.2.17 *Fluctuations in numbers at the stern in the German Bight (hauls 43-46), 16 February 1993, RV Tridens.*

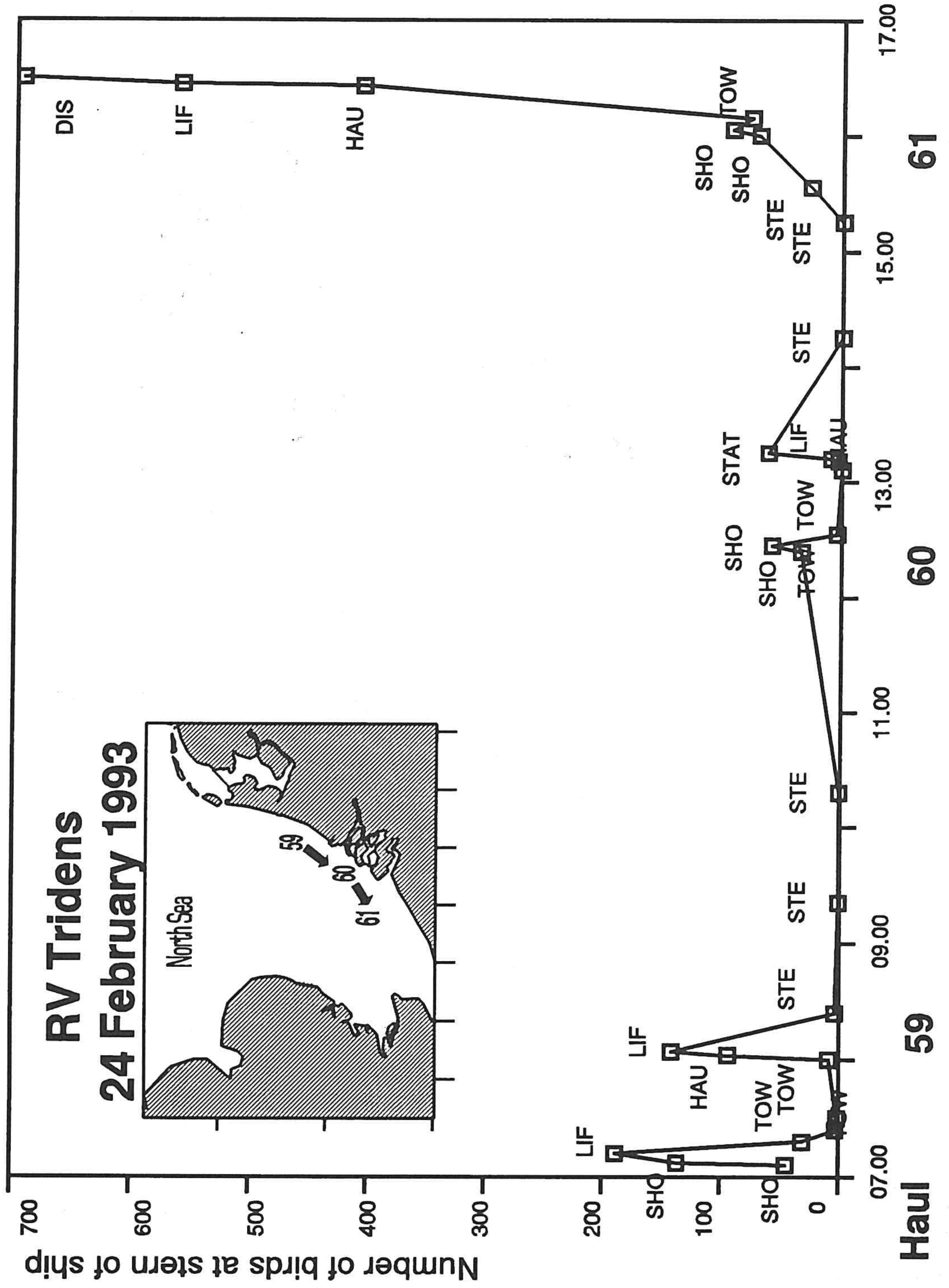


Figure 4.2.18 *Fluctuations in numbers at the stern in the Southern Bight (hauls 59-61), 17 February 1993, RV Tridens.*

For Gannet, Great Black-backed Gull and Kittiwake, the proportion of adults among ship associates differed significantly from the % adults recorded at sea during transect counts (table 4.1.5). In the case of Gannets, this difference was only small and not significant in any of the subregions. In the North Sea, the proportion of adult gulls at the stern was generally higher than recorded in transect counts. Differences were usually only small and only significant in some subregions (Great Black-backed Gull in C, CW, and NW, Herring Gull in CE, CW, and NW, Kittiwake in all subregions except NW). In the Skagerrak, however, although immatures were still less numerous than adults, the proportion of immature Herring Gulls, Great Black-backed Gulls and Kittiwakes was higher among ship associates than at sea. The stronger predominance of adults at the stern compared to numbers at sea, suggests that immatures are more often outcompeted than adults in the scramble for discards and offal behind boats. Remarkably, in the Skagerrak immature Great Black-backed Gulls, Herring Gulls and Kittiwakes were comparatively more abundant at the stern than at sea, with 36.9% ship-associated Kittiwakes being immature. This is hard to account for. From observations of fishing vessels near the shore in The Netherlands it is known that, occasionally, nearshore trawlers are joined by only the immature fraction of the Herring Gulls present on the beach, while adults show no interest at all (C.J. Camphuysen *pers. obs.*). Presumably, these adults had been feeding elsewhere or earlier, leaving the second choice to immatures. The Skagerrak/Kattegat area is surrounded by land offering scavengers alternative feeding sites which may be more attractive at times. From numbers and size of commercial trawlers recorded in subregion Sk during the IBTS (*i.e.* only four small fishing boats in Sk; see section 4.3) it could be concluded that discards may be a relatively minor food source here compared to the North Sea.

Obviously, there is a general tendency for scavenging seabirds to assemble around stationary vessels (*cf.* Reinsch 1969, Watson 1981, Griffiths 1982, this study). Dändliker & Mülhauser (1988) recorded seabird numbers at the stern of a commercial trawler during towing, hauling, lifting and discarding (while steaming) and found highest numbers of all scavengers during discarding. There was a general increase of scavenging birds at the stern during the respective phases of fishing (TOW - HAU - LIF - SOR), but a distinct dip in numbers of Kittiwakes and Great Skuas during lifting (LIF), the only phase studied during which the vessel was not moving. This finding is similar to that found for Kittiwakes on board RV *Tridens* (figure 4.2.13), indicating that smaller, more agile species are more easily outcompeted by species like Fulmar and large gulls when the discarding vessel is not moving. Watson (1981), however, working in the Irish Sea onboard a commercial trawler concluded that Kittiwakes were most abundant when the net was lifted or while towing and discarding, and least abundant when steaming while discarding. Fulmars, which are scarce in the Irish Sea, were most numerous when discarding while steaming as well as during lifting. Boswall (1960) concluded from studies off NW Scotland that Fulmars obtained virtually all offal at boats which discarded while stationary, whereas gulls and Gannets had a distinct advantage over Fulmars when the boat was moving. Assuming that feeding success at the stern is reflected in relative abundance during each of the phases of fishing, the timing of discarding in particular whether the vessel is moving or stationary is an aspect that would deserve more attention in future studies. On certain types of commercial vessels (*e.g.* beamtrawlers, large stern trawlers) most discards are released during steaming or towing. In several other fisheries (*e.g.* small whitefish trawlers around Shetland; Hudson & Furness 1988, 1989), discarding boats are often stationary. More exact knowledge of discarding practices in commercial fisheries and a better understanding of feeding efficiency of scavengers attending moving or stationary vessels are therefore required.

4.3 SEABIRDS ASSOCIATED WITH COMMERCIAL TRAWLERS

Commercial trawlers are frequently seen during ship-based seabird surveys. The majority are too far away to see any details; beyond about 2 km it is usually impossible to identify the boat or birds around it. However, considerable numbers can be identified to type of vessel and activity and numbers of associated seabirds can be recorded. Thus a valuable impression is obtained of the species, numbers and distribution of scavenging seabirds assembling around these vessels without actually working onboard commercial boats (*cf.* Camphuysen 1993b). The IBTS programme is particularly useful for assessing trawler distribution and hence, distribution of scavengers at these vessels, because of the North Sea wide coverage. Other ship-based surveys are often biased towards certain fisheries or areas.

In this section, details of nearby commercial trawlers are analysed, including sightings from RV *Pelagia* and RV *Navicula*, during January-February 1993. The *Navicula* (owned by NIOZ, Texel) was engaged in nearshore seabird surveys off the Dutch coast and in the German Bight north to Blåvandshuk in Denmark (M.F. Leopold *pers. comm.*). This source is particularly valuable because inshore waters were mainly unsurveyed by the IBTS scheme. Species composition of birds associated with commercial boats is compared with that recorded at research vessels and the recent sightings are compared with those collected in British (1980-92; Seabirds at Sea Team (SAST), Aberdeen) and Dutch (1987-1992; NIOZ, Texel and DGW/NZG) schemes.

TRAWLER SIGHTINGS Details of 101 commercial trawlers were collected from IBTS research vessels, RV *Pelagia* and RV *Navicula*. For convenience, as most of the boats were operating some form of trawl gear, commercial fishing vessels are referred to throughout this report as trawlers. Most of the trawlers recorded were actively fishing (82). Of these, 71 were identified to type: 41 beamtrawlers, 10 stern trawlers, 6 pair trawlers, 2 seiners, 8 shrimpers and 4 'small fishing vessels' (table 4.3.1). Eleven unidentified trawlers were probably all stern trawlers or seiners. Beamtrawlers, most of which were Dutch, were restricted to the southern North Sea (south of 55°N, subregions CW, C, CE, and S; figure 4.3.1). Most stern trawlers and unidentified trawlers were encountered in the northern North Sea in deeper waters. Fishing shrimpers were only seen close to the shore and in the Dutch Waddensea. Pair trawlers were seen in the central North Sea and near the Dutch coast. The 19 trawlers which were recorded as steaming and showing no sign of recent fishing activity were excluded from further analysis.

Several distinct fishing fleets (concentrations of similar trawlers in a small area) were encountered; stern trawlers to the north of Shetland and beamtrawl fleets in the southern North Sea, off the Humber (East England), north of Borkum (German Bight), over the Brown Bank and off the Delta area (both Southern Bight). More fleets were spotted on radar screens, but these have not been systematically recorded during the surveys.

For further analysis, four distinctly different fisheries were identified: northern North Sea (stern) trawlers (subregions NW and NE, offshore, n= 15), southern North Sea beamtrawl fisheries (part of subregions CW, C, CE, and S, all south of 55°N, offshore, n= 41), Dutch shrimp fisheries (subregions S and CE, inshore and Waddensea, n= 8), and 'small' fishing boats in the Skagerrak/Kattegat area (subregion Sk, n= 4) (figure 4.3.1).

Considering the total area surveyed using a 2km wide transect on both sides of the research vessels during steaming in the North Sea (n= 31,111 km²), it can be estimated that some 1,533 fishing trawlers occurred in the areas of the North Sea surveyed during the February 1993 IBTS (note that these data are biased away from inshore waters). Translated to the above fisheries, this could mean 649 (stern) trawlers in the northern North Sea, 544 beamtrawlers in the southern and central North Sea, and 95 'small trawlers' in Sk and 245 'other' trawlers spread out over the North Sea (table 4.3.2).

SCAVENGING SEABIRDS: RELATIVE ABUNDANCE AND SPECIES COMPOSITION A total number of 23,767 seabirds were recorded with 101 trawlers, 19,932 (83.9%) of which were associated with trawlers reported to be actively fishing (n= 82). Since the coastal waters in the southern North Sea were not very well covered during the IBTS, 10 trawler sightings from RV *Navicula* were treated separately. At the remaining 72 fishing trawlers, 18,898 scavengers were recorded (table 4.3.3). The largest concentration of birds was 3,862 scavengers at a stern trawler towing near Shetland. Over the North Sea as a whole, Fulmar, Herring Gull and Kittiwake predominated as scavengers at commercial trawlers, with smaller numbers of Great Black-backed Gulls and, locally, Common Gulls (tables 4.3.3-4). Maxima of common scavengers recorded at commercial trawlers were:

3500 Fulmar	(stern trawler, NW)
80 Gannet	(stern trawler, NW)
1000 Black-headed Gull	(pair trawler, S)
500 Common Gull	(shrimper, S)
400 Herring Gull	(unidentified, NE)
300 Great Black-backed Gull	(unidentified, NW)
1000 Kittiwake	(stern trawler, NW)

Mean numbers associated with commercial trawlers in each of the subregions were often different from those associated with research vessels (tables 4.2.2, 4.3.3) and species composition differed in each of the four fisheries described above (table 4.3.5). It should be realized, however, that relatively small numbers of trawlers were recorded and that this sample size hampers direct comparisons with stern counts at research vessels. In NW, many more Fulmars were recorded at trawlers than at research vessels, whereas most other species occurred in rather similar numbers at both (table 4.3.3). Gannets and Herring Gulls were slightly more abundant and much more frequently present at the stern of research vessels. In NE, major difference occurred with respect to the relative abundance and presence of Gannets, Herring Gulls, and Kittiwakes at trawlers and research vessels. Gannets and Kittiwakes were virtually absent at commercial trawlers, whereas Herring Gulls were more frequently recorded but in smaller numbers at research vessels. Fulmars were numerous and frequent in both situations. Numbers associated with research vessels and trawlers in Sk were very similar, with Herring Gulls, Great Black-backed Gulls, and Kittiwakes dominating. In CW, comparatively few scavengers were recorded associated with trawlers. Fulmars and Gannets, both numerous at the stern of research vessels, were virtually absent and most *Larus*-gulls occurred in small numbers. Only Kittiwakes were observed in similar numbers at trawlers and research vessels. Kittiwakes were considerably more numerous at the stern of research vessels than associated with trawlers in C, but the other (common) scavengers occurred in similar numbers. All gulls were more numerous at the stern of research vessels than near trawlers in CE, whereas Fulmars occurred in similar numbers. Finally, in S, all species were comparatively abundant near trawlers, although species composition was rather similar in both situations.

Species composition and relative abundance of associated scavengers at trawlers recorded from RV *Navicula* in inshore waters of The Netherlands was different from the rest of the southern North Sea (table 4.3.3). Black-headed Gulls and Common Gulls were much more numerous at these boats, whereas Fulmars and Gannets were absent and Kittiwakes were scarce.

TRAWLERS SIGHTINGS IN WINTER: OLDER DATA Winter sightings of trawlers from the SAST database and Dutch seabird at sea studies, were plotted to look for any major concentrations of commercial trawlers over a series of years (figures 4.3.2-3). Unfortunately, the type of fishing vessel was usually not recorded and the eastern half of the North Sea was virtually unsurveyed by these two schemes (*cf.* Tasker *et al.* 1987, NIOZ & DGW/NZG unpubl. data). In the northwestern North Sea, trawlers were sighted frequently in an offshore area east of the Moray Firth and Orkney (figure 4.3.3). This is known as an area for Norway Pout fisheries (probably mainly trawlers or seiners; M.L. Tasker *pers. comm.*). Other concentrations were located from SAST sightings in the Moray Firth, coastal fisheries off northeast England, just west of the Dogger Bank and in the Southern Bight midway between England and The Netherlands. The latter was also encountered in the Dutch scheme (figure 4.3.4) and this is a beamtrawl fleet which mainly fishes for Plaice in the Brown Bank area. Beamtrawlers from this fishery were encountered by both RV *Pelagia* in January and by RV *Tridens* in February. Most prominent in the Dutch data is the coastal fleet of (mainly) shrimpers. From an earlier compilation of trawler sightings data it is known that winter fisheries in this area (with the exception of beamtrawlers at the Brown Bank), are rather concentrated on the shallow coastal zone, with relatively little effort offshore (Camphuysen 1993b).

DISCUSSION The maximum recorded numbers of Fulmar, Black-headed Gull, Common Gull, Great Black-backed Gull, and Kittiwake with commercial trawlers were higher than at research vessels. Overall, however, there was no consistent difference between numbers at trawlers and at research vessels (tables 4.2.2, 4.3.3). Fulmars were slightly more abundant at trawlers than at research vessels, mainly because of the much higher numbers recorded at trawlers in NW. Gannets and gulls occurred in similar numbers, while all these species were more frequently present at the stern of research vessels. This may have been due to the difficulty of long-distance identification of species associated with trawlers. Moreover, counts at commercial trawlers were not necessarily 'maximum' counts and as such perhaps not directly comparable to those at research vessels. It can be concluded, however, that the counts of birds associated with research vessels are not necessarily proportional to the numbers as commercial fishing vessels in the same area. The ranking of the five most numerous scavengers in each of the subregions at research vessels and at commercial trawlers is shown below:

NW

RV	*comm trw*
Fulmar	Fulmar
Kittiwake	Kittiwake
Herring G	Great BbG
Great BbG	Herring G
Gannet	Gannet

NE

RV	*comm trw*
Fulmar	Fulmar
Kittiwake	Herring G
Herring G	Great BbG
Great BbG	Kittiwake
Gannet	Gannet

Sk

RV	*comm trw*
Herring G	Herring G
Great BbG	Kittiwake
Kittiwake	Great BbG
Comm G	Comm G
Fulmar	Fulmar

CW

RV	*comm trw*
Kittiwake	Kittiwake
Fulmar	Herring G
Herring G	Great BbG
Gannet	Fulmar
Great BbG	Gannet

C

RV	*comm trw*
Kittiwake	Fulmar
Fulmar	Herring G
Herring G	Great BbG
Great BbG	Kittiwake
Gannet	Comm G

CE

RV	*comm trw*
Kittiwake	Fulmar
Herring G	Kittiwake
Fulmar	Great BbG
Great BbG	Herring G
Comm G	Comm G

S

RV	*comm trw*
Kittiwake	Common G
Herring G	Herring G
Fulmar	Kittiwake
Comm G	Fulmar
Great BbG	Great BbG

Counts at research vessels were apparently biased towards gulls, while Fulmars seemed proportionally more numerous near commercial trawlers, probably because of the large quantities of offal produced when stripping marketable fish. Offal production on board and the frequent discarding of small fish (<20 cm length) are important factors in attracting Fulmars and Kittiwakes (see section 4.4), and this could be a reason for 'disproportionally' large numbers of Fulmars at commercial trawlers and relatively more Kittiwakes at research vessels. Another reason for the proportionally larger number of Fulmars at commercial trawlers could be that these vessels are working the same area for a length of time, giving birds the opportunity to assemble and stay with trawlers.

Species composition was compared be-

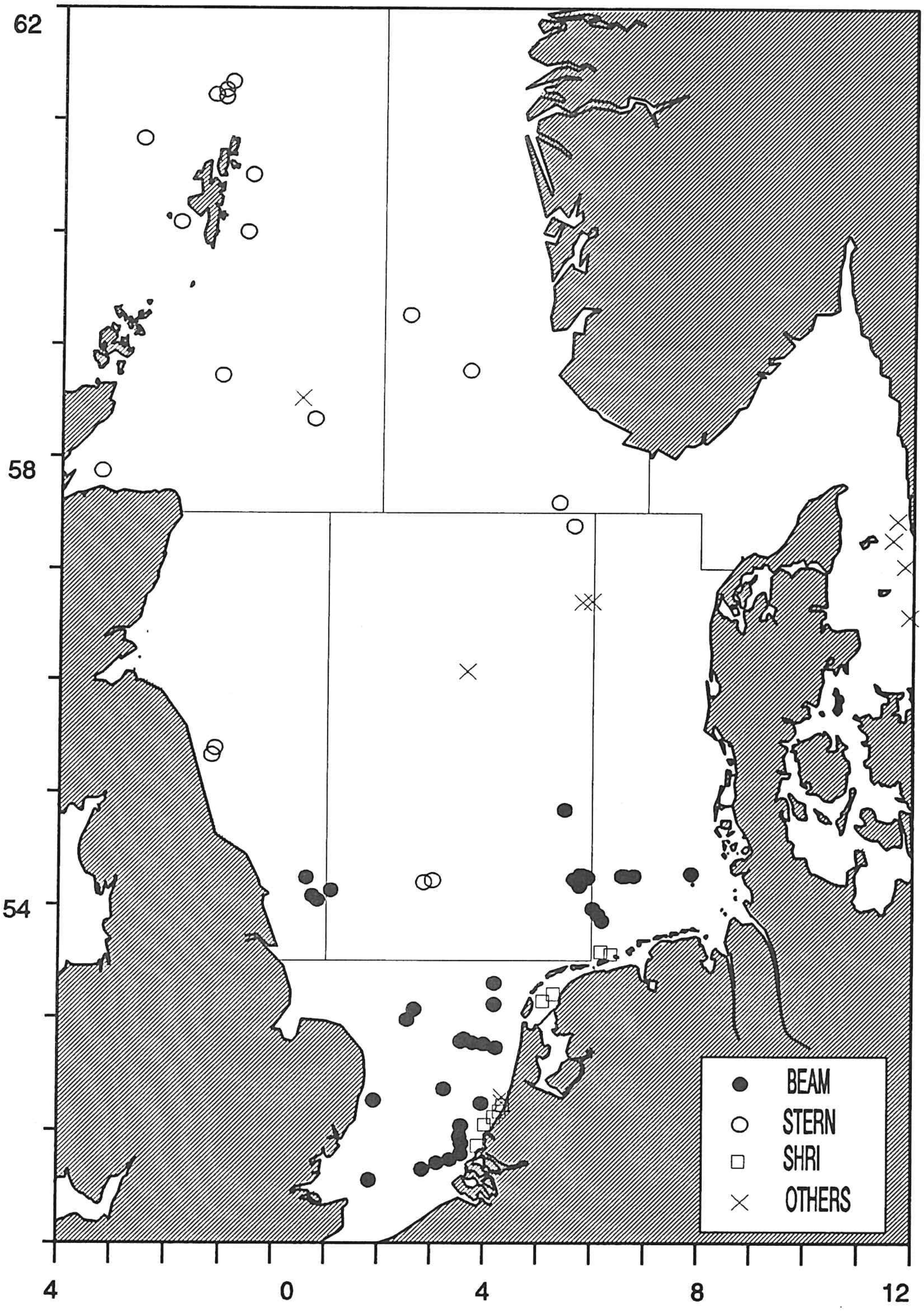


Figure 4.3.1 *Sightings of nearby commercial trawlers from fisheries research vessels, IBTS February 1993 (n = 82).*

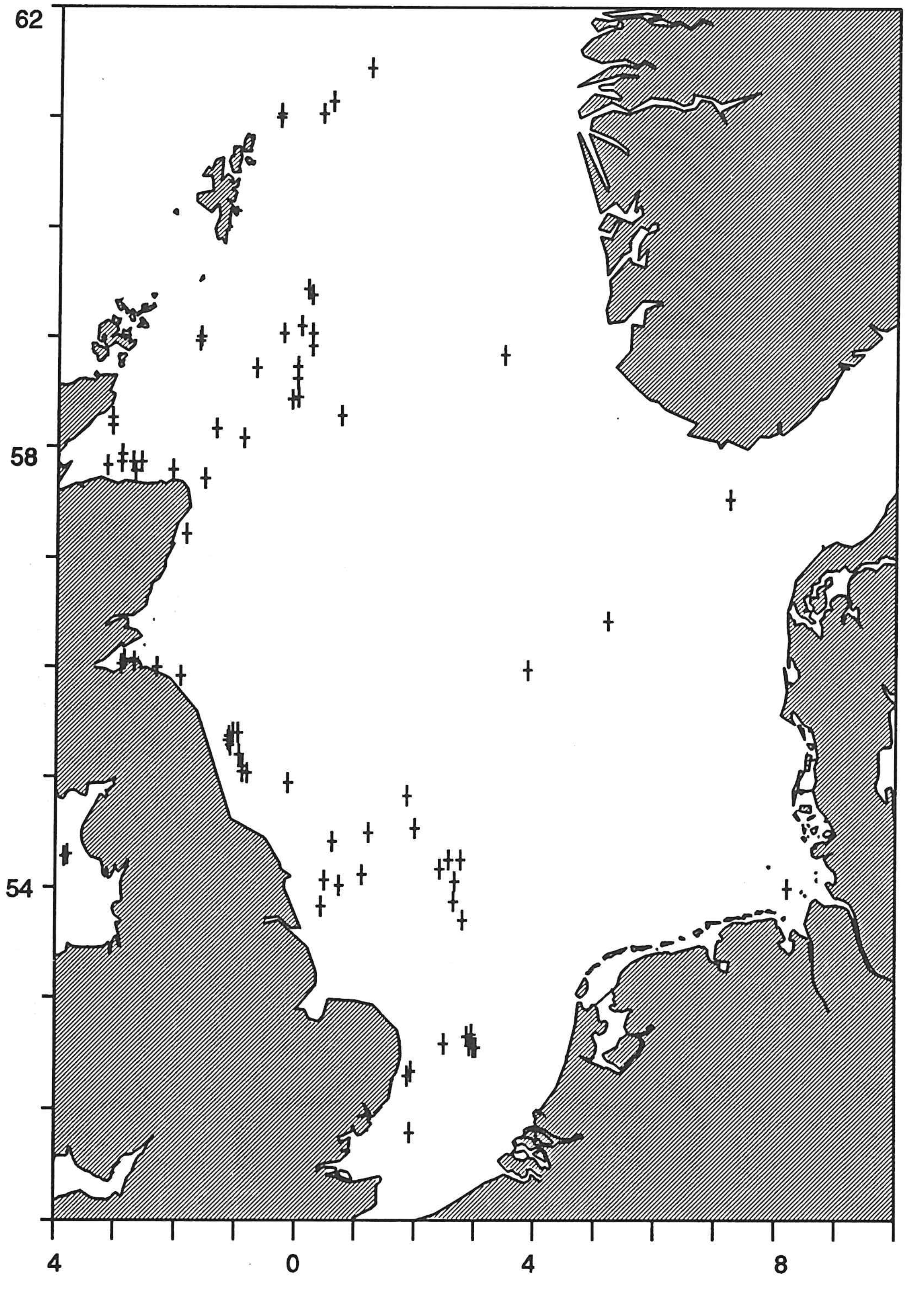


Figure 4.3.2 *Sightings of commercial trawlers during seabirds at sea surveys by the British Seabirds at Sea Team (Aberdeen), 1980-1992.*

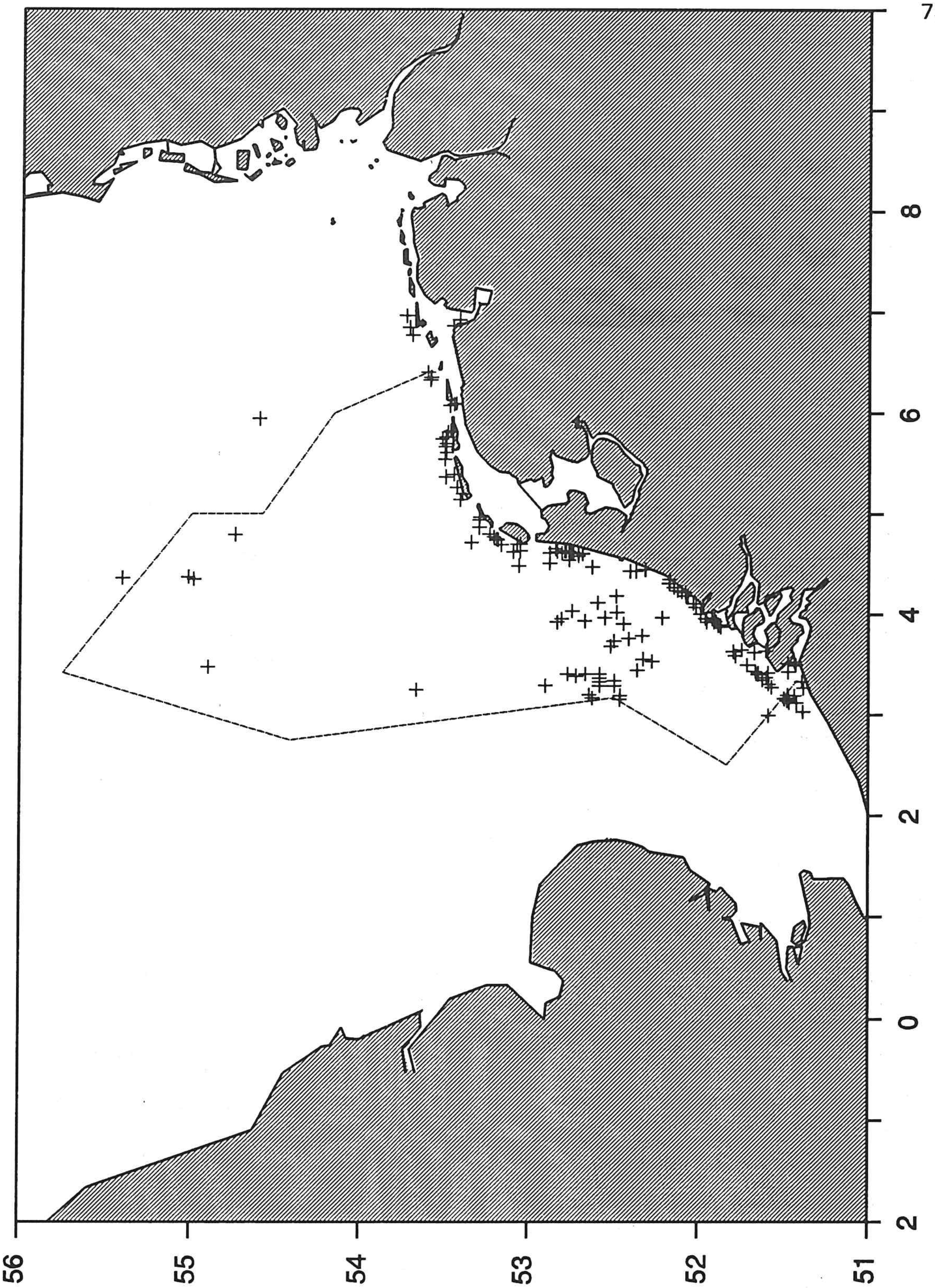


Figure 4.3.3 *Sightings of commercial trawlers during seabirds at sea surveys in Dutch waters, January-March 1987-1992, NIOZ & DGW/NZG data.*

tween research vessels and commercial vessels in the two main fisheries, *i.e.* sterntrawlers in the north and beamtrawlers in the south (table 4.3.5). Differences in flock composition at trawlers and at research vessels north of 57°N and west of 7°E were highly significant (G= 2.159, df= 4, p< 0.001). In the southern North Sea, south of 55°N, significant differences were also found when species composition at beamtrawlers was compared to research vessels (G= 806, df= 5, P< 0.00001). Here, Herring Gulls as well as Fulmars occurred in larger numbers at the commercial boats while Gannets and Great Black-backed Gulls occurred in similar proportions at both types of vessel. Kittiwakes and Common Gulls occurred in smaller numbers at beamtrawlers than at research vessels. Rather few (424) Common Gulls were recorded near beamtrawlers, compared to large numbers associated with other fishing vessels, mostly inshore shrimp trawlers and a pair of trawlers in the southern North Sea (table 4.3.3-5). Coastal fisheries were inadequately surveyed in this study and there are indications that species composition at coastal trawlers (and Waddensea fisheries) was quite different from that at offshore trawlers.

