# Sea- and coastal bird data as tools in the policy and management of Belgian marine waters

Het gebruik van zee- en kustvogelgegevens ter ondersteuning van het beleid en beheer van de Belgische kustwateren

Jan Seys

*Proefschrift voorgelegd tot het behalen van de graad van doctor in de Wetenschappen, groep Biologie*

*Promotor*: *prof. dr. Eckhart Kuijken*
*Co-promotor: prof. dr. Patrick Meire*
*prof. dr. Magda Vincx*

**oktober 2001**
Universiteit Gent
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# Stellingen:

1. Het woord ‘indicator’ heeft een hoge marktwaarde. Ecologen promoten dan ook maar al te graag hun favoriete dier- of plantengroep als dé perfecte indicator. Maar zoals met modewoorden wel vaker het geval is, neemt men het soms wel eens te vlot in de mond, zonder echt goed te weten wat het betekent. Te vergelijken met de mop die verteld wordt op een receptie en waar iedereen hartelijk mee lacht.... zonder hem echt te snappen.

2. De zeevogelverspreiding in het zuidelijkste deel van de Noordzee wordt vooral bepaald door een land-zee en een west-oost gradiënt. Helder diep water in de richting van het Kanaal trekt met name alkachtigen, Drieteenmeeuwen en Jan van Genten aan; ondieper en troebel water in de estuariene pluim van de Schelde is dan weer geliefd bij duikers, futen en allerhande meeuwen. Het globale beeld wordt vertroebeld door voortdurende verplaatsingen van meeuwen ten gevolge van visserijactiviteiten en onder invloed van kortstondige voedelassociaties tussen soorten. De verspreiding van pelagische vis in functie van de hydrografie is dé grote onbekende in het zoeken naar sluitende verklaringen voor de verspreiding van de overwegend visetende zeevogels in het Belgisch deel van de Noordzee.

3. Zeevogels zijn zeer geschikt als conditie-indicatoren voor oppervlakteverontreiniging van de zee en als compositie-indicatoren voor verschillende lagere trofische niveaus. Ze zijn verspreid en talrijk aanwezig en relatief gemakkelijk te tellen. Bovendien kan men terugvallen op uitgebreide databanken en op de steun van een enthousiast vrijwilligerspubliek bij het uitvoeren van tellingen.

4. Ook onder de zeevogels zijn er eenzaten en vlotte jongens, kwetsbaren en opportunisten. Associaties tussen soorten zijn veeleer beperkt en van korte duur. Het lijkt dan ook weinig zinvol bepaalde soorten als paraplusoort voor andere zeevogels te gebruiken.

5. Binnen de relatief soortenarme zeevogelgemeenschappen van de zuidelijke Noordzee, brengt een waardebeoordeling op basis van biodiversiteit weinig zoden aan de dijk.

6. Lange-termijn monitoring van zeevogels op vaste ferry-routes is enkel zinvol als ook kritisch wordt gekeken naar ongewenste neveneffecten van waarnemersverschillen en weersfactoren. Voor dit doel dringt een verdere optimalisatie van de telmethode zich op.

7. Onze kustwateren zijn meer dan een bemeste en omgeploegde onderwaterakker. De uitzonderlijke rijkdom zowel op geomorfologisch, cultuurhistorisch als ecolologisch vlak worden schromelijk onderschat. Niet alleen komen er elf soorten zeevogels voor in internationaal belangrijke aantallen en biedt onze kust onderdak aan enkele van de allergrootste sternenkolonies van Europa. Het zuidelijkste deel van de Noordzee is ook een doortrektunnel voor naar schatting 1-1,3 miljoen zeevogels.

8. Een degelijk ruimtelijk Noordzeebeleid ontbreekt. Marien beschermde gebieden zijn er nodig om - net als op het land - de aanwezige natuurwaarden te vrijwaren en te versterken. Om succesvol te zijn dienen ze ontwikkeld te worden in nauw overleg met alle gebruikers van de zee. Afhankelijk van de noodzaak kunnen beperkte, dan wel meer ingrijpende beheersmaatregelen nodig blijken om minstens voor de meest kwetsbare zeevogelsoorten een vorm van ‘bestaansminimum’ te kunnen garanderen.

9. Gemiddeld wordt slechts 10-20% van alle vogels die sterven op zee bij wekelijkse tellingen op het strand aangetroffen. Er is nood aan bijkomend experimenteel- en modelmatig onderzoek om geval per geval te kunnen oordelen hoe deze sterfte op zee zich verhoudt tot de aantallen gevonden kadavers op het strand. Met name het ‘gedrag’ van een gezonken kadaver verdient bijzondere aandacht.

10. De Noordzee is anno 2001 nog steeds ‘half zo zwart’ als 40 jaar terug. De moeilijkste helft staat nu voor de deur…

11. Met doorgedreven aselectieve strandreinigingen tijdens de winter ontneem je de overheid het instrument om olieverontreiniging van diezelfde stranden te bestrijden. Beter één dode vogel in de hand, dan tien onder ’t zand.

12. De zwarte WC-eend (zie voorkaft) is een minder bruikbare indicator voor mariene olieverontreiniging dan de zwarte zeeëend, enkel en alleen omdat hij zeldzamer is.

13. De olieslachtoffers die verzameld worden aan onze kust geven vooral aanwijzingen over wat fout gaat in Franse wateren.

# WOORD VAN DANK

Dit woord van dank kwam er ruimschoots een maand voor indienen, als gevolg van een niet helemaal onbewuste keuze. Dit werk is immers - waarschijnlijk nog meer dan veel van zijn voorgangers - het product van een intense samenwerking tussen uitvoerende en financierende instellingen, van een tomeloze inzet van honderden vrijwillige tellers en van een onmisbare logistieke en morele steun van velen. Door iets langer op dit ei te broeden wou ik alvast het risico verkleinen belangrijke schakels te vergeten in deze welgemeende dankbetuiging. Hopelijk is dit gelukt.

Eerst en vooral zijn er de meer dan tweehonderd (!) plaatselijke vogelliefhebbers die weer, wind, golfslag en luchtzakken trotseerden bij het assisteren bij zeevogeltellingen vanop schepen of uit kleine vliegtuigjes, en sinds 1962 samen zo'n 8000 km strand afschuimden op zoek naar 'stookolieslachtoffers'. Ook de tientallen personen die zich de moeite getroostten om één van de op zee uitgeworpen, gelabelde vogelkadavers terug te melden bij vondst op het strand, ben ik bijzonder erkentelijk voor hun cruciale bijdrage aan de wetenschap.

Het is een ware eer en genoegen prof. dr. Eckhart Kuijken als promotor te mogen voordragen. Dat hij met een dergelijk druk programma hiervoor alsnog de tijd vond, heeft ongetwijfeld veel van doen met het hem kenmerkende en aanstekelijke idealisme en met een stuk heimwee naar de vervlogen tijd van zijn pioniersdaden in het zeevogelwerk. Prof. dr. Magda Vincx steunde me voluit tijdens mijn doctoraatsopleiding en liet niet na haar vertrouwen in het welslagen van de operatie te laten blijken. Prof. dr. Patrick Meire wil ik via deze weg speciaal danken voor zijn niet aflatende enthousiasme bij het opleiden van zijn 'Meire-boys' en voor de zovele geboden kansen sinds 1987, niet in het minst die bij de start van het vernieuwde Belgische zeevogelonderzoek begin de jaren negentig. Wim Van den Bossche hield de inspanningen van de eerste jaren op het goede spoor en Henk Offringa bouwde het zeevogelwerk gedurende de daaropvolgende drie jaar en half uit tot een stevig verankerd geheel. Henk wil ik trouwens ook graag herinneren aan de gezellige uren op de Belgica en danken voor de vele suggesties bij alle artikels van dit proefschrift, het ter beschikking stellen van de mooie digitale vogelbeeldjes en de nieuw geboden kans om alsnog mijn zeevogelopdracht te volbrengen in de vorm van dit doctoraat. Ook Jeroen Van Waeyenberge wil ik graag danken voor de vele aangename uren, zijn altijd goede humeur en de plichtsgetrouwheid waarmee hij steevast de vele tellingen minutieus uitvoerde.

Onontbeerlijk voor de uitbouw van het Belgische zeevogelwerk waren de inspanningen van de financierende instanties. Het Wereldnatuurfonds-België maakte middelen vrij om in 1992 een blitz-start mogelijk te maken, en graag wil ik hiervoor een speciaal woordje van dank richten aan Nadine Moens, Jean-Luc Roux en Luc Dries. Daarna waren er de niet-aflatende injecties van eerst BMM en later DWTC, die tot op vandaag de continuïteit van dit onderzoek garanderen. Ook de goede samenwerking binnen het interventienetwerk voor zeevogels en zeezoogdieren 'MARIN' wil ik graag in de verf zetten. Met dr. Thierry Jacques en Jan Haelters in het bijzonder werden heel aangename contacten gelegd en werd regelmatig inhoudelijk overlegd over de materie, en Jan Tavernier (KBIN) nam het leeuwendeel van de administratie en de transporten van het verdriftingsexperiment met zeevogels voor zijn rekening. Walter Roggeman wil ik graag danken voor het ter beschikking stellen van de KBIN-zeevogelringgegevens en Geert Spanoghe voor het ontsluiten ervan. Ook de zeevogel- en zeezoogdieronderzoekers van de universiteiten van Luik en Brussel, de al of niet officiële vogelopvangcentra aan de kust en veearts John Van Gompel ben ik erkentelijk voor de uitwisseling van informatie. Dr. Virginie Debacker was zo vrij een aantal teksten kritisch door te nemen. Graag zou ik ook dr. An Cliquet, Jan Haelters en Ronny Schallier danken voor het nalezen van conceptteksten en Steven Vantieghem en dr. Jaap van der Meer (NIOZ) voor hulp bij de statistische verwerking. Het Maritiem Instituut van de Universiteit Gent wil ik verder nog danken voor de vlotte samenwerking, ondermeer rond het Noordzeeatlas-project. Ook met Jean-Louis Herrier, Geert Fierens en de andere medewerkers van AMINAL-Natuur was er een goede verstandhouding. Het was een hele eer met Kees Camphuysen (NIOZ) te mogen samenwerken. Niet alleen bood Kees ons de mogelijkheid om bij de start van het project de zeevogelteltechnieken te leren aan boord van de Tridens en hielp hij bij de verankering van Belgische gegevens in de internationale databanken ESAS en EBBS, hij was ook steeds bereid te fungeren als ‘lichtbaken’ op zee.

Toen Rudy Vanaght ons introduceerde bij de Régie voor Maritime Transport (RMT), om aan boord van de Prins Filip met zeevogeltellingen te starten, konden we er enkel van dromen zoveel steun te zullen ondervinden in de daaropvolgende jaren vanwege de bemanningen en verantwoordelijken van de Prins Filip, Prins Albert en Princesse Marie-Christine (RMT), Ter Streep (AWZ), Belgica (BMM) en EuroTraveller (Sally-Lines). Ik houd dan ook de beste herinneringen over aan de honderden uren in gezelschap van boordpersoneel, staf en nieuwsgierige medereizigers op elk van die schepen. Ook bij de Noordzee Vliegclub was er steeds een warme en hartelijke sfeer. Dank hiervoor, Johnny en Jenny. Tenslotte stelden dr. Hovart en dr. Vyncke graag de diepvrieskamers op het Departement Zeevisserij (toen nog Rijksstation voor Zeevisserij) ter beschikking voor het tijdelijk bewaren van de vogelkadavers.

En dan rest mij nog de talloze collega’s aan het Instituut voor Natuurbehoud, de sectie Mariene Biologie van de Universiteit Gent en het Vlaams Instituut voor de zee te danken voor de aangename jaren, de warme vriendschap, de inhoudelijke steun (of het nu over kievitten, benthos of zeevogels ging) en nog zoveel meer... Sta me toe in het bijzonder dr. Jan Mees, Jan Haspeslagh en de andere VLIZ-ers te bedanken voor de heel stevige duw in de rug in het afgelopen ‘goedgevulde’ jaar, Koen Devos voor de ronduit schitterende tekeningen, dr. Tom Ysebaert voor de toffe jaren, de al even gezellige symposia en de statistische hulp, Dirk Maes als gids en indicator en Eric Stienen voor de erg goede verstandhouding en zijn geäppreciëerd aanbod om voor dit doctoraat als paranimf op te treden.

Aan mijn vrienden en ouders...
Aan Danielle en Tineke...

Jan

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## Sea- and coastal bird data as tools in the policy and management of Belgian marine waters

# CHAPTER ONE

## INTRODUCTION AND OUTLINE

# Introduction and outline

J. Seys

## PREFACE

Seabirds are one of the most conspicuous faunal groups of the coastal and marine environment. For millennia humans have followed birds at sea to locate fish and mammals (MONTEVECCHI 1993). In ancient times they formed both a source of food and a rich mythological tradition. Still, the ubiquitous calls of gulls constitute an integral and natural sound of coastal areas and mass strandings of oiled seabirds keep on attracting great public attention. Worldwide, seabird research has undergone a major evolution in terms of data collection, interpretation of the information and application in the field of management and policy (CAMPHUYSEN 1996, TASKER & REID 1997).

In this work, we will describe, analyze and interpret the substantial amount of information, collected on sea- and coastal birds in the Belgian coastal area. By processing these data we hope to contribute to a better understanding of the ecology of this faunal group and to provide tools to policy-makers, managers and researchers to use seabirds for purposes of sustainable development of the marine environment.