Considering that about 28% of the total number of scavengers recorded in the North Sea was associated with fishing commercial trawlers (see section 4.1), ignoring the possibility that specialized individuals might occur, it could be concluded that these seabirds spend over a quarter of their time at fishing boats. For the common scavengers the ratio of numbers seen at and away from fishing vessels varied from <10% - >30%:

Fulmar	35.2%
Gannet	8.4%
Common Gull	10.1%
Herring Gull	27.6%
Great Black-backed Gull	22.8%
Kittiwake	24.1%

From these data it is rather obvious that discards and offal are important as a food source for these species in winter.

4.4 DISCARD EXPERIMENTS: CONSUMPTION RATES AND FEEDING EFFICIENCY

During the IBTS programmes of RVs *Dana*, *Scotia*, *Tridens* and *Walter Herwig*, and during the intercallibration exercise on the RV *Pelagia*, in January-March 1993, 101 discarding experiments were carried out to examine the consumption of discards by scavenging seabirds. The experimental discarding was performed in a manner modelled on previous work by Hudson & Furness (1988; see chapter 2.2 for a description of methods), and provides the first results that allow comparisons to be made of discard utilization by scavenging seabirds throughout the North Sea. The aim was to (1) assess the quantity of discards that was consumed by scavenging seabirds, (2) examine differences between subregions in the species composition of seabirds scavenging on discards, (3) determine the proportions of discards being consumed, and (4) record selectivity and competitive abilities of different species of scavenging seabirds.

NUMBERS OF ITEMS OF EACH TYPE EXPERIMENTALLY DISCARDED During the 101 discard experiments carried out (figure 4.4.1), 6469 items were thrown over the side. These comprised 5327 roundfish, 632 items classified as offal, 451 flatfish, 49 benthic animals and 10 cephalopods. The numbers of items of each taxon discarded in each subregion are shown in table 4.4.1.

LENGTHS OF EXPERIMENTAL DISCARDS Lengths of discarded fish tended to be largest in the NW subregion and were smaller to the east and south (table 4.4.2). Differences in the sizes of discards between subregions can be expected to affect discard utilization by scavenging seabirds. When examined on a single-taxon basis, lengths of discards showed the same general trend, with discards in the NW subregion being largest (table 4.4.3). For seven of the nine major types of fish (Herring, Sprat, Cod, Haddock, Whiting, gurnards, and Dab) discards in the NW subregion had a larger median length than for the North Sea as a whole, while other medians for NW discards were similar to the North Sea as a whole (table 4.4.3). Most of the differences in the distributions of discard sizes among subregions of the North Sea were statistically significant when examined by Kruskal-Wallis 1-way nonparametric ANOVA.

FATES OF ITEMS EXPERIMENTALLY DISCARDED
The overall results of discarding experiments performed from each of the research vessels were in broad agreement: the fate of between 3.8% and 10.6% of items discarded was unknown, between 3.1% and 18.9% of items discarded sank, and between 76.6% and 86.4% of items discarded were consumed by scavenging seabirds (table 4.4.4). Disregarding the discards for which the fate was unknown, it is clear that consumption by seabirds varied among types of discard; for the whole North Sea sample where the fate of the discard was known, seabirds consumed 100% of offal discards (605), 92.4% of roundfish discards (5000), 35.5% of flatfish discards (372) and 16.7% of benthic invertebrate or cephalopod discards (54). These totals also being closely matched by results from each individual research vessel (table 4.4.5).

CONSUMPTION OF EXPERIMENTAL DISCARDS BY SEABIRDS The proportion of the discards of known fate that were consumed by seabirds varied little between subregions, being consistently high (table 4.4.6). Consumption was close to 90% for all sizes of roundfish experimentally discarded (figure 4.4.2), though very slightly less for the larger fish. Counts of numbers of scavenging seabirds associating with the research vessels during experimental discarding show differences in species composition in different subregions of the North Sea. In particular, Gannets became less numerous from NW to SE, whereas Common Gulls became more numerous from NW to SE (table 4.4.7). The mean number of birds at research vessels during discarding was highest in the two northern subregions (540 and 624) and lowest in C (128) and CE (100). These counts are required to assess the success achieved by different species of scavenging seabirds in consuming experimental discards. Consumers of discards varied among subregions (table 4.4.8). In each subregion the largest number of items was swallowed by Kittiwakes, but the second and third most important consumers varied among subregions: in the NW Gannet and Fulmar; NE and CW Herring Gull and Gannet; C, CE and S Herring Gull and Great Black-backed gull.

SUCCESS RATES ACHIEVED BY SPECIES OF SCAVENGING SEABIRDS Success rates are defined as the proportion of discarded items of a particular type that are consumed by species A, divided by the proportion of all the scavenging seabirds at the vessel that are of species A. Thus if all seabirds are equally-successful in obtaining discards the success index will be 1.0 for each species. A success index greater than 1.0 indicates that the species in question obtained a greater proportion of the discards than would have been expected from the numbers present. It is possible to analyse whether such differences are statistically significant by calculating the number of discards that one would expect to be eaten on the basis of the numerical abundances of each scavenging seabird species (on the null hypothesis of equal success for all species), and to compare expected numbers with observed numbers using a chi-squared test. Because seabird and fish numbers-by-species varied among subregions it is necessary to perform tests separately for each subregion.

Amounts of offal discarded were adequate for statistical analysis of consumption only in the NW subregion. There the main consumers of offal were Fulmars and Kittiwakes, which obtained considerably more offal than their numerical abundance predicted (table 4.4.9). In subregion C only 38 experimental discards of offal were made, but 21 of these were taken by Fulmars (expected = 7.3) and 17 by Kittiwakes (expected = 19.4). These results confirm the general view that Fulmars are especially successful in competing for offal (Hudson & Furness 1988, 1989).

However, under the experimental conditions prevailing in this study, Kittiwakes obtained a considerable quantity of offal. There is a hint in the data that Kittiwakes were the primary consumers of offal at boats in the southern North Sea (table 4.4.10), but the quantities of data are inadequate to evaluate this.

In all subregions Fulmars obtained very many fewer common gadids (Whiting, Haddock, Cod, Saithe, Norway Pout) than predicted from their numerical abundance (table 4.4.12). Setting aside the Fulmars, in the five subregions where Gannets were observed, Gannets obtained very many more gadids than their numerical abundance relative to gulls predicted (table 4.4.13). Among the gulls only, the pattern was less obvious or consistent, with Great Black-backed gulls obtaining more gadids than predicted in the NW, NE, CW, CE and S subregions and Herring Gulls obtaining less than predicted in NW, but more than predicted in C, CE and S, Kittiwakes obtained less than predicted in every subregion, and Common Gulls obtained much less than predicted even in the subregions where they occurred in large numbers (table 4.4.14). The rank orders of major consumers of experimentally discarded common gadids in each of the subregions are given below (see also table 4.4.11):

NW	Gannet Kittiwake Great Black-backed Gull
NE and CW	Kittiwake Gannet Herring Gull
C	Kittiwake Herring Gull Gannet
CE	Herring Gull Kittiwake Great Black-backed Gull
S	Kittiwake Herring Gull Great Black-backed Gull

The rank orders of major consumers of experimentally discarded common clupeids (Herring and Sprat) were rather consistent: in NW, Gannet, Kittiwake, Herring Gull; in all other subregions Kittiwake, Herring Gull, with the third species varying and of little importance (table 4.4.15). As with gadids, Fulmars obtained very many fewer clupeids than predicted from their relative abundance at the vessels (table 4.4.16). With clupeids, Gannets obtained significantly more than predicted in the NW subregion but less than predicted in all other subregions, though significantly so only in C (table 4.4.17). Among the gulls, Great Black-backed Gulls obtained less clupeids than expected in all subregions and Kittiwakes obtained more than expected in all subregions, the difference being most pronounced in subregions C, CE and S (table 4.4.18). Common Gulls obtained less than expected in the only two subregions in which they were present in large numbers.

SUCCESS RATES ACHIEVED BY DIFFERENT AGE GROUPS IN SCAVENGING GULLS The success indices for both adult and immature (including subadults and juveniles) Great Black-backed Gulls, Herring Gulls, and Kittiwakes were similar. Comparisons between numbers of common gadids (table 4.4.19) and clupeids (table 4.4.20) swallowed, showed that adult Herring Gulls were slightly more successful than immatures, whereas immature Kittiwakes were much more effective than the older conspecifics.

DISCARD SIZE SELECTION BY SCAVENGING SEABIRDS There is a clear separation between the lengths of experimentally discarded fish taken by the different scavenging seabird species. In general, the rank order of size of gadids and clupeids taken by scavenging seabirds was (from smallest to largest) Common Gull, Kittiwake, Fulmar, Herring Gull, Great Black-backed Gull and Gannet (tables 4.4.21-32). For six of the seven most abundant fish species discarded during the survey, significant differences between the length choices by Fulmar, Gannet, Herring Gull, Great Black-backed Gull and Kittiwake

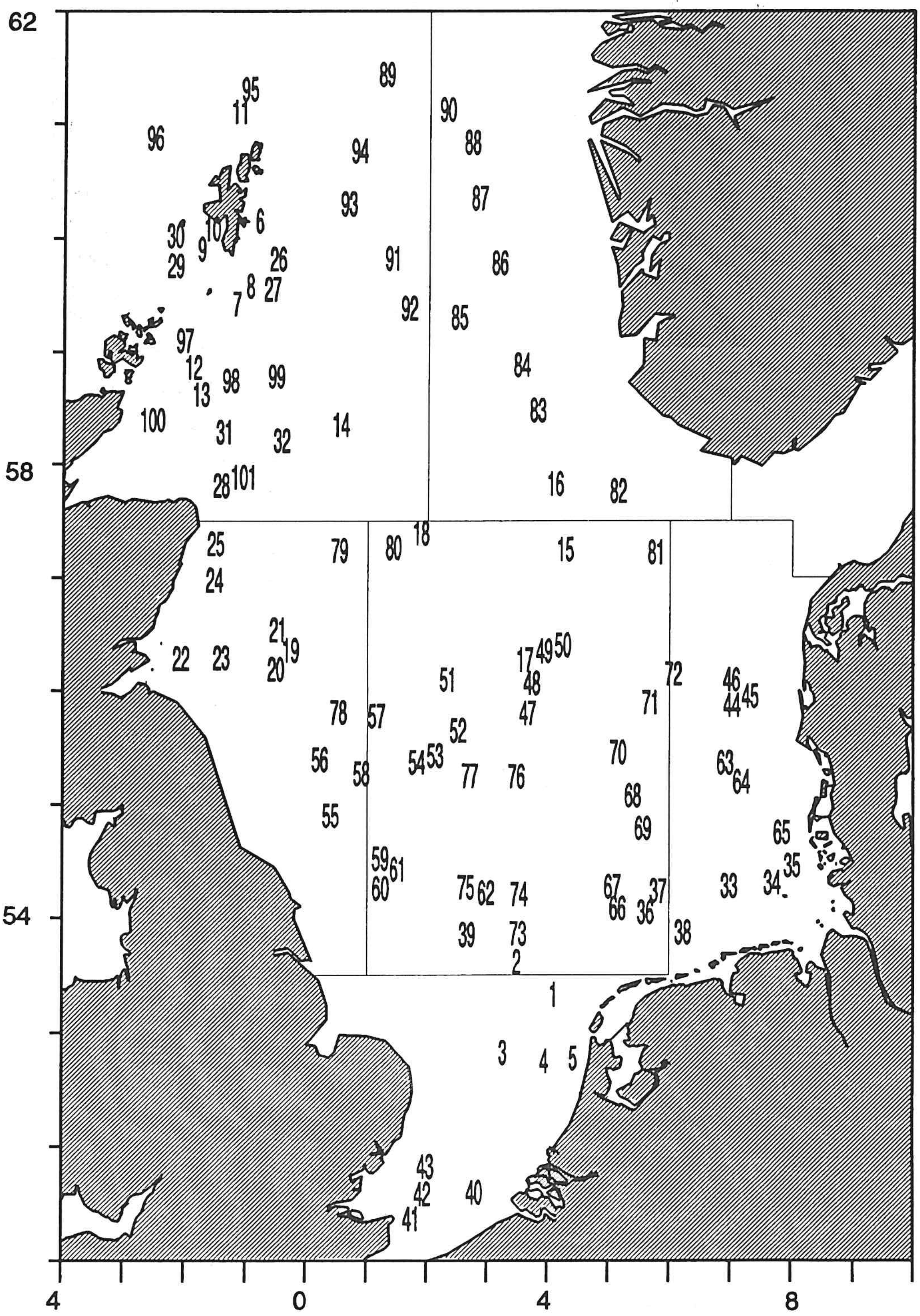


Figure 4.4.1 Plots of discard experiments, IBTS February 1993.

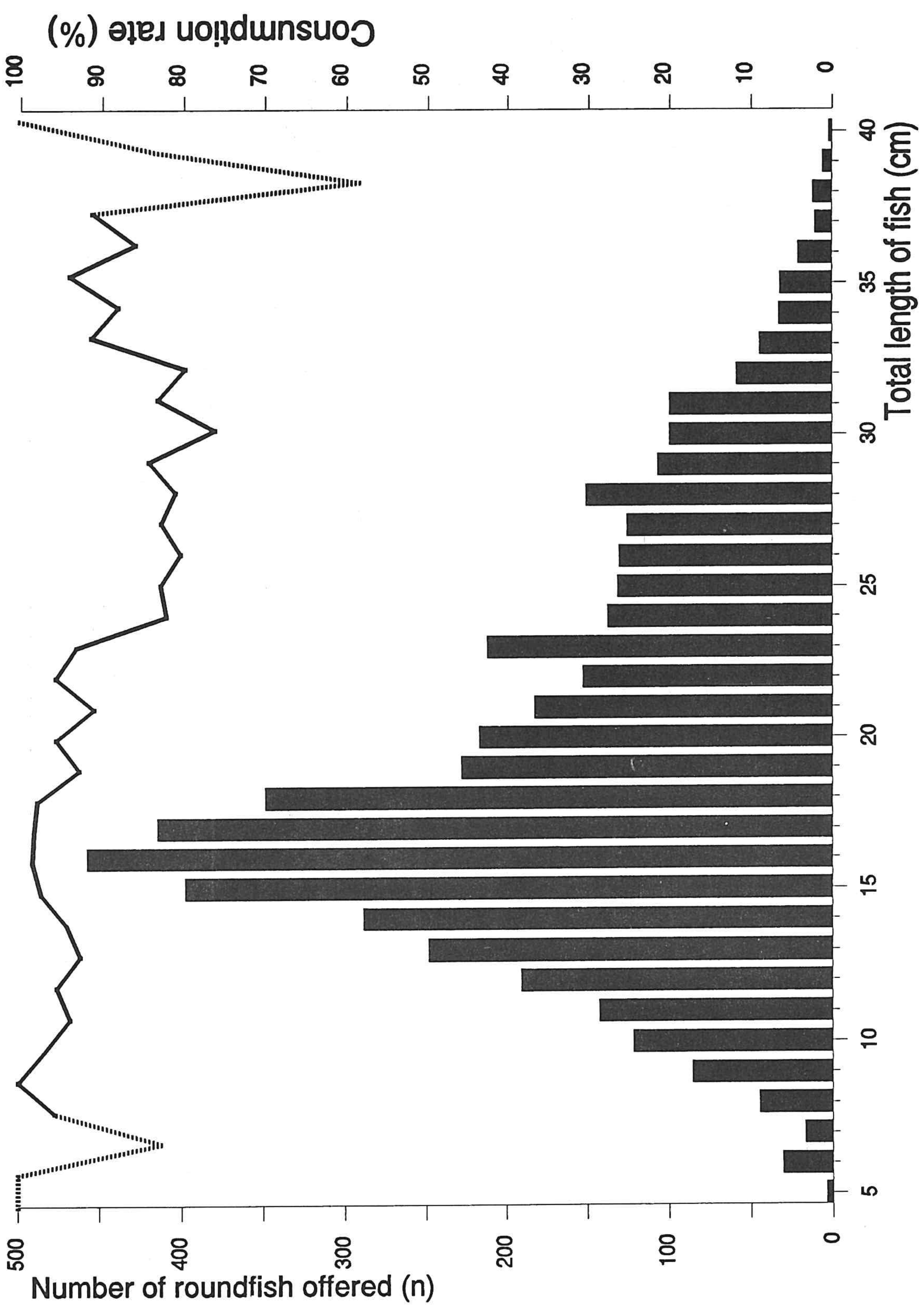


Figure 4.4.2 *Consumption rate (line) and lenght distribution of experimentally discarded roundfish of which fate is known (bars; n= 5000), IBTS February 1993, all subregions combined.*

were found (table 4.4.33). This sequence matches the rank order by body size. Kittiwakes were clearly separated by the other species taking only relatively small fish. Also, Gannets took most fish species in maximum lengths.

The selection of fish size by scavenging seabird species is clearly illustrated by figure 4.4.3 which aggregates all the data over the North Sea. Fish that sank were often larger than average; median lengths were only once smaller (Dab) and once equal sized (Norway Pout) (tables 4.4.21-32). A similar pattern of size-selection was evident in the consumption of experimentally discarded flatfish (figure 4.4.4) but in this case no scavenging seabirds consumed the largest discarded fish (over 28cm length).

One mechanism by which fish size-selection occurs appears to be the decision of larger scavenging seabirds to rarely take small fish. Alternatively, Kittiwakes may be so quick in reaching and swallowing small fish (*e.g.* 5-10cm long clupeids or 10-15cm long gadids) that Gannets are often hardly able to take them in the face of competition with Kittiwakes (*cf.* Camphuysen 1993a). These alternate hypotheses could be tested by analysis of fish consumption by Gannets in the presence and in the absence of Kittiwakes, but suitable data are not available from our study. Another mechanism causing fish-size selection is due to scavenging seabirds being unable to swallow fish above a certain size. Also, attempting to swallow fish close to this size limit takes considerable time and leaves the individual vulnerable to attack and piracy. It is evident from our results that there was considerable competition for discards. Of 5832 experimental discards of measured length (including roundfish, flatfish, benthic animals and cephalopods), 4935 were picked up and were swallowed by scavenging seabirds, but 857 (17.4%) of these were stolen from the first bird by another before they could be swallowed by the first. Of the 857 stolen items, 292 (34.1%) were stolen a second time. Of these, 106 (36.4%) were stolen for a third time, and further stealing led to sequences of up to 14 birds handling a discard before it was swallowed (table 4.4.34). There is a trend for discards to be more likely to be stolen if they are large; only 5.1% of discards less than 10cm in length were stolen from the bird that picked them up whereas over 30% of discards more than 21cm in length were stolen (table 4.4.34). In general, larger scavenging seabirds stole more than smaller ones, Kittiwakes being especially vulnerable to being robbed and Great Black-backed Gulls being the most consistently successful pirates (table 4.4.35).

DISCUSSION A number of results confirm findings of similar studies limited to the breeding season or to small areas of the North Sea. Seabirds avidly consumed offal, part or all of every experimentally discarded piece of offal being swallowed, mostly by Fulmars or Kittiwakes. The importance of the Kittiwake as a consumer of offal has not been evident in many previous studies (*e.g.* Hudson & Furness 1989, Furness 1992, Furness *et al.* 1992), possibly because these have often been focussed on the NW North Sea, where Fulmars dominate as consumers of offal. Also the situation may differ between summer and winter. Alternatively, the high numbers of Kittiwakes at the research vessels and their high consumption of offal, especially further south where total numbers of scavengers, particularly Fulmars were lower, may reflect the poor quality of some research vessels as feeding sites compared with commercial trawlers. This may have resulted in Kittiwakes obtaining rather more food than they might have done in more competitive conditions at commercial vessels. Since we do not know very much about the birds following the different types of commercial trawlers, and their responses to different discard practices (see section 4.3), this can only be an assumption at the moment.

Adult Herring Gulls were slightly more succesful than immatures considering the consumption of common gadids and clupeids at the trawl. Young Kittiwakes, however, had a much higher success index than adults (tables 4.4.19-20). For Great Black-backed Gulls, the results are different regarding gadids and clupeids, with adults being more successful feeding on gadids, and immatures having a higher success index feeding on clupeids. Differences between success indices are generally rather small, except in Kittiwakes where immatures appeared clearly more successful than adults. Possibly, immatures suffered more from food-shortages than their adult conspecifics and were therefore more aggressive than adults at the trawl.

Research to ascertain the extent of differences between research vessel results and results to be obtained at commercial fishing vessels should be a high priority in future studies. Kittiwakes swallowed more of the roundfish experimental discards than did any other scavenging seabird species (table 4.4.8). This result is in marked contrast to the findings of Hudson & Furness (1988) in Shetland in summer, where Kittiwakes failed to obtain any discards, apparently because they were unable to compete with the large numbers of larger scavenging seabirds present, especially Gannets, Great Black-backed Gulls and Great Skuas. If future work validates the research vessel results and confirms that Kittiwakes are a major consumer of discards and offal from fishing vessels in the North Sea, perhaps especially in southern subregions and in winter, some reappraisal of the implications for seabirds of changes in discarding practices will be required. Kittiwakes have one of the lowest wing loadings of all North Sea seabirds and are consequently highly manouverable. This outstanding flight ability may permit them to get to discards particularly quickly, which would assist their success rate in competition with larger seabirds. However, Kittiwakes clearly have difficulty in swallowing gadids or clupeids of more than 23cm length (tables 4.4.21-32) and so the difference in the success of Kittiwakes in this study and that reported in previous work by Hudson & Furness (1988, 1989) may be due to the differences in the size distributions of discards made available. In this study the median length of experimental discards was 18cm (table 4.4.2), with 75% of all discards being less than 23cm in length. Hudson & Furness (1988, 1989) used discards sorted by fishermen on commercial trawlers at Shetland, and these discards were much larger; over 90% of the gadids discarded were 23cm or longer, making them too large for Kittiwakes to utilize. Thus the results of the discarding from research vessels with smaller meshed nets provide especially small discards that favour Kittiwakes in a way that many North Sea fishing fleets would not (see chapter 8).

Differences in the sizes of fish experimentally discarded in different subregions of the North Sea, with those in the NW being generally of larger size than those further south and east, may reflect differences in the size distributions of North Sea fish stocks in these different subregions. The differences correspond to a certain extent to differences in the size distributions of scavenging seabirds in the different subregions: the scavenging seabird community in the NW subregion comprised more of the larger seabirds (Gannets, Great Black-backed Gulls) and fewer of the smaller species (Common Gulls, Kittiwakes) than found in the subregion to the south and east.

Such differences in distributions of scavenging seabirds in the North Sea in winter might be in part a consequence of the sizes of discards available in the different subregions. However, each scavenging seabird appears to have a somewhat distinct niche. Fulmars feed successfully on offal but obtain few (whole) fish discards. This species is able to master a large spectrum of fish length, but they only swallow small-sized fish totally, pecking intestines out of larger fish instead. Kittiwakes take offal and the smallest whole fish discards, Gannets take the largest whole fish discards but not offal or small (<15cm) fish to any great extent, Great Black-backed Gulls take large discards, rather similar in size to those taken by Gannets, Herring Gulls feed in a rather generalised way on offal on some occasions, in small to medium sized whole fish discards (spanning rather a wide range of fish lengths). Herring Gulls achieved only rather low success indices by comparison with Great Black-backed Gulls when both were taking gadids (table 4.4.11) or by comparison

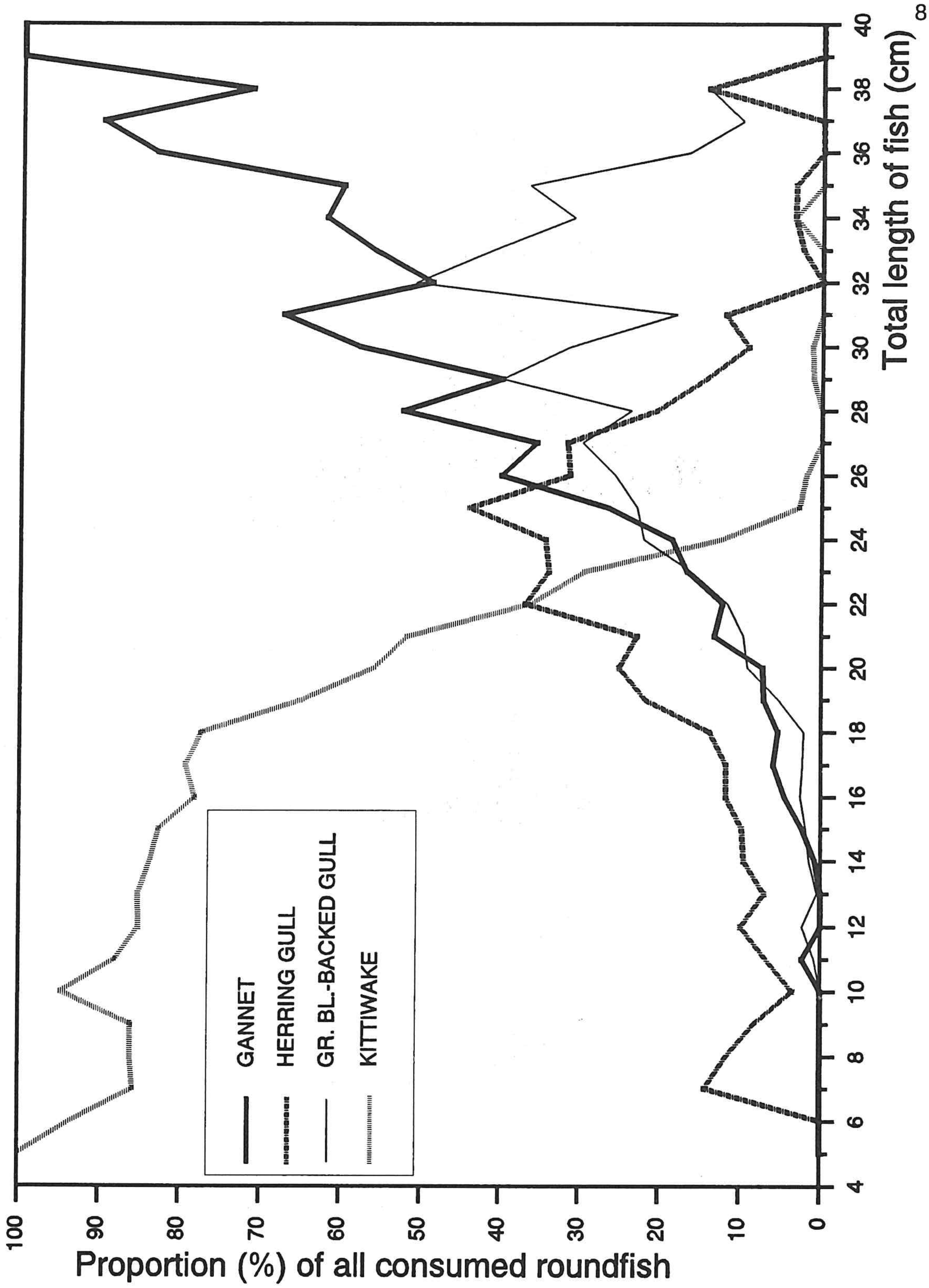


Figure 4.4.3 *Proportion of consumed roundfish taken by Gannet, Herring Gull, Great Black-backed Gull and Kittiwake, IBTS February 1993, all subregions combined.*

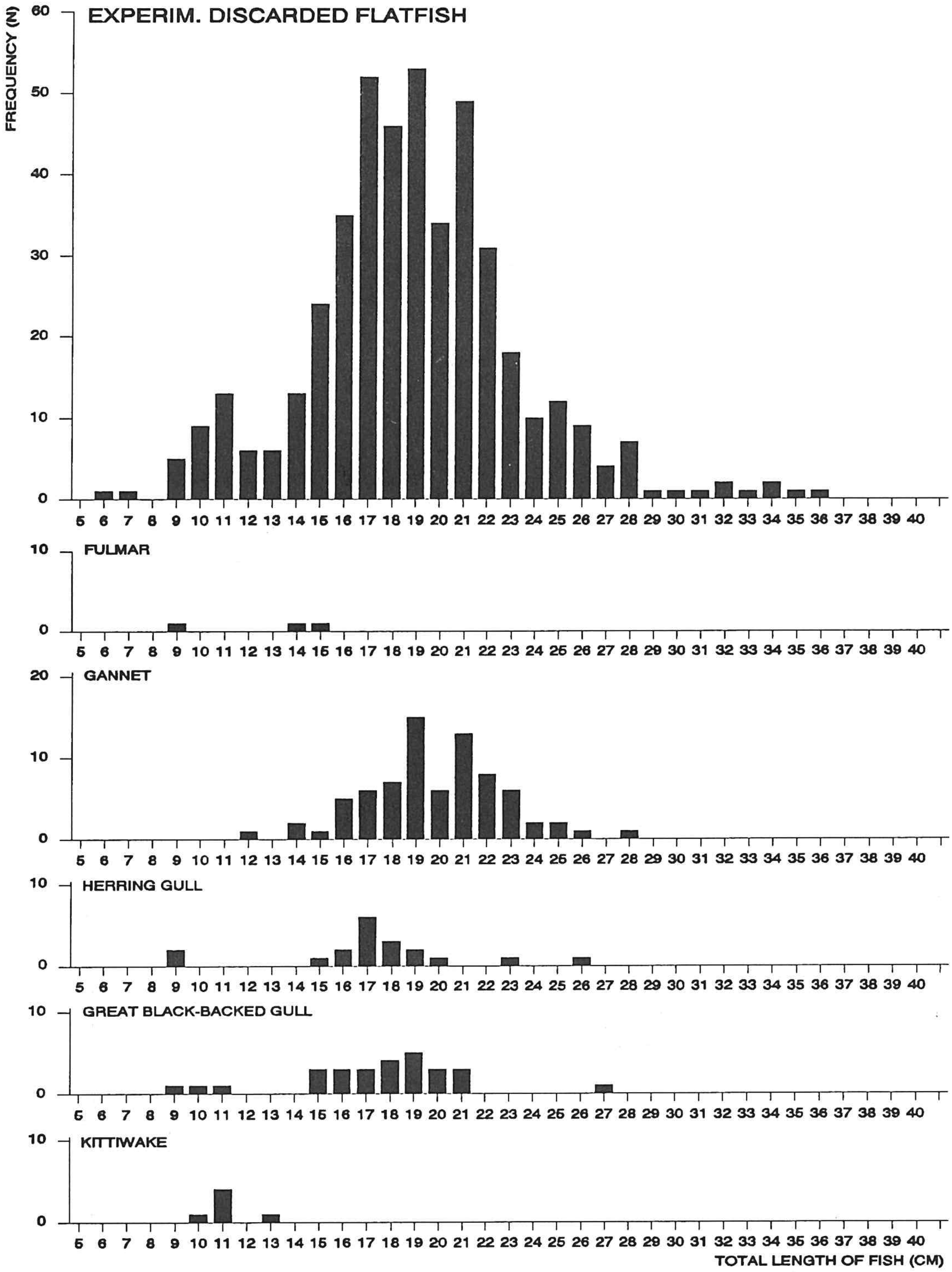


Figure 4.4.4 *Length distribution of experimentally discarded flatfish (top; n= 372) and length of fish taken by Fulmar, Gannet, Herring Gull, Great Black-backed Gull and Kittiwake, IBTS February 1993, all subregions combined.*

with Kittiwakes when taking clupeids (table 4.4.15), suggesting that they are less specialised and more vulnerable to interspecific competition. Too few data were available to examine the performance or preferences of Lesser Black-backed Gulls, but the performance of Common Gulls was generally poor by comparison with that of Kittiwakes or Herring Gulls (tables 4.4.11 and 4.4.15).

Flatfish consumption (35.5%) was much less than roundfish consumption (92.4%). There are two probable reasons for this. Firstly, flatfish sink faster than most roundfish since they are not buoyed to the surface by an expanded swimbladder as gadids are. Secondly, they appear to be less attractive to scavenging seabirds because their shape makes them difficult to swallow, and their energy content is less than that of many roundfish. Hudson & Furness (1988) found only about 4% of experimentally discarded flatfish in Shetland were known to be eaten by seabirds, whereas over 60% of experimentally discarded gadids were known to be swallowed (the fate of many fish remained uncertain). Experimental discarding around Helgoland in 1991, however, revealed rather similar proportions: 88% of all discarded roundfish and 38% of all flatfish were consumed by (large) *Larus*-gulls (Hüppop & Garthe 1993).

One might anticipate that clupeids would sink faster than gadids and so be less thoroughly utilized. Of 2245 clupeids experimentally discarded and of known fate, 158 (7.0%) sank (tables 4.4.27-32). Of 2526 experimentally discarded gadids of known fate, 192 (7.6%) sank (tables 4.4.21-26). The difference is trivial; possibly a slightly faster sinking rate of clupeids is offset by their generally smaller size and their higher energetic value, making them both easier to swallow for a wider size range of birds and also a more attractive food nutritionally. As found in previous studies, there was considerable scramble competition for discards, and frequent robbery (kleptoparasitism, or piracy) (table 4.4.34). As previously reported (*e.g.* Hudson & Furness 1988), smaller scavenging seabirds tended to be robbed by larger species, Great Blackbacked Gulls being the most successful at obtaining fish through robbery (table 4.4.35). The high risk of being robbed must be one factor that influences selection by Kittiwakes; overall the birds that took larger discards suffered the greatest rates of robbery, and so Kittiwakes would be most likely to obtain high foraging success by selecting the smallest discards and swallowing these quickly. Such opportunities may arise only at certain fishing fleets where the bycatch includes large numbers of fish less than 20cm in length.

5. SPECIES ACCOUNTS

In the following accounts, sections 4.1-4 are summarized for the commoner scavenging species. Summaries include (1) distribution and relative abundance at sea, (2) presence at the stern of research vessels, (3) numbers at trawlers, (4) prey selection and feeding efficiency, (5) aggression at the trawl and vulnerability to kleptoparasitism, and (6) feeding strategy at the trawl. Species accounts include a summary of current knowledge with respect to the status as a scavenger at trawlers, recent estimates of the North Sea breeding population and estimates of numbers at sea in winter.

Fulmar *Fulmarus glacialis*

> *"Avec 200 à 2000 individus suivant le bateau en permanence, cette espèce était de loin la plus commune. A une exception près, elle constituait toujours plus de 90% des oiseaux entourant le chalutier"*
> G. Dändliker & G. Mülhauser 1988.
> Oiseaux de mer et chalutier.

Fulmars are well known as scavengers at commercial trawlers (*e.g.* Van der Heide 1938, Lockley & Marchant 1951, Fisher 1952, Hillis 1971, Manikowski 1971, Dändliker & Mülhauser 1988, Hudson & Furness 1989, Garthe 1992). The species is abundant near trawlers in arctic and subarctic waters, around Iceland, the Faeroe Islands, and Scotland, off Norway and in the North

Sea. It is also common in the Irish Sea but scarce or absent further south and in the Baltic (Camphuysen 1993b). The North Sea breeding population is estimated at just over 300,000 pairs (Tasker *et al.* 1987, Dunnet *et al.* 1990, Tasker & Becker 1992). Many of these breeding birds stay in winter in the North Sea and if an equal number of immature birds is included, the North Sea wintering population could possibly number over 1 million individuals. Results of systematic surveys at sea indicated that about 1.35 million Fulmars are present in the North Sea in February and up to 2 million in March and April (Dunnet *et al.* 1990). Highest densities were recorded around Shetland and Orkney and off the east coast of Scotland and NE England. Very low densities were recorded in the Southern and German Bights and in the Skagerrak (Tasker *et al.* 1987). Significant correlations were found between the presence of (fishing) trawlers and high densities of Fulmars at sea during most of the year and it seemed likely that fishing activities were important as a determinant in Fulmar distribution. Hence, fishing vessels were likely to generate an important food source.

Hudson & Furness (1989) found that Fulmars obtained most of the offal discharged from whitefish trawlers around Shetland, excluding other species by their aggression, but that Fulmars usually ignored discarded whole fish. Similarly, Boswall (1960) reported that Fulmars obtained most of the offal which was experimentally discarded from a commercial trawler off NW Scotland, but also that gulls and Gannets had a distinct advantage over Fulmars when the ship moved. In the southern North Sea, where Fulmars are less abundant, their status as scavengers was much less well known. Fulmars occurred in variable numbers at trawlers through the year (Camphuysen 1987, 1993b), particularly in the offshore zone (>50km from the nearest mainland coast). Garthe (1992) found Fulmars around Helgoland in small numbers, both in summer and in winter.

During February 1993, Fulmars occurred in highest densities around Shetland, off E Scotland and in the central and southern North Sea. Very small numbers were recorded in the Skagerrak/Kattegat region (figures 4.1.2-3). The occurrence of Fulmars in the Southern Bight was much more pronounced in the 1993 survey than in previous studies (table 4.1.4). Numbers in the central North Sea (subregion C) and in the German Bight (CE) were similar to previous studies, although comparatively low densities were found in the Dogger Bank area. From strip-transect counts and numbers at commercial trawlers it was estimated that about 720,000 Fulmars occurred in the North Sea (table 4.1.4), which is considerably less than the 1.35 to 2 million birds estimated for February from earlier surveys. Only 1.6% of the Fulmars were dark phase birds (*i.e.* from high arctic origin, *cf.* Van Franeker & Wattel 1982; n= 2,259). In the northern North Sea (subregion NW, NE), Fulmars predominated at the trawl. The maximum number recorded at research vessels was 2000 Fulmars (subregion NW; table 4.2.2). Fulmars were common scavengers in most of the other subregions, except in the east (eastern half of CE and in Sk) where small numbers were attracted (figure 4.2.3). The maximum number of Fulmars recorded at a commercial stern trawler was 3,500 (subregion NW; section 4.3). In the northern North Sea, Fulmars were considerably more abundant at commercial trawlers than expected from sightings at research vessels, particularly in NW. Some two thirds (65.5%, n= 10,896) of all scavengers at stern trawlers in the northern North Sea were Fulmars (table 4.3.4). In the central and southern North Sea (subregions CW, C, CE, and S), Fulmars were more numerous at commercial trawlers than at research vessels, except in subregion CW. Just over a quarter (26.7%, n= 5,204) of all scavengers at beamtrawlers to the south of 55°N were Fulmars. Fulmars were absent at inshore shrimp trawlers in The Netherlands (subregions CE, S) and rare at 'small trawlers' in the Kattegat region (subregion Sk).

Fulmars obtained considerably more offal than their numerical abundance predicted: part or all of every experimentally discarded piece of offal was taken, mostly by Fulmars or Kittiwakes (tables 4.4.9, 4.4.10). These results confirm the general view that Fulmars are especially successful in competing for offal (Hudson & Furness 1988, 1989). By contrast, Fulmars had by far the lowest success index (<0.08 for common gadids, <0.14 for clupeids) for consumption of experimentally discarded roundfish (tables 4.4.11, 4.4.15) and consumed much less than expected on the basis of the relative abundances at the vessels during experimental discarding (tables 4.4.12, 4.4.16). Median lengths for common gadids and clupeids consumed by Fulmars in the North Sea were 23 cm (n= 52) and 15 cm (n= 14) respectively (tables 4.4.21-32). When the research vessel was towing the net, Fulmars flew around in circles, settling only occasionally on the water and usually not very near the stern of the ship. When the net came to the surface, numbers at the stern increased and birds settled near the net to obtain some escaping small fish. Most Fulmars were attracted, however, when discards were produced from a stationary vessel, usually just after lifting the net (figure 4.2.11). Fulmars would aggregate near the port where discards were released and swim into the area where discards were floating. Most fights were between Fulmars, and they would even dispute a fish when sufficient others were floating around. The species appeared quite capable of diving under water to obtain sinking scraps of offal or discards, either straight after landing or from a swimming position, but not deeper than one or two metres. Although highly aggressive, Fulmars were the second most vulnerable species to robbery from other scavengers, losing 1.5 times more fish than obtained by stealing (table 4.4.35). Many fish were stolen by other Fulmars (33.8%, n= 130), most of the rest were picked up by large gulls or Gannets (Herring Gull 19.2%, Great Black-backed Gull 26.2%, Gannet 15.4%). Fulmars managed to steal fish mainly from Kittiwakes (37.9%, n= 87) or other Fulmars (50.6%).

Gannet *Sula bassana*

> *"Vermutlich haben die Tölpel auch schon wie die Möwen gelernt, daß der Lärm der Winde auf einem stilliegenden Schiff (also when das Netz gehievt wird) Nahrung bedeutet."*
> H.H. Reinsch 1969. Der Baßtölpel.

Gannets are large seabirds which catch shoaling fish by plunge diving, often from great heights (Nelson 1978, 1980). In contrast to Fulmars, the 'natural' feeding methods of Gannets are spectacular and distract attention from the frequent presence of Gannets as scavengers at trawlers. From dietary studies of Gannets, conducted mostly during the breeding season, this species was seldom labelled as a frequent scavenger (Nelson 1966, 1978, Montevecchi *et al.* 1988, Martin 1989, Okill 1989). However, observations of Reinsch (1969) and Furness *et al.* (1992) do indicate that a substantial part of the food of Gannets may be obtained at trawlers. Gannets are highly aggressive at the trawl, screaming loudly before diving, and part of their success as scavengers is due to the ability to dive deep for fish which have already sunk (Reinsch 1969, Hudson & Furness 1989). Furness *et al.* (1992) concluded that Gannets west of Britain mainly exploit discards in spring, when they reduced the feeding success of and partially displace Herring Gulls from feeding at boats. In the southern North Sea, Gannets are most numerous as scavengers at commercial trawlers between August and April, but virtually absent in summer (Camphuysen 1993b). Apparently, scavenging is of relatively greater importance in winter, for the few individuals remaining in the southern North Sea at that time of year. Numbers at trawlers are usually not very large, compared with many of the scavenging gulls or Fulmars, but Gannets are commonly recorded as scavengers at trawlers in the entire NE Atlantic region, except in arctic waters (Camphuysen 1993b). Up to 1000 Gannets have been observed at trawlers (Manikowski 1971, Dändliker & Mülhauser 1988), but these records are apparently quite exceptional (*cf.* Boswall 1960, Hillis

1971, Watson 1981, Dare 1982, Hudson & Furness 1989, Furness *et al.* 1992, Garthe 1992, Camphuysen 1993ab). The North Sea breeding population is estimated at nearly 40,000 pairs, most of which breed on Shetland (17,000), Bass Rock (Firth of Forth; 22,000) and Bempton Cliffs (780) (Lloyd *et al.* 1991). From seabirds at sea studies it was estimated that nearly 100,000 Gannets occur in the North Sea in February (Tasker *et al.* 1987, Dunnet *et al.* 1990). Most Gannets were found to the west of 3°E and highest densities were recorded around Shetland, in the Firth of Forth and locally off NE England.

The Gannet was the fifth most numerous scavenger at the trawl of IBTS research vessels during February 1993, occurring in largest numbers around Shetland and off Bass Rock. Numbers of Gannets found in subregions NE and in C were considerably lower during the 1993 IBTS than expected from earlier surveys in February (ESASD unpubl. data, table 4.1.4). Small numbers were recorded in the southern North Sea and virtually all Gannets were observed to the west of 6°E (figures 4.1.4, 4.1.5, 4.2.4). From strip-transect counts and trawler sightings it was estimated that 70,000 Gannets were in the North Sea during these surveys, of which 97.2% were adults (tables 4.1.4-5). Considering the most recent estimate of breeding numbers in the North Sea, this is close to the entire North Sea breeding population and only slightly less than numbers estimated for February from earlier surveys at sea (Dunnet *et al.* 1990). The maximum number recorded at the trawl of research vessels was 250 Gannets (subregion NW; table 4.2.2). Gannets were relatively scarce at commercial boats compared to research vessels (table 4.3.3). Some 80 Gannets were the maximum number recorded at a commercial trawler (stern trawler, subregion NW; section 4.3). Gannets represented only 1.8% of scavengers at northern North Sea stern trawlers (n= 10,896; table 4.3.4) and 1.6% of scavengers at beam-trawlers south of 55°N (n= 5,204). Gannets occurred mainly well offshore and were not observed near inshore fishing vessels (*e.g.* shrimpers; table 4.3.4).

Gannets seldom took any offal and obtained much less than their numerical abundance predicted (tables 4.4.9, 4.4.10). By contrast, Gannets had by far the highest success index for the consumption of experimentally discarded gadids (tables 4.4.11) and consumed many more discarded gadids than expected on the basis of the relative abundances at the vessels during experimental discarding (table 4.4.13). Gannets were much less successful when feeding on clupeids (tables 4.4.15, 4.4.17). Gannets had the highest success index and consumed more clupeids than expected only in subregion NW. The median length for common gadids and clupeids consumed by Gannets in the North Sea was 28 cm (n= 512 and n= 43 respectively; tables 4.4.21-32). Numbers of Gannets at the stern increased rapidly as long as discards were being produced (figure 4.2.11), but the turnover appeared to be substantial. As a result, numbers did not increase to levels reached by most gulls and Fulmars. Interest in the vessel was soon lost if no discards were available. Very small numbers joined the ship when it was steaming at full speed, and low numbers were observed when the vessel was stationary (hydrographic observations, no discards) or towing. When discards were produced, Gannets came closer to the ship, hovered over the scavenging seabirds, screaming loudly and diving. Most discards were taken from under water, swimming with half open wings several metres deep and taking fish from below. When swimming at the surface, other birds were robbed and some discards were taken from the surface or during a shallow dive. Gannets were one of the species least vulnerable to robbery from other scavengers, stealing 3 times more fish than they lost by kleptoparasitism (table 4.4.35). Most stolen fish were lost to other Gannets (88.5%, n= 52), the rest were stolen by Great Black-backed Gulls (3x), Herring Gull (2x), and Fulmar (1x). Gannets managed to steal fish, excluding those stolen from other Gannets, mainly from Kittiwakes (21.3%), Fulmars (42.6%), Herring Gulls (21.3%), and Great Black-backed Gulls (14.9%, n= 47).

Common Gull *Larus canus*

> *"Das Pelagial ist demnach der wichtigste Nahrungsraum der bei Helgoland überwinternden Sturmmöwen. Hier erbeuten sie Fisch (überwiegend Arten, die aus dem Beifang der Fischerei stammen dürften) und schwärmende Nereidae."*
> J. Prüter 1986. Ökologie der Möwen.

Few earlier studies on scavenging seabirds included Common Gulls (*cf.* Camphuysen 1993b). Common Gulls were absent or scarce at the trawl in most areas in the NE Atlantic, but were common in the southern North Sea (Berghahn & Rösner 1992, Garthe 1992, Camphuysen 1993ab). From dietary studies of Common Gulls it was concluded that some populations of this species obtained a considerable amount of marine fish, much of which was apparently picked up at fishing vessels (Arbouw 1980, Arbouw & Swennen 1985, Keijl *et al.* 1986, Prüter 1986). However, there were virtually no data to document the use of fishery waste by Common Gulls, and for that reason, Furness (1992) did not consider this species any further in his review. Camphuysen (1993b) demonstrated that 10.6% of all scavenging gulls (n= 63,523) at commercial trawlers in the southern North Sea were Common Gulls. Most were recorded at fishing boats in winter and only in a narrow band along the (Dutch) coast. Exceptionally, over 900 Common Gulls were seen attending a trawler. The lack of Common Gulls at commercial trawlers in summer did not match conclusions drawn from diet studies in nearby coastal colonies. From earlier seabirds at sea surveys it can be estimated that some 160,000 Common Gulls occur in the North Sea in February (ESAS database unpubl. data, table 4.1.6). Tasker *et al.* (1987) found the highest numbers per km off SE England, in the Southern Bight and locally in the German Bight and Skagerrak, but these data were biased towards British waters. Within the European database, most were found in the southern and eastern North Sea and densities were particularly low in subregions NE and NW.

During February 1993, Common Gulls occurred in high densities in the Kattegat, the German Bight, off the Dutch coast and, locally, off East England (figures 4.1.6-7). In the central and northern North Sea very few Common Gulls were recorded, except off East Scotland and in Boknafjorden (SW Norway). From strip-transect counts and numbers at commercial trawlers it was estimated that at least 57,500 Common Gulls occurred in the North Sea (table 4.1.4). High numbers found in subregion NE (approx. 14,500 Common Gulls) were due to high densities found inshore in Boknafjorden. Some 85.5% of Common Gulls observed during transect counts were adults (n= 325), and so were a similar proportion (87.4%) of those associated with research vessels (n= 697; table 4.1.8). Distribution patterns derived from stern counts were very similar to those from strip-transect counts (figure 4.2.5), but the species was not found at the trawl in NE, where only offshore trawling stations were worked. By far the highest numbers at the stern were reported in the south and east (subregions S and CE) but, although in smaller numbers, Common Gulls occurred most frequently at the trawl in Sk (present at 82.5%; table 4.2.2). The maximum number recorded at the trawl of research vessels was 150 Common Gulls (subregion S). Some 500 Common Gulls were the maximum number recorded at a commercial trawler (shrimper, subregion S; section 4.3). At commercial boats this species was only found commonly in subregion S where 28.3% of all scavengers were Common Gulls (n= 6,049; table 4.3.2). There were no Common Gulls at stern trawlers in the northern North Sea, but 8.1% of all scavengers (n= 5,204) at offshore beamtrawlers to the south of 55°N and 1.7% of all scavengers (n= 758) near 'small trawlers' in subregion Sk were Common Gulls. Inshore shrimpers and a pair of trawlers near the Dutch coast attracted the largest numbers of Common Gulls. Common Gulls formed 46.3% of all scavengers (n= 3,035) in Dutch inshore waters (tables 4.3.2, 4.3.4).

The performance of Common Gulls at the trawl was generally poor by comparison with that of Kittiwakes or Herring Gulls (tables 4.4.11 and 4.4.15). Considering its relative abundance at the trawl in subregions C and CE, fewer gadids and clupeids were consumed than expected (tables 4.4.14 and 4.4.18). Common Gulls were too scarce in most subregions to assess their vulnerability to robbery by other species. In the central North Sea (C), Common Gulls lost twice so much fish through robbery than were obtained by stealing, whereas in the German Bight (CE) the species was quite successful (vulnerability to robbery index 0.3; table 4.4.35). Only a single gadid was consumed by a Common Gull (20 cm length). The median length for clupeids consumed by Common Gulls in the North Sea was 14 cm (n= 60; tables 4.4.27-32). Most Common Gulls were observed at the trawl when the net came to the surface and when the vessel was stationary just after fishing. Numbers of Common Gulls at the stern were lower at stationary vessels when discards were produced (when most other scavengers peaked in numbers) than at non-moving boats when nothing was discarded (figure 4.2.12). This could indicate that Common Gulls are simply outcompeted when larger numbers of scavengers assemble at the trawl. The feeding strategy at the trawl was quite similar to that of Kittiwakes (see below). Small fish and particles of offal were picked up very near the ship, flying close to the stern of the ship away from the main flock of scavengers which consisted of more powerful birds. Kittiwakes and Common Gulls usually operated together in a tight flock of birds, but Common Gulls were not seen to dive quite as deeply as Kittiwakes (only shallow plunge-dives, <0.5 metre).

Herring Gull *Larus argentatus*

"Herring Gulls immediately came aboard to scavenge the odd scraps of fish lying in and near the pounds, boldly swallowing whole small haddock, megrim and squid up to a foot in length."
R.M. Lockley & S. Marchant 1951.
A midsummer visit to Rockall.

Herring Gulls are common scavengers at trawlers in the Irish Sea, off West Scotland, around Shetland and in the North Sea (Camphuysen 1993b). Hillis (1971) recorded Herring Gulls as the chief scavenging species in the Irish Sea, with up to 500 individuals at a fishing vessel. Of 21,500 scavengers at the trawl of northern Irish Sea *Nephrops*-trawlers, 65.9% were Herring Gulls (Watson 1981). In the open Atlantic, off Ireland and West Scotland, small numbers of Herring Gulls were reported (Dare 1982, Dändliker & Mülhauser 1988), but Herring Gulls occurred frequently off northern Norway (Strann & Vader 1992). Hudson & Furness (1989) found that proportions of Herring Gulls and Fulmars at trawlers interchanged at various distances from the nearest coast, with Herring Gulls becoming increasingly more numerous near land. In the southern North Sea the Herring Gull is one of the more important scavengers at trawlers, particularly close to the coast (Berghahn & Rösner 1992, Garthe 1992, Camphuysen 1993b). Near Helgoland, 58% of experimentally discarded offal was taken by Herring Gulls and at least in the offshore waters of the German Bight, these gulls were extremely dependent on fishery waste (Hüppop & Garthe 1993). Over 60% of all scavenging Herring Gulls at commercial vessels off the Dutch coast were within 10km of the shore, which is significantly different from expected frequencies based on trawler distribution in five distance zones to the coast ($G= 54.7$, $p< 0.001$, $df= 4$; Camphuysen 1993b). There was some evidence that more Herring Gulls occurred offshore outside the breeding season (*cf.* Tasker *et al.* 1987, Camphuysen 1993a, *in prep.*), but few data were available to document any increase as a scavenger offshore. Tasker *et al.* (1987) estimated that peak numbers of Herring Gulls occurred in November and December in the North Sea (about 1.6 million individuals), with highest densities in the northwest and lowest numbers in the eastern North Sea. In summer some 150,000-200,000 Herring Gulls were found in the North Sea; lower numbers in relation to the breeding numbers than is the corresponding ratio for Lesser Black-backed Gulls, indicating that a substantial proportion of the (adult) Herring Gull population feeds in other habitats during the breeding season. Significant correlations between Herring Gull densities at sea and the presence of trawlers were found in February, April, November and December. Camphuysen (1993b) found that Herring Gulls were most numerous at trawlers in the southern North Sea between October and July, but were virtually absent in August and September (when breeding birds moult their primaries). In the southern North Sea, Herring Gulls were the most numerous (48.6% of all identified gulls at commercial trawlers, n= 63,523) and frequent (presence 62.3%, n= 461 trawlers) scavengers.

Herring Gulls were widespread during February 1993, occurring both offshore and inshore, but densities were generally low (figures 4.1.8-9). High numbers were recorded in the central and northern North Sea (subregions C and Sk, NW, NE; table 4.1.4), comparatively low densities were found in the Southern Bight (subregion S). From strip-transect counts and numbers at commercial trawlers it was estimated that at least 297,000 Herring Gulls occurred in the North Sea (table 4.1.4). Distribution patterns derived from stern counts were rather different. Large numbers of Herring Gulls were attracted in all subregions, particularly in NW, Sk, CE, and S (figure 4.2.6). The majority of the Herring Gulls observed at sea (71.1%, n= 1,642) and at the trawl (71.8%, n= 8,519) were adults. The highest proportions of immatures were recorded in the southern North Sea (table 4.1.8). The maximum number recorded at the trawl of research vessels was 650 Herring Gulls (subregion Sk; table 4.2.2). The maximum number of Herring Gulls recorded at a commercial trawler was 400 (unidentified trawler, subregion NE; section 4.3).

Herring Gulls took less offal than expected from the relative numerical abundance at the trawl during discard experiments in NW (table 4.4.9) and little offal was obtained during experiments in other subregions (table 4.4.10). The success index of Herring Gulls feeding on experimentally discarded gadids ranged from 1.05 in NW to 2.00 in NE (table 4.4.11). Considering the relative numerical abundance at the trawl, fewer than expected gadids were consumed in subregions NW and CW, but Herring Gulls performed rather well in the other subregions (table 4.4.14). Success indices for clupeids were slightly less than those for gadids (range 0.65 in S to 2.24 in NE; table 4.4.15) and Herring Gulls took many fewer clupeids than expected from the relative abundance at the trawl in most subregions (table 4.4.18). Success indices for adult and immature (including subadults and juveniles) Herring Gulls were rather similar. Comparisons between numbers of gadids (table 4.4.19) and clupeids (table 4.4.20) swallowed, showed that Herring Gull adults were slightly more successful than immatures. Median lengths for gadids and clupeids consumed by Herring Gulls in the North Sea were 23 cm (n= 389) and 18 cm (n= 314) respectively (tables 4.4.21-32). Herring Gulls were moderately vulnerable to robbery from other scavengers, but obtained twice as much fish as they lost through kleptoparasitism (table 4.4.35). Many fish were stolen by other Herring Gulls (39.6%) or Great Black-backed Gulls (37.6%, n= 101), the rest were stolen by Gannets (9.9%), Fulmars (5.9%) or even Kittiwakes (6.9%). Herring Gulls managed to steal fish from all other common scavengers, but, excluding those stolen from other Herring Gulls, mainly from Kittiwakes (78.5%) and Fulmars (16.8%, n= 149). Largest numbers of Herring Gulls were present when the ship was discarding fish, whether stationary or not (figure 4.2.12). Discards were mainly taken at some distance from the ship, the birds flying slowly, alighting only briefly and ignoring most fish which was below the surface.

Great Black-backed Gull *Larus marinus*

"Herring gulls and fulmars were unable to swallow a large proportion of the fish discarded, while gannets and great black-backed gulls could swallow all but the very largest discards."
A.V. Hudson & R.W. Furness 1988. Seabirds scavenging at trawlers.

Great Black-backed Gulls have been reported as scavengers at trawlers in most of the NE Atlantic region (Camphuysen 1993b). Numbers at commercial boats usually did not exceed a few hundreds of individuals (*e.g.* Boswall 1960, Hillis 1971, Watson 1981, Dare 1982, Dändliker & Mülhauser 1988, Berghahn & Rösner 1992, Garthe 1992, Camphuysen 1993a), but Hudson & Furness (1989) recorded as many as 1100 Great Black-backed Gulls at a single haul near Shetland and Manikowski (1971) recorded maxima of 1500 and 2000 in October in the northern North Sea. Great Black-backed Gulls are powerful scavengers, at the top of the dominance hierarchy at the trawl, which obtain much by kleptoparasitism from other birds (Boswall 1960, Hillis 1971, Dändliker & Mülhauser 1988, Hudson & Furness 1988, 1989, Garthe 1992, Camphuysen 1993a). Nearly 25,000 Great Black-backed Gulls are breed on North Sea coasts (Tasker *et al.* 1987, Dunnet *et al.* 1990, Tasker & Becker 1992). From seabirds at sea surveys it was estimated that peak numbers occur in the North Sea in winter, with up to 600,000 individuals during October-December and half a million birds during January-March (Tasker *et al.* 1987, Dunnet *et al.* 1990). Most Great Black-backed Gulls occurred in the western half of the North Sea with highest densities off E England. Great Black-backed Gulls were widespread in the northwestern North Sea, but occurred in low densities. Wintering numbers in the North Sea greatly exceed the numbers that breed on North Sea coasts and imply that around half a million Great Black-backed Gulls come to the North Sea in winter from other breeding areas (Furness 1992).

During the February 1993 IBTS, Great Black-backed Gulls were widespread but occurred mainly in low densities (figures 4.1.10-11). Concentrations were found in the Southern and German Bights, south of Shetland and near the Firth of Forth. Relatively high densities were recorded around Shetland (NW), in the German Bight (CE) and close to the Swedish coast (Sk; table 4.1.4). From strip-transect counts and numbers at commercial trawlers it was estimated that nearly 175,000 Great Black-backed Gulls occurred in the North Sea (table 4.1.4). Great Black-backed Gulls were found at most trawl stations, but were particularly numerous around Shetland and Orkney, in the Skagerrak/Kattegat area and in the German Bight (figure 4.2.7). A significantly higher proportion of adult Great Black-backed Gulls were recorded at the trawl (72.4%, n= 3,870) than at sea (58.0%, n= 923), except in Sk where significantly higher numbers of immatures occurred at the trawl than at sea (table 4.1.8). The maximum number recorded at a research vessel was 250 Great Black-backed Gulls (subregion Sk; table 4.2.2). Some 300 Great Black-backed Gulls was the maximum number recorded at a commercial trawler (unidentified trawler, subregion NW; section 4.3).

Great Black-backed Gulls did not feed on offal (table 4.4.9), but were rather successful with regard to experimentally discarded gadids (success indices ranged from 1.02-2.12 for gadids, 0.17-1.07 for clupeids; tables 4.4.11, 4.4.15). Median lengths for gadids and clupeids consumed by Great Black-backed Gulls in the North Sea were 28 cm (n= 316) and 20 cm (n= 74) respectively (tables 4.4.21-32). Considering numbers present at the trawl, Great Black-backed Gulls took more gadids, but considerably less clupeids than expected (tables 4.4.14, 4.4.18). The success indices for adult and immature (including subadults and juveniles) Great Black-backed Gulls were rather similar (tables 4.4.21-32). Great Black-backed Gulls were least vulnerable to robbery from other scavengers, stealing 10 times more fish than they lost by kleptoparasitism (table 4.4.35). Most stolen fish were taken by other Great Black-backed Gulls (68.9%, n= 45), the rest were stolen by Fulmar (2x), Herring Gull (5x), and Gannet (7x). Great Black-backed Gulls managed to steal fish, excluding those stolen from other Great Black-backed Gulls, mainly from Kittiwakes (47.2%), Fulmars (23.6%), and Herring Gulls (26.4%, n= 144). Only 3 fish were stolen from Gannets (2.1%). Most fed at some distance from the ship, usually joining the most severe fights for discards, flying slowly and picking up discards without settling on the water. Great Black-backed Gulls were clearly dominant in hierarchies at the trawl and the mere presence of these gulls was often sufficient to make smaller gulls drop the fish which they had just picked up.