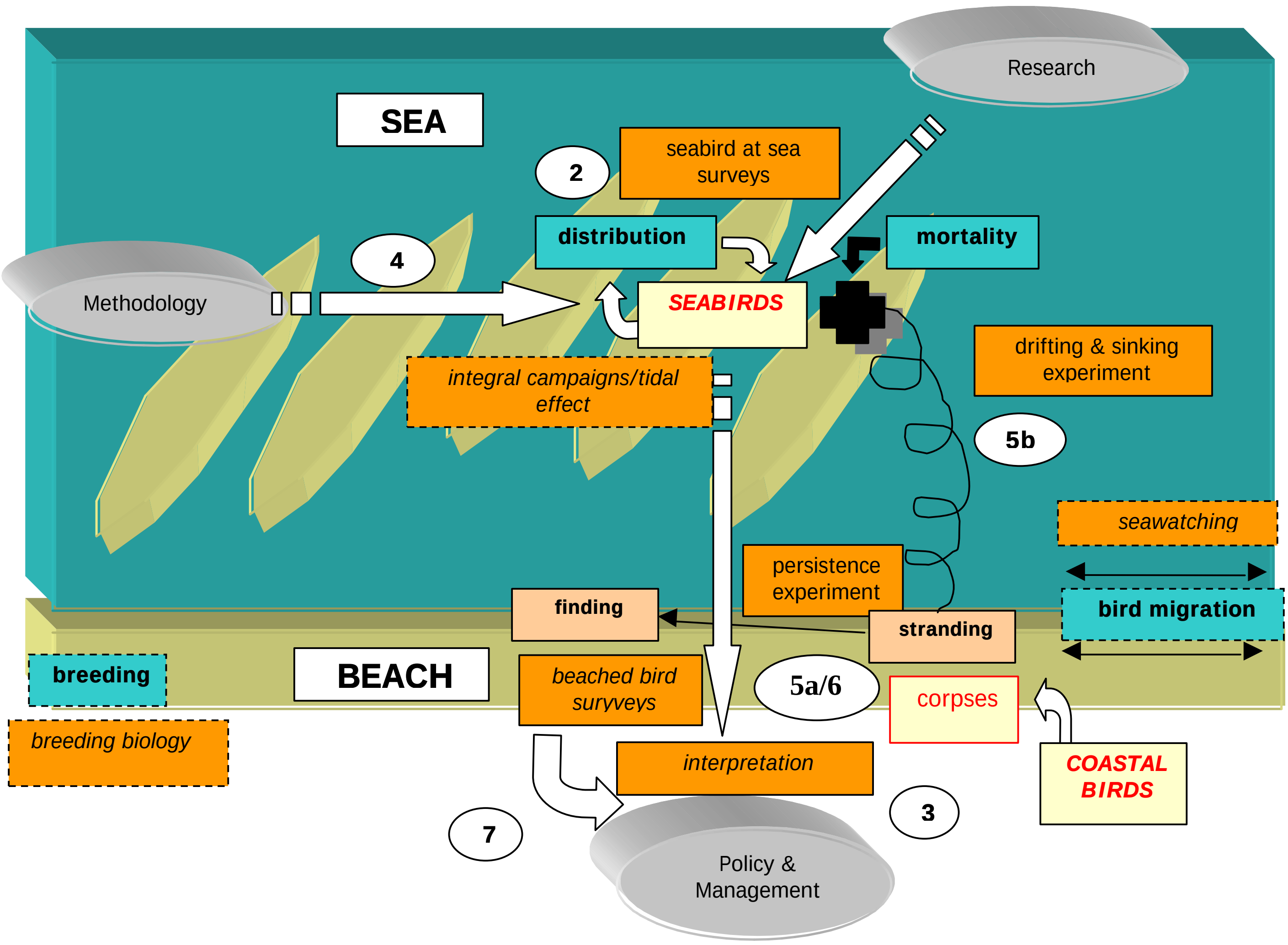



*Fig. 1. Conceptual diagram of the various sources and approaches in seabird data collection and processing. The numbers refer to the chapters of this thesis, in which this particular aspect is dealt with. Boxes with a dashed outline were not a major focus of this study.*

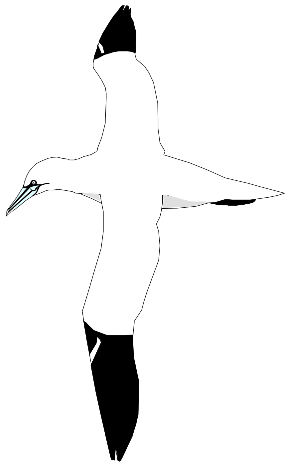
The data can be approached in various ways (Fig. 1). A researcher will be primarily interested in analysing and understanding the patterns of distribution, whereas policy-makers and managers are much more focused on how these data can be interpreted for the sake of conservation. Both groups should keep in mind that the methodology not only determines the efforts in the field, but also affects the final results. In general terms seabirds disperse or migrate in a coastal or marine environment (to be quantified during seawatching activities), and reside in favourable areas for longer periods (to be counted during 'seabird at sea surveys'). In these areas they are distributed according to food availabilty, disturbance, abiotic environment or inter- and intraspecific interactions. Dedicated surveys focussing on the impact of tides or the interrelationships between various biotic and abiotic parameters ('integral campaigns') are useful for the understanding of the reasons behind the observed distribution patterns. When seabirds die, they may drift to the coast and eventually strand. Beached bird surveys might hence provide information on the causes and scale of mortality. By carrying out additional experiments on the drifting and sinking behaviour of bird corpses and on the disappearance and detection rates once they have beached, it is possible to better relate what is found on the beach with what has died at sea. This study mainly concentrates on seabird distribution at sea and on the mortality as observed during beached bird surveys. Breeding biological aspects as well as results of seawatching will only be dealt with briefly.

In the following introductory chapter, we will give a definition and amplify on some major characteristics of seabirds ('*Sea- and coastal birds*'). Meanwhile we try to shed some light on the jumble of 'indicator' definitions, before summarizing how seabirds have been used worldwide as focal species ('*Seabirds as focal species*'). Furthermore we sketch the study-area briefly ('*Study-area with a focus on Belgian marine waters'*) and give a historical overview of seabird research in Belgium ('*Historical setting of seabird research in Belgium'*). Finally, the objectives and the outline of this thesis are presented ('*Objectives and general outline*').

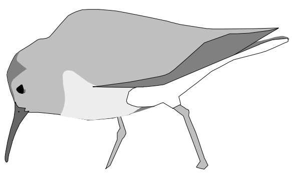
## SEA- AND COASTAL BIRDS

### A DEFINITION

Seabirds are birds that obtain at least part of their food from the sea, not simply by wading into it as do shorebirds, but by travelling some distance over its surface (FURNESS & MONAGHAN 1987). They typically breed on offshore islands or coastal areas and spend much of their time at sea. Worldwide, main seabird groups fall into four taxonomic orders and involve about 275 species (HARRISON 1985, FURNESS & MONAGHAN 1987). A total of 55 seabird species from eleven (out of twenty) seabird families have been observed in our study-area: divers (Gaviidae), grebes (Podicipedidae), petrels and shearwaters (Procellariidae), storm-petrels (Hydrobatidae), gannets (Sulidae), cormorants (Phalacrocoracidae), skuas (Stercorariidae), gulls (Laridae), terns (Sternidae), auks (Alcidae) and seaducks (part of the Anatidae). The latter include Greater Scaup *Aythya marila*, Common Eider *Somateria mollissima*, Long-tailed Duck *Clangula hyemalis*, Common Scoter *Melanitta nigra*, Velvet Scoter *Melanitta fusca,* Common Goldeneye *Bucephala clangula,* Smew *Mergus albellus,* Red-breasted Merganser *Mergus serrator* and Goosander *Mergus merganser (Appendix I)*. The seabirds using the North Sea may be conveniently divided into two groups: offshore species (petrels, gulls, auks, gannets,..), that rely heavily on the marine environment and of which some only come ashore to breed (the latter often termed 'pelagic species'), and inshore species (seaduck, divers, cormorants, terns, some gull species and the Black Guillemot *Cepphus grylle*) that normally occur within sight of land, although they may move further offshore especially in areas of shallow water.



Coastal birds are those living in coastal areas and feeding on intertidal sand and mud flats (CARTER *et al*. 1993). They include wading birds and (non-sea) ducks. Within the scope of this thesis, focus is on seabirds. The 43 coastal species (as well as the 64 terrestrial bird species of *Appendix I*) will only be mentioned when found as corpses during beached bird surveys.



## SEABIRDS: SOME MAJOR CHARACTERISTICS

Despite the enormous amount of food potentially available in surface waters, only a comparatively small number of birds (3% of the c. 10,000 bird species) exploit this two-thirds of the world's surface. Though seabirds are composed of various taxa, adaptations to this hostile and variable environment has pushed them to develop some major common features (FURNESS & MONAGHAN 1987).

Like many waterbirds, seabirds have webbed feet and a well-developed preen gland situated at the base of the tail, from which the bird secretes a waterproof oil which is smeared onto feathers during preening. A seabird is able to get rid of excess salt by excretion from the salt gland in the nasal passages. They tend to have a monochromatic coloration (black, white, brown or grey) with little sexual dimorphism. Underparts are often white, a characteristic that may have a social signalling function and make them less visible for mobile underwater prey, such as fish. Generally their legs are not well adapted for walking on land. Seabirds can be broadly divided into those which are good fliers and those which are good underwater swimmers, specialisations that are to some extent mutually exclusive. Most seabirds migrate or disperse outside the breeding season. Some (petrels, shearwaters, skuas, albatrosses, terns) are real champions in long-distance flights (JOUVENTIN & WEIMERSKIRCH 1990, ALERSTAM 1993, WEIMERSKIRCH *et al*. 1993, GEORGES *et al*. 1997, MARTIN 1997).

Most seabirds feed on small pelagic fishes, squids and crustaceans that occur in the upper and mid-water column (MONTEVECCHI & MYERS 1996). The gulls are particularly opportunistic when foraging and adapt their diet accordingly. They are equally at home feeding behind fishing boats at sea, on estuarine mudflats and rocky shores, inland behind a plough or on rubbish tips, and by hawking for aerial insect swarms. Seabirds locate their food predominantly in a visual way, though some nocturnal foragers locate prey by touch and some procellariforms, such as Fulmar *Fulmarus glacialis* and Sooty Shearwaters *Puffinus griseus*, can apparently locate prey by smell (HUTCHINSON *et al*. 1982). Flock foraging is very frequent in seabirds, using various methods such as underwater pursuit diving, plunge diving, feeding from the surface or from the air, shoreline feeding, scavenging or kleptoparasitism (ASHMOLE 1971). Larger diving seabirds have to overcome their natural buoyancy in order to reach food deeper in the water column or on the bottom of the sea. Gannets solve this problem by plunge-diving from 10-40 metres above the water, cormorants have a poorly developed preen gland so that their plumage is barely waterproof and unable to hold much air. After a diving session, they need to dry their waterlogged feathers on a prominent perch with outspread wings (LLOYD *et al*. 1991). Seabirds that are adapted for pursuit of prey underwater are comparatively inefficient fliers and therefore tend to concentrate in polar or sub-polar regions or upwelling systems, where the considerable abundance of prey makes long foraging trips unnecessary. Seabirds feed generally on fish and marine invertebrates, which are high in energy in relation to volume and weight. This diet is a necessary adaptation for a lifestyle, which requires long periods of flying when bulky, or heavy food in the digestive system would be a disadvantage. Thus no seabirds rely upon a diet entirely of plants since this would require the consumption and digestion of bulk food (LLOYD *et al*. 1991)

Seabirds are almost invariably monogamous. They tend to pair with individuals of a similar age to themselves and, provided the pair is successful, they will continue to breed together while both remains alive (HUNT 1980). In comparison with other birds, seabirds are generally long-lived, lay small clutches and delay breeding until at least the second year of life (and many much longer). Some 98% of all seabird species typically nest in colonies, and colony size can range from only a few breeding pairs to over a million birds. They have a strong tendency to return to their colony of birth. Adult survival is generally high, and annual reproductive output low. Hence they represent extreme *K*-selected species. The small clutch size, low breeding success, higher juvenile than adult mortality and prolonged period of immaturity of seabirds make threats to adult seabirds the greatest conservation danger (FURNESS & MONAGHAN 1987).

Northwestern European waters host a breeding seabird population of some 6,5 million pairs (or roughly 7 million pairs, when grebes, divers and seaducks are included: STONE *et al.* 1995, ROSE & SCOTT 1997). The four most common species, Fulmar (1.17 million pairs), Atlantic Puffin (1.10 million pairs), Common Guillemot (0.98 million pairs) and Kittiwake (0.89 million pairs) are all offshore species, breeding on cliffs. The North Sea attracts a substantial part of this richness in seabirds. Some 2.5 million pairs breed here, the majority being offshore cliff-nesting concentrated off the coasts of Northeast England and Scotland (TASKER *et al*. 1987, STONE *et al*. 1995). The continental coast of the North Sea (from the Straits of Dover up to the southernmost part of Norway) lacks vast rocky areas, but is a major breeding area for *Larus*-gulls (c. 700,000 pairs) and terns (c. 70,000 pairs).

## SEABIRDS AS 'FOCAL SPECIES'

Conservation biologists often use one or a small number of species as surrogates or indicators to help them tackle conservation problems. Indicators should be used merely as a part of a comprehensive strategy of risk analysis that focuses on key habitats as well as species. The idea of indicator species is a relatively old concept (HALL & GRINNELL 1919). The development of terrestrial bio-indicators has been one of the growth industries of the nineties, and, with few exceptions, everyone's pet group just happens to be a great indicator. However, the validity of a proposed indicator is often poorly substantiated, there is considerable confusion over what is being indicated (ANDERSEN 1999) and definitions and terms are sometimes substituted for one another. Before going into the subject of how seabirds may or may not be considered suitable indicators or how they can be used to identify important areas of conservation in the coastal zone, it is necessary to enlarge upon some definitions and terms, related to the indicator concept.

### A JUMBLE OF DEFINITIONS AND TERMS

As with many other vogue words ('sustainability', 'ecosystem health',...), they are widely used, but often without a clear notion of what they really mean and how they can be applied. Generally we follow ZACHARIAS & ROFF (2001) in using 'focal species' as a species of interest in the broadest sense. <u>Focal species</u> or taxa are those which, for ecological or social reasons, are believed to be valuable for understanding, managing or conserving natural environments and which our attention is preferentially focussed upon for one reason or another. In this sense, it coincides (excluding 'flagship species') with what LANDRES *et al*. (1988) defined as an 'indicator species' ('an organism whose characteristics – e.g. presence/absence, population density, dispersion, reproductive success – are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest'). While there are many names for the various types of focal species (see Table 1), the ecological concepts and societal rationale behind the nomenclature can be distilled into four distinct categories, namely: 'indicators', 'keystones', 'umbrellas' and 'flagships' (SIMBERLOFF 1998). In broad terms they may be defined as follows (ZACHARIAS & ROFF 2001):

* '<u>Indicator species'</u> are species, whose presence denotes either the composition ('<u>composition indicators'</u>) or condition ('<u>condition indicators'</u>) of a particular habitat, community or ecosystem.
* '<u>Keystone species'</u> are critical to the ecological function of a community or habitat, where the importance of these species is disproportionate to their abundance or biomass.
* '<u>Umbrella species'</u> are those whose conservation will also conserve other species, even if relationships between the umbrella species and the community type is poorly established (they are used to specify the size and type of habitat to be protected rather than its location – BERGER 1997 in CARO & DOHERTY, 1999).
* '<u>Flagship species'</u> are merely tools to garner public support for charismatic megafauna. The ultimate goals of advocating flagships is the protection of their habitats and constituent species.

*Table 1. Various 'focal species' terms, fitted in the general framework proposed by ZACHARIAS & ROFF (2001). Dutch translations are added in italics, following BRICHAU* et al.*(2000). References are:* [1] ZACHARIAS & ROFF (2001); [2] CARO & DOHERTY (1998); [3] DALE *et al*. (2000); [4] MCGEOCH (1998); [5] DAWSON *et al*. (1986); [6] SCHAMINÉE & JANSEN (1998); [7] BLOCK *et al*. (1986); [8] FLEISHMAN *et al.* (2000); [9] PAINE (1995); [10] FERRIS & HUMPHREY (1999); [11] LAMBECK (1997); [12] LAUNER & MURPHY (1994); [13] NOSS (1990); [14] SIMBERLOFF (1998); [15] BOND (1993); [16] DUFRÊNE & LEGENDRE (1997); [17] BRICHAU *et al*. (2000).

| | | | | |
|---|---|---|---|---|
| | Focal species ('*aandachtsoort*') [1,11] = Target species ('*doelsoort*') [6] | | | |
| | Surrogate species = sentinel species [2] | | | |
| **Keystone** [1,9,13,14,15] ('*sleutelsoort', 'hoeksteensoort'* ) | Indicator [1,16] *('toetssoort'*) = Proxy = Monitor | | **Umbrella** [1,2,8,12,13,14] ('*paraplusoort*') | **Flagship** [1,2,13,14] = charismatic species ('*symboolsoort*' ) |
| | **Composition indicator** [1] | **Condition indicator** [1] | | |
| Link species[3] ('*transfersoort* ') | Biodiversity indicator [2] ('*biodiversiteitsindicator'* ) | Management indicator species[5] *('beheerindicator')* | | Game species[17] ('*jachtwildsoort*' ) |
| | Guild indicator species [7] ('*gemeenschaps indicator'* ) | Compositional species [10] ('*structuurindicator*') | | Economic species [17] |
| | Population indicator species [2] ('*populatie indicator'* ) | Environmental indicator = Health indicator [2] ('*vervuilingsindicator'* ) | | |
| | Vulnerable species [13] ('*kwetsbare soort'* ) | Ecological indicator [4,13] ('*ecologische indicator'* ) | | |
| | Protected species [17] ('*beschermde soort'* ) | '*indifferente soort'* [17] | | |
| | Red list species [17] = Red data book species ('*rode-lijst soort*') | | | |
| | '*habitat specifieke soort'* [17] | | | |
| | '*kensoort'* [17] | | | |
| | '*begeleidende soort'* [17] | | | |

ZACHARIAS & ROFF (2001) consider the use of 'indicator species' (opposed to flagships, umbrellas and keystone species) as most suitable in matters of marine conservation and management. The composition indicator is most relevant to efforts to determine areas of priorities for conservation, while the role of condition indicators in marine conservation falls under the evaluation of conservation efforts. As most important benefits they mention: (1) the ability to predict community-composition based on a few observable species; (2) indicators can identify representative and distinctive habitats, communities or ecosystems and are often more effective than other methods, such as species richness, for conservation and management purposes; (3) there is little disagreement that the indicator concept is valid, the indicator species is the most ecologically concrete of all the focal species; (4) numerous clustering and ordination techniques have been developed to statistically define communities and habitats, including indicator species (TWINSPAN) analysis, methods that are not available to identify keystones, umbrellas or flagship species. Disadvantages to using composition indicators for marine conservation and management are: (1) not a single species has been shown to indicate the structure or functioning of a community (they may be more efficient when used to indicate the presence of species from a specific guild); (2) marine indicator species may not be as geographically or temporally persistent as terrestrial ones; (3) marine species are notoriously difficult to observe and census; (4) the majority of species that are readily observable are generally harvested by humans and therefore make poor indicators (the types of marine species that would make the best composition indicators are those not adversely affected by pollution, habitat loss, alien introductions or global climate change).