Kittiwake *Rissa tridactyla*

> *"Während in anderen Gebieten (mit weniger starker Kutterfischerei?) Fisch nur 24-41% der Dreizehenmöwen-Nahrung ausmacht, sind die Helgoländer Dreizehenmöwen total 'umgeziegen' und leben fast ausslieẞlich vom Beifang der Kutterfischerei"*
> G. Vauk & I. Jokele 1975. Vorkommen, Herkunft und Winternahrung Helgolander Dreizhenmöwen.

Kittiwakes are well known as scavengers at trawlers in the NE Atlantic (Camphuysen 1993b). Hillis (1971) listed the Kittiwake as most numerous at trawlers in the Irish Sea after the Herring Gull (up to 200-300 at a time). Watson (1981) found that 25.6% of 21,500 recorded scavengers in the northern Irish Sea were Kittiwakes. Dare (1982) and Dändliker & Mülhauser (1988) recorded small numbers of Kittiwakes at trawlers off NW Scotland. Hudson & Furness (1989) found that around Shetland, Kittiwakes were often present at the trawl in small numbers. Manikowski (1971) reported up to 2000 Kittiwakes at commercial trawlers in the northern North Sea (October). In the southern North Sea, up to 500 Kittiwakes were recorded near commercial trawlers, and most were recorded in winter (September-March; Camphuysen 1993b). Kittiwakes were usually described as rather timid scavengers, feeding on the periphery of the main flock of scavengers at the trawl and avoiding the most heavy fights for scraps (Boswall 1960, Furness *et al.* 1988, Hudson & Furness 1989). In the Clyde (West Scotland), Kittiwakes were never seen stealing fish from other scavengers (Furness *et al.* 1988). Several recent studies showed that Kittiwakes were quite successful in feeding on offal, particularly in areas where Fulmars were scarce (Garthe 1992, Camphuysen 1993a). From experiments in the Barents Sea, Erikstad *et al.* (1988) concluded that Kittiwakes followed trawlers on average for 8-10 hours (departure rate 4.2-5.1% per hour, turnover 32 hours).

The North Sea breeding population is estimated at 415,000 pairs, most of which breed on English and Scottish coasts (Dunnet *et al.* 1990, Tasker & Becker 1992). From seabirds at sea surveys, it was found that peak numbers in the North Sea occur in February (*ca.* 2 million) and November (1.5 million) (Dunnet *et al.* 1990). High densities were found around Shetland and off E England, but Kittiwakes were widespread and occurred in substantial numbers both offshore and inshore, particularly in the western half of the North Sea. Significant correlations between seabird densities and presence of fishing trawlers were found only for December and February (Tasker *et al.* 1987) and they suggested that trawlers represent an important source of food only during (late) winter, perhaps due to a reduction in the availability of their natural prey at this time.

During February 1993, Kittiwakes were the most numerous and frequent scavengers at research vessels throughout the North Sea. The species was widespread, but occurred in highest densities around Shetland, east of the Moray Firth and Orkney, in the Firth of Forth, and in the Southern Bight (figures 4.1.12-13). From strip-transect counts and trawler sightings it was estimated that about 298,000 Kittiwakes were present in the North Sea (table 4.1.4). Adult Kittiwakes predominated at sea in most subregions (92.0%, n= 3,122), but significantly more so at the trawl (96.6%, n= 10,922). In the Skagerrak, by contrast, significantly more immature Kittiwakes were recorded at the trawl (63.1% adult, n= 407) than at sea (86.7% adult, n= 135; table 4.1.8). At research vessels, Kittiwakes predominated in the southernmost four subregions (CW, C, CE, S) and in the north Kittiwakes were the second most abundant scavengers (section 4.2). The maximum number recorded at research vessels was 452 Kittiwakes (subregion NW; table 4.2.2). Comparatively fewer

Kittiwakes occurred at commercial trawlers in most subregions, but this species was still one of the most numerous scavengers recorded. The maximum, 1000 Kittiwakes at a stern trawler in NW, was in excess of that at any of the research vessels (section 4.3).

Kittiwakes were the second most important consumers of offal after Fulmars (table 4.4.10). The importance of the Kittiwake as a consumer of offal has not been evident in studies in the NW North Sea (*e.g.* Hudson & Furness 1989, Furness 1992, Furness *et al.* 1992), where Fulmars dominate as consumers of offal. Earlier studies in other parts of the North Sea, where Fulmars are less abundant, showed that Kittiwakes were successful in competing for offal (Garthe 1992, Camphuysen 1993a). Kittiwakes swallowed more of the roundfish experimental discards than any other species (section 4.4, table 4.4.8). Kittiwakes are highly manouverable and their flight ability permits them to get to discards quickly, increasing their success rate in competition with larger seabirds (*cf.* Camphuysen 1993a). The success index of Kittiwakes for experimentally discarded gadids ranged from 0.96 in S and C to 1.84 in NE (table 4.4.11). Considering the relative numerical abundance at the trawl, slightly fewer gadids than expected were consumed in all subregions (table 4.4.14). Success indices for clupeids were slightly higher than those for gadids (range 1.42 in NW to 2.41 in NE; table 4.4.15) and Kittiwakes took many more clupeids than expected from the relative abundance at the trawl in most subregions (table 4.4.18). Success indices for adult and immature (including subadults and juveniles) Kittiwakes were rather similar. Comparisons between numbers of gadids (table 4.4.19) and clupeids (table 4.4.20) swallowed, showed that immature Kittiwakes were much more effective than adults. Kittiwakes usually selected gadids and clupeids of less than 23cm length. The median length of gadids and clupeids consumed by Kittiwakes in the North Sea were 17 cm (n= 1,061) and 15 cm (n= 1,580) respectively (tables 4.4.21-32). In this study, the median length of experimental discards was 18cm (table 4.4.2), with 75% of all discards being less than 23cm in length. By comparison, over 90% of the gadids discarded by fishermen on commercial trawlers around Shetland were much larger, too large for Kittiwakes to swallow (Hudson & Furness 1988, 1989). Discarding from research vessels with rather small-meshed nets provides especially small discards that favour Kittiwakes in a way that many North Sea fishing fleets would not (see chapter 6.4, chapter 8). Commercial trawlers recorded during February 1993, attracted fewer Kittiwakes than the research vessels (section 4.3).

The strategy followed at the trawl, was very similar to that described for Kittiwakes scavenging at RV *Tridens* in November 1992 (Camphuysen 1993a). Kittiwakes congregated near the port from which discards were released, and reacted promptly to pick up the smaller discards (< 20cm length) or offal particles. Fish which could not be swallowed immediately was often dropped. Kittiwakes were seen to dive deeper (sometimes at least 0.5 metre) than any of the other gulls to pick up discards. Herring Gulls in the southern North Sea stole many Herrings which were 'recovered' from below the surface by Kittiwakes. Kittiwakes were the most vulnerable species to robbery, losing 13.5 times more fish than they obtained by stealing (table 4.4.35). Many fish were stolen by other Kittiwakes (52.9%, n= 493), most of the rest were stolen by Fulmars (6.7%), Herring Gulls (23.7%), or Great Black-backed Gulls (13.8%). Kittiwakes managed to steal fish, excluding those stolen from other Kittiwakes, only from Fulmars (7x) and Herring Gulls (7x). Kittiwakes also dropped many fish (318) which they had just picked up. Some of these fish were apparently too large to be easily swallowed, but many of these fish were dropped in response to calling Gannets hovering or diving nearby or fights of large gulls which were not yet aiming at that particular fish. Kittiwakes usually avoided fights with other scavengers (except other Kittiwakes and Common Gulls).

OTHER SPECIES Of other scavengers at the trawl, only Black-headed Gull, Lesser Black-backed Gull, Glaucous Gull, Guillemot and

Species (weight)	Distribution: Inshore	Distribution: Offshore	Relative abundance: NW	NE	Sk	CW	C	CE	S	Behaviour: Vulnerability to robbery index	Feeding: joining fights for scraps	Feeding: surface	Feeding: < 0.5m depth	Feeding: > 0.5m depth	Prey selection: Offal	Gadids	Gadids: median length	Clupeids	Clupeids: median length
Kittiwake 300-500g	++	++	⬤	⬤	●	●	●	●	●	13.5	-	++	++	+	++	+	17	++	15
Common Gull 300-500g	++	-	○	○	•	•	•	●	●	0.6	-	++	-	--	?	-	?	+	14
Fulmar 700-900g	+	++	⬤	⬤	•	●	●	●	●	1.5	++	++	+	-	++	-	23	--	15
Herring Gull 800-1200g	++	++	●	●	●	●	●	●	●	0.5	+	++	-	--	-	++	23	+	18
Great Bb. Gull 1100-2000g	++	++	●	●	●	•	•	●	●	0.1	++	++	-	--	--	++	28	+	20
Gannet 2800-3200g	+	++	●	●	•	●	•	•	•	0.3	++	-	+	++	--	++	28	+	28
Black-h. Gull 250-350g	++	-	○	○	•	○	○	•	•	?	?	+?	?	-?	?	?		?	
auks 400-800g	+	+	•	○	•	•	•	•	•	?	(-)	-?	?	++	?	+ [1]	(16) [1]	+	(11)
Less. Bb. Gull 700-1000g	+	+	○	○	○	○	•	•	•	(0.2)	(-)	++	(-)	--	?	?		?	

⬤ ++ = very frequent
● + = frequent
• - = not usually
○ -- = not or rarely

[1] Leopold & Camphuysen (1992)

Figure 5.1 *Characteristics of scavenging seabirds in winter in the North Sea, IBTS February 1993. Shown are status as scavenger inshore and offshore and in subregions used throughout this project (cf. figure 2.1), vulnerability to robbery index (table 4.4.35), feeding behaviour and prey selection (tables 4.4.8-33). In parantheses: insufficient data. Median lengths of gadids and clupeids consumed by auks according to studies of stranded birds (see Leopold & Camphuysen 1992).*

Razorbill occurred in any numbers (table 4.2.3). However, numbers were too low to expect a significant effect on overall consumption at trawlers. Great Skuas, well known scavengers at trawlers in the northwestern North Sea in summer (Hudson & Furness 1988, 1989), leave the North Sea in winter. Few Black-headed Gulls were recorded at the trawl of research vessel (maximum number 10; table 4.2.2), but the largest number of Black-headed Gulls associated with a commercial trawler was 1000 individuals at a pair of trawlers near the coast of The Netherlands (section 4.3). In inshore waters, this species can be an important scavenger at trawlers and future studies should be designed in a way that also this species can be considered. In February, Lesser Black-backed Gulls are just returning to the North Sea from southerly wintering areas. Earlier studies have shown that Lesser Black-backed Gulls do not return at full strength in the southern North Sea until April (Camphuysen & Van Dijk 1983, Camphuysen 1993b). Numbers observed during discard experiments were too low to allow comparisons with Herring Gulls and Great Black-backed Gulls. Glaucous and Iceland Gulls occurred in very small numbers in the northern North Sea. They were not seen to pick up any of the experimentally discarded fish or offal, but behaved similar as other large gulls at the trawl. The frequent reports of Guillemots and Razorbills at the trawl are remarkable. Earlier reports of scavenging auks are scarce (*cf.* Hillis 1971, Ewins 1987, Camphuysen 1993b), but dietary studies of oiled beached auks in The Netherlands showed that wintering auks are likely to feed on discards (Leopold & Camphuysen 1992). Both species were seen to come to the ships and dive towards the net and, although they were not actually observed to take discarded fish, it is very likely that these birds were stealing fish from the net or took fish that escaped. Besides observation from research vessels engaged into the IBTS, reports from auks in February and March 1993 near other research vessels as well as near commercial trawlers were received (N.F. van der Ham, M.F. Leopold, J. Seys *pers. comm.*). Obviously, auks could easily feed on sinking discards without being noticed and their behaviour places them in a somewhat different position. The size of otoliths found in stomachs of beached auks indicates that Whiting up to 27cm length are taken (median length gadids 16cm, median length clupeids 11cm; Leopold & Camphuysen 1992).

DISCUSSION From the above data it is obvious that the six species of seabirds which were abundant in the North Sea at sea and frequently numerous at the trawl (*i.e.* Fulmar, Gannet, Common Gull, Herring Gull, Great Black-backed Gull and Kittiwake) obtained a substantial part of their food at boats. Most of these species were widespread and occurred both offshore and nearshore, but Common Gulls were restricted to the eastern and southern half of the study area. The Black-headed Gull is probably of greater importance as a scavenger than results from this study suggest, but only in inshore waters. Estimates of total numbers in the North Sea during February 1993 were low compared to previous estimates. Generally, North Sea estimates derived from British studies (see Tasker *et al.* 1987, Dunnet *et al.* 1990, Furness 1992), were much higher than results from this project, but also much higher than estimates derived from the European database (ESASD, unpubl. data). The latter two sources have probably provided more accurate estimates, because of better coverage. It should be realized that in all these studies, the coastal zone, *i.e.* the nearest 5-10 km to the shore, is relatively poorly covered. The coastal zone holds substantial numbers of seabirds, particularly *Larus*-gulls, and all estimates from ship-based surveys, but particularly those obtained during IBTS cruises, would be likely to be lower than the actual situation.

The characteristics of the commoner and of some of the scarcer scavengers in winter are summarised in figure 5.1. Some (smaller) species were clearly more vulnerable to robbery than others and distinct 'niches' were found with respect to species behaviour, diving capacities, 'preferences' and size selection. These characteristics were described using observations from research vessels. As stressed earlier in this report, these characteristics need to be studied further onboard commercial trawlers and in inshore waters.

Roundfish and offal are of greatest importance to seabirds scavenging at the trawl. All size classes which are discarded in commercial fisheries could be handled and swallowed by seabirds. Kittiwakes were the most successful species at swallowing clupeids (tables 4.4.16-18), probably because these fish sink too fast for the *Larus* group. Kittiwakes were quite capable of diving after clupeids, but also acted much faster and nearer the ship, before the fish sank. Gannets performed poorly when clupeids were discarded in quantities in the Southern Bight. There was much greater competition for discarded gadids (tables 4.4.12-14). Generally, Gannets and Great Black-backed Gulls performed best, mainly because these were the most aggressive scavengers at the trawl, never avoiding any of the fights for discards. These two species were capable of handling the largest discards. Flatfish and benthic invertebrates were not favoured, although substantial numbers were taken on occasions.

6. ESTIMATES OF THE AMOUNTS DISCARDED IN THE NORTH SEA AND THE NUMBERS OF SEABIRDS SUPPORTED

The data in this report show clearly that scavenging seabirds make extensive use of discarded offal and roundfish, and some use of discarded flatfish, cephalopods and benthic invertebrates, as a food supply. This conclusion is in agreement with previous studies based on smaller areas of the North Sea and predominantly during summer (Hudson & Furness 1989, Furness 1992, Garthe 1992). Although the quantities of fish, offal and benthic invertebrates discarded by all of the fisheries in the North Sea are not accurately known, a number of estimates of these amounts have been made, and these allow a calculation of the numbers of scavenging seabirds that may be supported by this food supply. Such an estimate has been made before (Furness *et al.* 1992) but this was based on very limited data on discarding rates, from Scottish fisheries only, extrapolated to the North Sea as a whole (and other sea areas around the British Isles). Recently, rather more data on discarding have been published, and it is now possible to build a more complete picture of discard availability to seabirds in the North Sea, though fragments remain missing and so some extrapolation is still required. This section presents a review of data on discard rates in North Sea fisheries, species composition of discards and size distributions within species. It then considers the numbers of seabirds that could by sustained by such a food supply.

METHODS We have access only to published data on discarding rates and to unpublished data obtained by seabird ecologists working on commercial fishing vessels or research ships. Unpublished discard data held by fisheries research institutes are generally confidential. In practice, these last data sets appear to be limited, but their implications have been summarised in reviews by Daan *et al.* (1990) and Gislason (1993). Our main sources of discard data are listed below.

Estimates of discarding of Haddock and Whiting in the North Sea, from Scottish Office Agriculture and Fisheries Department (SOAFD) studies extrapolated for all North Sea national demersal seine and gadid-directed trawl fisheries combined, are available from a number of sources (data tabulated in Furness 1992 - Appendix 1-12, in Gislason 1993 - table 4.5.2 (taken from Anon. 1992 b), in Jermyn & Robb (1981), and Daan *et al.* (1990)). Independent estimates of discarding rates, species compositions and fish sizes from Shetland light trawlers and demersal seiners fishing for Haddock and Whiting were reported by Hudson (1986), Hudson & Furness (1988) and Furness (1987). Discard rates from the beamtrawl fishery in the south-eastern North Sea are reported by Van Beek (1990), Damm & Weber (1990), Anon. (1992a), and Garthe (1992). Discarding from the south-eastern

North Sea shrimp fishery is reported by Tiews (1978), Berghahn (1990), Tiews & Wienbeck (1990) and Berghahn *et al.* (1992). These studies provide a basis for estimating the total quantities discarded by the major North Sea fisheries. Rather little information is available on discarding rates from industrial fisheries, though these appear generally to provide very little food for seabirds (Furness *et al.* 1988, 1992), though on rare occasions vessels catching excessive quantities in a haul may discard fish. Fisheries for *Nephrops norvegicus* produce large quantities of small fish and benthic invertebrate discards, but discarding rates have been reported only from the Clyde Sea area, west Scotland (Furness *et al.* 1988, 1992). Extrapolation of these data to the North Sea *Nephrops* fishery is probably an acceptable procedure in the context of this study since the North Sea fishery for *Nephrops* is small compared to the fisheries for gadids or flatfish. The additional contribution of discards from the *Nephrops* fishery is therefore minor, for example representing rather less than the normal variation in discard masses from the gadid fishery from one year to the next.

Studies of the utilization of offal or discards from fishing vessels in the North Sea, prior to the work forming this project, include Manikowski (1971), Ewins (1987), Furness (1987, 1988, 1992), Hudson (1986, 1989), Hudson & Furness (1988, 1989), Furness *et al.* (1988, 1992), Camphuysen (1987, 1993ab), Tasker *et al.* (1987), Berghahn & Rösner (1992), and Garthe (1992). These, together with results of the present project (see section 4.4), provide estimates of the proportions of discards of each type consumed by scavenging seabirds.

Two independent methods, bioenergetics modelling and the use of labelled water, can be used to provide estimates of the daily food requirements of seabirds. These two methods provide results in good agreement. Average daily food requirements in terms of kilojoules of energy having been measured for a wide range of seabirds under a variety of conditions, and include the scavenging seabirds Gannet, Kittiwake and Herring Gull (Birt-Friesen *et al.* 1989). Recently the energy expenditures of Gannets and Fulmars in the North Sea have been measured using labelled water (Furness & Bryant, unpublished report to NERC). As a result of such studies it is possible to estimate the daily food requirements of scavenging seabirds with considerably more accuracy than we can estimate the quantities of discards. Thus in estimating the numbers of seabirds that could be supported by discards in the North Sea, the estimate of total discards is the major source of error.

Discarding rates and species composition

Daan *et al.* (1990) estimated on the basis of unpublished SOAFD data that the Haddock and Whiting fisheries in the North Sea produced Haddock and Whiting discard totals of around 270,000 tonnes per year in 1969-76 and 115,000 tonnes in the 1980s. A more detailed (annual) breakdown of these figures is given in Gislason (1993) and Anon. (1992b), which show rather erratic figures from year to year (in part due to fluctuations in recruitment) and a general trend for a decrease in discards of both Haddock and Whiting (table 6.1), largely reflecting recent declines in stock sizes. Estimated masses of Haddock and Whiting discards varied from a peak in 1975 of 395,000 tonnes to lows in 1982 of 67,000 tonnes and in 1989 of 61,000 tonnes. A study of discarding from Shetland light trawl and seine vessels provided more detailed data on discarding rates in this local area in summer than obtained by SOAFD studies (which sampled only 1 vessel of each type in each region of the North Sea in each quarter of the year). The study (Hudson 1986) found that between 7% and 82% of the catch of fish was discarded, averaging 27% over 23 fishing trips in 1985. It was also estimated from this study that 74-78% of the discarded fish were eaten by scavenging seabirds. Furness *et al.* (1988, 1992) used discard data of Jermyn & Robb (1981), Hudson (1986), Hudson & Furness (1988) and Furness (1987) to estimate that the North Sea human-consumption fisheries for gadids and *Nephrops* in 1982 produced 44,000 tonnes of fish discards in ICES area

IVa, 38,800 tonnes in IVb and 5,310 tonnes in IVc, a total for the North Sea of 88,110 tonnes. The discards from Shetland trawl and seine vessels were predominantly of Haddock and Whiting, with smaller amounts of Long Rough Dab and gurnards (table 6.2). The total is comparable with the estimate of Gislason (1993) of 67,000 tonnes of Haddock plus Whiting in the North Sea as a whole, since the discards from the *Nephrops* fisheries add only slightly to the totals from the main Haddock and Whiting fisheries.

Gislason (1993) estimated discard rates for major fisheries in each part of the North Sea in 1987-89. His working group estimated that western and northwestern North Sea trawlers discarded 52% by mass of all fish caught, 45% being discards of commercial species and 7% being discards of noncommercial species; western and northwestern North Sea seiners discarded 55% by mass of all fish caught, 49% being discards of commercial species and 6% being discards of non-commercial species; eastern North Sea trawl and seine vessels discarded 27% by mass of all fish caught, 12% being discards of commercial species and 15% being discards of non-commercial species; and southern North Sea beamtrawl vessels discarded 56% by mass of all fish caught, 18% being discards of commercial species and 38% being discards of non-commercial species. In addition, the eastern North Sea trawl and seine vessels discarded a mass of benthos and debris equal to 9% of the total mass of fish caught, while southern North Sea beamtrawlers discarded a mass of benthos and debris equal to 58% of the total mass of fish caught. Discarding of benthos and sediment by western and northwestern North Sea trawl and seine vessels was considered to be negligible.

The discarding rate from the southeastern North Sea Sole fishery during 1989-91 has been estimated at around 5 times the mass of Sole landed (Anon. 1992a, Garthe 1992) and so can be estimated from data on Sole landings (Grainger 1992, Will 1992). These calculations provide the results summarised in table 6.3. The estimated total discard of 67,000 (1988) and 174,000 (1990) tonnes for the North Sea Sole fishery alone, predominantly from the southeastern North Sea, indicates that the discard mass from this fishery is of the same order of magnitude as that from the Haddock and Whiting fishery, which is predominantly from the northwestern North Sea. The discards in Sole fishery consist mainly of flatfish (≥85%): 148,000 tonnes of flatfish and 26,000 tonnes of roundfish were discarded in 1990 in ICES sub-area IV only by beamtrawl fisheries.

Van Beek (1990) examined discarding from the southeastern North Sea beamtrawl fishery and reported discarding rates in terms of debris (benthic invertebrates, especially *Asterias rubens*, *Echinocardium cordatum*, *Corystes cassivelaunus* and *Eupagurus bernhardus*, rubbish and sediment), landings fraction and discard fraction. He reported that in 1989 and 1990 the debris fraction represented between 37% and 75% of the catch, landings fraction represented from 5% to 43%, and the discard fraction represented from 13% to 37%. However, discarding varied enormously among species, being 99% of all Dab caught, 46% of Plaice, 22% of Sole, 96% of Whiting, 66% of Cod, 81% of Flounder, virtually 0% of Turbot, Brill and Lemon Sole, 100% of Mackerel, Scad and Herring, nearly 0% of Tub Gurnard but nearly 100% of Grey Gurnard, and 100% of Dragonet, Scaldfish, Solenette, Hooknose, Lesser Weever, Bib, Poor Cod, and Sandeel species. In terms of mass, discards were dominated by Dab (61%), Plaice (24%), Whiting (7%), while Dab represented 76% of the discards by numbers. Verboom (1991), using beamtrawl gear north of the Waddensea islands in August, estimated a landed fraction of 15.7-27.4% and a discarded fish fraction of 32.9-38.1% of the catch (benthic invertebrates 34.5-51.4%; debris fraction ignored). Based on observations by Van Beek and Verboom, some 2.3-21.3kg of fish is discarded on each kg landed (mean 7.2kg). Data from 1978-82 compared to the 1989-90 sampling suggested an overall increase in the discarding rate (as numbers of fish discarded per 100 fishing hours), discarding rates in 1989-90 being approximately twice those in 1978-82. Thus these data suggest that discarding in the southeastern North Sea (predominantly of Dab and Plaice) has increased over the last 15 years, whereas discarding in the northwestern North Sea (predominantly of Haddock and Whiting) has decreased.

Species composition of discards varies from year to year but the major species in the discards tend to remain the same (Van Beek 1990, Furness 1987, table 6.4). For the purposes of calculating numbers of seabirds that could be supported by offal and discards in the North Sea we use the following figures, derived from consideration of the above data, for discard quantities in the North Sea as a whole (ICES IVabc), during the period 1985-92:

Haddock and Whiting	110,000 tonnes
Other roundfish	36,000 tonnes
Flatfish	148,000 tonnes
Benthic invertebrates	100,000 tonnes

SIZE DISTRIBUTIONS OF FISH DISCARDS Since the ability of scavenging seabirds to swallow discards is affected by the species of fish and the size of the fish, it is essential to consider the size distributions of discards from the different North Sea fisheries. Sizes of fish discarded from light trawl and seine vessels at Shetland in summer 1985 (table 6.2) show that most discards were between 20 cm and 35 cm in length, median discard lengths being 28 cm for Haddock and 29 cm for Whiting, these species representing over 70% of all discards (Hudson & Furness 1988). Only 28 fish (0.4% of the total sampled) were 40 cm or longer. Gannets have been recorded swallowing fish up to 55cm in length (this study), though it is likely to be the girth of the fish that is most critical; this record length of fish consumed was a Ling and so would pose less of a problem than a similar length Cod or Saithe. Nevertheless, Gannets and Great Black-backed Gulls can swallow 40 cm Haddock and Whiting and so virtually all of the discards would be of a suitable size for these species to take.

Changes in fisheries regulations may have profound effects on discarding. One would anticipate that an increase in minimum net--mesh size would result in less discarding and a tendency for smaller fish species to become less frequent in the discards and for median lengths of discards of all species to be increased. Studies of discards before and after small increments in net mesh size do not necessarily show the predicted outcome. For example, net mesh size in the Haddock and Whiting fishery in the North Sea was increased from 80 to 85 mm in January 1987, but analysis of discards in summer 1985 and summer 1987 showed no significant increases in discard sizes after the increase in net mesh size (tables 6.5-14). Indeed, the median lengths of the most abundant species of discards all fell between 1985 and 1987. The lack of an increase in discard sizes seems to have been due to measures taken by the fishermen to alter the cod-end extension and diameter to counter the imposed change in net mesh size, an effect demonstrated by research into net selectivity (Reeves *et al.* 1992).

One clear feature of the discards from the Haddock and Whiting fishery is that very few are of roundfish less than 20cm in length. From the data of Hudson (1986), only 24 of 5448 (0.4%) Haddock and Whiting discards were less than 20 cm in length. This would appear to explain why no Kittiwakes took discards at Shetland in summer (Hudson & Furness 1988, 1989) since the present study found that Kittiwakes predominantly swallowed gadids of less than 20 cm and were frequently robbed by larger seabirds when attempting to take larger fish.

Length composition of Haddock and Whiting discards is also presented from a separate (SOAFD) data set, for the North Sea in the late 1980s (table 6.15). The size distributions produced by that data set are generally in agreement with those from the Shetland studies of Hudson (1986) and Furness (1987), but show slightly larger numbers of small (<20cm) Haddock and Whiting than in the local Shetland area. In addition the SOAFD data show seasonal changes in discard sizes, with more smaller discard Haddock in October-December and Whiting in January-March, when the younger fish recruit into the fishery.

Van Beek (1990) gives detailed tabulations of the sizes of fish landed by and discarded by the southeastern North Sea beamtrawl fishery and less detailed data sets are reported by Anon. (1992a) and Garthe (1992). Dab discards were predominantly in the size range 12-24 cm, Plaice discards predominantly in the range 16-27 cm, Sole discards predominantly in the range 17-26 cm and Whiting discards predominantly in the range 15-30 cm. The sizes of Whiting and flatfish discarded from the beamtrawl fishery are thus rather similar to those discarded in the Haddock and Whiting fishery further north in the North Sea.

QUANTITIES OF OFFAL DISCARDED Offal (fish intestines and livers) represents about 10-15% of the total body mass of gadid fish and 6-7% of the mass of flatfish (Boswall 1960, Bailey & Hislop 1978, Furness *et al.* 1988). The mass of offal that might be available to seabirds in the North Sea can be estimated from the above figures for offal mass as a proportion of fish mass and the landings data for ICES areas. This calculation would assume that all demersal fish for human consumption were gutted at sea and that all offal so produced was discharged at sea. Neither of these assumptions is correct. Because they could find no data on the proportion of demersal fish landed gutted and landed intact, and no data on the proportion of offal discharged at sea and the proportion retained for incorporation into fishmeal or other uses (Furness *et al.* 1988), we have estimated the maximum quantities of offal that might be made available to seabirds if all demersal fish were gutted at sea and all offal discharged at sea. These figures could be adjusted at a later stage if the relevant data became available.

Using 1982 fisheries landings data, Furness *et al.* (1988) estimated that the amounts of offal that could be made available to seabirds in that year were 40,000 tonnes in ICES IVa, 34,000 tonnes in ICES IVb and 9700 tonnes in ICES IVc; total for the North Sea 83,700 tonnes. Since catches of demersal fish in the North Sea have decreased slightly since 1982 the figures for more recent years will be slightly less than these.

CONSUMPTION RATES BY SEABIRDS This study found that scavenging seabirds consumed 100% of discarded offal, 92.4% of discarded roundfish, 35.5% of discarded flatfish and 16.7% of discarded benthic invertebrates and cephalopods (see section 4.4). However, a number of reservations have been expressed regarding the extrapolation of these data to commercial fishing vessels. In particular, sizes of fish discarded in this study were much smaller than typical discards from fishing vessels. If for our research vessel data set only the experimental discards of the sizes found at commercial vessels are considered, consumption rates by scavenging seabirds are altered to 91% of discarded roundfish and 30% of discarded flatfish. Furthermore, although experimental discarding from the research vessels was done during discarding of other waste fish whenever possible, the amounts discarded from the research vessels were generally much less than from commercial fishing boats, and in the case of Scotia and Dana were very much less because most waste fish was macerated before discharge. Three effects seem likely. Firstly, scavenging seabird feeding was clearly of a lower intensity than at commercial fishing boats, suggesting less competition for the experimental discards. Secondly, birds 'offered' an experimental discard may have had less choice than at commercial fishing vessels where several fish are often discarded at once. Thirdly, when commercial fishing vessels discharge large batches of discards at once, flatfish may sink while scavenging seabirds are occupied consuming the gadids at the surface. The extent to which these effects may alter discard consumption rates is not known, but it seems likely that consumption of flatfish is often less than 30%, while consumption of gadids may be <90% when discarding occurs as batches of fish (typical of large trawlers) rather than as a steady trickle (as from smaller fishing vessels, especially those without shelter decks).

Hudson & Furness (1988) reported that less than 10% of experimental discards from commercial fishing vessels in Shetland in summer 1985 were known to have sunk, while at least 60% of Haddock, Whiting, Grey Gurnard, Cod, Norway Pout, Lesser Argentine and Scad discards were known to have been swallowed by scavenging seabirds. Less than 4% of flatfish were known to have been swallowed. The fate of about 30% of the experimental discards could not be determined because of the difficulties of making observations from working fishing boats attended by large flocks of seabirds. Thus their data also suggest that about 80-90% of the main roundfish discarded (Haddock and Whiting) were consumed by scavenging seabirds but only a very few percent of discarded flatfish, perhaps 5-10%, were consumed. Hudson & Furness (1989) reported from the same study that virtually 100% of the offal discharged was consumed by seabirds, predominantly Fulmars.

Using much the same approach as Hudson & Furness (1988), Garthe (1992) found that seabirds took 83% of offal, 51-79% of discarded fish and 11-56% of discarded benthic invertebrates in the southeastern North Sea. Consumption rates were especially high in November 1991 after a period of bad weather. A different approach to the quantification of discard utilization by scavenging seabirds was developed by Berghahn & Rösner (1992). They deployed a net behind a vessel from which fish were discarded and recorded the number of discards recaptured in the net (being those not consumed by scavenging seabirds). This technique, used on a shrimp vessel in the German Wadden Sea, found that scavenging seabirds consumed about 70-90% of discarded Smelt and 73-82% of discarded Whiting.

For the purposes of calculations below we have taken the following figures for consumption of discards:

10% of benthic invertebrates,
20% of flatfish,
80% of roundfish,
90% of offal.

ESTIMATED NUMBERS OF SCAVENGING SEABIRDS SUPPORTED Bioenergetics modelling and labelled water studies suggest that the daily energy requirement of seabirds is around three times Basal Metabolic Rate (BMR), and this figure is sufficiently precise for a crude calculation of the sort being done here. For the sake of simplicity we will consider a hypothetical 1000g scavenging seabird (typical body masses of scavenging seabirds in the North Sea are Kittiwake 300-500g, Fulmar 600-1000g, Herring Gull 900-1100g, Great Black-backed Gull 1.5-1.9kg, Gannet 2.5-3.6kg). The BMR of a 1000g seabird at the latitude of the North Sea can be estimated at 480 kJ/day (Ellis 1984). With an assimilation efficiency of around 80%, this means that the daily energy intake must be around 3 times 600 kJ/day, or 657,000 kJ/year.

The calorific value of fish offal is around 7-13 kJ/g, while that of discard gadids is *ca.* 4-5 kJ/g but somewhat higher for more lipid-rich roundfish (Harris & Hislop 1978, Hudson 1986). For calculation purposes we use figures of 10 kJ/g for offal, 5 kJ/g for roundfish, 4 kJ/g for flatfish, and we guess that the calorific value of benthic invertebrates will average around 2.5 kJ/g.

The remaining data required for these calculations have been outlined in previous sections as follows: discard quantities in the North Sea as a whole (ICES IVabc), during 1985-92: offal 83,700 tonnes, roundfish 146,000 t, flatfish 148,000 t, benthic invertebrates 100,000 t; Consumption by seabirds: 90% of offal, 80% of roundfish, 20% of flatfish, 10% of benthic invertebrates. These data give the following estimates:

83,700 tonnes of offal could support 1.1 million 1000g scavenging seabirds in the North Sea,

146,000 tonnes of roundfish discards could support 880,000 1000g scavenging seabirds in the North Sea,

148,000 tonnes of discarded flatfish could support 180,000 1000g scavenging seabirds in the North Sea, and

100,000 tonnes of discarded benthic invertebrates could support 38,000 1000g scavenging seabirds in the North Sea (table 6.16).

DISCUSSION The conclusion from the calculations in this section is that around 2 million 1000g scavenging seabirds may be supported by the offal and discards made available from North Sea fishing vessels in recent years. Because of its high calorific value and high consumption rate, offal represents the most important portion of this waste, but is monopolised by only a few scavenging species, especially Fulmars and Kittiwakes. Discarded roundfish are consumed more than flatfish or benthic invertebrates, and may support rather more scavenging seabirds. However, data on the utilization of flatfish and benthos are in short supply and further work, especially from beamtrawlers and shrimpers in the southeastern North Sea and from *Nephrops* trawlers anywhere in the North Sea would be valuable in clarifying the extent to which flatfish and benthic invertebrates are consumed at commercial vessels.

7. DISCUSSION

SCAVENGING SEABIRDS AT THE TRAWL All seabirds which were commonly found at the trawl during this project were known as scavengers in the North Sea from previous studies (*e.g.* Hudson & Furness 1989, Garthe 1992, Camphuysen 1993b) and all these species were known to be numerous, or even abundant in the North Sea in winter (*e.g.* Tasker *et al.* 1987). However, the use of discards in winter has not been previously thoroughly investigated. This project demonstrated that Fulmars, Gannets, Common Gulls, Herring Gulls, Great Black-backed Gulls and Kittiwakes, either opportunistically or systematically, feed on a large scale at trawlers in winter. The Herring Gull, restricted at trawlers to the coastal zone during the breeding season (Hudson & Furness 1989, Camphuysen 1993b), was found to assemble at trawlers throughout the North Sea in winter. The importance of commercial fisheries for Kittiwakes has not been evident from many previous studies. The species appeared widespread, abundant both offshore and inshore, and was the second most important consumer of offal. Gannets were frequently encountered at fishing vessels in the western half of the North Sea and fed extensively on waste. Fulmars, appeared less successful at the trawl then found in most previous studies, and were more numerous in the southern North Sea than in previous years, particularly in the Southern Bight.

SEABIRD DISTRIBUTION Distribution patterns of most species were similar to those described from earlier surveys (Tasker *et al.* 1987, ESASD, unpubl. data). Relatively minor differences include Fulmars being more numerous in the Southern Bight in 1993 and scarcer in the Skagerrak, and Common Gulls being less widespread in the Skagerrak and Kattegat. Densities found during this project were generally rather low. High densities of all species found in previous studies off East England (53-56°N, 1-2°W) were missed, probably because this important area was poorly covered during the February 1993 IBTS (figure 4.4.1-3).

ABUNDANCE ESTIMATES OF SEABIRDS IN THE NORTH SEA Abundance estimates derived from this project were generally lower than previous estimates. Comparing total numbers derived from the February 1993 IBTS and the European database (ESASD, unpubl. data), showed that around 1.8 times more birds were estimated from the latter source:

	IBTS 1993	*ESASD*
Fulmar	720,000	1,200,000
Gannet	70,000	105,000
Common Gull	57,500	170,000
Herring Gull	297,000	495,000
Great Bl.-b. Gull	175,000	190,000
Kittiwake	398,000	690,000
Totals	1,620,000	2,870,000

The main reasons for these differences are probably (1) important bird areas off E England and off NW Shetland were not surveyed, and (2) the coastal zone (generally within 10 km from land) was poorly covered. Hence, the present estimate of 1.62 million scavengers in the North Sea is probably too low.

SEABIRDS AND COMMERCIAL FISHERIES IN WINTER IN THE NORTH SEA The maximum recorded numbers of Fulmar, Black-headed Gull, Common Gull, Great Black-backed Gull, and Kittiwake with commercial trawlers were higher than at research vessels. There was considerable variation in mean numbers of birds, both at trawlers and at research vessels. Species composition at trawlers and research vessels differed significantly in all subregions and the counts of birds associated with research vessels were not necessarily proportional to the numbers associated with commercial fishing vessels in the same area. Counts at research vessels in most subregions were biased towards gulls, while Fulmars in subregion NW were proportionally more numerous near commercial trawlers. Discarded small fish (<20 cm length) attracted small scavengers like Kittiwakes, and this could explain the 'disproportionally' large numbers of these birds at research vessels. Offal production on board commercial trawlers was an important factor attracting Fulmars and Kittiwakes, and therefore, numbers at commercial trawlers of these two species could be relatively high compared with research vessels. Although the distribution of scavengers was clearly different from that of the plankton feeding example of a 'non-fishery-influenced' species (the Little Auk), distribution patterns of scavengers could not be totally explained by the presence or absence of commercial trawlers. Fulmars did not occur in shallow coastal waters in the southern North Sea where commercial trawlers obviously produced offal. Common Gulls, coastal birds which mainly occur in the SE North Sea, did not associate in numbers with offshore beamtrawlers. Gannets occurred predominantly in the western half of the North Sea, despite extensive fisheries elsewhere.

On average, scavengers spend over a quarter of their daytime at trawlers (section 4.3). Obviously, not all this time is necessarily spent actually feeding, but this illustrates the relative importance of trawlers for these species as a source of food. However, flocks of seabirds around trawlers are a very 'visible' form of foraging behaviour and in the absence of less easily gathered data on natural feeding, the importance of scavenging cannot be estimated from these sightings alone. Coastal waters and their fisheries were inadequately surveyed in this study and there are indications that species composition at coastal trawlers (and Waddensea fisheries) is quite different. Black-headed Gulls are probably more important as scavengers at trawlers than results in this study indicate. Future studies should therefore include coastal waters.

CONSUMPTION OF DISCARDS BY SEABIRDS IN WINTER In the North Sea, the proportion of adult among gulls at the stern was generally higher than recorded in transect counts. The stronger predominance of adults at the stern compared to numbers at sea, suggests that immatures are generally often outcompeted than adults in the scramble for discards and offal behind boats. However, differences between feeding success indices of adult and immature *Larus*-gulls during experimental discarding were generally rather small. Young Kittiwakes had a much higher success index at the trawl than adults. Only in Sk, where no experimental discarding was performed, immature Kittiwakes were more numerous at the stern than at sea.

Obviously, there is a general tendency for scavenging seabirds to assemble around stationary vessels (*cf.* Reinsch 1969, Watson 1981, Griffiths 1982, this study). However, the relative abundance of each of the scavengers differed between fishing activities, with some being most abundant when the ship discarded fish while stationary and others predominating when the ship moved during discarding. Assuming that feeding success at the stern is reflected in relative abundance during each of the phases of fishing, the timing of discarding, in particular whether the vessel is moving or stationary, is an aspect that would deserve more attention in future studies. Methods of discarding in commercial fisheries as well as quantities and composition of discards should also be studied in the near future. Future experimental discarding should be performed from both moving and stationary vessels.

For six of the seven most abundant fish species discarded during the survey, significant differences were found between the length choices of Fulmar, Gannet, Herring Gull, Great Black-backed Gull and Kittiwake were found. This sequence matches the rank order by body size. Each scavenging seabird appeared to have a somewhat distinct niche. Fulmars were feeding successfully on offal but obtained few (whole) fish discards. Kittiwakes took offal and the smallest whole fish discards, Gannets took the largest whole fish discards but not offal or small (<15cm) fish to any great extent, Great Black-backed Gulls took large discards, rather similar in size to those taken by Gannets. Herring Gulls fed in a rather generalised way on offal on some occasions, on small to medium sized whole fish discards (spanning rather a wide range of fish lengths). Kittiwakes were clearly separated by the other species, taking only relatively small fish.

One mechanism causing fish-size selection is due to scavenging seabirds being unable to swallow fish above a certain size. However, it is evident from our results that there was considerable competition for discards and attempting to swallow fish close to the maximum size limit takes considerable time and leaves the individual vulnerable to attack and piracy. In general, larger scavenging seabirds stole more than smaller species. Kittiwakes were especially vulnerable to being robbed and Great Black-backed Gulls were the most consistently successful robbers.

Two mechanisms might determine fish size-selection. First, larger scavenging seabirds may avoid smaller fish. Alternatively, Kittiwakes may be so quick in reaching and swallowing small fish (*e.g.* 5-10cm long clupeids or 10-15cm long gadids) that slower species like Gannets may be unable to reach them first (*cf.* Camphuysen 1993a). These alternate hypotheses could be tested by analysis of fish consumption by Gannets in the presence and in the absence of Kittiwakes, but suitable data were not available in our study. Kittiwakes swallowed more of the roundfish experimental discards than did any other scavenging seabird species. This is in marked contrast to the findings of Hudson & Furness (1988) in Shetland in summer. If future work validates the research vessel results and confirms that Kittiwakes are a major consumer of discards and offal from fishing vessels in the North Sea, perhaps especially in southern subregions and in winter, some reappraisal of the implications for seabirds of changes in discarding practices will be required. The opportunity for Kittiwakes to consume small discards and swallow these quickly may occur only at certain fishing fleets where the bycatch includes large numbers of fish less than 20cm in length.

Discarded roundfish are more frequently consumed than flatfish or benthic invertebrates, and may support rather more scavenging seabirds. However, data on the utilization of flatfish and benthos are in short supply and further work, especially from beamtrawlers and shrimpers in the southeastern North Sea and from *Nephrops* trawlers anywhere in the North Sea, would be valuable in clarifying to which extent flatfish and benthic invertebrates are consumed at commercial boats.

NUMBERS OF SEABIRDS POTENTIALLY SUPPORTED BY DISCARDS AND OFFAL In view of the many uncertainties and the lack of detailed quantitative data on discarding practices from North Sea fisheries, the conclusion that around 2 million seabirds may be supported by the offal and discards made available from North Sea fishing vessels must be treated as tentative. It is unlikely though, that the numbers of scavenging seabirds supported are of a different order of magnitude. A total of 2 million dependent on waste from fishing boats would indicate discards and offal are a very important source of food for scavenging seabirds. The total of 1.62 million scavenging seabirds in the North Sea in February 1993 is considered a too low estimate. Previous estimates are higher: 2.9 million (ESASD, unpubl. data), or perhaps over 5 million scavenging seabirds present in the North Sea in February (Dunnet *et al.* 1990, Furness 1992). Assuming that at least 3 million scavenging seabirds occur in the North Sea in February, these birds must often feed on natural foods in the North Sea.

THE EFFECT OF MEASURES TO REDUCE THE AMOUNTS OF DISCARDS IN COMMERCIAL FISHERIES The supply of offal and discards to seabirds in the North Sea over previous decades has almost certainly affected the species composition of the North Sea seabird community, by increasing the abundance of scavenging seabirds. Thus, the North Sea seabird community is not that of a 'pristine' ecosystem. Considering the extensive competition for discards at the trawl and the vast numbers of scavengers which have been observed in this and previous studies, it must be concluded that a significant decline in rates of discarding in commercial fisheries would have a pronounced effect on these birds. In summer, reductions in this food source might lead to decreases in reproductive output (Paterson *et al.* 1992, Camphuysen *in prep.*). For wintering seabirds, this would probably lead to a lower survival and reduced recruitment into the breeding stock.

Furness (1992) indicated that there is some evidence to support the idea that scavenging seabird numbers are limited by offal and discard availability. Offal and discard quantities rose to a peak in the 1970s and declined in the 1980s. Further declines would inevitably lead to increased competition and would considerably reduce the amount of fishery waste available to seabirds. Reductions in discarding and discharge of offal may help to return the balance of the North Sea seabird community towards that of a more natural ecosystem, unaffected by these fishery practices. However, a gradual reduction in the amounts of discarding would probably be more succesful in reversing the situation than would be an abrupt ending of the practice. Sudden removal of this food supply might lead to starving scavenging seabirds, of which the larger species may turn to other feeding methods that could be damaging to smaller seabird seabirds. An increase in net mesh size would mainly affect species which exploit the smaller discards (in winter mainly Kittiwakes and Common Gulls). Reduced fishing effort would probably affect all species, but the more powerful and aggressive species would probably obtain a greater part at the trawl than more timid, smaller scavengers. Reductions in the amount of offal made available to seabirds would mainly affect Fulmars and Kittiwakes. Reductions in the survival of wintering seabirds would not only affect seabirds breeding in the North Sea, but also birds originating from more northerly and more easterly breeding areas.

STANDARDIZATION OF METHODS Standardization of methods was one of the aims of this project. During the evaluation of the results on the workshop on Texel in April 1993, it was found that due to mis-interpretations, minor differences in methods had occurred. Future studies in the North Sea should follow the recommendations following from this project, in order to achieve comparable results. For any follow-up of this sort of work, the preparation of manuals which should be strictly followed are recommended.

RECOMMENDATIONS FOR FURTHER STUDIES Future experimental discarding should be performed separately from moving and stationary vessels.

In any future study it would be preferable to define consumed as swallowed, since pecking by fulmars or kittiwakes probably removes only part of the fish mass.

Research to ascertain the extent of differences between research vessels and commercial fishing vessels should be a high priority in future studies.

Methods of discarding in commercial fisheries should be studied in more detail. Questions might include: Are discards released in large quantities at a time or as a constant stream? How does offal become available? and What proportion of vessels macerate discards?

Further North Sea wide studies of scavenging seabirds prior to, during and after the breeding season, following the same methods as developed for this project and described in this report are recommended. The IBTS programme offers an excellent opportunity to do so in early summer (May), late summer (Aug/Sep), and autumn (Oct).

8. CONCLUSIONS

Fulmar, Gannet, Common Gull, Herring Gull, Great Black-backed Gull and Kittiwake are the commonest scavengers at trawlers in the North Sea in winter. Minimum estimates for numbers of scavengers present in the North Sea in February 1993 were 720,000 Fulmars, 70,000 Gannets, 57,500 Common Gulls, 297,000 Herring Gulls, 175,000 Great Black-backed Gulls and 298,000 Kittiwakes. Most scavengers were widely distributed and occured offshore and inshore in substantial numbers. Common Gulls were mainly restricted to the coastal zone in the southeastern North Sea and in the Skagerrak.

The main fisheries in the North Sea in winter were beamtrawlers in the southern North Sea, stern trawlers and seiners in the northern North Sea, shrimpers in coastal waters in the southeastern North Sea and small fishing boats in the Skagerrak.

Seabirds utilize mainly offal and roundfish at the trawl and are capable of swallowing all size classes which are usually discarded in commercial fisheries. Smaller amounts of flatfish and benthic invertebrates are consumed. In contrast to other species, Kittiwakes took only relatively small fish. 90% of offal was consumed by seabirds. For roundfish, flatfish and benthic invertebrates, consumption rates were 80%, 20% and 10% respectively.

Discard quantities in the North Sea as a whole (ICES IVabc), during the period 1985-92, were estimated at: 83,700 tonnes of offal, 146,000 tonnes of roundfish, 148,000 tonnes of flatfish, and 100,000 tonnes of benthic invertebrates.

Around 2 million scavenging seabirds may be supported by the offal and discards made available from North Sea fishing vessels in recent years. Offal could support 1.1 million, roundfish 880,000, flatfish 180,000, and benthic invertebrates 38,000 1000g scavenging seabirds in the North Sea.

Reductions in the quantities of discards and offal made available to seabirds in winter would lead to reduced survival and reduced recruitment into the breeding stock.

9. EVALUATION OF THE PROJECT

The study of scavenging seabirds on a North Sea wide scale proved better than expected. Since most trawling was during the day and because 5 similar vessels could be manned simultaneously, an excellent overview of seabird distribution was achieved. The facilities on board were adequate for the project. The amount of data which was generated was underestimated, however, and future projects should allow more time to analyse all data. Besides the data presented in this report, valuable information with respect to the distribution and relative abundance of 20 other species of seabirds and wildfowl and 5 species of marine mammals were collected. The inter-callibration cruise and the evaluation on a workshop were valuable parts of the project and these should be repeated prior to any future studies.

10. REFERENCES

ANONYMOUS 1992a. Effects of beamtrawl fishery on the bottom fauna in the North Sea III: The 1991 studies. BEON-Rapport 16: 27pp, NIOZ, Texel.

ANONYMOUS 1992b. Report of the study group on ecosystem effects of fishing activities. ICES C.M. 1992/G: 11, sess. T.

ARBOUW G.J. 1980. Enkele gegevens over de voedseloecologie en de broedbiologie van de Stormmeeuw *Larus canus* L. op Texel. Rep. Neth. Inst. Sea Res., Texel.

ARBOUW G.J. & SWENNEN C. 1985. Het voedsel van de Stormmeeuw *Larus canus* op Texel. Limosa 58: 7-15.

BAILEY R.S. & HISLOP J.R.G. 1978. The effects of fisheries on seabirds in the northeast Atlantic. Ibis 120: 104-105.

BEEK F.A. VAN 1990. Discard sampling programme for the North Sea. Dutch participation. Internal RIVO-report, Demvis 90-303.

BERGHAHN R. 1990. On the potential impact of shrimping on the trophic relationships in the Wadden Sea. *In:* M. BARNES & R.N. GIBSON (eds): Trophic Relationships in the Marine Environment. Proc. 24th EMBS, Aberdeen University Press, 130-140..

BERGHAHN R. & RÖSNER H.-U. 1992. A method to quantify feeding of seabirds on discards from the shrimp fishery in the North Sea. Neth. J.

Sea Res. 28(4): 347-350.
BERGHAHN R., WALTEMATH M. & RIJNSDORP A.D. 1992. Mortality of fish from the bycatch of shrimp vessels in the North Sea. J. Appl. Ichtyol. 8: 293-306.
BIRT-FRIESEN V.L., MONTEVECCHI W.A., CAIRNS D.K. & MACKO S.A. 1989. Activity-specific metabolic rates of free-living Northern Gannets and other seabirds. Ecology 70: 357-367.
BLAKE B.F., TASKER M.L., JONES P.H., DIXON T.J., MITCHELL R. & LANGSLOW D.R. 1984. Seabird Distribution in the North Sea. Nature Conservancy Council, Huntingdon.
BOSWALL J. 1960. Observations on the use by seabirds of human fishing activities. Brit. Birds 53: 12-215.
CAMPHUYSEN C.J. 1987. De Noordse Stormvogel aan de Noordhollandse kust: nu talrijker dan ooit? Graspieper 7: 6-14.
CAMPHUYSEN C.J. 1990. Fish stocks, fisheries and seabirds in the North Sea. Techn. Rapport Vogelbescherming nr. 5, Vogelbescherming, Zeist.
CAMPHUYSEN C.J. 1993a. De exploitatie van op zee overboord geworpen vis en snijafval door zeevogels: een verkennend onderzoek. Het Vogeljaar 41(3): 106-113.
CAMPHUYSEN C.J. 1993b. Scavenging seabirds behind fishing vessels in the Northeast Atlantic, with emphasis on the southern North Sea. NIOZ report 1993-1, BEON report no. 20, Neth. Inst. Sea Res., Texel, 83pp.
CAMPHUYSEN C.J. & DIJK J. VAN 1983. De trek van zee- en kustvogels langs de Nederlandse kust, 1974-1979. Limosa 56: 81-230.
DAAN N., BROMLEY P.J., HISLOP J.R.G. & NIELSEN N.A. 1990. Ecology of North Sea fish. *In:* WOLF P. DE, LINDEBOOM H.J. & LAANE R.W.P.M. (eds). Proc. int. symp. Ecol. North Sea, May 1988. Neth. J. Sea Res. 26(2-4): 343-386.
DAMM U. & WEBER W. 1990. Analysis of catch rates in experimental fishing on North Sea sole with FRV 'Solea'. Arch. Fisch. wiss. 40: 49-55.
DÄNDLIKER G. & MÜLHAUSER G. 1988. L'exploitation des dechets de chalutage par les oiseaux de mer au large des Orcades et des Shetland (Nord-Est Atlantique). Nos Oiseaux 39(6): 257-288.
DARE P.J. 1982. Notes on seabirds attending a commercial trawler fishing in shelf waters off Ireland. Seabird 6: 110-114.
DIXON T.J. 1977. The distance at which sitting birds can be seen at sea. Ibis 119: 372-375.
DUNNET G.M., FURNESS R.W., TASKER M.L. & BECKER P.H. 1990. Seabird ecology in the North Sea. *In:* WOLF P. DE, LINDEBOOM H.J. & LAANE R.W.P.M. (eds). Proc. int. symp. Ecol. North Sea, May 1988. Neth. J. Sea Res. 26(2-4): 387-425.
ELLIS H.I. 1984. Energetics of free-ranging seabirds. *In:* WHITTOW G.C. & RAHN H. (eds). Seabird Energetics, pp. 203-234. Plenum Press, New York.
ERIKSTAD K.E., BUSTNES J.O. & JACOBSEN O. 1988. Duration of ship-following by Kittiwakes *Rissa tridactyla* in the Barents Sea. Pol. Res. 6: 191-194.
EWINS P.J. 1987. Opportunistic feeding of Black Guillemots *Cepphus grylle* at fishing vessels. Seabird 10: 58-59.
FISHER J. 1952. The Fulmar. Collins New Naturalist Series, Facsimile 1984, Collins, London 496pp.
FRANEKER J.A. VAN & WATTEL J. 1982. Geographical variation of the Fulmar *Fulmarus glacialis* in the North Atlantic. Ardea 70(1-2): 31-44.
FURNESS R.W. 1987. Effects of changes in whitefish net-mesh size on scavenging seabird ecology. NCC Chief Scientist Directorate Report No. 799.
FURNESS R.W. 1992. Implications of changes in net mesh size, fishing effort and minimum landing size regulations in the North Sea for seabird populations. Contr. Rep. to JNCC and Scottish Office, Appl. Orn. Unit. Dept. Zool., Univ. Glasgow, Glasgow, 62pp.
FURNESS R.W. & BRYANT D.M. *unpubl.* (1993). Validation of seabird bioenergetics modelling by using labelled water to obtain direct measures of energy costs of seabirds. Final report on NERC Grant GR9/242, 25pp.
FURNESS R.W., ENSOR K. & HUDSON A.V. 1992. The use of fishery waste by gull populations around the British Isles. *In:* SPAANS A.L. (ed.). Population dynamics of Lari in relation to food resources. Ardea 80: 105-113.
FURNESS R.W. & HISLOP J.R.G. 1981. Diets and feeding ecology of Great Skuas during the breeding season in Shetland. J. Zool., Lond. 195: 1-23.
FURNESS R.W., HUDSON A.V. & ENSOR K. 1988. Interactions between scavenging seabirds and commercial fisheries around the British Isles. *In:* BURGER J. (ed). Seabirds & Other Marine Vertebrates: Competition, Predation and Other Interactions. Columbia Univ. Press, New York pp 240-268.
GARTHE S. 1992. Quantifizierung von Abfall und Beifang der Fischerei in der südöstlichen Nordsee und deren Nutzung durch Seevögel. Diplomarb. Math.-Naturw. Fakult., Inst. Meeresk., Christian-Albr. University, Kiel, 111pp.
GISLASON H. 1993. Report of the study group on ecosystem effects of fishing activities. Copenhagen, 7-14 April 1992, ICES C.M. 1992/G: 11, Ref.: Session T.
GRAINGER R.J.R. 1992. ICES Fisheries Statistics. ICES Bull. Stat. Peches Marit. vol. 73: 1-116.
GRIFFITHS A.M. 1982. Reactions of some seabirds to a ship in the southern Ocean. Ostrich 53: 228-235.
HARRIS M.P. & HISLOP J.R.G. 1978. The food of

young puffins *Fratercula arctica*. J. Zool., Lond. 185: 213-236.

HEIDE G. VAN DER 1938. Waarnemingen over het voorkomen van enkele zeevogels bij de Doggersbank in October 1936. Ardea 27: 256-258.

HILLIS J.P. 1971. Seabirds scavenging at trawlers in Irish waters. Irish Nat. J. 17: 129-132.

HUDSON A.V. 1986. The biology of seabirds utilising fishery waste in Shetland. Ph. D. thesis, Univ. Glasgow, Scotland.

HUDSON A.V. & FURNESS R.W. 1988. Utilization of discarded fish by scavenging seabirds behind white fish trawlers in Shetland. J. Zool., Lond. 215: 151-166.

HUDSON A.V. & FURNESS R.W. 1989. The behaviour of seabirds foraging at fishing boats around Shetland. Ibis 131: 225-237.

HÜPPOP O. & GARTHE S. 1993. Seabirds and fishe ries in the southeastern North Sea. Sula 7: 9-14.

JERMYN A.S. & ROBB A.P. 1981. Review of the Cod, Haddock and Whiting discarded in the North Sea by Scottish fishing vessels for the period 1975-1980. ICES C.M. 1981 /G: 47, Dem. Fish. Comm.

KEIJL G.O., ROOMEN M. VAN & VELDHUIJZEN VAN ZANTEN H. 1986. Voedselecologie van de Stormmeeuw (*Larus canus*) te Schoorl 1986: Voedselkeuze en fourageerritme in de periode dat de jongen worden grootgebracht. Inst. lerarenopl., Hogeschool Holland, sektie biologie, Diemen 64pp.

LEOPOLD M.F. & CAMPHUYSEN C.J. 1992. Olievogels op het Texelse strand, februari 1992. NIOZ-rapport 1992-5, 29pp.

LLOYD C., TASKER M.L. & PARTRIDGE K. 1991. The Status of Seabirds in Britain and Ireland. T. & A.D. Poyser, London.

LOCKLEY R.M. & MARCHANT S. 1951. A midsummer visit to Rockall. Brit. Birds 44: 373-383.

MANIKOWSKI S. 1971. The influence of meteorological factors on the behaviour of sea birds. Acta Zool. Cracoviensia 16(13): 582-657.

MARTIN A.R. 1989. The diet of Atlantic Puffin *Fratercula arctica* and Northern Gannet *Sula bassana* chicks at a Shetland colony during a period of changing prey availability. Bird Study 36: 170-180.

MONTEVECCHI W.A., BIRT V.L. & CAIRNS D.K. 1988. Dietary changes of seabirds associated with local fisheries failures. Biol. Ocean. 5: 153-161.

NELSON J.B. 1966. The breeding biology of the Gannet *Sula bassana* on the Bass Rock, Scotland. Ibis 108: 584-626.

NELSON J.B. 1978. The Gannet. T. & A.D. Poyser, Berkhamsted.

NELSON J.B. 1980. Seabirds: their biology and ecology. Hamlyn, London/New York 224pp.

NOORDHUIS R. 1987. Voedseloecologie van zilveren kleine mantelmeeuw op Terschelling: een geval van het 'competitive exclusion principle'. RIN, intern rapport, Arnhem 90pp.