By contrast, for ZACHARIAS & ROFF (2001) the 'keystone' concept is currently not a globally useful concept for marine conservation in the same manner as indicator species. The processes that permit the establishment of a keystone species may be absent in many marine communities. Marine food webs generally vary over spatial and temporal scales to a greater degree than most terrestrial environments; therefore the probability that the composition and diversity of a community rests on a single species is low (NYBAKKEN 1997). This is especially apparent when migratory species (such as seabirds) are identified as keystones, which can avoid unsuitable areas as a result of changes in oceanic conditions.

For the 'umbrella species' concept, it is not clear whether marine species, and in particular seabirds, can function as umbrellas. The use of umbrella species as focal taxa in marine environments is intuitively appealing, but the application of the concept is fraught with difficulties. A primary limitation concerns the considerable unexplained spatial and temporal variation in many marine communities. CARO & DOHERTY (1999) add that they know of no study in which a strong, empirically based argument can be made to support the efficacy of an umbrella species in protecting other species. On the other hand they mention that migratory species may be particularly effective as umbrella species, a statement in firm contrast with ZACHARIAS & ROFF's citation that: "A further flaw in the application of the umbrella concept in marine systems is the requirement that an umbrella species be non-migratory". Umbrella species differ from (bio)diversity indicators in that they are used to specify the size and type of habitat to be protected rather than its locations (BERGER 1997).

There are few strict criteria in choosing flagships, which is one of the main points differentiating them from other focal species classes. Flagship species are frequently chosen post hoc, after a species has suffered from exploitation or habitat destruction, consequently they may be species that are sensitive to disturbance (CARO & DOHERTY 1999). The ultimate purpose of the conservation of flagship species is the preservation of habitat. Because of the loosely coupled association between species and habitats in most marine environments, the charismatic concept lacks the advantages of its use in terrestrial systems. However there is no doubt that seabirds may and very often do perform as flagships. Together with marine mammal species, they are probably the most 'touching' animals of the sea.

## SEABIRDS AND THEIR ENVIRONMENT

For millennia humans have followed birds at sea to locate fish and mammals. Seabirds are highly visible wide-ranging upper trophic level consumers that can indicate marine productivity and biotic interaction. Compared with fish, marine mammals, and other animals that live primarily or exclusively underwater, seabirds are easy to survey, census and study (MONTEVECCHI 1993). Moreover some seabird populations have probably the longest history of detailed monitoring at their colonies of any marine organisms (TASKER & REID 1997). As far as it concerns the Belgian situation, at present seabirds are probably one of the best monitored focal taxa in the marine as well as the terrestrial context (VAN DYCK *et al*. 1999). In comparison with many other biotic taxa, counting methods are well-standardized, data are relatively easy to obtain and fitted in an international scheme and database and certain aspects have already been monitored for decades (see 'Historical setting of seabird research in Belgium').

From a general point of view, seabirds possibly demonstrate some major drawbacks to function as good indicators (MORRISON 1986, TEMPLE & WIENS 1989).

HILTY & MERENLENDER (2000) examined how well some hundred vertebrate and 32 invertebrate taxa, documented in the conservation science literature, acted as proper indicators of ecosystem health. Based on the referenced criteria, seabirds might demonstrate the following shortcomings: (1) They are highly mobile and may easily flee unfavourable conditions; (2) Their longevity and low reproductive rates make them bad early warning detectors (when detection is focussed on population size); (3) Some are generalistic feeders and switch easily from one food-source to another; (4) Correlations to ecosystem changes are often poorly established. However, it appears most of these arguments can easily be refuted, depending on what managers or scientists want to see indicated and on which methods they apply. By concentrating not on population size in se, but on e.g. prey choice, behaviour, condition, life-history response, etc. valuable information can be obtained from the ecosystem they live in (MONTEVECCHI 1993). Their mobility, at first appearing to be a drawback for a (bio)monitor, can be an advantage if the aim is to monitor over a broad scale and the ranging behaviour of the birds is known. Moreover, using seabirds as tools in conservation issues can rely on their wide distribution, the detailed knowledge of general seabird ecology, taxonomy, abundance and productivity, the existence of some long-term datasets, the relative ease of data-collection, the extensive availability of manpower to carry out designed fieldwork, the standardisation in survey methods, the specialistic nature in some species (terns, mollusc-feeders,...), the colonial nature of breeding seabirds (allowing large quantities of data to be collected in a short period of time) and their attractiveness as flagships (FURNESS & CAMPHUYSEN 1997).

There is a wealth of publications dealing with seabirds as proxies or indicators of (aspects of) their environment. FURNESS & CAMPHUYSEN (1997) made a review of how seabirds can be used as monitors of the marine environment. They focused on seabirds as indicators of fish stocks or fisheries activities and of pollution (oil, heavy metals, organochlorines). In addition, MONTEVECCHI (1993) reviewed the types, utilities and limitations of avian indicators of the **condition of fish stocks**. Pelagic fish and young demersal fish often occur in shallow inshore areas that are not surveyed and in the upper water column that is hydroacoustically invisible. Measurements of prey availability derived from seabirds are appropriate tools to complement fisheries data (stock-assessment) with information from regions (upper water column, inshore areas) and age-groups (pre-recruits) inaccessible to traditional surveys. Different behavioural, physiological and ecological patterns of seabirds integrate influences of food conditions over different spatial and temporal scales. Prey landings and foraging trip durations usually reflect food conditions over fine- to macro-scale areas during periods of hours or days and could provide real time assessments of prey availability. Egg and clutch sizes integrate feeding conditions over days, and growth and breeding success develop over weeks and months. Population trends integrate activities over large areas that include migratory ranges, and over annual and decadal time scales. Studies of reproductive success as an indicator of prey conditions are most successful in small surface-feeding species (such as terns) that produce multi-egg clutches and that have less flexible time and activity budgets than larger species. Breeding success, growth of chicks and fledging mass can provide useful indications of food supplies during moderate to poor conditions (CAIRNS 1987) and these indicators are most informative when multi-species comparisons are used. The use of telemetry and activity recorders already enables the quantification of foraging behaviour, time and success for individual, large birds and is not necessarily linked to breeding colonies. Differences in reproductive output of surface and subsurface feeders can indicate major vertical shifts in prey, due to large-scale oceanographic perturbations (DUFFY *et al*. 1984). Extreme cases of overfishing resulted in population crashes in various parts of the world (overview in MONTEVECCHI 1993). The relative abundance of various prey stocks can be assessed through the diet composition of generalist seabirds (MARTIN 1989). Although most of the information above must be collected at breeding colonies, there have been examples of major shifts in distribution and condition of seabirds due to changes in prey-availability during winter. During the eighties there was a major southward shift in the wintering distribution of Common Guillemot, Kittiwake and Razorbill attributed to a retreat of Sprat (*Sprattus sprattus*) in the northern North Sea, and resulting in mass strandings ('wrecks') on the continental coasts (CAMPHUYSEN 1990). In addition to acting as monitors of fish stocks, seabirds are sometimes used as a monitor of **fisheries activities**. Sampling regurgitated pellets at colonies or roost sites, and identifying the species, size-frequency and age of the fish through a study of the otoliths can assess the composition of discarded fish.

During beached bird surveys dead, stranded bird corpses are collected at beaches in order to gain public awareness for the oil pollution issue and to provide the necessary data to underpin the policy. Where the numbers of seabirds washing ashore are subject to massive fluctuations due to various reasons (the distribution and abundance of the birds at sea, the wind direction and –strength, temperature, etc...), variation in oil rates (the proportion of complete bird corpses with external signs of oil) has proved to be minimal. Hence beached birds surveys, in particular if coupled with the chemical analysis of feather samples, can be effective indicators of pollution at sea by **oil and other lipophilic substances** (CAMPHUYSEN & VAN FRANEKER 1992, DAHLMANN *et al*. 1994). Compared to aerial surveillance for oil slicks at sea, they are a very cost-effective method, with a proven efficacy and application on a very wide scale. Feather samples of seabirds can be treated with fingerprinting techniques, in which an enormous range of mineral oils and other chemical compounds can be identified. As such, they become an effective tool in the prosecution of polluters and provide essential information on changes in the sources of pollution at sea. Seabird feathers can also be used for monitoring **heavy metal pollution** in marine food webs (MONTEIRO & FURNESS 1995, FURNESS *et al*. 1986). Comparison of mercury concentrations in feathers from museum skins collected up to 150 years ago shows that mercury concentrations have increased about four-fold in seabirds from Britain and Ireland (THOMPSON *et al*. 1992), the German North Sea coast (THOMPSON *et al*. 1993) and the Azores (MONTEIRO 1996). Additionally stable isotope ratios can be measured in the same feathers to look for evidence of dietary change or constancy (THOMPSON & FURNESS 1995). Stable-isotope analysis may be a good indicator of inshore vs. offshore feeding preference (HOBSON *et al*. 1994) and offers many advantages over conventional dietary approaches since trophic inferences are based on time-integrated estimates of assimilated and not just ingested foods, and isotopic abundance represents a continuous variable that is amenable to statistical analysis. Also for other contaminants than lipophilic substances and heavy metals, seabirds can have an important indicator's role. The sudden collapse of colonies of Sandwich Tern (*Sterna sandvicensis*) and Common Eider (*Somateria mollissima*) in the Dutch Wadden Sea in the mid-1960s, gave rise to analyses of tissues, eggs, and prey fish and the detection of considerable concentrations of the **insecticides** dieldrin, endrin and telodrin (KOEMAN *et al*. 1972, SWENNEN 1972).

Another issue that can probably be monitored much easier and cheaper by using seabirds is the occurrence of **lost/discarded nets, nylon fibres and plastic pellets/debris** in the marine environment. As the use of plastics and other synthetic materials has expanded, the quantity of plastic debris entering the marine environment has undergone a corresponding increase. In an analysis of findings of Northern Gannet (*Morus bassanus*) corpses during beached bird surveys in The Netherlands (1977-2000), CAMPHUYSEN (2001) demonstrated a significant increase in entanglement, with most victims trapped in fishnets and various types of ropes and nylon fibres from trawlers in the 1980s, shifting to nylon fish line as main offender in the 1990s. Similarly, ROBARDS *et al.* (1995, 1997) showed that the frequency of plastic particles in the Subarctic North Pacific increased substantially, by examining the gut contents of various seabirds.

It follows from this discussion that in order to indicate and monitor changes in the environment, a multi-species approach is to be preferred to relying on one single species. It is also clear that the abundance of a species or a group of species is but one of the parameters that can function as a monitor. Behavioural aspects, biometrical data, diet composition, levels of contaminants in feathers, etc. are only a few examples of measurable aspects that may give information on the marine environment. Indicators may also be combined into sets of indices that allow the monitoring and evaluation of developments in the ecosystem, and as such provide managers with practical and workable tools. A good example is the outcome of the Dutch 'GONZ' project ('Graadmeter Ontwikkeling Noordzee', i.e. Development of Indicating indices for the North Sea), in which 13 indicating indices ('*graadmeters*') have been selected as monitors for the management of the Dutch part of the North Sea (KABUTA & DUIJTS 2000). 'Graadmeters' are defined as standardized descriptions of biotic and abiotic system characteristics that can be used in order to get insight in the condition of the aquatic system and the interrelationships. It can consist of one or more parameters (indicator species, groups of species or elements) that are representative for characteristics of the system, and are eventually combined into an index. Two out of 13 indices include seabird data: (1) the abundance of seven inshore and offshore seabird species (divers *Gavia stellata* and *G. arctica*, Common Scoter *Melanitta nigra*, Herring Gull *Larus argentatus*, Kittiwake *Rissa tridactyla*, Sandwich Tern *Sterna sandvicensis*, Little Tern *S. albifrons*, Common Guillemot *Uria aalge*/Razorbill *Alca torda*); (2) the number of breeding pairs and the breeding success of the Sandwich Tern. It appears GONZ might be an important step forward, as it implicitly includes feasibility and user-friendly protocols as preconditions in the selection process (ANDERSEN 1999, CARO & DOHERTY 1999) and since a broad, multispecies indicator spectrum has been chosen. On the other hand, the apparent simplicity is partly undone by the statement that shifts in occurrence should never be interpreted without further, dedicated research (KABUTA & DUIJTS 2000). In a more general way, the Convention for the Protection of the Marine Environment of the Nort-East Atlantic (OSPAR) has adopted a strategy to protect and conserve ecosystems and the biological diversity of the marine environment which are affected as a result of human activities, and to restore where practicable, marine areas which have been adversely affected. To do so, OSPAR is currently elaborating techniques for the development of describers of Ecological Quality (EcoQ) and Ecological Quality Objectives (EcoQOs) to contribute to the development of an ecosystem approach to environment management (SKJOLDAL 1999).

The use of seabird data is not restricted to their application as indicators of the marine environment. Some species deserve special attention, simply because they are vulnerable to various types of impact and have threatened and declining populations. There is a network of international legislation that aims at protecting habitats and species (for an overview see TUCKER & EVANS 1997), including marine ones. Of the 55 seabird species observed during the study-period in our study-area, 15 are listed on the *Annex I* of the EC Birds Directive, meaning that these species "shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution". Under the Bern Convention ('Convention on the Conservation of European Wildlife and Natural Habitats') 20 species listed in *Appendix II* and 32 species in *Appendix III* have been observed during our study. The Bern Convention states "parties to the convention should give special attention to the protection of areas of importance for the migratory species on *Appendices II* and *III*, and to prohibit the deliberate damage or destruction of sites for species listed in *Appendix II*". The *Appendix II* of the Bonn Convention (Convention on the Conservation of Migratory Species of Wild

Animals) applies to 17 species of our study-area and indicates that: "parties shall conclude agreements covering the conservation and management of those migratory species and where appropriate, provide for the maintenance of a network of suitable habitats disposed in relation to migratory routes". In addition to international legislation, national governments should increase the number and area of their statutory protected areas and should make sure that all habitat-types are adequately represented in protected-area networks. Protected areas require effective implementation, management planning, staffing, funding, local involvement and public support, if they are to fulfil their role in conserving biodiversity and promoting the conservation of species and habitats. There is no doubt that in all these matters, seabirds can play an important role as vulnerable or protected species (in the designation of marine protected areas – MPAs), as indicators of the environment and the success of a management plan, or as flagships to gain public support.