NOORDHUIS R. & SPAANS A.L. 1992. Interspecific competition for food between Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* in the Dutch Wadden Sea area. *In:* SPAANS A.L. (ed.). Population dynamics of Lari in relation to food resources. Ardea 80: 115-132.

OKILL D. 1989. Breeding success of Shetland's seabirds: Red-throated Diver, Fulmar, Gannet, Cormorant and Shag. *In:* HEUBECK M. (ed.). Seabirds and sandeels: Proc. Seminar Lerwick, Shetland, 15-16 Oct 1988. Shetland Bird Club, Lerwick.

PATERSON A.M., MARTÍNEZ V.A. & DIES J.I. 1992. Partial breeding failure of Audouin's Gull in two Spanish colonies in 1991. Brit. Birds 85(3): 97-100.

PRÜTER J. 1986. Untersuchungen zum Bestandsaufbau und zur Ökologie der Möwen (Laridae) im Seegebiet der Deutschen Bucht. Unpubl. Ph.D. thesis, 'Vogelwarte Helgoland' & Tierärztl. Hochschule Hannover, 142pp.

REEVES S.A., ARMSTRONG D.W., FRYER R.J. & COULL K.A. 1992. The effect of mesh size, cod-end extension length and cod-end diameter on the selectivity of Scottish trawls and seines. ICES J. Mar. Sc. 49: 279- 288.

REINSCH H.H. 1969. Der Basstölpel. Neue Brehm Bücherei 412, Wittenberg Lutherstadt 111pp.

STRANN K.-B. & VADER W. 1992. The nominate Lesser Black-backed Gull *Larus fuscus fuscus*, a gull with a tern-like feeding biology, and its recent decrease in northern Norway. *In:* SPAANS A.L. (ed.). Population dynamics of Lari in relation to food resources. Ardea 80: 133-142.

TASKER M.L. & BECKER P.H. 1992. Influences of human activities on seabird populations in the North Sea. Neth. J. Aquat. Ecol. 26(1): 59-73.

TASKER M.L., JONES P.H., DIXON T.J. & BLAKE B.F. 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101: 567-577.

TASKER M.L., WEBB A., HALL A.J., PIENKOWSKI M.W. & LANGSLOW D.R. 1987. Seabirds in the North Sea. Nature Conserv. Council, Peterborough 336pp.

TIEWS K. 1978. Non-commercial fish species in the German Bight: records of bycatches of the Brown Shrimp fishery. Rapp. P.-v. Reun. Cons. int. Explor. Mer 172: 259- 265.

TIEWS K. & WIENBECK H. 1990. Grundlagenmaterial zu 35-Jahres-trend (1954-1988) der häufigkeit von 25 Fisch- und Krebstierbeständen an der deutschen Nordseeküste. Veröff. Inst. Küsten- und Binnenfisch., Hamburg, Nr. 103/1990, Bundesforsch. Fischerei.

VAUK G. & JOKELE I. 1975. Vorkommen, Herkunft und Winternahrung Helgoländer Dreizehnmöwen

(Rissa tridactyla). Veröff. Inst. Meeresf. Bremerhaven 15: 69-77.
VERBOOM B.L. 1991. BEON Bodemverstoringsonderzoek 1990 - discards. Rapp. MO 91-01, Rijksinst. Visserij Onderz., IJmuiden.
WAHL T.R. & HEINEMANN D. 1979. Seabirds and fishing vessels: co-occurrence and attractions. Condor 81: 390-396.
WATSON P.S. 1981. Seabird observations from commercial trawlers in the Irish Sea. Brit. Birds 74: 82-90.
WILL K.R. 1992. Die duetsche Seezungenfischerei seit Einführung der Quotierung. Fischereiblatt 40: 4-12

Table 3.1. Observer effort at IBTS research vessels and RV Pelagia

km² surveyed	NW	NE	Sk	CW	C	CE	S	km²
Argos	0	0	197.3	0	0	0	0	197.3
Scotia	178.8	37.8	0	71.4	28.7	0	0	316.6
Dana	0	0	9.8	70.6	194.9	86.3	0	361.6
Pelagia	0	0	0	0	0	0	46.2	46.2
Tridens	145.2	0	0	123.5	43.1	47.3	177.4	536.4
Walter Herwig	106.2	43.9	0	28.1	72.1	40.6	0	290.9
Total	430.1	81.7	207.1	293.5	338.8	174.1	223.6	1749.1
km steamed	**NW**	**NE**	**Sk**	**CW**	**C**	**CE**	**S**	**km**
Argos	0	0	658.4	0	0	0	0	658.4
Scotia	595.9	125.8	0	238.0	95.7	0	0	1055.3
Dana	0	0	32.7	235.2	649.8	287.6	0	1205.3
Pelagia	0	0	0	0	0	0	180.4	180.4
Tridens	522.0	0	0	411.8	143.3	158.0	593.9	1828.9
Walter Herwig	388.6	186.4	0	102.5	254.9	177.5	0	1109.9
Total	1506.5	312.2	691.1	987.4	1143.7	623.1	774.3	6038.2

Table 4.1.1. Numbers of Fulmars, Gannets, skuas, gulls and auks recorded at sea during strip-transect counts (tr) and in the scan (sc), IBTS February 1993.

Species		NW	NE	Sk	CW	C	CE	S	Total	% in transect
Fulmar	tr	442	22	19	163	242	85	254	4931	
	sc	2243	97	7	292	493	306	266		24.9
Gannet	tr	91	1		76	14		10	877	
	sc	363	7		239	27	1	48		21.9
Great Skua	tr			1	3				7	
	sc	1			2					57.1
Little Gull	tr							6	12	
	sc							6		50.0
Black-headed Gull	tr				1			4	25	
	sc					7	1	12		20.0
Common Gull	tr	2	10	17	3	2	57	20	329	
	sc	3	81	5	10	2	23	94		33.7
Lesser Black-backed Gull	tr						2	2	16	
	sc	1	1			1	2	7		25.0
Herring Gull	tr	113	5	269	80	76	51	43	1824	
	sc	330	52	475	63	77	55	135		34.9
Glaucous Gull	tr						2		14	
	sc	11	1							14.3
Great Black-backed Gull	tr	89	2	99	38	45	36	69	1074	
	sc	241	22	122	66	43	68	134		35.2
unidentified large gull	tr								2513	
	sc		212	2300			1			0.0
Kittiwake	tr	106	16	80	203	77	55	100	3194	
	sc	1587	78	66	349	116	127	234		19.9
Guillemot	tr	522	8	235	1396	493	41	404	5949	
	sc	1551	22	51	666	208	23	329		52.1
Razorbill/Guillemot	tr	9	1	4	39	19	12		375	
	sc	88	11	18	150	15	7	2		22.4
Razorbill	tr	22		53	86	48	19	143	571	
	sc	42	1		55	21	11	70		65.0
Black Guillemot	tr			1					1	
	sc									100.0
Little Auk	tr	23	105	19	145	62			469	
	sc	13	53	11	15	23				75.5
Puffin	tr	15	3	2	192	34		2	280	
	sc	9	1		18	2		2		88.6

Table 4.1.2. Comparison presence of scavenging seabirds per subregion in transect or scan per quarter ICES square.

Fulmar	in transect -	+	pres%	in scan -	+	pres%
NW	18	50	73.4	10	58	84.6
NE	13	7	35.3	8	12	61.1
CW	17	27	62.2	11	33	75.7
C	28	35	55.3	11	52	82.6
CE	17	15	48.0	9	23	72.0
S	14	19	58.6	8	25	76.7
Herring Gull	-	+	pres%	-	+	pres%
NW	48	20	29.7	32	36	52.3
NE	15	5	23.5	9	11	55.6
CW	39	5	10.8	31	13	29.7
C	52	11	17.0	37	26	41.3
CE	18	14	44.4	13	19	60.0
S	20	13	37.9	10	23	70.0
Great Black-backed Gull	-	+	pres%	-	+	pres%
NW	49	19	28.1	20	48	70.8
NE	18	2	11.8	9	11	55.6
CW	30	14	32.4	17	27	62.2
C	56	7	10.6	38	25	39.1
CE	27	5	14.8	15	17	52.0
S	19	14	41.4	12	21	63.3
Kittiwake	-	+	pres%	-	+	pres%
NW	36	32	46.9	17	51	75.4
NE	15	5	23.5	11	9	44.4
CW	20	24	54.1	11	33	75.7
C	42	21	34.0	18	45	71.7
CE	20	12	37.0	8	24	76.0
S	5	28	86.2	0	33	100.0

Table 4.1.3. Densities of birds (number/km²) in the southern part of subregion NW, used for comparison between vessels.

	Scotia	Tridens	Walter Herwig
Fulmar	1.11	0.68	1.99
Gannet	0.02	0.32	0.03
Herring Gull	0.05	0.92	0.16
Great Black-backed Gull	0.11	0.19	0.09
Kittiwake	0.43	0.23	0.07
Little Auk	0.02	0.05	0.09

Table 4.1.4. Estimate of total numbers present in the North Sea during February 1993 IBTS, as derived from numbers in transect per subregion, corrected for stratum (see text), combined with numbers observed and estimated at commercial trawlers (assuming a 2km transect on both sides of the ship; see table 4.3.3), plus comparisons with abundance estimates from European Seabirds At Sea Database for February (ESAS unpublished data). In the right hand column, the difference between ESAS data and February 1993 IBTS is indicated for each subregion.

Fulmar Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	442	1.03	1.11	174166	6350	164769	338935	NW	4.04	633902	(1.9 x)
NE	22	0.27	0.29	28209	790	61469	89678	NE	2.24	217888	(2.4 x)
Sk	19	0.09	0.09	5307	1	24	5331	Sk	0.59	34781	(6.5 x)
CW	163	0.56	0.63	43752	2	35	43787	CW	1.65	114588	(2.6 x)
C	242	0.71	0.75	105700	500	15092	120792	C	1.10	155026	(1.3 x)
CE	85	0.49	0.52	32646	196	2272	34918	CE	0.63	39552	(1.1 x)
S	254	1.13	1.35	76630	1181	9528	86158	S	0.39	22137	(0.3 x)
Totals				466409	9020	253190	719598			1217875	(1.7 x)

Gannet Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	91	0.21	0.23	36088	193	5008	41096	NW	0.25	39227	(1.0 x)
NE	1	0.01	0.01	973	1	78	1051	NE	0.07	6809	(6.5 x)
Sk	0	0.00	0.00	0	0	0	0	Sk	0.00	248	
CW	76	0.26	0.27	18751	2	35	18786	CW	0.36	25001	(1.3 x)
C	14	0.04	0.04	5637	6	181	5818	C	0.21	29596	(5.1 x)
CE	0	0.00	0.00	0	0	0	0	CE	0.00	270	
S	10	0.04	0.05	2838	78	629	3467	S	0.10	5676	(1.6 x)
Totals				64287	280	5931	70218			106826	(1.5 x)

Common Gull Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	2	0.00	0.01	1569	0	0	1569	NW	0.02	3766	(2.4 x)
NE	10	0.12	0.15	14591	0	0	14591	NE	0.02	2335	(0.2 x)
Sk	17	0.08	0.08	4718	13	310	5028	Sk	0.77	45393	(9.0 x)
CW	3	0.01	0.01	694	0	0	694	CW	0.09	6250	(9.0 x)
C	2	0.01	0.01	1409	90	2717	4126	C	0.10	14093	(3.4 x)
CE	57	0.33	0.37	23229	25	290	23519	CE	0.63	39552	(1.7 x)
S	20	0.09	0.10	5676	309	2493	8169	S	1.02	57898	(7.1 x)
Totals				51887	437	5810	57697			169286	(2.9 x)

Herring Gull Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	113	0.26	0.29	45503	641	16633	62136	NW	0.47	73746	(1.2 x)
NE	5	0.06	0.07	6809	420	32680	39489	NE	0.07	6809	(0.2 x)
Sk	269	1.30	1.30	76664	585	13955	90619	Sk	2.70	159169	(1.8 x)
CW	80	0.27	0.29	20140	63	1113	21253	CW	1.35	93754	(4.4 x)
C	76	0.22	0.24	33824	321	9689	43513	C	0.32	45099	(1.0 x)
CE	51	0.29	0.31	19462	30	348	19810	CE	0.60	37669	(1.9 x)
S	43	0.19	0.22	12488	945	7624	20112	S	1.40	79468	(4.0 x)
Totals				214889	3005	82042	296931			495713	(1.7 x)

Great Bl-b Gull Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	89	0.21	0.24	37657	648	16814	54471	NW	0.30	47072	(0.9 x)
NE	2	0.02	0.03	2918	120	9337	12255	NE	0.17	16536	(1.3 x)
Sk	99	0.48	0.48	28307	75	1789	30096	Sk	0.39	22991	(0.8 x)
CW	38	0.13	0.14	9723	27	477	10200	CW	0.30	20834	(2.0 x)
C	45	0.13	0.14	19731	261	7878	27609	C	0.25	35233	(1.3 x)
CE	36	0.21	0.25	15695	48	557	16252	CE	0.24	15067	(0.9 x)
S	69	0.31	0.37	21002	382	3082	24084	S	0.55	31219	(1.3 x)
Totals				135033	1561	39934	174967			188953	(1.1 x)

(table 4.1.4. continued)

Kittiwake Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	106	0.25	0.28	43934	1880	48782	92716	NW	0.99	155337	(1.7 x)
NE	16	0.20	0.20	19454	10	778	20232	NE	0.30	29181	(1.4 x)
Sk	80	0.39	0.34	20050	84	2004	22054	Sk	1.78	104934	(4.8 x)
CW	205	0.70	0.80	55558	157	2774	58332	CW	0.79	54864	(0.9 x)
C	77	0.23	0.24	33824	234	7063	40887	C	1.94	273410	(6.7 x)
CE	55	0.32	0.37	23229	110	1275	24504	CE	0.74	46458	(1.9 x)
S	100	0.45	0.53	30084	1154	9311	39395	S	0.48	27246	(0.7 x)
Totals				226133	3629	71987	298120			691430	(2.3 x)

All scavengers Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	estim. in transect (n)	assoc. trawlers (n)	estim. trawlers (n)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	843	1.96	2.16	338917	9712	252005	590922	NW	6.07	953050	(1.6 x)
NE	56	0.68	0.75	72953	1341	104341	177294	NE	2.87	279558	(1.6 x)
Sk	484	2.34	2.29	135046	758	18082	153128	Sk	6.23	367516	(2.4 x)
CW	565	1.93	2.14	148617	251	4434	153051	CW	4.54	315292	(2.1 x)
C	456	1.34	1.42	200125	1412	42620	242745	C	3.92	552457	(2.3 x)
CE	284	1.64	1.82	114261	409	4742	119003	CE	2.84	178568	(1.5 x)
S	496	2.21	2.62	148719	4049	32668	181387	S	3.94	223645	(1.2 x)
Totals				1158638	17932	458892	1617530			2870084	(1.8 x)

Little Auk Subregion	in transect (n)	density (n/km²)	corr. density (n/km²)	IBTS total North Sea (n)		ESAS Database (n/km²)	est. (n)	ESAS/IBTS
NW	23	0.05	0.07	10983	NW	0.13	20398	(1.9 x)
NE	105	1.29	1.76	171197	NE	0.05	4864	(0.0 x)
Sk	19	0.09	0.09	5307	Sk	8.85	521722	(98.3 x)
CW	145	0.49	0.69	47918	CW	0.15	10417	(0.2 x)
C	62	0.18	0.25	35233	C	0.25	35233	(1.0 x)
CE	0	0.00	0.00	0	CE	0.06	3767	
S	0	0.00	0.00	0	S	0.00	238	
Totals				270640			596639	(2.2 x)

Table 4.1.5. Age composition of Gannet and gulls during transect counts and at the stern.

Gannet	Transect counts ad	imm	%ad		Stern counts ad	imm	%ad	G-test G adj	p<
C	39	2	95.1	C	115	3	97.5	0.437	n.s.
CE		1		CE	2				
CW	306	8	97.5	CW	165	5	97.1	0.050	n.s.
NE	8			NE	98	1	99.0		
NW	349	5	98.6	NW	1297	9	99.3	1.397	n.s.
S	52	6	89.7	S	54	2	96.4	1.951	n.s.
Sk				Sk	1				
Σ	754	22	97.2	Σ	1731	21	98.8	7.759	0.01
Common Gull	ad	imm	%ad		ad	imm	%ad	G adj	p<
C	4			C	47	5	90.4		
CE	71	9	88.8	CE	213	43	83.2	1.500	n.s.
CW	11	2	84.6	CW	3	2		1.000	n.s.
NE	68	23	74.7	NE					
NW	5			NW					
S	99	12	89.2	S	215	27	88.8	0.012	n.s.
Sk	20	1	95.2	Sk	131	11	92.3	0.233	n.s.
Σ	278	47	85.5	Σ	609	88	87.4	0.636	n.s.
Herring Gull	ad	imm	%ad		ad	imm	%ad	G adj	p<
C	84	69	54.9	C	316	211	60.0	1.261	n.s.
CE	57	48	54.3	CE	257	128	66.8	5.459	0.05
CW	75	65	53.6	CW	117	49	70.5	9.274	0.01
NE	35	22	61.4	NE	208	80	72.2	2.530	n.s.
NW	326	114	74.1	NW	2204	607	78.4	3.959	0.05
S	92	55	62.6	S	202	168	54.6	2.747	n.s.
Sk	99	101	83.2	Sk	2816	1156	70.9	42.831	0.001
Σ	1168	474	71.1	Σ	6120	2399	71.8	0.342	n.s.
Great Black-backed Gull	ad	imm	%ad		ad	imm	%ad	G adj	p<
C	43	45	48.9	C	243	120	66.9	9.585	0.01
CE	37	26	58.7	CE	166	65	71.9	3.839	n.s.
CW	39	65	37.5	CW	36	16	69.2	14.047	0.01
NE	19	5	79.2	NE	188	98	65.7	1.903	n.s.
NW	185	143	56.4	NW	1230	327	79.0	67.260	0.001
S	113	74	60.4	S	82	38	68.3	1.960	n.s.
Sk	99	30	76.7	Sk	857	404	68.0	4.358	0.05
Σ	535	388	58.0	Σ	2802	1068	72.4	70.405	0.001
Kittiwake	ad	imm	%ad		ad	imm	%ad	G adj	p<
C	178	15	92.2	C	2101	43	98.0	16.027	0.01
CE	134	48	73.6	CE	548	20	96.5	72.416	0.001
CW	445	107	80.6	CW	636	7	98.9	131.485	0.001
NE	94		100.0	NE	1740	11	99.4	0.889	n.s.
NW	1665	25	98.5	NW	4482	101	97.8	3.454	n.s.
S	238	38	86.2	S	787	39	95.3	22.760	0.01
Sk	117	18	86.7	Sk	257	150	63.1	29.245	0.01
Σ	2871	251	92.0	Σ	10552	370	96.6	108.287	0.001

Table 4.2.1. Number of hauls, numbered maximum stern counts for each research vessel (cf. figure 6.2.2), and numbered stern counts during discard experiments (cf. figure 6.4.1), IBTS 1993.

Res. vessel	number of hauls	total stern counts	numbered 'max.'counts	numbered experim.counts
RV Argos	40	43	nos. 149-188	nos. -
RV Dana	40	214	109-148	44-72
RV Pelagia	6	33	1-6	1-5
RV Scotia	17	169	7-23	6-18
RV Tridens	41	343	24-64	19-43
RV Walter Herwig	44	61	65-108	73-101

Table 4.2.2. Relative abundance of scavengers at the stern IBTS 1993

		Fulm	Gann	Bl-h Gull	Comm Gull	Herr Gull	L Bb Gull	G Bb Gull	Kitt	Other Gull	Gull sp.	Gr. Skua	Alca/ Uria	Total Gull	Total Birds
N	Frequency (n= 188)	131	78	8	76	174	14	169	179	12	1	1	16	185	187
o	Total number seen	11397	1793	23	749	9576	44	4463	12110	14	150	1	30	27129	40350
r	Maximum	2000	250	10	150	650	13	250	452	2	150	1	5	917	2499
t	Presence (%)	69.7	41.5	4.3	40.4	92.6	7.4	89.9	95.2	6.4	0.5	0.5	8.5	98.4	99.5
h	Mean	60.6	9.5	0.1	4.0	50.9	0.2	23.7	64.4					144.3	214.6
S	S.E.	13.3	2.2	0.1	1.1	7.0	0.1	2.8	6.8					12.0	21.2
e	% Adults		98.8	91.3	86.0	65.7	90.9	64.3	92.0						
a	(n=)		1752	23	708	9312	44	4362	11472						
N	Frequency (n= 36)	36	29	0	0	32	0	35	36	7	0	0	0	36	36
W	Total number seen	5931	1346	0	0	3168	0	1805	4756	9	0	0	0	9738	17015
	Maximum	2000	250			580		220	452	2				741	2499
	Presence (%)	100.0	80.6			88.9		97.2	100.0	19.4				100.0	100.0
	Mean	164.8	37.4			88.0		50.1	132.1					270.5	472.6
	S.E.	57.0	10.0			21.3		8.8	22.5					35.0	73.6
	% Adults		99.3			78.4		79.0	97.8						
	(n=)		1306			2811		1557	4583						
N	Frequency (n= 8)	8	8	0	0	8	0	8	8	2	0	0	0	8	8
E	Total number seen	2887	99	0	0	288	0	286	1751	2	0	0	0	2327	5313
	Maximum	800	35			70		65	362	1				403	1238
	Presence (%)	100.0	100.0			100.0		100.0	100.0	25.0				100.0	100.0
	Mean	360.9	12.4			36.0		35.8	218.9					290.9	664.1
	S.E.	83.8	4.4			7.6		6.2	30.7					27.5	110.5
	% Adults		99.0			72.2		65.7	99.4						
	(n=)		99			288		286	1751						
S	Frequency (n= 40)	10	1	2	33	40	0	39	37	0	0	0	5	40	40
k	Total number seen	38	1	2	142	3972	0	1271	407	0	0	0	13	5794	5846
	Maximum	7	1	1	14	650		250	65				5	917	917
	Presence (%)	25.0	2.5	5.0	82.5	100.0		97.5	92.5				12.5	100.0	100.0
	Mean	1.0	0.0	0.1	3.6	99.3		31.8	10.2					144.9	146.2
	S.E.	0.3	0.0	0.0	0.5	22.5		8.6	2.1					29.7	29.7
	% Adults		(0)	(2)	92.3	70.9		68.0	63.1						
	(n=)		1	2	142	3972		1261	407						
C	Frequency (n= 13)	12	9	0	4	12	0	10	13	0	1	0	3	13	13
W	Total number seen	562	170	0	5	282	0	107	1017	0	150	0	4	1561	2297
	Maximum	240	88		2	110		26	250		150		2	300	446
	Presence (%)	92.3	69.2		30.8	92.3		76.9	100.0		7.7		23.1	100.0	100.0
	Mean	43.2	13.1		0.4	21.7		8.2	78.2					120.1	176.7
	S.E.	23.2	6.7		0.2	8.4		2.6	24.9					28.5	41.4
	% Adults		97.1		(3)	70.5		69.2	98.9						
	(n=)		170		5	166		52	643						
C	Frequency (n= 49)	41	20	0	12	44	1	41	44	1	0	0	3	46	47
	Total number seen	1193	119	0	52	819	1	471	2487	1	0	0	5	3831	5148
	Maximum	302	44		14	210	1	60	400	1			3	650	700
	Presence (%)	83.7	40.8		24.5	89.8	2.0	83.7	89.8	2.0			6.1	93.9	95.9
	Mean	24.3	2.4		1.1	16.7		9.6	50.8					78.2	105.1
	S.E. C	6.6	1.0		0.4	4.8		1.8	9.9					15.1	18.4
	% Adults		97.5		90.4	60.0		66.9	98.0						
	(n=)		118		52	527		363	2144						
C	Frequency (n= 22)	11	2	3	12	20	2	19	22	0	0	0	2	22	22
E	Total number seen	314	2	12	297	506	2	308	683	0	0	0	2	1808	2126
	Maximum	130	1	10	81	120	1	45	150				1	220	240
	Presence (%)	50.0	9.1	13.6	54.5	90.9	9.1	86.4	100.0				9.1	100.0	100.0
	Mean	14.3	0.1	0.5	13.5	23.0	0.1	14.0	31.0					82.2	96.6
	S.E.	6.4	0.1	0.5	5.2	5.7	0.1	2.8	7.1					13.5	16.0
	% Adults		(2)	91.7	83.2	66.8	(2)	71.9	96.5						
	(n=)		2	12	256	385	2	231	568						
S	Frequency (n= 20)	13	9	3	15	18	11	17	19	2	0	1	3	20	20
	Total number seen	472	56	9	253	541	41	215	1009	2	0	1	6	2070	2605
	Maximum	353	24	6	150	220	13	68	175	1		1	4	442	694
	Presence (%)	65.0	45.0	15.0	75.0	90.0	55.0	85.0	95.0	10.0		5.0	15.0	100.0	100.0
	Mean	23.6	2.8	0.5	12.7	27.1	2.1	10.8	50.5					103.5	130.3
	S.E.	17.5	1.4	0.3	7.4	11.1	0.7	3.9	12.8					24.5	36.9
	% Adults		96.4	(8)	88.8	54.6	100.0	68.3	95.3						
	(n=)		56	8	242	370	38	120	826						

Table 4.2.3. Rarer species at the stern (all stern counts), all research vessels, IBTS 1993.

Subregion	Manx Shw	Gr. Skua	Litt Gull	Med Gull	Bl-h Gull	L Bb Gull	Glauc Gull	Icel Gull	Guill	Razor	Total
NW							17	2	2		21
NE							3				3
Sk	1				2				16	13	32
CW		1				3			5		9
C						2	1		7		10
CE					12	22				2	36
S		1	1	1	18	109			10	1	141
Number of records	1	2	1	1	14	42	17	2	21	7	89
Total number	1	2	1	1	32	136	21	2	40	16	252
Maximum at a haul	1	1	1	1	10	20	2	1	11	5	20

Table 4.2.4. Number of birds at the stern of research vessels compared with densities (n/km²) at sea that same day, and estimates of surface area (km²) and radius (km) from which scavengers could have been attracted

	Fulmar	Gannet	Common Gull	Herring Gull	Gr. Bl.-b. Gull	Kittiw.
mean density	0.8	0.2	0.3	0.4	0.4	0.4 /km²
min	0.02	0.02	0.03	0.02	0.03	0.05 /km²
max	4.72	1.62	1.97	3.79	1.65	1.79 /km²
mean at stern	78.8	25.2	14.4	43.6	23.7	75.4
min	1	1	1	1	1	1
max	2000	250	150	580	220	452
mean surface	176	230	223	338	152	421 km²
min	0.2	1.3	1.5	0.9	0.9	2.1 km²
max	3456	1863	1653	2938	901	4554 km²
mean radius	7.5	8.5	8.4	10.4	7.0	11.6 km
min	0.3	0.6	0.7	0.5	0.5	0.8 km
max	33.2	24.4	22.9	30.6	16.9	38.1 km
duration of flight at 40 km/h (minutes)						
mean	11.2	12.8	12.6	15.6	10.4	17.4 min
min	0.4	1.0	1.0	0.8	0.8	1.2 min
max	49.8	36.5	34.4	45.9	25.4	57.1 min

Table 4.2.5. Numbers at the stern during different activities, all subregions combined, RV Tridens IBTS 1993. Shown are mean number present during each activity (mean ± S.E.), total number observed, maximum number observed, number of records and presence (%). The total number of stern counts (n) for each activity is shown bottom right in the table under 'sample'. For Common Gull Larus canus only counts made south of 55°N latitude were used (n= 214; 62.4% of all stern counts).

	Fulmar						Gannet					
Activity	Mean	S.E.	Total	Max.	Freq.	Pres%	Mean	S.E.	Total	Max.	Freq.	Pres%
Stat. & discarding	55.0	17.18	1211	353	18	81.8	21.4	7.47	471	142	14	63.6
Ste/tow & discarding	16.1	3.25	403	60	21	84.0	13.3	5.71	332	140	16	64.0
Lifting net	20.9	9.73	834	383	25	62.5	12.1	6.67	482	250	19	47.5
Hauling net	19.0	7.48	818	280	25	58.1	7.1	4.38	305	182	16	37.2
Stationary, no discards	7.1	4.01	50	30	5	71.4	0.7	0.57	5	4	2	28.6
Shooting net	9.7	2.31	502	64	33	63.5	4.7	3.01	242	150	13	25.0
Towing, no discards	6.1	1.40	404	48	30	45.5	0.9	0.29	58	11	16	24.2
Steaming, no discards	4.8	1.40	425	80	34	38.6	1.3	0.64	110	47	11	12.5

	Common Gull (< 55°N)						Herring Gull					
Activity	Mean	S.E.	Total	Max.	Freq.	Pres%	Mean	S.E.	Total	Max.	Freq.	Pres%
Stat. & discarding	15.7	8.17	157	81	10	100.0	83.4	24.48	1834	400	20	90.9
Ste/tow & discarding	10.0	5.56	89	46	5	55.6	46.6	13.72	1165	250	24	96.0
Lifting net	17.9	6.35	484	150	20	74.1	29.0	7.78	1159	220	36	90.0
Hauling net	8.7	4.31	218	86	8	32.0	16.4	6.46	704	250	34	79.1
Stationary, no discards	26.7	17.63	187	130	6	85.7	22.7	8.95	159	72	7	100.0
Shooting net	8.1	3.61	291	120	22	61.1	7.5	2.44	390	100	33	63.5
Towing, no discards	5.6	2.28	265	80	25	53.2	7.2	2.14	474	120	36	54.5
Steaming, no discards	0.3	0.15	15	7	5	9.4	6.2	2.45	548	140	28	31.8

	Great Black-backed Gull						Kittiwake					
Activity	Mean	S.E.	Total	Max.	Freq.	Pres%	Mean	S.E.	Total	Max.	Freq.	Pres%
Stat. & discarding	27.5	8.66	604	170	19	86.4	89.8	16.21	1975	250	22	100.0
Ste/tow & discarding	18.8	6.64	471	150	21	84.0	106.0	22.59	2649	400	25	100.0
Lifting net	9.8	2.53	390	70	31	77.5	35.0	6.26	1400	180	37	92.5
Hauling net	9.8	4.32	423	175	26	60.5	40.4	11.73	1738	400	40	93.0
Stationary, no discards	5.6	3.01	39	23	6	85.7	22.0	5.57	154	44	7	100.0
Shooting net	3.3	1.60	171	80	24	46.2	24.9	7.63	1295	300	47	90.4
Towing, no discards	3.5	0.91	231	32	23	34.8	16.0	3.58	1057	175	57	86.4
Steaming, no discards	1.7	0.69	149	40	31	35.2	5.5	1.57	485	80	40	45.5

	All gulls						All scavenging seabirds						Sample
Activity	Mean	S.E.	Total	Max.	Freq.	Pres%	Mean	S.E.	Total	Max.	Freq.	Pres%	n=
Stat. & discarding	207.9	35.37	4574	705	22	100.0	284.4	49.96	6256	927	22	100.0	22
Ste/tow & discarding	175.0	34.67	4375	650	25	100.0	204.4	37.67	5110	700	25	100.0	25
Lifting net	85.9	14.46	3434	442	40	100.0	118.8	21.58	4750	562	40	100.0	40
Hauling net	71.7	19.19	3084	593	42	97.7	97.8	26.44	4207	887	42	97.7	43
Stationary, no discards	77.0	15.77	539	142	7	100.0	84.9	16.28	594	144	7	100.0	7
Shooting net	41.3	10.36	2147	382	50	96.2	55.6	13.50	2891	582	50	96.2	52
Towing, no discards	30.7	6.61	2027	317	61	92.4	37.7	7.28	2489	351	61	92.4	66
Steaming, no discards	13.6	4.46	1197	235	47	53.4	19.7	5.64	1732	269	54	61.4	88

Table 4.3.1. Number of sightings of (fishing) commercial trawlers per subregion, IBTS February 1993 and RV Navicula Jan-Feb 1993.

Type / Region:	NW	NE	Sk	CW	C	CE	S	Total
beamtrawler				3	8	7	23	41
seine					1	1		2
shrimper							8	8
'small trawler'			4					4
span	2				2		2	6
stern trawler	9				1			10
unknown	2	4		3	2			11
Total	13	4	4	6	14	8	33	82

Table 4.3.2. Estimated number of fishing commercial trawlers in the North Sea during February 1993 IBTS (excluding sightings from RV Navicula), from 4 km wide transect counts (obs) in each subregion and total number of scavengers observed and estimated.

Subreg	surface km²	surveyed km²	%	obs	estimated number: total	beam	seine	shrimp	small	pair	stern	?
NW	156906	6047	3.9	13	338	0	0	0	0	52	234	52
NE	97271	1250	1.3	4	311	0	0	0	0	0	0	311
Sk	58952	2471	4.2	4	95	0	0	0	95	0	0	0
CW	69447	3931	5.7	6	106	53	0	0	0	0	0	53
C	140933	4669	3.3	14	421	241	30	0	0	60	30	60
CE	62781	5415	8.6	10	93	81	12	0	0	0	0	0
S	56763	7035	12.4	21	169	169	0	0	0	0	0	0
				72	1533	544	42	0	95	112	264	476

observed	Fulmar	Gannet	Common Gull	Herring Gull	GBb Gull	Kittiw	Total
NW	6350	193	0	641	648	1880	9712
NE	790	1	0	420	120	10	1341
Sk	1	0	13	585	75	84	758
CW	2	2	0	63	27	157	251
C	500	6	90	321	261	234	1412
CE	196	0	25	30	48	110	409
S	1181	78	1714	1498	416	1162	6049
Total observed	9020	280	1842	3558	1595	3637	19932

estimated	Fulmar	Gannet	Common Gull	Herring Gull	GBb Gull	Kittiw	Total
NW	164769	5008	0	16633	16814	48782	252005
NE	61469	78	0	32680	9337	778	104341
Sk	24	0	310	13955	1789	2004	18082
CW	35	35	0	1113	477	2774	4434
C	15092	181	2917	9689	7878	7063	42620
CE	2272	0	290	348	557	1275	4742
S	9528	629	2493	7624	3082	9311	32668
Total observed	253190	5931	5810	82042	39934	71987	458894

Table 4.3.3. Relative abundance of scavengers associated with commercial trawlers in the North Sea and Skagerrak (excluding sightings from RV Navicula)

		Fulm	Gann	Bl-h Gull	Comm Gull	Herr Gull	L Bb Gull	G Bb Gull	Kitt	Gull sp.	Total
NSea	Frequency (n= 72)	44	20	4	19	46	2	41	49	10	
	Presence (%)	61.1	27.8	5.6	26.4	63.9	2.8	56.9	68.1	13.9	
	Total number seen	9020	280	13	437	3005	16	1561	3629	935	18898
	Maximum	3500	80	10	80	400	15	300	1000	350	3862
	Mean	125.3	3.9	0.2	6.1	41.7	0.2	21.7	50.4	13.0	262.5
	S.E.	54.0	1.5	0.1	2.0	8.5	0.2	5.1	15.6	6.5	64.6
NW	Frequency (n= 13)	8	8	1	0	6	0	8	7	1	
	Presence (%)	61.5	61.5	7.7	0.0	46.2	0.0	61.5	53.8	7.7	
	Total number seen	6350	193	10	0	641	0	648	1880	10	9734
	Maximum	3500	80	10	0	250	0	300	1000	10	3862
	Mean	488.5	14.8	0.8	0.0	49.3	0.0	49.8	144.6	0.8	748.8
	S.E.	267.4	6.8	0.7	0.0	22.8	0.0	21.9	74.4	0.7	298.1
NE	Frequency (n= 4)	4	1	0	0	2	0	2	1	1	
	Presence (%)	100.0	25.0	0.0	0.0	50.0	0.0	50.0	25.0	25.0	
	Total number seen	790	1	0	0	420	0	120	10	20	1361
	Maximum	600	1	0	0	400	0	100	10	20	1100
	Mean	197.5	0.3	0.0	0.0	105.0	0.0	30.0	2.5	5.0	340.3
	S.E.	119.2	0.2	0.0	0.0	85.3	0.0	20.6	2.2	4.3	221.0
Sk	Frequency (n= 4)	1	0	0	4	4	0	3	4	0	
	Presence (%)	25.0	0.0	0.0	100.0	100.0	0.0	75.0	100.0	0.0	
	Total number seen	1	0	0	13	585	0	75	84	0	758
	Maximum	1	0	0	5	200	0	35	50	0	280
	Mean	0.3	0.0	0.0	3.3	146.3	0.0	18.8	21.0	0.0	189.5
	S.E.	0.2	0.0	0.0	0.7	15.9	0.0	6.5	9.4	0.0	29.4
CW	Frequency (n= 6)	2	2	0	0	5	0	2	6	0	
	Presence (%)	33.3	33.3	0.0	0.0	83.3	0.0	33.3	100.0	0.0	
	Total number seen	2	2	0	0	63	0	27	157	0	251
	Maximum	1	1	0	0	30	0	21	59	0	110
	Mean	0.3	0.3	0.0	0.0	10.5	0.0	4.5	26.2	0.0	41.8
	S.E.	0.2	0.2	0.0	0.0	4.0	0.0	3.1	7.0	0.0	13.8
C	Frequency (n= 14)	11	2	0	2	7	0	7	8	2	
	Presence (%)	78.6	14.3	0.0	14.3	50.0	0.0	50.0	57.1	14.3	
	Total number seen	500	6	0	90	321	0	261	234	315	1727
	Maximum	250	5	0	50	100	0	120	100	300	550
	Mean	35.7	0.4	0.0	6.4	22.9	0.0	18.6	16.7	22.5	123.4
	S.E.	16.7	0.3	0.0	4.2	8.5	0.0	8.8	7.4	20.6	39.7
CE	Frequency (n= 8)	5	0	0	4	6	0	4	6	0	
	Presence (%)	62.5	0.0	0.0	50.0	75.0	0.0	50.0	75.0	0.0	
	Total number seen	196	0	0	25	30	0	48	110	0	409
	Maximum	150	0	0	15	15	0	40	50	0	191
	Mean	24.5	0.0	0.0	3.1	3.8	0.0	6.0	13.8	0.0	51.1
	S.E.	17.1	0.0	0.0	1.7	1.7	0.0	4.6	7.4	0.0	23.1
S	Frequency (n= 23)	13	7	3	9	16	2	15	17	6	
	Presence (%)	56.5	30.4	13.0	39.1	69.6	8.7	65.2	73.9	26.1	
	Total number seen	1181	78	3	309	945	16	382	1154	590	4658
	Maximum	700	41	1	80	200	15	125	322	350	992
	Mean	51.3	3.4	0.1	13.4	41.1	0.7	16.6	50.2	25.7	202.5
	S.E.	30.8	1.9	0.1	5.1	11.2	0.6	5.6	16.7	15.3	50.8

(table 4.3.3. continued: Including trawler sightings from RV Navicula in subregion S)

	Fulm	Gann	Bl-h Gull	Comm Gull	Herr Gull	L Bb Gull	G Bb Gull	Kitt	Gull sp.	Total
North Sea										
Mean (n= 82)	110.0	3.4	25.0	22.5	43.4	0.2	19.5	44.4	11.4	279.7
S.E.	47.6	1.3	14.0	8.1	8.1	0.2	4.6	13.8	5.7	57.8
S Mean (n= 33)	35.8	2.4	61.9	51.9	45.4	0.5	12.6	35.2	17.9	263.6
S.E.	21.8	1.3	33.8	18.8	11.0	0.4	4.1	12.3	10.9	45.8

Table 4.3.4. Species composition at the stern of research vessels and at (fishing) commercial trawlers for each subregion, IBTS February 1993.

	Research vessels							Fishing commercial trawlers								
	Fulm	Gann	Comm Gull	Herr Gull	G Bb Gull	Kitt	Total birds	Fulm	Gann	Comm Gull	Herr Gull	G Bb Gull	Kitt	Total birds	G=	p<
NW																
Total	5931	1346	0	3168	1805	4756	17015	6350	193	0	641	648	1880	9712	2654	0.00001
%	34.9	7.9	0.0	18.6	10.6	28.0		65.4	2.0	0.0	6.6	6.7	19.4			
NE																
Total	2887	99	0	288	286	1751	5313	790	1	0	420	120	10	1341	1276	0.00001
%	54.4	1.9	0.0	5.4	5.4	33.0		58.9	0.1	0.0	31.3	8.9	0.7			
Sk																
Total	38	1	142	3972	1271	407	5846	1	0	13	585	75	84	758	175	0.00001
%	0.7	0.0	2.4	68.1	21.8	7.0		0.1	0.0	1.7	77.2	9.9	11.1			
CW																
Total	562	170	5	282	107	1017	2297	2	2	0	63	27	157	251	174	0.00001
%	26.2	7.9	0.2	13.2	5.0	47.5		0.8	0.8	0.0	25.1	10.8	62.5			
C																
Total	1193	119	52	819	471	2487	5148	500	6	90	321	261	234	1412	636	0.00001
%	23.2	2.3	1.0	15.9	9.2	48.4		35.4	0.4	6.4	22.7	18.5	16.6			
CE																
Total	314	2	297	506	308	683	2126	196	0	25	30	48	110	409	228	0.00001
%	14.9	0.1	14.1	24.0	14.6	32.4		47.9	0.0	6.1	7.3	11.7	26.9			
S																
Total	472	56	253	541	215	1009	2605	1181	78	309	945	382	1154	4049	146	0.00001
%	18.5	2.2	9.9	21.2	8.4	39.6		29.2	1.9	7.6	23.3	9.4	28.5			
North Sea																
Total	11397	1793	749	9576	4463	12110	40350	9020	280	437	3005	1561	3629	17932	4170	0.00001
%	28.4	4.5	1.9	23.9	11.1	30.2		50.3	1.6	2.4	16.8	8.7	20.2			

Table 4.3.5. Number of scavengers associated with 4 distinctly different fisheries in the North Sea: stern trawlers in subregion NW and NE, beamtrawlers south of 55°N, shrimp trawlers in Dutch coastal waters, and small trawlers in the Kattegat; IBTS February 1993 and from RV Navicula January-February 1993.

Type	n=	Fulm	Gann	Comm Gull	Herr Gull	GBb Gull	Kitt	Total
Stern trawlers	15	7140	192	0	1061	763	1740	10896
		65.5	1.8	0.0	9.7	7.0	16.0	
Beamtrawlers	41	1389	84	25	1214	536	1557	4805
		28.9	1.7	0.5	25.3	11.2	32.4	
Shrimp trawlers*	8	0	0	1195	542	32	3	1772
		0.0	0.0	67.4	30.6	1.8	0.2	
Small trawlers	4	1	0	13	585	75	84	758
		0.1	0.0	1.7	77.2	9.9	11.1	

*Note: 1035 Black-headed Gulls Larus ridibundus at Shrimp trawlers in S

Table 4.4.1. Items experimentally discarded from research vessels in areas of the North Sea during the February IBTS surveys.

Type	Item	NW	NE	CW	C	CE	S	Total
Cephalopod	Octopus	0	0	0	0	0	1	1
	Squid	1	2	3	2	0	1	9
Benthic	Astropecten	0	0	0	2	0	0	2
	Liocarcinus	0	0	0	2	0	0	2
	Nephrops	0	0	0	1	0	0	1
	Seamouse	1	1	0	7	0	0	9
	Starfish	3	2	1	7	0	16	29
	Swimming crab	0	0	0	4	0	2	6
Offal	Offal	480	0	19	40	0	38	577
	Fish eggs/roe	0	0	2	13	0	0	15
	Fish head	0	0	7	31	0	0	38
	Fish tail	0	0	2	0	0	0	2
Flatfish	Anglerfish	3	0	0	0	0	0	3
	Dab	20	2	32	201	28	21	304
	Flatfish	0	0	0	1	0	0	1
	Flounder	0	0	0	0	0	1	1
	Lemon sole	18	0	0	0	0	0	18
	Long rough dab	42	26	4	5	1	0	78
	Norwegian topknot	0	0	0	1	0	0	1
	Plaice	3	0	1	5	1	21	31
	Scaldfish	1	0	0	2	0	0	3
	Sole	0	0	0	3	1	0	4
	Solenette	0	0	0	4	1	1	6
	Witch	0	0	0	1	0	0	1
Roundfish	Allis shad	1	0	0	0	0	0	1
	Bib	0	0	0	1	0	2	3
	Blue whiting	7	0	0	0	0	0	7
	Cod	44	16	2	19	0	3	84
	Dragonet	5	1	0	7	2	1	16
	Greater sandeel	0	0	0	0	1	0	1
	Gurnards	45	3	14	65	2	1	130
	Haddock	455	205	110	180	0	0	950
	Hake	6	0	0	0	0	0	6
	Herring	65	165	119	958	319	94	1720
	Hooknose	0	0	0	3	1	0	4
	Lesser argentine	27	6	0	0	0	0	33
	Lesser weever	0	0	0	0	2	1	3
	Ling	0	0	0	4	0	0	4
	Mackerel	18	0	0	1	0	0	19
	Norway pout	221	35	111	25	0	0	392
	Poor cod	0	3	2	7	0	0	12
	Redfish	4	0	0	0	0	0	4
	Rockling	1	0	0	3	0	0	4
	Saithe	44	0	0	0	0	0	44
	Sandeel	0	0	0	0	2	0	2
	Scad	14	0	0	0	0	0	14
	Sprat	33	0	11	280	37	245	606
	Spurdog	0	0	0	1	0	0	1
	Whiting	404	70	242	360	51	140	1267
Totals								
Cephalopods		1	2	3	2	0	2	10
Benthic animals		4	3	1	23	0	18	49
Offal and fragments		480	0	30	84	0	38	632
Flatfish		87	28	37	223	32	44	451
Roundfish		1394	506	611	1914	415	487	5327
Total all items		1966	539	682	2246	447	589	6469

Table 4.4.2. Quartiles and median lengths of experimental discards (of all types except offal) in each area.

Discard length (cm)	NW	NE	CW	C	CE	S	Total
25 centile	18	17	16	14	13	11	15
Median	24	18	18	16	15	14	18
Rank of median	1	2=	2=	4	5	6	
75 centile	29	23	21	21	19	24	23
Sample size	1486	539	652	2158	447	550	5832
Mean	23.5	20.2	18.8	17.3	16.2	17.7	19.3
Standard error	0.17	0.21	0.17	0.12	0.22	0.31	0.09

Table 4.4.3. Quartiles and medians of fish length (cm) for the ten most abun dant experimental discards, by areas of the North Sea. n = sample size, 25% = 1st quartile, 50% = median, 75% = 3rd quartile. Differences between length distributions were tested by Kruskal-Wallis 1-way ANOVA.

Fish species		NW	NE	CW	C	CE	S	Total	ANOVA	p
Herring	n	65	165	119	958	319	94	1720		
	25%	21	17	15	15	14	24	15	432.8	<0.001
	50%	26	18	15	16	15	25	17		
	75%	29	20	17	19	18	27	20		
Sprat	n	33	0	11	280	37	245	606		
	25%	12	-	8	9	6	10	9	94.5	<0.001
	50%	13	-	9	10	10	11	11		
	75%	13	-	13	11	11	13	12		
Cod	n	44	16	2	19	0	3	84		
	25%	29	27	-	22	-	-	28	19.7	<0.001
	50%	31	30	26	27	-	36	30		
	75%	35	31	-	31	-	-	33		
Haddock	n	455	205	110	180	0	0	950		
	25%	19	16	18	20	-	-	18	176.0	<0.001
	50%	26	18	19	26	-	-	21		
	75%	29	20	20	30	-	-	28		
Whiting	n	404	70	242	361	51	140	1268		
	25%	23	24	17	15	19	17	17	269.1	<0.001
	50%	26	28	21	18	21	24	23		
	75%	29	29	24	23	26	28	27		
N. pout	n	221	35	111	24	0	0	391		
	25%	16	16	15	12	-	-	15	10.6	<0.05
	50%	17	17	17	16	-	-	17		
	75%	17	18	17	17	-	-	17		
gurnards	n	45	3	14	65	2	1	130		
	25%	20	-	19	17	-	-	18	11.8	<0.05
	50%	23	20	24	20	28	-	21		
	75%	26	-	30	24	-	-	25		
Dab	n	20	2	32	201	28	21	304		
	25%	20	-	18	16	11	18	16	63.2	<0.001
	50%	22	22	19	17	13	19	18		
	75%	27	-	21	20	18	22	21		
L.R. Dab	n	42	26	4	5	1	0	78		
	25%	18	17	-	-	-	-	17	4.7	n.s.
	50%	19	22	18	17	-	-	19		
	75%	24	25	-	-	-	-	24		

Table 4.4.4. Total numbers of items of each type discarded in experiments on each research vessel, and the outcome of the trial.

Vessel	Number of discards	Sunk		Consumed		Fate Unknown	
		Number	%	Number	%	Number	%
Scotia	1810	149	8.2	1513	83.5	148	8.2
Tridens/Pelagia	1673	317	18.9	1283	76.7	73	4.4
Dana	1533	47	3.1	1324	86.4	162	10.6
W. Herwig	1453	152	10.5	1246	85.8	55	3.8
Totals	6469	665	10.3	5366	82.9	438	6.8

Table 4.4.5. Fates of discards where the outcome was known, compared among research vessels for each type of discard.

Research vessel	Discard type	Consumed by seabirds Number	%	Sunk Number	%	Total
Scotia	Benthic & Cephalopod	1	20.0	4	80.0	5
	Flatfish	29	52.7	26	47.3	55
	Roundfish	1006	89.4	119	10.6	1125
	Offal	477	100.0	0	0.0	477
Tridens/ Pelagia	Benthic & Cephalopod	5	12.5	35	87.5	40
	Flatfish	9	7.1	118	92.9	127
	Roundfish	1238	88.3	164	11.7	1402
	Offal	31	100.0	0	0.0	31
Dana	Benthic & Cephalopod	1	-	0	-	1
	Flatfish	35	53.0	31	47.0	66
	Roundfish	1191	98.7	16	1.3	1207
	Offal	97	100.0	0	0.0	97
Walter Herwig	Benthic & Cephalopod	2	25.0	6	75.0	8
	Flatfish	59	47.6	65	52.4	124
	Roundfish	1185	93.6	81	6.4	1266
	Offal	0	-	0	-	0
Totals	Benthic & Cephalopod	9	16.7	45	83.3	54
	Flatfish	132	35.5	240	64.5	372
	Roundfish	4620	92.4	380	7.6	5000
	Offal	605	100.0	0	0.0	605

Table 4.4.6. Proportions of experimentally discarded items consumed by scavenging seabirds in each area of the North Sea.

Result	Area NW	NE	CW	C	CE	S	Total
Consumed	1712	463	610	1785	367	427	5364
% of total	92.5	91.1	92.7	87.3	89.3	76.7	89.0
Sunk	139	45	48	259	44	130	665
Total	1851	508	658	2044	411	557	6029

Table 4.4.7. Counts of scavenging seabirds at the research vessel during 100 of the 101 experimental discarding periods (no accurate count was available for 1 bout). Numbers below the count totals for each species are the average per count and the percentage of the total birds represented by each species.

Area		Number of counts	Total birds	Gannet	Gr-Bb Gull	Herring Gull	Fulmar	Kittiwake	Common Gull
NW	Σ	28	15141	1609	1403	1814	6539	3769	0
	mean		540.8	57.5	50.1	64.8	233.5	134.6	0
	%			10.6	9.3	12.0	43.2	24.9	0.0
NE	Σ	9	5613	99	286	331	3008	1886	0
	mean		623.7	11.0	31.8	11.8	334.2	209.6	0
	%			1.8	5.1	5.9	53.6	33.6	0.0
CW	Σ	11	2390	129	78	256	543	1377	4
	mean		217.3	11.7	7.1	23.3	49.4	125.2	0.4
	%			5.4	3.3	10.7	22.7	57.6	0.2
C	Σ	33	4240	89	384	731	813	2166	53
	mean		128.5	2.7	11.6	22.2	24.6	65.6	1.6
	%			2.1	9.1	17.2	19.2	51.1	1.2
CE	Σ	11	1104	1	119	334	124	279	244
	mean		100.4	0.1	10.8	30.4	11.3	25.4	22.2
	%			0.1	10.8	30.3	11.2	25.3	22.1
S	Σ	8	1411	14	183	229	428	539	4
	mean		176.4	1.8	22.9	28.6	53.5	67.4	0.5
	%			1.0	13.0	16.2	30.3	38.2	0.3

Note that small numbers of Lesser Black-backed Gull, Black-headed Gull, and Glaucous Gull are not separately tabulated.

Table 4.4.8. Numbers of experimentally discarded items consumed by each seabird species in each area.

Species	Area NW	NE	CW	C	CE	S	Total
Gannet	486	42	87	87	0	8	710
Great black-backed gull	201	37	28	98	51	40	455
Herring gull	168	62	90	316	109	68	813
Lesser black-backed gull	0	0	0	0	0	5	5
Fulmar	314	13	10	58	4	6	405
Kittiwake	542	309	395	1213	154	299	2912
Common gull	0	0	0	13	49	0	62
Black-headed gull	0	0	0	0	0	1	1
Unidentified seabird	1	0	0	0	0	0	1
Totals	1966	463	610	1785	367	427	5364

Table 4.4.9. Observed and expected numbers of items of offal consumed by species of scavenging seabirds in NW North Sea. Expecteds are calculated from the relative numerical abundance of seabird species at the vessels during discarding experiments.

Species	Number of items of offal consumed Observed	Expected	
Fulmar	290	207.4	
Gannet	3	50.9	
Great Black-backed Gull	1	44.6	
Herring Gull	21	57.6	
Kittiwake	165	119.5	
Totals	480	480.0	$\chi^2 = 161.2$, $p<0.0001$

Table 4.4.10. Numbers of items of experimentally discarded offal consumed by scavenging seabirds during experimental discarding in different areas of the North Sea (no data from areas NE or CE).

Species Area	NW	CW	C	S
Fulmar	290	1	21	2
Gannet	3	4	0	0
Great Black-backed Gull	1	0	0	1
Herring Gull	21	11	0	3
Kittiwake	165	3	17	10
Totals	480	19	38	16

Table 4.4.11. Consumption of experimentally discarded common gadids (Had dock, Whiting, Cod, Saithe, Norway Pout) by scavenging seabirds in each area of the North Sea. Note: S.I. = success index (percent of all gadids that were swallowed by this species divided by percent of all birds present that were this species). Where no birds or very few birds of a species were present the success index is not calculable and is marked -.

Area	Value	Fulmar	Gannet	G-Bb Gull	Herring Gull	Kittiwake	Common Gull	L-Bb Gull	Total
NW	n	18	385	180	125	314	0	0	996
	%	1.8	35.9	18.1	12.6	31.5	0.0	0.0	
	S.I.	0.04	3.39	1.95	1.05	1.27	-	-	
NE	n	11	34	31	34	178	0	0	288
	%	3.8	11.8	10.8	11.8	61.8	0.0	0.0	
	S.I.	0.07	6.56	2.12	2.00	1.84	-	-	
CW	n	7	61	23	49	289	0	0	429
	%	1.6	14.2	5.4	11.4	67.4	0.0	0.0	
	S.I.	0.07	2.63	1.64	1.07	1.17	0.00	-	
C	n	13	51	42	126	222	0	0	454
	%	2.9	11.2	9.3	27.8	48.9	0.0	0.0	
	S.I.	0.06	5.33	1.02	1.62	0.96	0.00	-	
CE	n	0	0	9	19	11	1	0	40
	%	0.0	0.0	22.5	47.5	27.5	2.5	0.0	
	S.I.	0.00	-	2.08	1.57	1.09	0.11	-	
S	n	3	8	31	36	47	0	3	128
	%	2.3	6.2	24.2	28.1	36.7	0.0	2.3	
	S.I.	0.08	6.20	1.86	1.73	0.96	-	2.56	

Table 4.4.12. Observed and expected numbers of experimentally discarded ga dids consumed by Fulmars and by other scavenging seabirds by areas of the North Sea. Expected numbers calculated on the basis of the relative abundances of seabird species at the vessels during experimental discarding.

Consumer	Category	Area	NW	NE	CW	C	CE	S
Fulmars	Observed		18	11	7	13	0	3
	Expected		430.3	154.4	97.4	87.2	4.5	38.8
Others	Observed		978	277	422	441	40	125
	Expected		565.7	133.6	331.6	366.8	35.5	89.2
χ^2			695.6	287.1	108.5	78.1	5.1	47.3
p<			0.001	0.001	0.001	0.001	0.05	0.001

Table 4.4.13. Observed and expected numbers of experimentally discarded gadids consumed by Gannets and by gulls by areas of the North Sea. Expected numbers calculated on the basis of the relative abundances of seabird species at the vessels during experimental discarding.

Consumer	Category	Area	NW	NE	CW	C	CE	S
Gannets	Observed		358	34	61	51	0	8
	Expected		182.9	10.5	29.5	11.5	0	1.8
Gulls	Observed		620	243	361	390	40	117
	Expected		795.1	266.5	392.5	429.5	40	123.2
χ^2			206.2	54.7	36.2	139.3	-	21.7
p<			0.001	0.001	0.001	0.001	-	0.001

Table 4.4.14. Observed and expected numbers of experimentally discarded ga dids consumed by Great Black-backed Gulls, Herring Gulls, Kittiwakes and (where appropriate) Common Gulls, by areas of the North Sea. Expected numbers calculated on the basis of the relative abundances of seabird species at the vessels during experimental discarding.

Consumer	Category Area	NW	NE	CW	C	CE	S
Great B-b.	Observed	180	31	23	42	9	31
	Expected	124.4	27.7	16.6	44.8	4.8	21.9
Herring gull	Observed	125	34	49	126	19	36
	Expected	160.9	32.1	54.2	85.4	13.6	27.5
Kittiwake	Observed	314	178	289	222	11	47
	Expected	334.3	183.2	290.6	253.1	11.4	64.6
Common Gull	Observed	-	-	-	0	1	-
	Expected	-	-	-	6.1	10.0	-
χ^2		34.1	0.6	3.0	29.3	13.9	11.2
p<		0.001	n.s.	n.s.	0.001	0.005	0.005

Table 4.4.15. Consumption of experimentally discarded common clupeids (Herring, Sprat) by scavenging seabirds in the North Sea. Note: S.I. = success index (percent of all fish that were swallowed by this species divided by percent of all birds present that were this species). Where no birds or very few birds of a species were present the success index is not calculable and is marked -.

Area	Value	Fulmar	Gannet	G-Bb Gull	Herring Gull	Kittiwake	Common Gull	L-Bb Gull	Total
NW	n	5	33	2	13	29	0	0	82
	%	6.1	40.2	2.4	15.9	35.4	0.0	0.0	
	S.I.	0.14	3.79	0.26	1.32	1.42	-	-	
NE	n	1	5	3	20	123	0	0	152
	%	0.7	3.3	2.0	13.2	80.9	0.0	0.0	
	S.I.	0.01	1.83	0.39	2.24	2.41	-	-	
CW	n	0	4	2	14	100	0	0	120
	%	0.0	3.3	1.7	11.7	83.3	0.0	0.0	
	S.I.	0.00	0.61	0.52	1.09	1.45	-	-	
C	n	4	1	24	148	948	12	0	1137
	%	0.4	0.1	2.1	13.0	83.4	1.1	0.0	
	S.I.	0.02	0.05	0.23	0.76	1.63	0.92	-	
CE	n	3	0	37	90	142	48	0	320
	%	0.9	0.0	11.6	28.1	44.4	15.0	0.0	
	S.I.	0.08	-	1.07	0.93	1.75	0.68	-	
S	n	1	0	6	29	238	0	2	277
	%	0.4	0.0	2.2	10.5	85.9	0.0	0.7	
	S.I.	0.01	-	0.17	0.65	2.25	-	0.78	

Table 4.4.16. Observed and expected numbers of experimentally discarded clupeids consumed by Fulmars and by other scavenging seabirds by areas of the North Sea. Expected numbers calculated on the basis of the relative abundances of seabird species at the vessels during experimental discarding.

Consumer	Category Area	NW	NE	CW	C	CE	S
Fulmars	Observed	5	1	0	4	3	1
	Expected	35.4	81.5	27.2	218.3	35.8	83.9
Others	Observed	77	151	120	1133	317	276
	Expected	46.6	70.5	92.8	918.7	284.2	193.1
χ^2		45.9	171.4	35.2	260.4	33.8	117.5
p<		0.001	0.001	0.001	0.001	0.001	0.001

Table 4.4.17. Observed and expected numbers of experimentally discarded clupeids consumed by Gannets and gulls by areas of the North Sea. Expected numbers calculated on the basis of the relative abundances of seabird species at the vessels during experimental discarding.

Consumer	Category	Area	NW	NE	CW	C	CE	S
Gannets	Observed		33	5	4	1	0	0
	Expected		14.4	5.7	8.4	29.5	0.3	3.9
Gulls	Observed		44	146	116	1132	315	276
	Expected		62.6	145.3	111.6	1103.5	314.7	272.1
χ^2			29.6	0.09	2.48	28.3	-	3.96
p<			0.001	n.s.	n.s.	0.001	-	n.s.