## STUDY-AREA WITH A FOCUS ON BELGIAN MARINE WATERS

### THE NORTH SEA: A GENERAL PICTURE

The North Sea is a small, shallow, semi-enclosed and productive continental shelf area, that reached its present shape and level merely 6000 years ago (EISMA 1987). It represents one of the world's most important fishing areas, with a contribution of about 5% to the global fisheries yield from a surface area of only 0.15% of the oceans (ZIJLSTRA 1988). The North Sea bottom gently slopes from the shallow southern part (on average 30 m deep) to the deep Skagerrak and Norwegian Trough in the north (maximal depths of more than 700 m). Most morphological features are the result of the last Weichselian glaciation in the North Sea region, when relative sea level was about minus 110 m, and of the subsequent transgression (EISMA *et al*. 1979). This history of climatic and water level changes has resulted in a mosaic of gravel, sand and mud beds on the North Sea floor. Sand bottoms are dominant, muddy sediments prevail immediately south and east of the Doggerbank and in the deep trenches off the Scandinavian coasts (VEENSTRA 1970). Atlantic water flows into the North Sea east of Scotland (20,000-45,000 $km^3\ yr^{-1}$) and to a much lesser extent through the Straits of Dover (1600-3400 $km^3\ yr^{-1}$). The major outflow takes place in the northeast, resulting in a major anticlockwise circulation. Most of the fresh water comes from rivers that flow into the southern North Sea. The residence time of the water amounts on average 0.6-0.9 years. The tidal currents are strongest (more than 1 $m\ s^{-1}$) and the tidal range is highest (up to 6 m in the Straits of Dover) in the shallow, southern part of the North Sea. This area is well-mixed and no stratification takes place here. Fronts are common where water masses of different density – due to differences in temperature and/or salinity – meet, such as in the zone separating the southern North Sea from more saline northern waters. Local gyres and other secondary circulations occur as a result of bottom topography, differences between nearshore and offshore waters or the configuration of the coast (EISMA 1987). Highest concentrations of nutrients are found near the river mouths of Forth, Thames, Schelde, Maas, Weser and Elbe. Primary production, although patchy on a small scale, is relatively uniform over the North Sea as a whole and is estimated at 100-300 $g\ C\ m^{-2}\ yr^{-1}$ (ZIJLSTRA 1988). For a more detailed description of the North Sea we refer to EISMA (1987), ZIJLSTRA (1988), NORTH SEA TASK FORCE (1993) and OSPARCOM (2000).

### BELGIAN MARINE WATERS

The study-area is situated in the southernmost part of the North Sea, roughly between the 51st and 52nd degree of latitude (Fig. 2)(OFFRINGA *et al*. 1996). The marine waters under Belgian jurisdiction (further referred to as 'Belgian marine waters'), constitute about 20% of this zone and have a surface area of 3500 $km^2$. They are characterised by a diverse geomorphologic underwater landscape of sand ridges (sandbanks), by the neighbourhood of the Channel and the Schelde estuary and by a very intensive use (for the latter see: MAES *et al*. 2000). The sea is bordered by 62.1 km of sandy beach. For jurisdictional aspects of the Belgian marine waters we refer to MAES & CLIQUET (1996) and CLIQUET (2000).

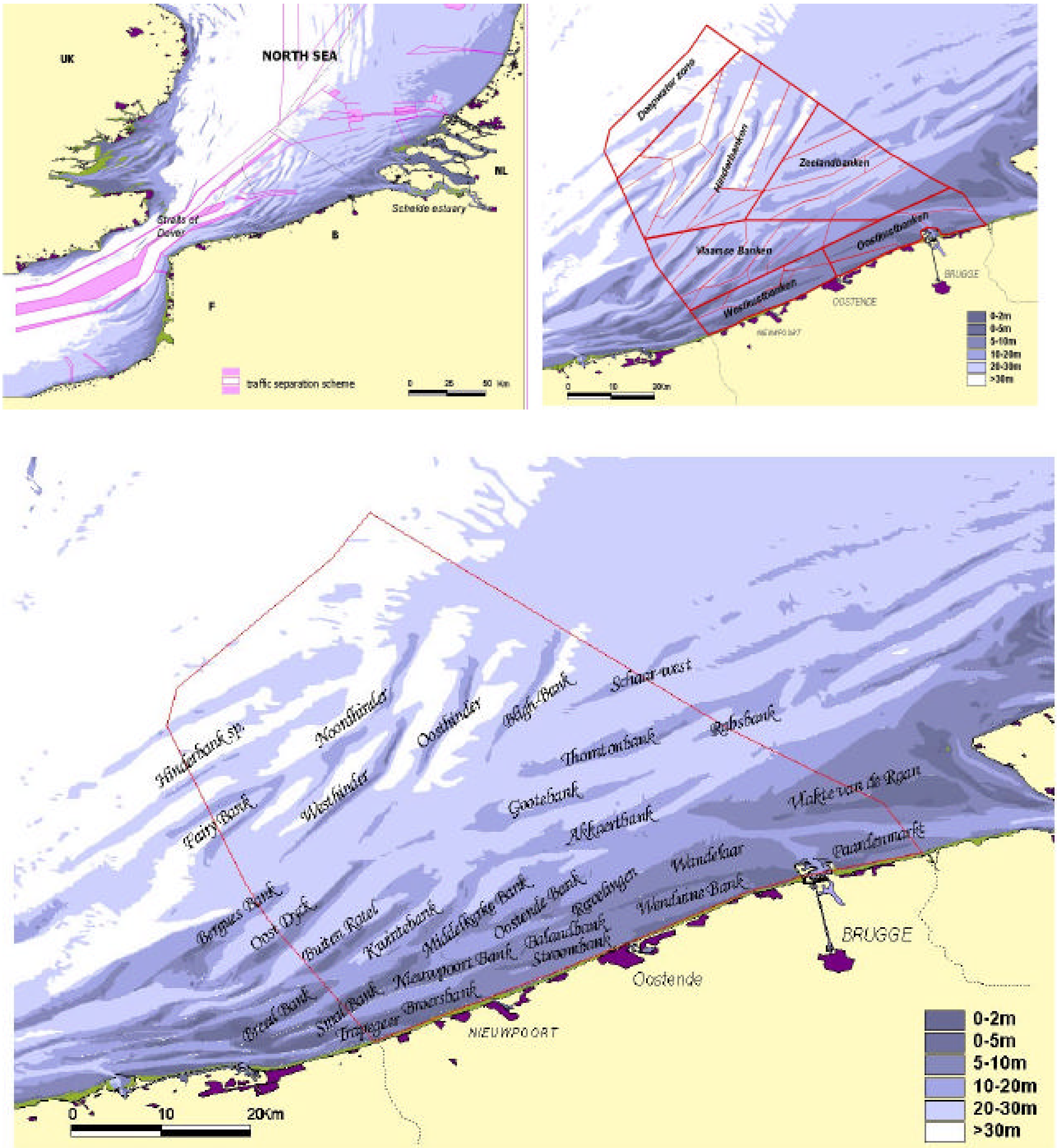



*Fig. 2. Belgian study-area, with: (a) setting within the Southern Bight of the North Sea; (b) subdivision in 6 subregions and 35 sandbanks; (c) most important sandbanks*

*Geomorphology and sedimentology*

The Young Sea-sands forming the present sea-floor nearly everywhere in the southern North Sea have been deposited as nearly planar beds, as megaripples with heights of 0.3-2.0 m, as sand waves of 2-15 m height and as linear sand ridges (sandbanks) up to 40 m high and 65 km long (EISMA *et al*. 1979). Belgian marine waters are unique in the North Sea in having several groups of linear sand ridges, each with their own characteristics. Comparable geomorphologic structures elsewhere in the North Sea are the Norfolk-, Thames Estuary-, Gabbard-, Falls- and Sandettie Banks in southeast England, the East Bank ridges northwest of the Doggerbank and the Brown Bank- and Zeeland ridges in The Netherlands (HOUBOLT 1968). Off the Belgian coast three groups of linear sand ridges occur (names of individual sand ridges or sandbanks in Belgian waters are added)(Fig. 2):

(1) the *Hinderbanken* (Hinder Banks): Fairy Bank, Westhinder, Noordhinder, Oosthinder, Bligh-Bank.
(2) the *Vlaamse Banken* (Flemish Banks): Bergues Bank, Breed Bank (only a small part in Belgian waters), Smal Bank, Oost Dyck, Buiten Ratel, Kwintebank, Middelkerke Bank, Oostende Bank, Ravelingen; the Vlaamse banken extend into French waters.
(3) the *Zeelandbanken* (Zeeland ridges): Akkaertbank, Gootebank, Thorntonbank (and small parts of Schaar west and Rabsbank); the majority of the Zeelandbanken are situated in Dutch waters; they have a resistant core of older deposits and are partly erosional remnants.

A fourth group of sandbanks, in the nearshore area and parallel to the coast, can be distinguished:
(4) the *Kustbanken* (coastal sandbanks): with Trapegeer, Broersbank, Den Oever, Nieuwpoort Bank, Stroombank, Balandbank, Wenduinebank, Paardenmarkt and the Vlakte van de Raan as the most distinct representatives; they originate from nearshore sand transport and sedimentation as a result of tidal currents and wave action. The Kustbanken include a subtidal extension of the sandy beaches and various shallow sandbanks, with a strike parallel to the coast. One sandbank off Koksijde (Broersbank) emerges during low spring tides.

All ridges are aligned parallel to the main ebb and flood current directions. On one side, the sand moves mainly in the flood direction (NE), on the other mainly in the ebb direction (SW). Most ridges are almost stationary. A comparison of the present situation with old maps shows that the Vlaamse Banken have only slightly changed in the last 300 years, and that the Hinderbanken have been stationary for at least 40 years. Sandwaves occur in well-defined fields on the slopes and crests (DE MOOR & LANCKNEUS 1988). They have a length of several hundreds of metres, a width of several tens of metres, a height of 1-8 m and a strike more or less parallel to the bank axis (LANCKNEUS *et al*. 1992). Sandwaves disappear in the transition area between bank slope and swale. Most of the sandwaves appear to be stable features, which can move in the directions of both their steep and gentle slopes. New sandwaves with heights up to 4.5 m can develop or disappear in a time span of a few months. Smaller bedforms, commonly named megaripples, occur on the slopes of the banks or on the flat seabottom. They have wavelengths of 1-10 m and a height of some tens of centimetres. Their strike is predominantly NW-SE. A study on the Vlaamse Banken revealed that median grain size increases to the NE-part of the bank and to the swales (HOUTHUYS 1990). Bank crests and the northwestern, steep (5-7%) slopes are composed of well-sorted sands, are mainly subject to erosion and are highly dynamic (megaripples). The gentle (2.5-3%) eastern slopes know a slight sedimentation. Sediments in the swales are not displaced under normal tidal conditions. Consequently, a benthic fauna of molluscs, echinoderms and polychaetes is well developed here. The Belgian marine waters have been divided in six subregions, on the basis of the various sandbank systems (Fig. 2). For each of these subregions some major characteristics are summarized in Table 2.

*Table 2. Characteristics of the Belgian marine waters, divided into six subregions on the basis of the occurrence of sandbank systems: OK=Oostkustbanken, WK=Westkustbanken, VB=Vlaamse Banken, ZB=Zeelandbanken, HB=Hinderbanken, DW=Deepwater zone.*

| VARIABLE | OK | WK | VB | ZB | HB | DW | SOURCE |
|---|---|---|---|---|---|---|---|
| Area ($km^2$) | 310 | 270 | 600 | 740 | 1210 | 370 | SEYS this study |
| Mean depth (m MLLWS) | 0-10 | 0-10 | 5-25 | 5-25 | 5-35 | 30-40 | SEYS this study |
| Minimal depth (m MLLWS) | 0 | 0 | 3 | 6 | 5 | 20 | SEYS this study |
| Mean elevation sandbanks to seafloor (m) | 2-5 | 2-5 | 15-20 | 10-20 | 25-30 | - | SEYS this study |
| Length sandbanks (km) | 10-20 | 2-15 | 10-30 | 20-30 | 15-25 | - | SEYS this study |
| Distance to coast (km) | 0-13 | 0-10 | 10-30 | 10-40 | 25-60 | 60-80 | SEYS this study |
| Strike of sandbanks (°) | 70 | 70 | 40 | 70 | 40 | - | SEYS this study |
| Mean surface temperature in February (°C) | 4.0 | 5.5 | 6.0 | 4.0 | 4.5 | 6.5 | OTTO *et al*. 1990 |
| Mean surface salinity in February (‰) | 30.5 | 32.0 | 33.0 | 32.0 | 33.5 | 34.8 | BENNEKOM & WETSTEYN 1990 |
| Max. tidal current velocity at surface ($m\ s^{-1}$) | 1.8 | 1.5 | 1.0 | 1.2 | 1.0 | 1.0 | OTTO *et al*. 1990 |
| Depth 1% daylight penetration in Dec. (m) | <5 | 5-10 | 10-20 | <5 | 5-10 | >20 | VISSER 1969 |
| Non-living suspended matter (ppm) | 40 | 30 | 25 | 20 | 10 | 2 | EISMA *et al*. 1979 |

The seabottom in Belgian marine waters is predominantly sandy, with median grain sizes of 200-300 µ at distances of 5-25 km from the shore and coarser sediments (300-400 µ) further offshore. Gravel deposits have a patchy distribution in the Vlaamse Banken and Hinderbanken area. Fine sediments (<200 µ) occur in the most inshore zone and in the mouth of the Schelde estuary (as far as Oostende)(ANONYMOUS 1993).

*Hydrography and prevailing wind conditions*

Belgian marine waters are situated to the west of the Schelde estuary mouth and at about 65 km east of the Straits of Dover. The mean tidal range amounts to 3.7-3.9 m at neap and 4.5-5 m at spring tide.
The average tidal movement corresponds to an elongated current ellipse with a southwest-northeast axis, i.e. parallel to the coast. Strongest current velocities occur from low water or high water till 1.30 h later (HOUTHUYS 1990). The velocity of the surface peak currents attains values of 1.7 knots at spring tide and 0.6 knots at neap tide (VAN CAUWENBERGHE 1992). They gradually decrease from the eastcoast (1.7 knots) to the westcoast (1.0-1.2 knots)(VERBOVEN 1979). There is a small net residual NE-circulation through the Straits of Dover. The prevailing wind direction in Oostende is S or SW (BELL 1994). During persistent westerly gales, the

velocity of surface water can be as high as 35 miles per twenty-four hours.

*Beaches*

The Belgian coastal strip consists of 62.1 km of sandy beach, only interrupted by the Zeebrugge outer harbour (Fig. 3). This outer harbour was constructed in 1974-86. More than half of the entire length of the coast (34 km) is bordered with buildings and boulevards. Groins are a common feature (on average every 200-400 m) and are only absent at the west coast, at Bredene-De Haan and near the Belgian-Dutch border. Beaches are generally narrow ('low tide bar/rip beaches')(SHORT 1996). The slopes of the beaches increase from the west (0.7°) to the east (1.2°), resulting in broad beaches ('ultra-dissipative beaches') near Oostduinkerke - De Panne (3 km)(DUFOURMONT 1979, DEGRAER 1999). Due to the construction of the harbour piers, broad and gently sloping beaches can now be found at Zeebrugge too.