Table 4.4.18. Observed and expected numbers of experimentally discarded clupeids consumed by Great Black-backed gulls, Herring gulls, Kittiwakes and (where appropriate) Common gulls, by areas of the North Sea. Expected numbers calculated on the basis of the relative abundances of seabird species at the vessels during experimental discarding.

Consumer	Category	Area	NW	NE	CW	C	CE	S
Great B-b.	Observed		2	3	2	24	37	6
	Expected		8.8	16.6	5.3	130.2	38.4	52.4
Herring gull	Observed		13	20	14	148	90	29
	Expected		11.4	19.3	17.4	247.9	108.4	65.8
Kittiwake	Observed		29	123	100	948	142	238
	Expected		23.9	110.1	93.4	734.7	90.6	154.8
Common gull	Observed		-	-	-	12	48	-
	Expected		-	-	-	18.1	78.9	-
χ^2			6.62	12.7	3.19	190.9	44.4	106.4
p<			0.05	0.005	n.s.	0.001	0.001	0.001

Table 4.4.19. Consumption of experimentally discarded common gadids (Haddock, Whiting, Cod, Saithe, Norway Pout) by adult and immature Herring Gulls, Great Black-backed Gull, and Kittiwake in the whole North Sea. Note: S.I. = success index (percent of all gadids that were swallowed by this age group, divided by percent of all birds present that were this age group; 'immature' includes subadults and juveniles).

	Herring Gull		Great Bl-b Gull		Kittiwake	
	ad	imm	ad	imm	ad	imm
n	238	136	202	107	739	92
%	59.6	40.4	58.7	41.3	94.4	5.6
S.I.	1.07	0.90	1.11	0.84	0.94	1.98

Table 4.4.20. Consumption of experimentally discarded common clupeids (Herring, Sprat) by adult and immature Herring Gulls, Great Black-backed Gull, and Kittiwake in the whole North Sea. See table 6.4.19 for conventions.

	Herring Gull		Great Bl-b Gull		Kittiwake	
	ad	imm	ad	imm	ad	imm
n	184	127	21	53	1059	244
%	53.0	47.0	53.1	46.9	89.6	10.4
S.I.	1.12	0.87	0.53	1.53	0.91	1.80

*Table 4.4.21. Lengths (cm) of experimentally discarded gadids (Haddock, Whiting, Saithe, Cod, Norway Pout) which sank and those which were consumed by different scavenging seabirds in the NW area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
11		3					10	
12				1			8	
13							6	1
14	1			3			24	
15	1	3	1	6			35	
16	3	15	1	9			64	2
17	1	18		9			60*	
18	4	11		4			45	2
19	7	6	2	5			19	1
20	1	6	4	6			14	1
21	1	11	2	2			7	2*
22		8	1	3			8	1
23		15	6	10			10	2
24	2	11	13	9*			4	3
25	2	12	11	15				1
26	5	27	11	18				
27	4	25	18	9				
28	10*	42*	13	7				1
29	6	22	21*	4				
30	6	24	16	2				
31	6	34	11	3				1
32	7	13	20					
33	1	10	12					
34	1	10	4					
35	2	9	9					
36	1	9	3					
37	1	9	1					
38	3	3						
39		2						
Total	76	358	180	125	0	0	314	18

*Table 4.4.22. Lengths (cm) of experimentally discarded gadids (Haddock, Whiting, Saithe, Cod, Norway Pout) which sank and those which were consumed by different scavenging seabirds in the NE area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
11	1							
12							2	
13							3	
14							13	3
15							22	1
16							32	
17				2			33*	1
18				3			29	
19		1		1			21	
20	1			5			17	
21	1		1	3			4	
22				2				
23		2	2	4*				
24	1	3	3	1			1	
25	2	2	1	2				
26	2	4	5	3				
27	3*	2	3	2				1*
28	1	7*	2*	2				1
29	1	2	8	2				3
30	5	5	2	2				
31	1	6						1
32			2					
33			1					
34			1				1	
Total	19	34	31	34	0	0	178	11

*Table 4.4.23. Lengths (cm) of experimentally discarded gadids (Haddock, Whiting, Saithe, Cod, Norway Pout) which sank and those which were consumed by different scavenging seabirds in the CW area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
10							1	
11								
12							9	
13							8	
14	1	1					18	
15	3	4		1			33	
16	2	1					21	
17	3*	6		5			63*	
18	1	4		3			40	
19	1	2		2			33	1
20	4	1	5	5			12	
21		6		4			19	
22		3	2	6*			14	1
23		5*	2	4			14	
24		2	2	8			2	2*
25		6	4*	5			2	1
26		3	2	1				1
27		3	3	1				
28	1	3	1	1				
29				1				1
30	1	3	1					
31		3		1				
32		2						
33		1	1					
34								
35		1		1				
36		1						
Total	17	61	23	49	0	0	289	7

*Table 4.4.24. Lengths (cm) of experimentally discarded gadids (Haddock, Whiting, Saithe, Cod, Norway Pout) which sank and those which were consumed by different scavenging seabirds in the C area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
10							1	
11							3	
12	1			1			11	
13	1		1	1			23	
14	1			2			20	
15	1	1		3			39	
16		1	2	8			35*	1
17	1			2			24	1
18		1	1	9			21	2
19	4	2	2	9			17	
20	2	1	2	6			12	1
21	2	1	6	9			8	1
22		2	4	16*			4	1*
23	2	3	6*	17				2
24	2			6			2	4
25	3	1	3	5			1	
26	4	2		7			1	
27	10*	2	6	10				
28	8	3	3	6				
29	5	2	2	1				
30	5	3	1	2				
31	8	3*	1	3				
32	1	3						
33	2	7	1	1				
34	2	5	1	1				
35		4						
36	1	2						
37	1							
38				1				
39		1						
40		1						
Total	67	51	42	126	0	0	222	13

*Table 4.4.25. Lengths (cm) of experimentally discarded gadids (Haddock, Whiting, Saithe, Cod, Norway Pout) which sank and those which were consumed by different scavenging seabirds in the CE area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
12								
13				1				
14			1					
15								
16			1				1	
17			3*	1			1	
18				1			1	
19				1			3*	
20				2		1	3	
21	1			1			2	
22			1					
23				1				
24				1				
25				3*				
26	2*		1	1				
27				4				
28			1					
29	1			1				
30				1				
31								
Total	4		9	19		1	11	

*Table 4.4.26. Lengths (cm) of experimentally discarded gadids (Haddock, Whiting, Saithe, Cod, Norway Pout) which sank and those which were consumed by different scavenging seabirds in the S area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
10								
11				1			2	
12							1	
13							2	
14				1			5	
15				1			2	
16							8	1
17				1			6*	
18			1		1		7	
19				4			2	
20				2			6	
21				2				
22				1			1	
23		1	1	2			1	
24				5*	2			
25			2	6				
26	1	1	7	2				
27	1			2				
28	1	1	8*	3				2
29	1		2	2				
30	1*		4					
31		2*	2	1				
32	1		2					
33		1	1					
34	1							
35			1					
36	1	2						
37								
38	1							
39								
Total	9	8	31	36	3	0	47	3

*Table 4.4.27. Lengths (cm) of experimentally discarded clupeids (Herring, Sprat) which sank and those which were consumed by different scavenging seabirds in the NW area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
5								
6								
7								
8								
9								
10								
11							1	
12	1			5			9	
13	2			2*			12*	2
14							2	
15								
16								
17				1				
18								
19	2	1		2			1	
20		1		1			3	
21	3*			1			1	
22								1*
23		1		1				
24	1	2						
25		1	1					1
26		2						
27		2						1
28		5						
29	1	9*						
30		8						
31	1	1						
32								
33								
34			1					
35								
36								
Total	11	33	2	13	0	0	29	5

*Table 4.4.28. Lengths (cm) of experimentally discarded clupeids (Herring, Sprat) which sank and those which were consumed by different scavenging seabirds in the NE area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
13								
14								
15							1	
16							5	
17				2			40	
18				2			48*	
19	1						14	
20				2			7	
21				1			3	
22				2			2	
23			1	4*			2	
24		1		2			1	
25	3*	4*	2*	3				1
26	1							
27				1				
28				1				
29								
30								
31								
32								
Total	5	5	3	20			123	1

*Table 4.4.29. Lengths (cm) of experimentally discarded clupeids (Herring, Sprat) which sank and those which were consumed by different scavenging seabirds in the CW area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
5								
6								
7							1	
8							2	
9							3	
10							1	
11	1						1	
12								
13	2						6	
14	2*	1		1			14	
15	2		1	4			33*	
16		2*		2*			14	
17	2			3			10	
18				3			4	
19								
20		1					1	
21				1			3	
22							2	
23							5	
24			1					
25								
26								
27								
28								
29								
30								
31								
32								
33								
Total	9	4	2	14			100	

*Table 4.4.30. Lengths (cm) of experimentally discarded clupeids (Herring, Sprat) which sank and those which were consumed by different scavenging seabirds in the C area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
5							4	
6						1	17	
7	3			2			8	
8	1			2		1	23	
9				3		3	39	
10	3			2		2*	66	
11	1		1	2		1	48	
12	3			5		1	59	1
13	1			6		1	84	
14				4			88	
15	2		2	12			134*	1
16			1	14		2	153	
17			2	9			73	
18	1	1	2	4			48	
19	1		3	9*			19	
20	1		3*	15			25	
21	8*		2	12			25	
22	5		2	20			19	
23	5		4	20			13	2
24	3		2	6			2	
25	1			1				
26							1	
27								
Total	39	1	24	148		12	948	4

*Table 4.4.31. Lengths (cm) of experimentally discarded clupeids (Herring, Sprat) which sank and those which were consumed by different scavenging seabirds in the CE area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
5								
6						1	11	
7							2	
8				1				
9							1	1
10	1			2			7	
11	4			3		1	6	1*
12	1		3	3		3	11	
13	12*			2		13	15	
14	11		3	14		8*	15	1
15	1		2	10		11	19*	
16			5	16*		7	12	
17			4	10		1	9	
18				10			6	
19			3*	10			1	
20			3	2		2	10	
21			4			1	7	
22			3	3			2	
23	2		6	3			8	
24			1	1				
25								
26								
27								
28								
29								
30								
Total	32		37	90		48	142	3

*Table 4.4.32. Lengths (cm) of experimentally discarded clupeids (Herring, Sprat) which sank and those which were consumed by different scavenging seabirds in the S area of the North Sea. Median values are marked with *.*

Fish length	Sunk	Gannet	G Bb Gull	Herring Gull	L Bb Gull	Common Gull	Kittiwake	Fulmar
5								
6							1	
7							1	
8				1			11	
9				4			28	
10							36	
11				2			46*	
12	2			2			43	
13	1			3			37	
14				1			27	
15								
16							1	
17	1							
18							2	
19								
20								
21								
22								
23	6						3	1
24	16		1		2		2	
25	11*		1	5*				
26	9		1	1				
27	4		1	3				
28	6		1	5				
29	2		1	2				
30	4							
31								
Total	62		6	29	2		238	1

Table 4.4.33. Minimum, median and maximum of fish length (cm) for the seven most abundant experimental discards. n = sample size. Differences between length choices were tested by Kruskal-Wallis 1-way ANOVA.

		offered	sunk	FUL	GAN	HG	GBB	K	ANOVA	p
Herring	n	1650	133	11	43	270	73	1069		
	min	8	10	9	14	10	12	8	250	<0.0001
	median	16	23	23	28	19	20	16		
	max	34	31	27	31	29	34	26		
Sprat	n	596	25	3	0	44	1	511		
	min	5	7	13		7		5	9.5	<0.05
	median	11	12	13		12	11	11		
	max	16	14	15		15		16		
Haddock	n	875	104	10	196	107	116	342		
	min	11	11	14	16	12	15	11	471.4	<0.0001
	median	21	27	19.5	28	22	27	17.5		
	max	40	39	29	40	35	36	23		
Whiting	n	1179	43	35	230	259	160	447		
	min	8	13	15	15	11	13	8	647	<0.0001
	median	23	28	24	28	24	27	17		
	max	40	38	31	37	31	36	26		
N. Pout	n	363	10	5	58	18	2	270		
	min	10	14	13	11	15	16	10	9.1	n.s.
	median	17	17	17	17	17	17.5	16		
	max	22	19	18	21	21	19	22		
Gurnards	n	99	13	1	35	25	18	6		
	min	8	18		15	8	12	12	26.1	<0.0001
	median	21	25	27	23	18	21.5	17.5		
	max	38	38		35	25	35	29		
Dab	n	247	169	2	43	11	21	1		
	min	9	10	9	12	9	9		17.3	<0.01
	median	19	18	11.5	19	18	17	13		
	max	29	29	14	23	23	21			

Table 4.4.34. Frequency of robbing of experimentally discarded items by one bird from another; combined data for all 101 North Sea experimental discarding sessions.

Discard length (cm)	Number of birds handling fish before it is swallowed							Percent stolen of items handled by			
	1+	2+	3+	4+	5+	6+	7+	1st	2nd	3rd	4th
<10	313	16	2	0	0	0	0	5	12	0	0
11-15	1245	68	11	4	1	0	0	6	16	36	25
16-20	1743	245	70	25	12	5	3	14	29	36	48
21-25	820	269	105	35	14	4	1	33	39	33	40
26-30	526	171	72	30	12	5	2	33	42	42	40
>31	288	88	32	12	8	3	2	31	36	38	67

Table 4.4.35. Vulnerability to robbery index (Number of experimental discards stolen from this species divided by the number of experimental discards stolen by this species).

Species	Vulnerability to robbery index in North Sea Area						
	NW	NE	CW	C	CE	S	Total
Kittiwake	10.0	21.0	10.0	21.8	34.0	5.6	13.5
Fulmar	1.8	1.7	1.7	1.4	0.0	0.4	1.5
Common Gull	-	-	-	2.0	0.3	-	0.6
Herring Gull	1.2	0.2	0.4	0.4	0.5	0.9	0.5
Gannet	0.3	0.3	0.3	0.0	-	0.0	0.3
Lesser Black-backed Gull	-	-	-	-	-	0.2	0.2
Great Black-backed Gull	0.2	0.1	0.1	0.1	0.1	0.1	0.1

Table 6.1. Estimated quantities of Haddock and Whiting discarded in the North Sea, 1971-1990 (from Gislason 1993, quoting Anon. 1992).

Year	Haddock		Whiting		Combined
	Numbers (millions)	Weight ('000 tonnes)	Numbers (millions)	Weight ('000 tonnes)	Weight ('000 tonnes)
1971	1282	177	458	63	240
1972	760	128	398	67	195
1973	660	115	659	110	225
1974	1091	167	477	85	252
1975	1862	260	699	135	395
1976	788	154	641	136	290
1977	226	44	547	163	207
1978	418	77	240	35	112
1979	286	42	640	77	119
1980	541	95	466	76	171
1981	298	60	210	35	95
1982	181	41	168	26	67
1983	389	66	360	48	114
1984	412	75	317	39	114
1985	458	86	226	28	114
1986	308	52	572	78	130
1987	334	59	408	53	112
1988	362	62	227	28	90
1989	111	26	275	35	61
1990	192	33	524	54	87

Table 6.2. Number and size of fish (length in cm) discarded from whi tefish trawlers in Shetland April-September 1985. Data from Hudson (1986).

Fish length	Haddock	Whiting	LRDab	Red gurnard	Lemon sole	Grey gunard	Witch	Cod	Saithe
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	1	1	0	1	0	0	0	0
15	1	2	6	1	0	0	1	0	0
16	0	2	27	6	1	0	5	0	0
17	1	1	58	9	2	9	2	0	0
18	5	0	67	16	8	0	1	0	0
19	9	2	71	18	15	0	10	0	0
20	30	5	101	50	22	0	0	0	0
21	39	5	89	71	35	0	4	0	0
22	74	18	52	71	57	1	7	0	0
23	133	35	60	77	53	2	3	0	0
24	160	76	44	55	39	3	8	1	0
25	207	137	30	49	34	4	7	4	0
26	261	238	31	45	16	10	2	3	0
27	347	325	21	32	11	6	4	6	0
28	411	439	23	23	14	17	10	6	0
29	419	386	14	23	5	10	10	10	0
30	333	331	11	12	5	18	2	7	0
31	226	237	13	7	1	26	4	4	1
32	111	151	6	0	2	20	7	10	0
33	59	117	5	0	0	22	1	9	3
34	18	41	0	0	0	17	1	4	5
35	10	22	0	0	0	14	0	1	0
36	2	11	2	0	0	5	0	2	4
37	1	2	0	0	0	6	1	6	2
38	1	4	0	0	0	9	0	9	1
39	1	1	0	0	0	1	0	4	7
40	0	0	0	0	0	1	0	2	2
41	0	0	0	0	0	0	0	0	5
42	0	0	0	0	0	3	0	0	2
43	0	0	0	0	0	1	0	0	3
44	0	0	0	0	0	3	0	0	1
45	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	1
	2859	2589	732	565	321	199	90	88	37

(table 6.2. continued)

Fish length	Norway Pout	Megrim	Herring	Plaice	Lesser Arg.	Scad	Mackerel	Skate	Angler
12	1	0	0	0	0	0	0	0	0
13	3	0	0	0	0	0	0	0	0
14	4	0	0	0	1	0	0	0	0
15	6	0	0	0	0	0	0	0	0
16	11	0	0	0	0	0	0	0	0
17	3	0	0	0	0	0	0	0	0
18	3	0	1	0	0	0	0	0	0
19	1	0	0	0	0	0	0	0	0
20	3	2	0	0	1	0	0	0	0
21	0	1	0	1	3	0	0	0	0
22	0	2	1	0	2	0	0	0	0
23	0	2	1	0	2	1	0	0	0
24	1	0	4	1	1	0	0	0	1
25	0	1	2	2	0	0	0	0	0
26	0	0	3	3	0	0	0	0	1
27	0	2	1	2	0	3	0	0	0
28	0	2	1	2	0	0	0	0	0
29	0	1	0	1	0	0	0	0	0
30	0	3	1	0	0	1	0	0	0
31	0	1	0	0	0	0	0	0	0
32	0	1	0	1	0	0	1	0	0
33	0	2	0	1	0	0	0	0	0
34	0	0	0	0	0	1	1	0	1
35	0	0	0	0	0	1	0	1	0
36	0	2	0	0	0	2	0	0	0
37	0	0	0	0	0	0	1	0	0
38	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	1	1	0
43	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	1	0
45	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0
	36	22	15	14	10	9	4	3	3

In addition, one 43 cm Hake, one 43 cm Ling and one 27 cm Dragonette were discarded.

Table 6.3. Masses of discarded fish (tonnes) in the southern North Sea beamtrawl fisheries for sole, estimated from data in Anon. (1992a), Garthe (1992), Grainger (1992) and Will (1992). Discards estimated at 5x sole landings (by mass).

Year	ICES area	Sole landings	discards
1988	IVa	15	75
	IVb	5594	27970
	IVc	7754	38770
	IVabc	13363	66815
	IIIa	784	3920
1990	IVabc	34800	174000

Table 6.4. Species composition of discards sampled in 1985 compared with species composition sampled in 1987. From Furness (1987).

Fish species	Percent of total sample 1985	1987
Haddock	37.6	57.9
Whiting	34.0	18.8
L.R. Dab	9.6	3.4
Red Gurnard	7.4	7.5
Lemon Sole	4.2	2.8
Grey Gurnard	2.6	0
Cod	1.2	3.9
Witch	1.2	2.3
Norway Pout	0.5	1.6
Saithe	0.5	0.1
Megrim	0.3	0.1
Herring	0.2	0.9
Plaice	0.2	0.6
9 other species	<0.1	<0.1
Total discards sampled	7605	5305

Other species: Angler, Dragonette, Hake, Scad, Lesser argentine, Ling, Mackerel, Monkfish, Skate.

Table 6.5. Lengths of Haddock Melanogrammus aeglefinus discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	%	June/July 1987 n	%
15	1	0.1	0	0.0
16	1	0.1	0	0.0
17	5	0.4	1	0.1
18	5	0.4	3	0.2
19	4	0.3	11	0.6
20	6	0.5	32	1.8
21	2	0.2	60	3.3
22	8	0.6	74	4.1
23	26	2.0	101	5.6
24	67	5.3	96	5.3
25	88	6.9	152	8.4
26	124	9.8	211	11.7
27	179	14.1	283	15.7
28	269	21.2	279	15.5
29	254	20.0	276	15.3
30	159	12.5	142	7.9
31	57	4.5	66	3.7
32	15	1.2	11	0.6
33	0	0.0	2	0.1
34	1	0.1	0	0.0
35	0	0.0	2	0.1
Total	1271		1802	
median	28		27	
mean	27.6		26.6	
S.E.	0.1		0.1	

Table 6.6. Lengths of Whiting Merlangius merlangus discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	April 1987 %	June/July 1987 n	June/July 1987 %
13	1	0.2	0	0.0
14	0	0.0	0	0.0
15	0	0.0	0	0.0
16	0	0.0	0	0.0
17	0	0.0	0	0.0
18	0	0.0	0	0.0
19	0	0.0	0	0.0
20	1	0.2	1	0.2
21	2	0.4	3	0.6
22	15	2.9	10	2.1
23	31	6.1	21	4.3
24	37	7.2	33	6.8
25	47	9.2	48	9.9
26	55	10.8	67	13.8
27	63	12.3	97	20.0
28	69	13.5	93	19.1
29	84	16.4	64	13.2
30	49	9.6	34	7.0
31	42	8.2	11	2.3
32	14	2.7	3	0.6
33	0	0.0	0	0.0
34	1	0.2	1	0.2
35	0	0.0	0	0.0
Total	511		486	
median	28		27	
mean	27.8		26.9	
S.E.	0.1		0.1	

Table 6.7. Lengths of Red Gurnard Aspitrigla cuculus discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	April 1987 %	June/July 1987 n	June/July 1987 %
14	1	0.7	0	0.0
15	2	1.3	4	1.6
16	6	4.0	16	6.5
17	14	9.4	37	14.9
18	10	6.7	51	20.6
19	16	10.7	27	10.9
20	14	9.4	43	17.3
21	17	11.4	22	8.9
22	19	12.8	17	6.9
23	17	11.4	7	2.8
24	13	8.7	8	3.2
25	7	4.7	7	2.8
26	5	3.4	2	0.8
27	7	4.3	1	0.4
28	0	0.0	3	1.2
29	1	0.7	2	0.8
30	0	0.0	0	0.0
31	0	0.0	0	0.0
32	0	0.0	0	0.0
33	0	0.0	0	0.0
34	0	0.0	1	0.4
Total	149		248	
median	21		19	
mean	21.1		19.6	
S.E	0.3		0.2	

Table 6.8. Lengths of Cod Gadus morhua discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	April 1987 %	June/July 1987 n	June/July 1987 %
15	0	0.0	0	0.0
16	0	0.0	0	0.0
17	0	0.0	0	0.0
18	0	0.0	0	0.0
19	0	0.0	0	0.0
20	0	0.0	1	0.5
21	0	0.0	3	1.6
22	0	0.0	3	1.6
23	3	16.7	4	2.1
24	1	5.6	3	1.6
25	0	0.0	12	6.3
26	0	0.0	10	5.3
27	0	0.0	15	7.9
28	0	0.0	19	10.0
29	2	11.1	18	9.5
30	3	16.7	27	14.2
31	2	11.1	24	12.6
32	1	5.6	24	12.6
33	3	16.7	18	9.5
34	0	0.0	6	3.2
35	3	16.7	2	1.1
36	0	0.0	1	0.5
Total	18		190	
median	30.5		30	
mean	29.9		29.3	
S.E.	1.0		0.2	

Table 6.9. Lengths of Norway Pout Trisopterus esmarkii discarded from white fish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	April 1987 %	June/July 1987 n	June/July 1987 %
12	0	0	1	1.2
13	0	0	5	6.3
14	1	25	25	31.3
15	2	50	21	26.2
16	1	25	7	8.7
17	0	0	13	16.2
18	0	0	5	6.3
19	0	0	3	3.7
20	0	0	0	0.0
Total	4		80	
median	15		15	
mean	15.0		15.3	
S.E	0.4		0.2	

Table 6.10. Lengths of Long Rough Dab Hippoglossoides platessoides discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	April 1987 %	June/July 1987 n	June/July 1987 %
14	2	1.2	0	0.0
15	3	1.8	2	14.3
16	9	5.4	0	0.0
17	10	6.0	1	7.1
18	22	13.2	1	7.1
19	14	8.4	1	7.1
20	16	9.6	4	28.6
21	16	9.6	1	7.1
22	17	10.2	1	7.1
23	17	10.2	0	0.0
24	7	4.2	2	14.3
25	6	3.6	0	0.0
26	5	3.0	0	0.0
27	8	4.8	0	0.0
28	4	2.4	1	7.1
29	5	3.0	0	0.0
30	4	2.4	0	0.0
31	1	0.6	0	0.0
32	1	0.6	0	0.0
Total	167		14	
median	21		20	
mean	21.4		20.2	
S.E.	0.3		1.0	

Table 6.11. Lengths of Lemon Sole Microstomus kitt discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	April 1987 %	June/July 1987 n	June/July 1987 %
14	0	0.0	0	0.0
15	1	0.7	0	0.0
16	1	0.7	0	0.0
17	2	1.4	0	0.0
18	6	4.3	0	0.0
19	5	3.6	0	0.0
20	8	5.8	0	0.0
21	13	9.4	0	0.0
22	29	21.0	3	23.1
23	23	16.7	1	7.7
24	16	11.6	2	15.4
25	13	9.4	4	30.8
26	6	4.3	2	15.4
27	2	1.4	1	7.7
28	4	2.9	0	0.0
29	3	2.2	0	0.0
30	3	2.2	0	0.0
31	3	2.2	0	0.0
Total	138		13	
median	23		25	
mean	23.0		24.3	
S.E.	0.3		0.5	

Table 6.12. Lengths of Plaice Pleuronectus platessa discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length	April 1987		June/July 1987	
(cm)	n	%	n	%
17	1	3.4	0	0.0
18	0	0.0	0	0.0
19	0	0.0	0	0.0
20	0	0.0	0	0.0
21	0	0.0	0	0.0
22	2	6.9	0	0.0
23	1	3.4	0	0.0
24	5	17.2	0	0.0
25	4	13.8	0	0.0
26	2	6.9	1	50.0
27	3	10.3	0	0.0
28	2	6.9	0	0.0
29	1	3.4	1	50.0
30	3	10.3	0	0.0
31	2	6.9	0	0.0
32	0	0.0	0	0.0
33	1	3.4	0	0.0
34	0	0.0	0	0.0
35	0	0.0	0	0.0
36	1	3.4	0	0.0
45	1	3.4	0	0.0
Total	29		2	
median	26		-	
mean	27.2		-	
S.E.	1.0		-	

Table 6.13. Lengths of Witch Glyptocephalus cygnoglossus discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length	April 1987		June/July 1987	
(cm)	n	%	n	%
14	2	1.7	0	0
15	5	4.2	0	0
16	9	7.5	0	0
17	12	10.0	0	0
18	16	13.3	0	0
19	21	17.5	0	0
20	8	6.7	0	0
21	15	12.5	0	0
22	9	7.5	0	0
23	8	6.7	1	100
24	5	4.2	0	0
25	4	3.3	0	0
26	3	2.5	0	0
27	1	0.8	0	0
28	0	0.0	0	0
29	1	0.8	0	0
30	0	0.0	0	0
31	0	0.0	0	0
32	1	0.8	0	0
Total	120		1	
median	19		-	
mean	19.8		-	
S.E.	0.3		-	

Table 6.14. Lengths of Herring Clupea harengus discarded from whitefish boats around Shetland in April 1987 and June/July 1987. From Furness (1987).

Fish length (cm)	April 1987 n	%	June/July 1987 n	%
20	1	2.1	0	0
21	1	2.1	0	0
22	7	14.6	0	0
23	9	18.8	1	100
24	11	22.9	0	0
25	10	20.8	0	0
26	4	8.3	0	0
27	2	4.2	0	0
28	2	4.2	0	0
29	0	0.0	0	0
30	1	2.1	0	0
Total	48		1	
median	24		-	
mean	24.2		-	
S.E.	0.3		-	

Table 6.15. Length composition of Haddock and Whiting discards (thousands) by all fleets in the North Sea fishing for haddock and whiting. Data from Furness (1992), based on estimates made by Scottish Office Agriculture and Fisheries Department (SOAFD) for mesh size 90mm and current levels of fishing effort, using Scottish discards data.

Fish length (cm)	Haddock Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Whiting Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
10	0	0	16	183	916	0	996	863
11	0	0	160	123	2135	1276	919	1510
12	4	1	222	189	4278	2832	725	1798
13	21	9	284	850	7534	4201	630	2499
14	239	44	107	1484	8472	4764	468	2534
15	613	138	57	1488	8526	4496	481	2184
16	785	251	53	986	7206	4450	652	1507
17	727	406	211	644	5489	4688	918	897
18	580	499	517	557	3642	5272	2740	1053
19	635	685	1253	493	2406	6200	3990	1790
20	1110	1254	2446	773	1818	6784	9409	4548
21	2126	2470	3283	1736	2119	7214	12757	10409
22	3325	3990	4333	3201	3865	7625	16667	15294
23	4154	5186	5003	4888	6024	9376	15217	18702
24	4371	5878	5334	5821	9303	10115	14944	18478
25	4652	5787	5896	6525	11014	10787	13474	15487
26	4857	5494	6195	7295	12218	10840	12448	13063
27	4746	4642	5727	6370	10759	9049	10075	8424
28	3954	3619	4771	4555	7364	6825	6439	4225
29	2747	2381	3733	3120	4668	3952	3776	2173
30	1648	1368	2149	2193	2330	2217	1460	1255
31	868	668	891	1151	835	1135	533	544
32	383	284	243	490	232	427	202	186
33	93	117	65	218	104	193	54	79
34	9	39	11	72	33	29	17	19
35	6	14	2	24	12	0	6	3
36	0	7	4	7	1	1	0	1
37	0	1	0	6	0	0	0	1
38	0	1	0	3	0	0	0	2
39	0	0	0	3	0	0	0	0
40	0	0	0	3	0	0	0	0

Table 6.16. Calculation of the numbers of 1000g scavenging seabirds that could be supported by offal and discards in the North Sea during recent years (data intended to be appropriate for the years 1985-92). See text for derivation of input data and assumptions made. Note that the estimates are based on input data of low accuracy (especially estimates of discard masses) and so the confidence intervals for these estimates will be wide.

Discard	Mass (tonnes)	Calorific value (kJ/g)	Consumption rate by seabirds	Number of 1000g seabirds supported
Offal	83,700	10	90%	1,146,000
Roundfish	146,000	5	80%	880,000
Flatfish	148,000	4	20%	180,000
Benthic inverts.	100,000	2.5	10%	38,000
Totals				2,244,000

CONTENTS