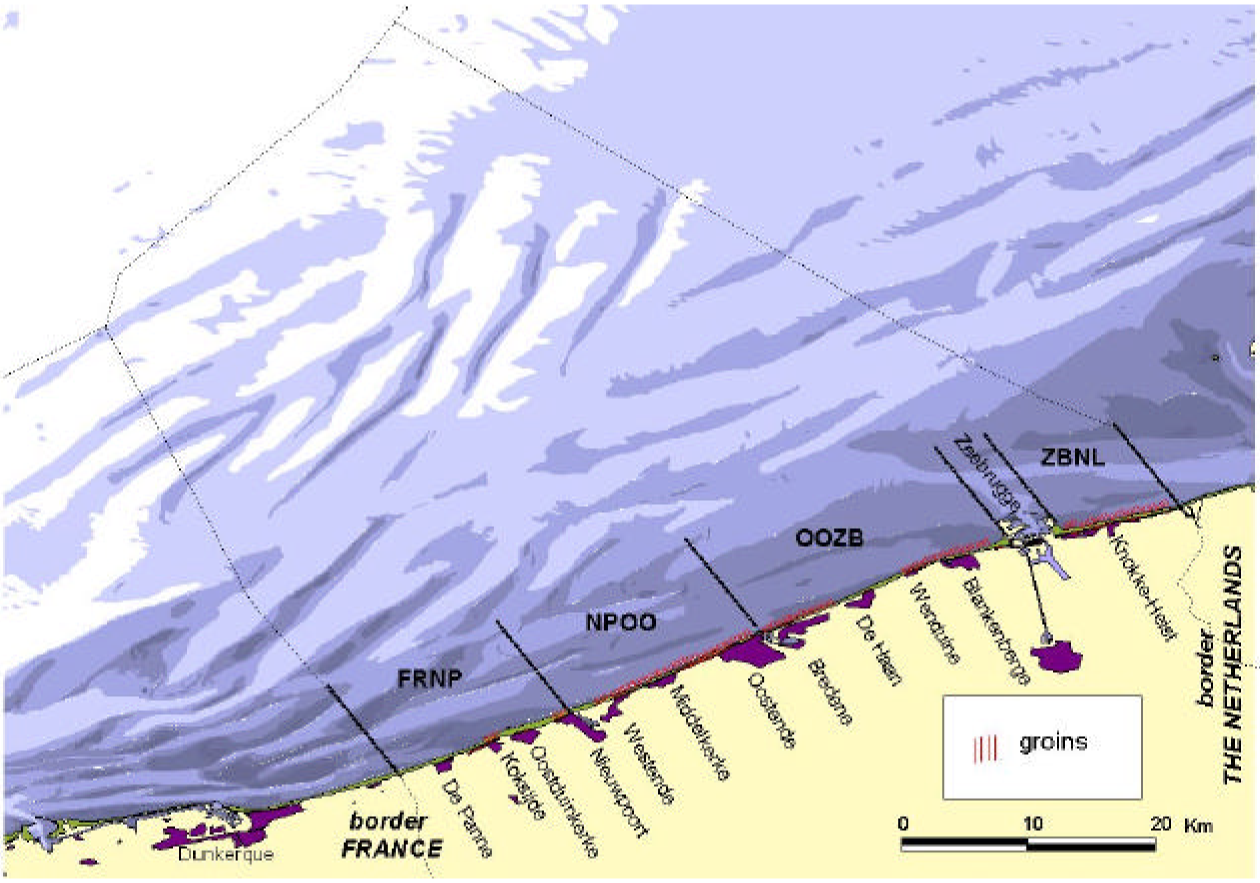
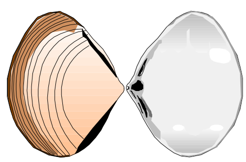



*Fig. 3. The Belgian coast divided in four major beach sections.*

*Macrobenthic communities*

Recently a review of the benthic diversity of Belgian marine waters has been compiled by CATTRIJSSE & VINCX (2001). According to a study of GOVAERE *et al*. (1980), three macrobenthic communities can be distinguished within Belgian marine waters: (1) an offshore community of medium-fine sands at greater depth (20-40 m), very rich in species (predominantly Polychaetes); (2) a diverse community of fine sands at the westcoast with higher silt and organic carbon contents at depths of 3-18 m, characterised by important numbers and biomasses of bivalves; (3) a poor inshore and eastcoast community with fine-very fine sands and an impoverished *Abra alba* community or a transition to a *Macoma balthica* community. The second community was studied more in detail by DEGRAER (1999) and further divided into five different communities of which the *Lanice conchilega* community coincides largely with Govaere's second group. This community is most interesting since it contains the highest densities of bivalves, the major food source for scoters wintering in the area. During a stock-assessment in autumn 1996 and spring 1997, VANHEE *et al*. (1998) calculated a stock of *Spisula subtruncata* of 232,000 ton fresh weight, equally distributed over the territorial waters to the west of Oostende.



## HISTORICAL SETTING OF SEABIRD RESEARCH IN BELGIUM

Seabird research activities in Belgium can roughly be divided into six main categories: (1) seawatching from elevated or protruding coastal points; (2) bird banding activities, mainly of terns and gulls; (3) breeding biological surveys and studies; (4) beached bird surveys; (5) ecotoxicology and pathology; (6) surveys of seabirds at sea. Bird banding activities (e.g.: ROGGEMAN *et al*. 1995) and assessments of biometry and moult in seabirds (e.g.: VANDENBUCLKE 1989 a,b) will not be treated any further, since they fall out of the scope of this thesis. Seawatching and breeding biological surveys are only roughly sketched below.

### SEAWATCHING

In Belgium seawatching is carried out predominantly by volunteers from local nature organisations. There is no coordination amongst seawatching groups and individuals, and little – apart from loose observations of less common species - has been published so far. The first Belgian publications dedicated to seawatching refer to observations (some 20 hours) from various coastal points in autumn 1963 (VANDE WEGHE & VAN IMPE 1964) and from dunes in De Panne (about 300 hours) in the period July 1965 – October 1968 (BULTEEL & VAN DER VLOET 1969). From 1974 onwards seawatching became more and more popular at the Belgian coast (FIERENS & DEVIAENE 1975, VANDENBULCKE 1978, 1979) and several groups or individuals started specialising in this activity. Major efforts are linked to the various ports and harbours along the coast. At Nieuwpoort, the seabird working group of the ornithological organisation 'De Wielewaal' initiated standardized counts from 1976 onwards, and counted year-round on average some 200 hours from 1978 onwards at the pier of Nieuwpoort (ZEEVOGELGROEP NIEUWPOORT 1981, 1982, BORREY *et al*. 1986). A smaller initiative was taken by an independent group at De Panne, counting from this most western part of the coast from early 1981 (ZEEVOGELWERKGROEP NIEUWPOORT 1982). In Oostende, another birding group of 'De Wielewaal' was set up in 1978, and specialised in seabird watching (JANSSEN 1991, ALLEIN *et al*. 1992, BOUDOLF *et al*. 1992, VANLOO 1994, 1996, BOUDOLF & ALLEIN 1997). From the early 1980s onwards they managed to seawatch some 750-1600 hours a year, mainly from the eastern pier at the Oostende port. The third major observation site of the Belgian coast is the Zeebrugge outer harbour and neighbourhood. Here thousands of hours were spent recording seabirds from the old mole (1974-early 1980s), from the newly build outer harbour piers and from an apartment building on the dyke by local ornithologists (LUST 1976, 1977, 1991, LUST & VANLOO 1990, POTTIER 1980, 1981). Published observations from the piers of Blankenberge harbour are limited (BAPTISTE 1988).

### BREEDING BIOLOGICAL SURVEYS

The breeding status of terns and gulls at the Belgian coast is fairly well documented. Since most of the published data are scattered over many volumes of the local journal *Mergus* or of the yearbooks dealing with the birds of NW-Flanders (published by the Brugge branche of the 'Jeugdbond voor Natuurstudie en Milieubescherming' - JNM and the 'Wielewaal'), we refer to VAN DEN BOSSCHE *et al*. (1995), SEYS *et al*. (1998) and SEYS *et al*. (this volume) for an overview. Voluntary ornithologists, many of them members of the nature organisations mentioned above, as well as wardens at the Zwin nature reserve made yearly censuses of the major colonies. More particularly the creation of vast, undisturbed terrains raised with sand in the newly developing harbour of Zeebrugge from 1983-84 onwards, attracted many gulls and terns and dedicated observers. Besides major bird ringing efforts here and in the Zwin nature reserve - coordinated by the Royal Institute for Natural Sciences (KBIN) – several studies were initiated on the breeding biology of the terns and gulls by the Institute of Nature Conservation (IN). In 1989, YSEBAERT & MEIRE (1989) studied the fledging success and foraging behaviour of Black-headed Gulls at the Zwin reserve. In 1991, ROSSAERT *et al*. (1993) investigated the breeding biology and diet of Common Terns in Zeebrugge, in order to assess the potential impact of organochlorines (PCBs, PCDDs and PCDFs). From 1997 onwards, a more regular monitoring programme was carried out within the framework of the actions for 'Sustainable management of the North Sea', funded by the federal Services for Scientific, Technical and Cultural affairs (DWTC-SSTC). As such, annual data on breeding numbers, breeding success and foraging ecology of the dominant species (with a focus on the Common Tern) could be gathered for the breeding seasons 1997 till 2001 (HOEKSTEIN & VAN WAEYENBERGE 1998, MANHOUT 1999, VAN WAEYENBERGE *et al*. 2000). The study is carried out in close cooperation with local ornithologists, who monitored the development of the seabird colonies from the very first beginning. It is thanks to these volunteers that large numbers of birds have been ringed and that breeding numbers and breeding success (sporadically) have been assessed from the very beginning (DE RUWE & DE PUTTER 1999).

### BEACHED BIRD SURVEYS

The first published counts of beached birds in Belgium go all the way back to September 1949, when HAUTEKIET (1955) started with weekly surveys of a 6-7 km beach stretch between Oostende and De Haan during the months September-April. More occasional counts of parts of the coast followed soon (KESTELOOT 1953, HAUTEKIET 1956, 1961, 1965, DE RIDDER 1961, HOUWEN 1968). In 1962, Kuijken coordinated the first survey of the entire Belgian coast, an initiative that was extended to substantial parts of the Dutch and northern French coasts in 1965 (BLANKENA & KUIJKEN 1967). These joint projects of the Belgian and Dutch youth nature organisations (BJN and NJN) were the earliest step towards the International Beached Bird Surveys (IBBS). Pioneers as KUIJKEN & ZEGERS (1968), KUIJKEN (1978a,b) and VERBOVEN (1978, 1979) published early reviews of time series on Belgian data. A period of centrally governed counts was concluded with counts coordinated by MEIRE (1978a,b). The 1980s were characterised by many individual actions, instigated by several large seabird strandings (DE WAELE 1981, VAN GOMPEL 1981, 1984, 1987, VERBOVEN 1985, SHERIDAN & PAMART 1988). From the winter 1991-92 onwards, beached bird surveys were centralised again, now by the Institute of Nature Conservation, of which Kuijken had become the general director (SEYS & MEIRE 1992). As from then, data are available from weekly surveys on a 16.7 km stretch (Oostende-Nieuwpoort), monthly surveys of the entire coast and from occasional counts in case of mass strandings. More or less annual reports on the data have been published for this period (SEYS & MEIRE 1993, SEYS *et al*. 1993, OFFRINGA & MEIRE 1995, OFFRINGA *et al*. 1995, 1997, SEYS *et al*. 1999).

During these beached bird surveys bird corpses were counted, identified, aged, sexed, checked for oil contamination or other causes of death, and eventually measured. In addition, several experiments have been designed to assess the persistence of corpses on the beach (HOUWEN 1968, VERBOVEN 1977, KUIJKEN 1978, SEYS *et al*. this volume) and the drifting and stranding behaviour of carcasses at sea (SEYS *et al*. this volume). The very important effort of individuals and rehabilitation centres, in collecting and treating moribund seabirds, has not been worked out any further in this context.

## ECOTOXICOLOGY AND PATHOLOGY

In 1989, the Belgian government launched a joint project of ecologists and veterinaries to monitor the health and causes of death of seabirds and marine mammals. The initiative fitted into the EC- North Sea Animal Programme (NORSAP) and substantiated in the Belgian Impulse Programme in Marine Sciences, with effect from February 1990. Fresh corpses of seabirds (and marine mammals) were collected on the beach (from January 1992 onwards by the Institute of Nature Conservation, see above) and from rehabilitation centres. Necropsies and tissues samplings were performed in the Department of Veterinary Pathology at the University of Liège (prof. Coignoul) and further toxicological studies were carried out on the same samples by two complementary teams: the Service of Oceanology of the University of Liège (prof. Bouquegneau) and the Laboratory for Ecotoxicology and Polar Ecology at the Free University of Brussels (prof. Joiris). These groups, together with the Royal Institute for Natural Sciences (KBIN) and the Management Unit of the Mathematical Model of the North Sea (BMM-MUMM), formed the MARIN group ('Marine Animals Research and Intervention Network'), a cooperation that was prolonged for another five years in 1997 with the start of the federal programme 'Sustainable Management of the North Sea' (project 'Ecotoxicology and pathology of marine mammals'). Major results have been published for: heavy metal contamination (ANTOINE *et al*. 1992, BOUQUEGNEAU *et al*. 1994, 1996, DEBACKER 2000, DEBACKER *et al*. 2000), parasites (BROSENS *et al*. 1996), pathology (JAUNIAUX *et al*. 1996, 1997, 1998) and organochlorines/heavy metals (JOIRIS *et al*. 1991, 1997, TAPIA 1998).

## SEABIRDS AT SEA

As in beached bird surveying, Belgium played an important role in the pioneering phase of seabird counting at sea. In 1971, professor Joiris of the Free University of Brussels was one of the very first to carry out systematic ship-based counts of seabirds, first in the southern North Sea (JOIRIS 1972) and later in the whole North Sea. He integrated the distribution data he found into the whole ecological structure of the North Sea ecosystem (JOIRIS 1978). From 1973 onwards, he turned his attention to more northern waters, with more than 15 expeditions in the Greenland and Norwegian seas, and later also in the Barents Sea and the Antarctic (JOIRIS 1976, 1978, 1983, 1989). In this pioneering period, observers of seabirds in the North Sea just recorded all birds seen along the ship's course line, or within a 360° radius on fixed stations (see also: BOER 1971, ENGELSMAN & HULSMANN 1974, BOURNE 1976, LEOPOLD 1987). This method had the advantage that larger samples could be obtained providing a good basis for distribution patterns, but as the area observed was not known, densities could not be calculated (CAMPHUYSEN & LEOPOLD 1994). Therefore a method of strip-transect counts was developed (TASKER *et al*. 1984), that became the standard for the North Sea. Soon afterwards, many other North Sea countries started seabird survey programmes on board various types of vessels. Since there was a growing need for detailed and up-to-date information on seabird distribution off the Belgian coast, the Institute of Nature Conservation (a Flemish, governmental research institute funded in 1986) commenced systematic ship-based surveys in September 1992. Initially the World Wide Fund for Nature (WWF-Belgium) funded the project. Later on, the Belgian government supported the continuation of this research programme, first through the Management Unit of the Mathematical Model for the North Sea (BMM-MUMM) and later (1997-2001) within the framework of the SSTC-funded programme 'Sustainable Management of the North Sea'.

Meanwhile, some occasional aerial counts between 1967 and 1976 (BURGGRAEVE 1969, 1974) had demonstrated that the Belgian coastal waters were an important wintering area for scoters, leading to the designation of part of the Kustbanken as Ramsar site. With the foundation of the Institute of Nature Conservation in 1986, aerial surveys of the coastal strip were organised in a systematical way (MAERTENS *et al*. 1988, 1990). From the winter 1986-87 onwards to this day, monthly aerial surveys are carried out on fixed routes from October till March and numbers of seaducks are assessed in the most inshore Belgian area (up to about 10 km offshore)(DEVOS & MEIRE 1995, OFFRINGA 1997, VAN WAEYENBERGE 1998).

Additionally, inshore concentrations of scoters, Eider *Somateria mollissima*, divers, grebes and other waterbirds caught attention from several local ornithologists, and were counted on a irregular base in the framework of the international waterfowl surveys (IWRB, now Wetlands International)(DEVOS 1986, 1990, DEVOS & MEIRE 1989, 1991, 1993, 1994, 1995,1997, DEVOS *et al*. 1987, 1989, 1991, 1997, DE PUTTER 1987, 1988, DE PUTTER & WILLEMYNS 1989, DE SCHEEMAEKER 1997, DE SCHUYTER 1988, DE SCHUYTER & DE PUTTER 1985). Single observations were published in the ornithological yearbooks of NW-Flanders (ANSELIN & DESMET 1980, DESMET 1982, 1983, DE SCHUYTER 1984, 1985, SEYS 1986, DE SCHEEMAEKER 1987, VANPRAET 1988, VANPRAET & DE SCHEEMAEKER 1989, DE SCHEEMAEKER & VANPRAET 1991) or in the local ornithological journal *Mergus* (1987-1999) under the heading 'Bijzondere waarnemingen' (special observations).

Although gulls are one of the most prominent seabird groups of the Belgian coast, their daily appearance and sometimes huge numbers have put off bird watchers to make accurate counts. Besides some published records of individual roost sites (e.g.: DESENDER & HOUWEN 1984), only three surveys of the entire Belgian coast had been conducted and published until the early 1990s (DEVOS & DEBRUYNE 1990, 1991). Recently, gull research and status assessment got a new stimulus in the Belgian coastal area, through a thesis at the University of Gent, under supervision of the Institute of Nature Conservation (SPANOGHE 1999). In the frame of this study, all gulls were counted in the coastal strip at five occasions during November 1998 – March 1999 and attention was paid to behaviour and habitat preference.

## OBJECTIVES AND GENERAL OUTLINE

### OBJECTIVES

This study focuses on the distribution of seabirds in the southernmost part of the North Sea and on the occurrence of beached corpses at the Belgian coast. Generally spoken, seawatching, breeding biology, ecotoxicological and pathological aspects fall beyond the scope of this work. An analysis of the 'seabird at sea' and the beached bird survey data will: (1) contribute to a better understanding of how seabirds thrive in the marine ecosystem; (2) evaluate the impact of human activities on sea- and coastal birds; (3) provide support for the policy-making and management in this most interesting part of the southern North Sea; (4) evaluate the cost-efficiency of the current seabird surveying methods and suggest ways of improving it. The intrinsic value of seabirds might lead to the designation and proper management of marine protected areas or to the implementation of species protection plans. Some seabirds may act as composition indicators for habitats or for other species and hence reduce the information load to a more transparent level. Finally they can act as condition indicators for human impacts or natural fluctuations in the ecosystem or as early warners for a proper management of our coastal zone.

More specifically we want to answer the following questions:
(1) How are seabirds distributed over Belgian marine waters in relation to environmental variables and how do numbers and distribution change in time and space?
(2) What are the consequences of these distribution patterns for the policy and management of Belgian marine waters?
(3) Can certain species play a role as indicators of their habitat or as surrogates for other species?
(4) Are regular surveys along fixed ferry routes a tool as perfect as always believed?
(5) What is the most cost-efficient way of organising a beached bird survey programme?
(6) What have we learned from almost forty years of beached bird surveying in Belgium?
(7) How big is the chance that a bird dying at sea is found by a beached bird surveyor, in other words: what is the link between results of beached bird surveying and counts of seabirds at sea?
(8) What should be the priorities for future seabird research?

### GENERAL OUTLINE

This thesis is composed of an introductory chapter (**Chapter 1**), six papers and an extended summary. An appendix contains some basic information, as well as a published report on major characteristics of seabird species found during beached bird surveys. The general outline of the thesis follows a division in a 'seabirds at sea' part and a 'beached bird survey' part. For both major parts, one contribution deals with methodological aspects, one with implications for the management and policy of the area, and one has a largely descriptive and analytic character.

**Chapter 2** describes the general patterns of distribution of seabirds in Belgian marine waters, in relation to environmental variables. With multivariate analysis and regression techniques, the reality of 'communities' of seabirds is evaluated and a selection of potential composition indicators is made. **Chapter 3** evaluates the importance of Belgian marine waters for resident and migrant seabird species. A selection of internationally threatened seabirds results in the identification of focal species for conservation and core-areas for seabirds in these waters. In addition, the vulnerability of species and core-areas is assessed for oil-pollution and disturbance by shipping activities. Finally the present state of conservation is discussed and suggestions for the future are being made. In **Chapter 4**, we examine the temporal patterns of seabird occurrence on the basis of surveys during some eighty crossings on board ferries from Belgium to the U.K. By means of a simple model we try to investigate which factors determine the observed numbers of seabirds. From this model we derive recommendations for future research and monitoring strategies.

The second part opens with **Chapter 5**, a link between the 'seabirds at sea' and the 'beached bird survey' part. Results of various drift experiments with seabird corpses in the southernmost part of the North Sea and of a two-year study on the persistence of carcasses on the beach form the basis for an assessment of the relation between what dies at sea and what is being detected by beach surveyors. In addition the impact of weather conditions on the abundance of stranded birds is examined. **Chapter 6** uses data of almost forty years of February beached bird surveys in Belgium to evaluate trends in oil pollution at sea. Specific problems associated with the short length of the Belgian coast are discussed. The latter is worked out in more detail in **Chapter 7**. This chapter compares the results obtained through one coastal rehabilitation centre and weekly, monthly and annual beached bird surveys in terms of density, oil rate and species composition. The impact of the method, the distance travelled and the frequency of the counts is analysed and discussed. An outline for a cost-efficient beached bird monitoring programme is sketched.

Finally, in an extended summary the major results of the preceding chapters are summarized and translated into suggestions for future research and for a fine-tuning of monitoring programmes (**Chapter 8**). In ***Appendix*** some basic tables are included, as well as a report with a detailed description of characteristics of seabirds, as found during almost forty years of corpse collection on Belgian beaches.

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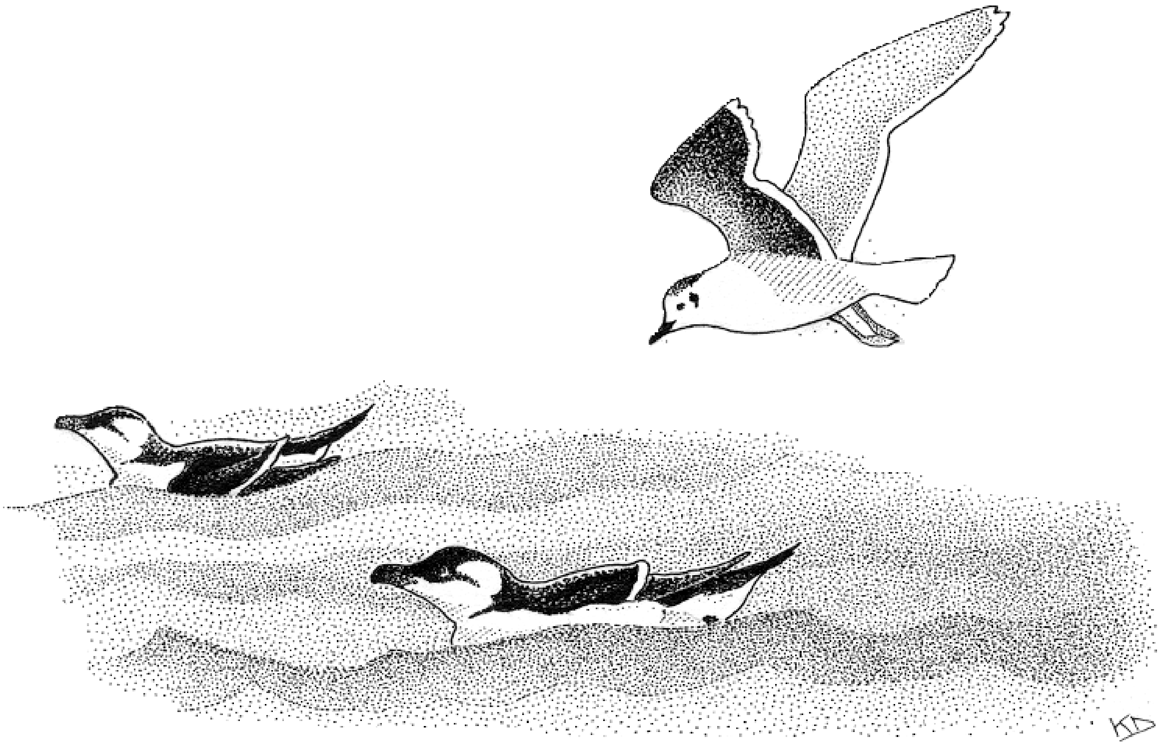
# CHAPTER TWO

## DISTRIBUTION PATTERNS OF SEABIRDS IN BELGIAN MARINE WATERS




*Jan Seys[1*], Henk Offringa[2], Jeroen Van Waeyenberge[1], Patrick Meire[3], Magda Vincx[4] & Eckhart Kuijken[1]*

*[1] Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
*[2] Ministry of Transport, Public Works and Water Management, Directorate General of Public Works and Water Management, North Sea Directorate, P.O.Box 5807, 2280 HV Rijswijk, The Netherlands*
*[3] University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
*[4] University Gent, Biology Department, Marine Biology Section, K.L.Ledeganckstraat 35, B-9000 Gent, Belgium*
*[*] present adress: Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

# Distribution patterns of seabirds in Belgian marine waters

J. Seys, H. Offringa, J. Van Waeyenberge, P. Meire, M. Vincx & E. Kuijken

## ABSTRACT

Intensive seabird surveying during seven years (1992-98) in the Belgian part of the southern North Sea revealed the existence of a land-sea and a longitudinal gradient from the Schelde estuary in the east to the deeper, less turbid waters in the west. Piscivorous species preferring clear water and mid- to offshore conditions (auks, Kittiwake and Northern Gannet) are more abundant in the west. Divers, grebes and *Larus*-gulls are commoner in the more turbid waters near the mouth of the Schelde estuary. Depth and topography are less dominant as explanatory variables for the distribution of most of the 17 dominant species/taxa. Multivariate and correlative analysis of the abundance of these species could not reveal strong temporal or spatial coherence of seabirds in communities. Highest correlations were found among *Larus*-gulls scavenging at trawlers, and in the group of auks, Kittiwake and Little Gull. The auks (Razorbill, Common Guillemot) and both gull species were often seen in short-lived multi-species feeding associations over presumed fish shoals. Razorbill is the species that associated most frequently (in 28% of all observations) and it appeared to be a more 'attractive' target for Kittiwake (34%) and Little Gull (23%) than the Common Guillemot. Kleptoparasitic behaviour was rarely observed (2.9-6.3% of the observations in skuas). The impact of fishery activities on the distribution of scavenging seabirds (8 of the 17 dominant species) is large. Some 65-70% of all large gulls in the study area were observed in association with trawlers. The general patterns of distribution described in this paper provide the basis for new future research. Major emphasis should go to the interactions between hydrography, prey-availability (pelagic fish) and the specific geomorphologic characteristics of this study-area. Priority species for more detailed research are proposed.

## INTRODUCTION

Since the start of systematic seabird counting in the North Sea in the late 1970s, eight atlases have been published of the area (Baptist & Wolf 1993, Carter *et al*. 1993, Camphuysen & Leopold 1994, Anonymous 1995, Camphuysen *et al*. 1995, Skov *et al*. 1995, Stone *et al*. 1995, Offringa *et al*. 1996). The maps produced in these publications are very often based on smoothing small-scale data over large areas and time-intervals, obscuring the detailed spatial and temporal patterns. As a result the generalised and rather rough pictures have only a limited value for those interested in the community structure and interactions between seabirds and their environment (Camphuysen 1996). Seabirds may use very fine-scale cues in exploiting the environment, often much finer or more ephemeral than those that can be detected with large-scale surveys (Begg & Reid 1997, Ribic *et al.* 1997, Tasker & Reid 1997, Wanless *et al*. 1997, Camphuysen & Webb 1999).

The unique geomorphologic characteristics of the Belgian marine waters - with four major formations of linear sand ridges ('sandbank systems') each with its own strike, distance to the coast and topography -, and its location in between the Straits of Dover and the mouth of the Schelde estuary, hold prospects to investigate distribution patterns of seabirds in more detail. During extensive seabird surveys in Belgian marine waters from September 1992 till December 1998, we put in a great effort (16,000 km) in a relatively short period and clear patterns in occurrence of seabirds could be observed. In this paper we want to analyse the spatial and temporal distribution patterns and try to find out whether communities of seabirds can be distinguished in relation to environmental conditions. The analysis will focus on how distance to the coast, longitude (distance to the Schelde estuary and the Straits of Dover), depth, topography (swale, slope or crest of a sandbank) and period of surveying may structure seabird populations.

By studying coexistence patterns of seabird species, we will try to gain more insight in the relationships among species and in the coherence of communities. Do communities of seabirds at sea exist or are they basically the artificial result of lumping and smoothing seabird data over large time-spans and areas, creating pictures of coexistence in species that are rarely found together? An analysis of associations and correlations between species can also help to answer whether certain seabird species may behave as 'umbrella species', i.e.: species with such demanding habitat requirements that saving it will automatically save many other species (Simberloff 1998). In general certain species might tell more about their environment or about associated species than others, and deserve more attention in the future in terms of research investment.

## MATERIAL & METHODS

### STUDY AREA

The study-area is situated in the southern North Sea, characterised by its shallowness and well-mixed waters. It forms the main and central part of what is internationally referred to as the 'Flemish Banks' (OSPAR COMMISSION 2000). Belgian marine waters occupy a small area (3500 km$^2$), are intensively used (MAES *et al*. 2000) and near to important sources of water input (situated at c. 55-75 km east of the Straits of Dover and immediately west of the mouth of the Schelde estuary). The structural variation in topography is unique for the North Sea (HOUBOLT 1968, EISMA *et al*. 1979), with various sand ridges resulting from sediment and melt water displacements during several glacial periods. Six subregions – including four major sandbank systems each with a characteristic strike, profile and distance to the coast – can be distinguished (Fig. 1, Table 1, CATTRIJSSE & VINCX 2001). These subregions were further divided in 36 'sandbanks', each split up into three strata. The strata 'crest', 'slope' and 'swale' are defined as <10 m deep, 10-20 m and > 20 m, except for the inshore Oostkust- and Westkustbanken where < 5m, 5-10 m and >10m respectively.

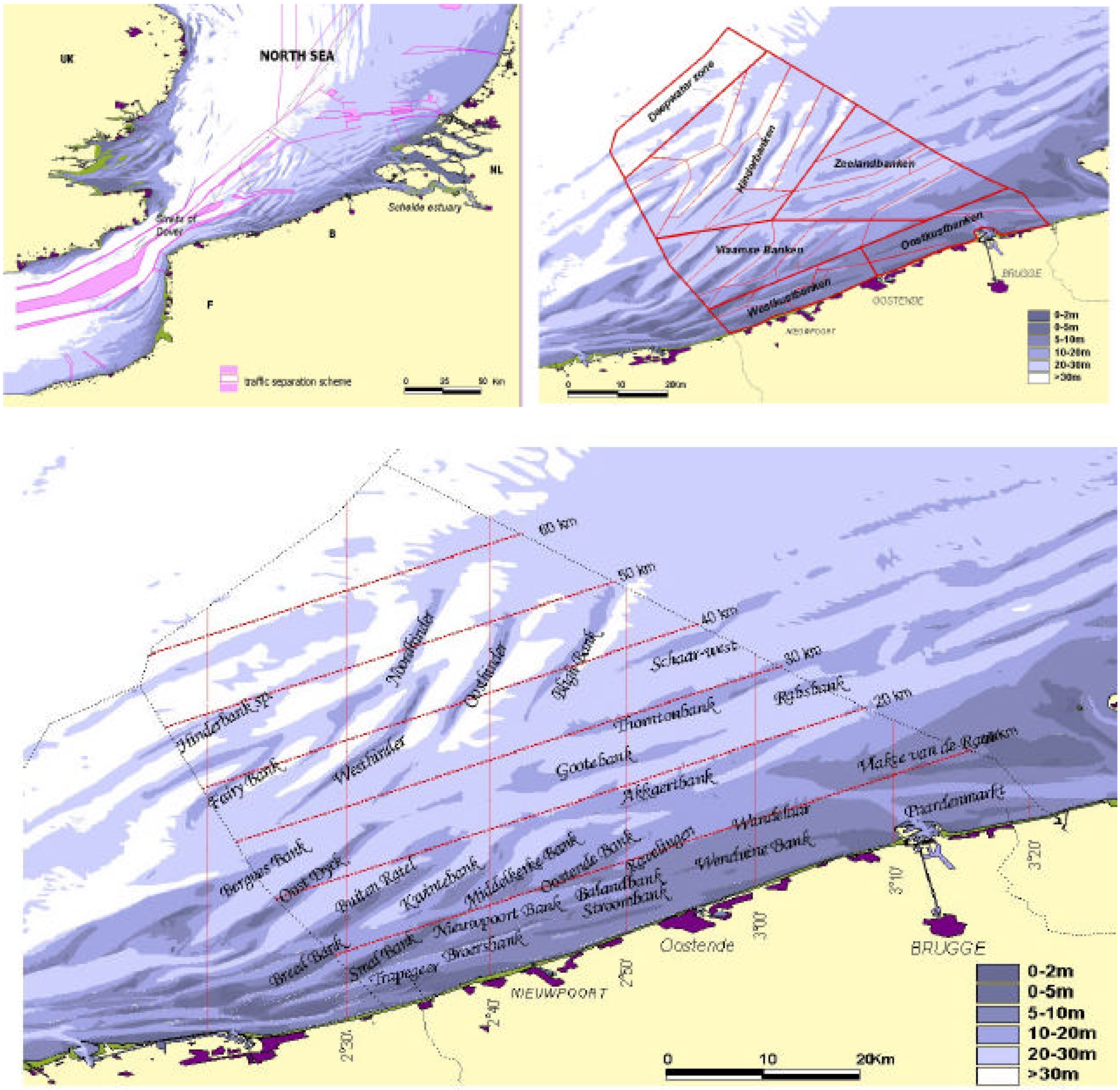



*Fig. 1. Belgian marine waters with: a) setting within the Southern Bight of the North Sea; b) subdivision in six subregions and 35 sandbanks; c) most important sandbanks*

*Table 1. General characteristics of the Belgian marine waters, divided into six subregions on the basis of the occurrence of sandbank systems: OK=Oostkustbanken, WK=Westkustbanken, VB=Vlaamse Banken, ZB=Zeelandbanken, HB=Hinderbanken, DW=Deepwater subregion. The figures indicated with Seys* et al *this study, have been derived from the official maritime charts and from a GIS application tool.*

| VARIABLE | OK | WK | VB | ZB | HB | DW | SOURCE |
|---|---|---|---|---|---|---|---|
| Area ($km^2$) | 310 | 270 | 600 | 740 | 1210 | 370 | SEYS *et al*. this study |
| Mean depth (m MLLWS) | 0-10 | 0-10 | 5-25 | 5-25 | 5-35 | 30-40 | SEYS *et al*. this study |
| Minimal depth (m MLLWS) | 0 | 0 | 3 | 6 | 5 | 20 | SEYS *et al*. this study |
| Mean elevation sandbanks to seafloor (m) | 2-5 | 2-5 | 15-20 | 10-20 | 25-30 | - | SEYS *et al*. this study |
| Length sandbanks (km) | 10-20 | 2-15 | 10-30 | 20-30 | 15-25 | - | SEYS *et al*. this study |
| Distance to coast (km) | 0-13 | 0-10 | 10-30 | 10-40 | 25-60 | 60-80 | SEYS *et al*. this study |
| Strike of the sandbanks (°) | 70 | 70 | 40 | 70 | 40 | - | SEYS *et al*. this study |
| Mean surface temperature in February (°C) | 4.0 | 5.5 | 6.0 | 4.0 | 4.5 | 6.5 | OTTO *et al*. 1990 |
| Mean surface salinity in February (‰) | 30.5 | 32.0 | 33.0 | 32.0 | 33.5 | 34.8 | BENNEKOM & WETSTEYN 1990 |
| Max. tidal current velocity at surface ($m.s^{-1}$) | 1.8 | 1.5 | 1.0 | 1.2 | 1.0 | 1.0 | OTTO *et al*. 1990 |
| Depth 1% daylight penetration in Dec. (m) | <5 | 5-10 | 10-20 | <5 | 5-10 | >20 | VISSER 1969 |
| Non-living suspended matter (ppm) | 40 | 30 | 25 | 20 | 10 | 2 | EISMA *et al*. 1979 |

Two dominant physical features characterise the area, resulting in distinct west-east and inshore-offshore gradients. To the east the Schelde estuary has a major impact on current velocities, sediment and water characteristics. To the west the Straits of Dover are an inlet for high saline, Atlantic water into the southernmost part of the North Sea. Both phenomena interfere in the area of the ‘Flemish Banks’.

The study area is rich in fish, edible for seabirds. During the International Bottom Trawl Surveys in the mid 1980s, Herring *Clupea harengus*, Sprat *Sprattus sprattus*, Cod *Gadus morhua*, Whiting *Merlangius merlangus*, Bib *Trisopterus luscus*, Poor Cod *Trisopterus minutus* and Sandeel *Ammodytidae* were all abundant in the area (KNIJN *et al*. 1993). Densities of pelagic Herring (<15 cm) and Sprat (<10cm) peak in February-March (OFFRINGA *et al*. 1996). Bivalve populations are particularly abundant in the coastal and most western part of the Belgian marine waters (GOVAERE 1978, DEGRAER 1999).

## DATA

*Bird survey methods*

The analysis is based on all ship-based surveys carried out in Belgian marine waters between September 1992 and December 1998. A standard strip transect method for counting seabirds at sea has been applied (TASKER *et al*. 1984), using a snapshot count for flying birds. In order to compensate for missed small and dark birds, the mean density of swimming birds has been multiplied with a correction factor (STONE *et al*. 1995). Regular surveys throughout the study-area were carried out on board the research vessels *Belgica* and *Ter Streep*. In addition seabirds were counted on fixed routes on a monthly basis (frequency much higher in wintertime) on board ferries of the companies RMT (Regie voor Maritiem Transport) and Sally Lines. Those trips embarked in Oostende (Belgium) with destination Dover (1992-93) or Ramsgate (1994-98). Four trained ornithologists, eventually assisted by other seabird watchers, carried out all ship-based surveys. The number of observers during each trip was small (one: 63%, two: 27%, more: 10%).

*Table 2. Seabird survey effort by season in the six subregions of the Belgian marine waters during 1992-1998. The relative effort is the absolute effort divided by the area ($km^2$).*

| Season | Effort | Deep water subregion | Hinder banken | Zeeland banken | Vlaamse Banken | Westkust banken | Oostkust banken | Belgian marine waters |
|---|---|---|---|---|---|---|---|---|
| Winter | absolute effort ($km^2$) | 7 | 251 | 269 | 768 | 309 | 160 | 1771 |
| *(Dec-Feb)* | *relative effort* | *0.02* | *0.21* | *0.36* | *1.28* | *1.14* | *0.52* | *0.51* |
| Spring | absolute effort ($km^2$) | 2 | 104 | 141 | 343 | 172 | 77 | 841 |
| *(Mar-May)* | *relative effort* | *0.01* | *0.09* | *0.19* | *0.57* | *0.64* | *0.25* | *0.24* |
| Summer | absolute effort ($km^2$) | 6 | 107 | 106 | 238 | 108 | 65 | 633 |
| *(Jun-Aug)* | *relative effort* | *0.02* | *0.09* | *0.14* | *0.40* | *0.40* | *0.21* | *0.18* |
| Autumn | absolute effort ($km^2$) | 17 | 122 | 216 | 695 | 354 | 165 | 1571 |
| *(Sep-Nov)* | *relative effort* | *0.05* | *0.10* | *0.29* | *1.16* | *1.31* | *0.53* | *0.45* |
| TOTAL | absolute effort ($km^2$) | 32 | 584 | 732 | 2045 | 945 | 468 | 4817 |
| | *relative effort* | *0.09* | *0.48* | *0.99* | *3.41* | *3.50* | *1.51* | *1.38* |

*Effort*

During the study-period about 16,000 km or a total transect area of 4817 km$^2$ was surveyed within the Belgian marine waters (Table 2). Only the deepwater subregion in the far north has been poorly covered (32 km$^2$). The Vlaamse Banken were the best-surveyed subregion (2045 km$^2$). Taking into account the area of the subregion, the Westkustbanken received as much attention as the Vlaamse Banken. On average every km$^2$ on the entire Belgian part of the North Sea has been surveyed 1.4 times during the six and a half year of the study. Twenty percent of the travelled distance refers to counts on board ferries from Oostende to Dover or Ramsgate. Winter and autumn received more than twice as much attention as spring and summer (Table 2). Monthly effort dropped to less than 500 km$^2$ in April-July. In February (1566 km$^2$), October (1317 km$^2$), August (1286 km$^2$) and March (1085 km$^2$) seabird watchers were allowed on board the Belgica for targeted surveys of 1-2 weeks, resulting in important survey efforts. During the rest of the year the observers were allowed on board but could not influence the survey route.

*Data-analysis*

The original bird data, collected within a 300 m transect width, were transformed into densities of birds (N km$^{-2}$ ) per counting unit. Counting units usually comprised ten minutes, equalling a travelled distance of c. 3 km at a speed of 10 knots. Interrupted counts of less than 1 km were not considered for further analysis. Only those 17 species/taxa were included that were observed at least 40 times in Belgian marine waters during the ship-based surveys (Fig. 2). Due to potentially unreliable identifications, all divers were grouped into 'divers species'. The same happened to Common Terns *Sterna hirundo*, Arctic Terns *S.arctica* and unidentified 'comic terns'. We considered 'seabirds' as: all divers, grebes, petrels, storm-petrels, cormorants, gannets, seaducks, skuas, gulls, terns and auks. 'Coastal birds' include the waders and other waterbirds. The remaining species are treated as 'terrestrial birds' (see *Appendix I*). For a subdivision in taxonomic groups we followed STOWE (1982). One of the most obvious and abundant functional groups of seabirds at sea are the scavengers. As scavengers we included species that occur very regularly at the trawl: Fulmar, Northern Gannet, Great Skua, Lesser Black-backed Gull, Great Black-backed Gull, Herring Gull, Common Gull and Kittiwake. Species that do so only occasionally (other skuas, shearwaters, Little Gull, Black-headed Gull, terns, auks and cormorants) were not included (CAMPHUYSEN *et al.* 1995).

In order to study the relationship between seabird communities and the environment, each counting unit of ten minutes was assigned a value for each of the following environmental variable classes, by using a GIS application tool (Fig. 1):

1) topography: 'crest', 'slope' or 'swale' (see above)
2) depth: '0-10 m', '10-20 m', '20-40 m'
3) distance to the coast: '0-5 km', '5-10 km', '10-20 km', '20-30 km', '30-40 km', '40-50 km', '50-60 km'
4) longitude: '2°10-2°20 E', '2°20-2°30', '2°30-2°40', '2°40-2°50', '2°50-3°00', '3°00-3°10', '3°10-3°20'

Weighted correlations between environmental variables revealed high values for depth and topography (0.734) and depth vs. distance to the coast (0.579). Due to the shape of the study-area, longitude showed an inverse correlation with distance to the coast (-0.419). With a multiple regression analysis on the log($x$+1) transformed data, we assessed which explanatory variables contributed most to a species response and which explanatory variables appeared to be unimportant.

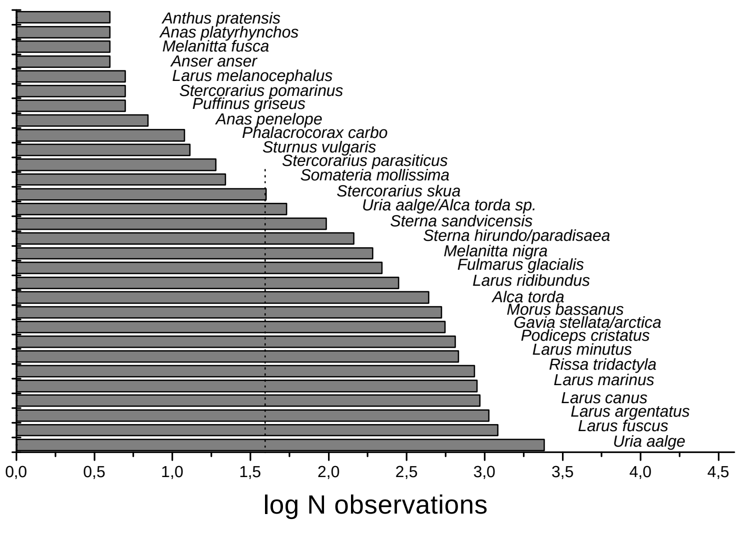



*Fig. 2. Number of observations (log N) of the most common bird species above Belgian marine waters during ship-based surveys in 1992-98.*

## RESULTS

### GENERAL DESCRIPTION OF SEABIRD DISTRIBUTION IN BELGIAN MARINE WATERS

*Species-diversity*

During the study-period 1992-98, 124 bird species were observed in Belgian marine waters. Migration periods (autumn, spring) showed the highest overall number of observed species (94 and 71, respectively); winter and summer had lower $N_0$ values (57 and 43 resp.). The mean number of species observed by bankstratum by season was comparable for autumn, winter and spring (13.4, 11.2 and 12.2 resp.) and only markedly reduced in summer (6.1). Throughout the year the number of species observed at the offshore Hinderbanken and in the deepwater subregion was much lower than in the more coastal zones (Fig. 3). This may at least partly be attributed to the large distance to the coast and hence the lower probability to observe land-oriented migrating birds here.

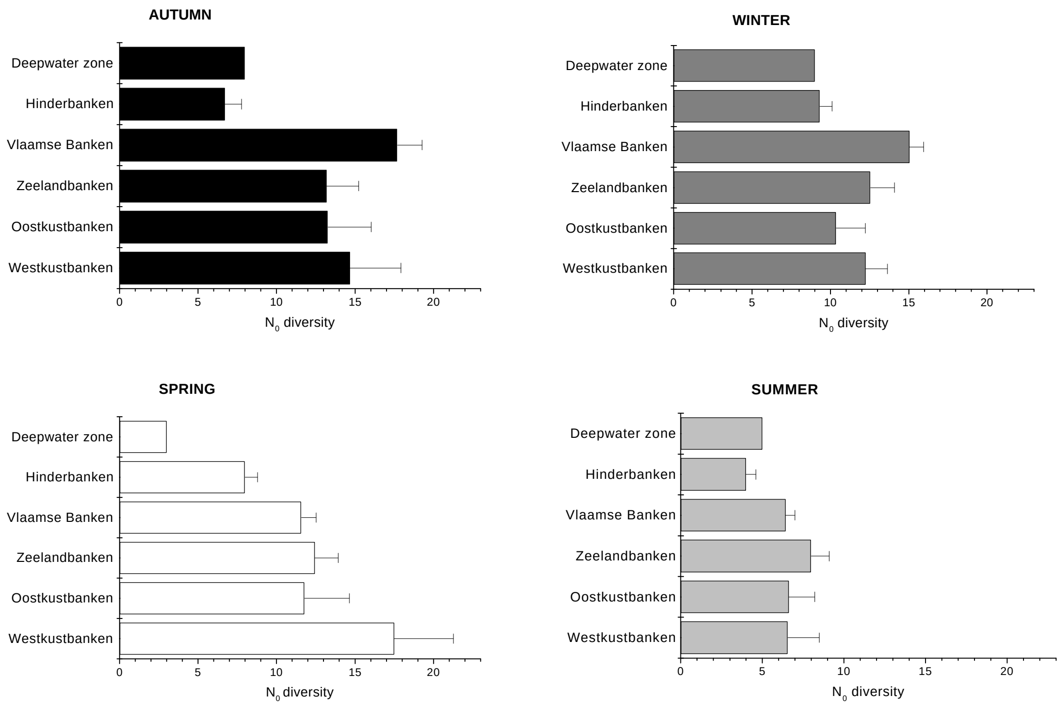



*Fig. 3. Mean bird diversity ($N_0$) by bankstratum by season for each of the six subregions in the Belgian marine waters during 1992-98.*

*Overall density*

Averaged over the entire study-period and study-area, the density of birds amounted to 6.89 $km^{-2}$ (range: 0-1151 $km^{-2}$), of which 98.1% were seabirds. *Larus*-gulls were most common (3.48 $km^{-2}$), then auks (1.34 $km^{-2}$), Kittiwake (0.57 $km^{-2}$), scoters (0.48 $km^{-2}$) and grebes (0.29 $km^{-2}$). At a species level, the Common Guillemot attained the highest mean densities (1.06 $km^{-2}$), higher than those of Lesser Black-backed Gull (0.92 $km^{-2}$), Herring Gull (0.74 $km^{-2}$), Common Gull (0.71 $km^{-2}$), Kittiwake (0.57 $km^{-2}$), Common Scoter (0.48 $km^{-2}$), Great Black-backed Gull (0.44 $km^{-2}$), Little Gull (0.39 $km^{-2}$), Great Crested Grebe (0.29 $km^{-2}$), Black-headed Gull (0.28 $km^{-2}$), Razorbill (0.25 $km^{-2}$), Northern Gannet (0.15 $km^{-2}$) and Red-throated Diver (0.12 $km^{-2}$). The year-round average density of all other species was lower than 0.10 $km^{-2}$. We did not observe a single brid within transect during 39% of all 5360 count units (of c. 10 minutes each).

### SPECIES DISTRIBUTION

*Year-to-year and month-to-month variability*

A Detrended Correspondence Analysis (DCA) on the mean densities of the 17 most abundant species/taxa per year and per month showed that major temporal variability is polarized along axis 1 (eigenvalue: 0.527)(Fig. 4). Samples of the months November-March were all grouped at the lower end of the first axis, those of April-October at the opposite side. In a TWINSPAN analysis on the same dataset, a similar division occurred with Great-crested Grebe, divers and Common Guillemot as indicators for the winter samples, and 'comic' Tern for the summer group. Data of certain years and individual months did not cluster, indicating that for further analysis all years could be combined and months could be regrouped in two major periods: a winter block (Nov-Mar) and a summer block (Apr-Oct).

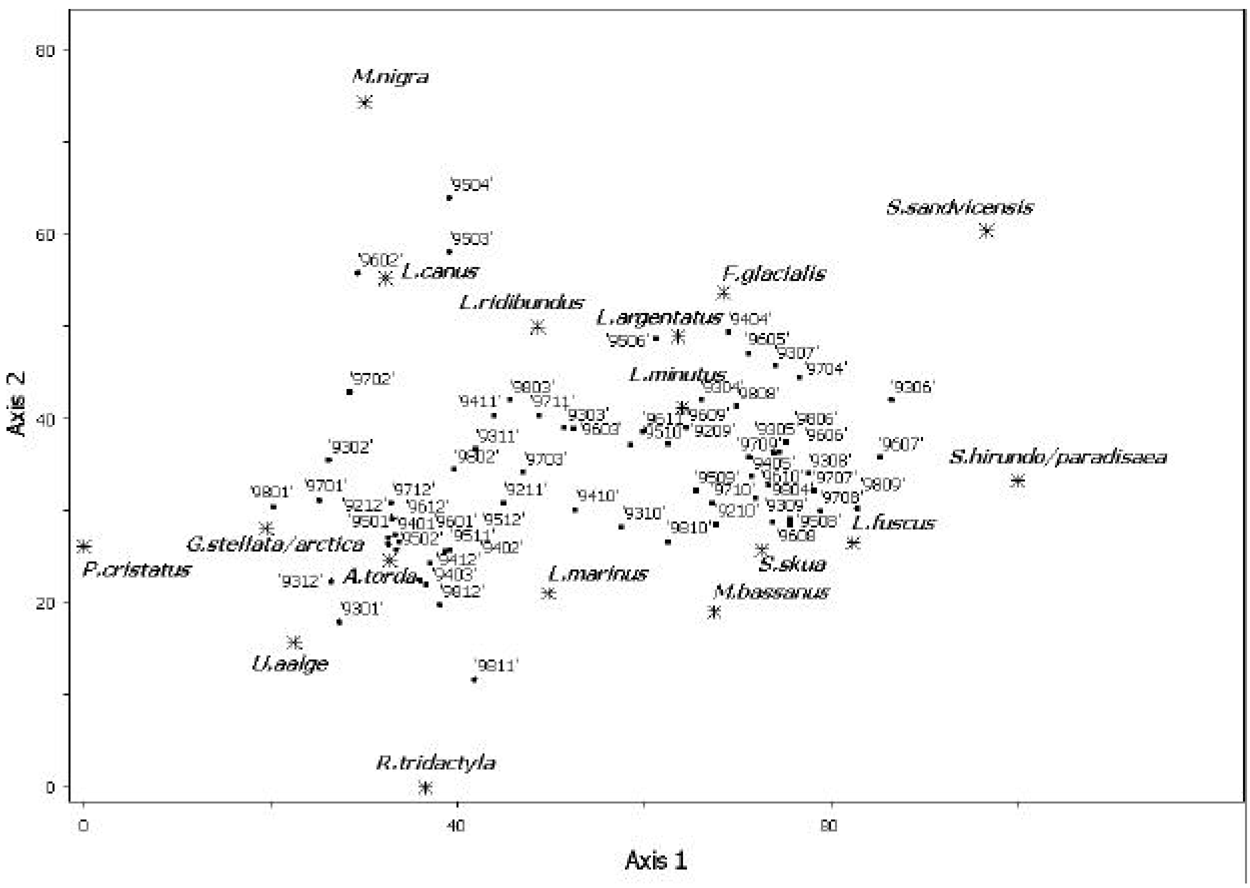



*Fig. 4. Ordination diagram of a DCA analysis on the monthly density data of the 17 most abundant species/taxa per year (see labels).*

*Distribution in relation to distance to the coast, depth, topography and longitude*

A multiple regression analysis on the log ($x$+1) transformed density data shows which explanatory variables contributed most to a species response and which explanatory variables appear to be unimportant (Table 3). For most species/taxa the 'distance to the coast' is the variable that performed best in explaining the distribution, followed by the 'month' of the year and the 'longitude'. That 'depth' and 'topography' are only of minor importance is rather surprising; for 'year' these findings are consistent with results obtained above.

*Table 3. Contribution of various environmental factors in the distribution of seabird species/taxa in Belgian marine waters during 1992-98. The table summarizes the result of a multiple regression analysis on the log (x+1) transformed density data and the environmental factors depth class (D), longitude class (L), topography (crest, slope, swale: T), year (Y), month (M) and distance to the coast class (A). The sequence of the importance of the variables for each species was determined by a forward stepwise selection procedure. For each variable the slope (b) of the regression and the significance (P) are given. For the selected set of environmental variables, the $R_{adj}$ is added.*

| Species | Var1 | *b* | *P* | Var2 | *b* | *P* | Var3 | *b* | *P* | Var4 | *b* | *P* | $R_{adj}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *G.stellata/arctica* | M | -.09 | *** | D | -.06 | *** | Y | -.03 | * | L | -.03 | * | 0.012 |
| *P.cristatus* | A | -.10 | *** | M | -.16 | *** | D | -.09 | *** | L | .04 | ** | 0.060 |
| *F.glacialis* | A | .19 | *** | Y | .06 | *** | | | | | | | 0.045 |
| *M.bassanus* | A | .17 | *** | M | .11 | *** | L | -.06 | *** | | | | 0.049 |
| *M.nigra* | A | -.13 | *** | M | -.08 | *** | Y | .03 | ** | | | | 0.019 |
| *S.skua* | A | .05 | *** | M | .05 | *** | | | | | | | 0.046 |
| *L.minutus* | A | -.08 | *** | M | .04 | ** | | | | | | | 0.008 |
| *L.ridibundus* | A | -.08 | *** | L | .07 | *** | D | -.05 | * | | | | 0.027 |
| *L.canus* | T | -.09 | *** | M | -.09 | *** | L | .08 | *** | Y | .07 | *** | 0.027 |
| *L.fuscus* | M | .11 | *** | L | .09 | *** | | | | | | | 0.023 |
| *L.argentatus* | L | .07 | *** | D | -.06 | *** | M | -.05 | *** | Y | .03 | * | 0.013 |
| *L.marinus* | M | .12 | *** | Y | -.03 | * | | | | | | | 0.014 |
| *R.tridactyla* | A | .16 | *** | M | .03 | * | | | | | | | 0.024 |
| *S.sandvicensis* | L | .04 | ** | | | | | | | | | | 0.001 |
| *S.hirundo/paradisaea* | L | .09 | *** | M | .05 | *** | T | -.04 | ** | Y | .03 | * | 0.014 |
| *U.aalge* | A | .16 | *** | M | -.17 | *** | L | -.11 | *** | Y | -.05 | *** | 0.090 |
| *A.torda* | L | -.09 | *** | M | -.07 | *** | A | .07 | *** | | | | 0.023 |

In our study-area we can distinguish three groups of seabirds on the basis of the observed densities in distance strips of 10 km (Fig. 1):

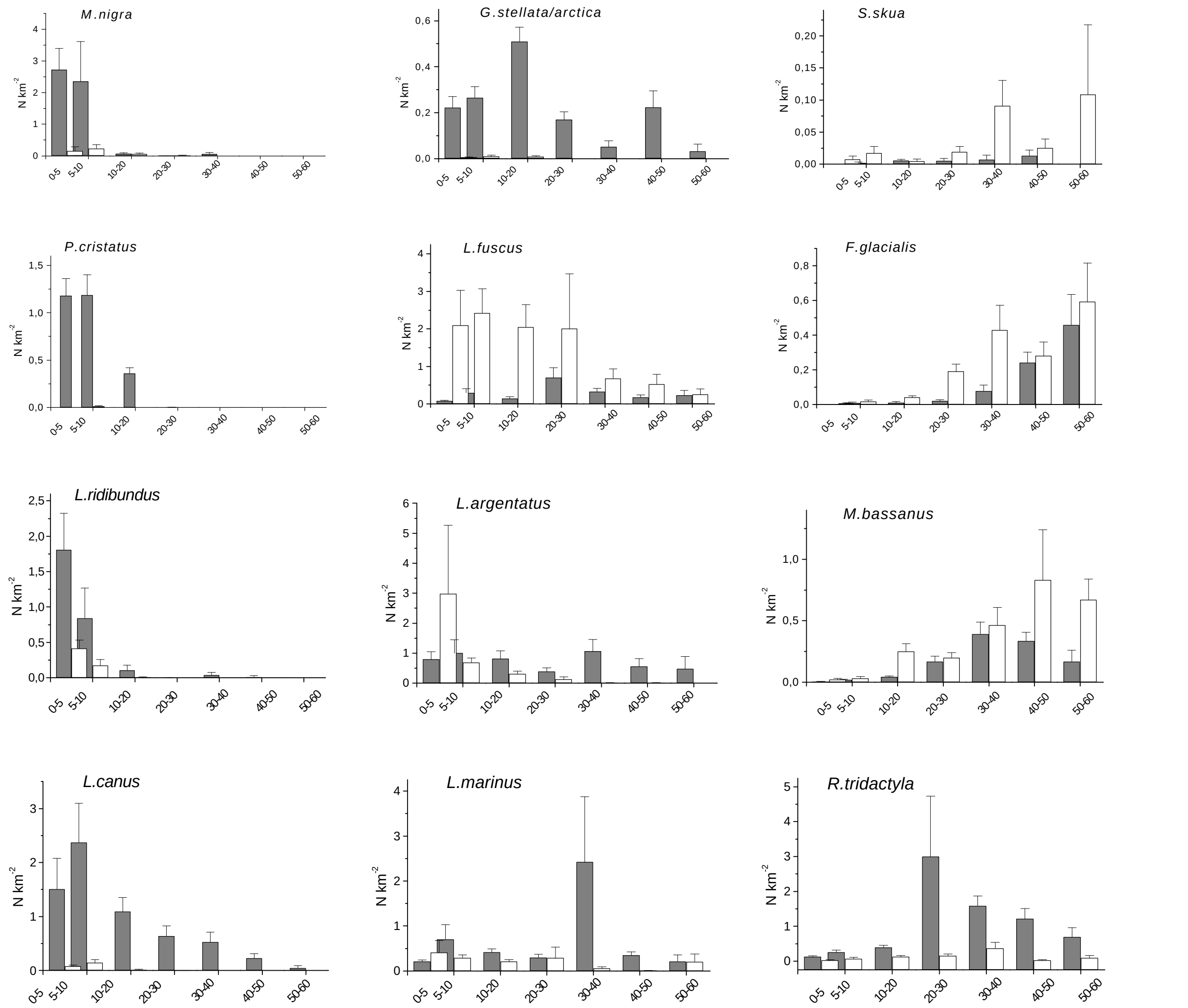
(1) inshore species: species such as Great-crested Grebe, Common Scoter, Black-headed Gull and terns that are most abundant within 10 km from the shoreline in all seasons (Fig. 5, *Appendix IV*).

(2) offshore species: species such as Fulmar, Northern Gannet, Great Skua and Kittiwake, that are rarely observed within 10 km from the coast and are most common beyond a distance of 20 km.

(3) midshore taxa: a mixed group of auks, divers and *Larus*-gulls that occur in a wide front and that are well-presented at a midshore distance of 10-20 km from the coast, compared to further on- or offshore areas.

Generally spoken, inshore species are most abundant in the Kustbanken subregion, offshore species in the Hinderbanken subregion and midshore taxa (mixed group) are well-represented on the Vlaamse Banken and Zeeland ridges. In some species the distribution pattern changes with season. Little Gull, Lesser Black-backed Gull and Herring Gull have a more inshore distribution between April and October than during winter. And Kittiwake and Northern Gannet peak on average ten kilometres more inshore during November-March.

**INSHORE** dominant (0-10 km) **MIXED** group **OFFSHORE** dominant (30-60 km)



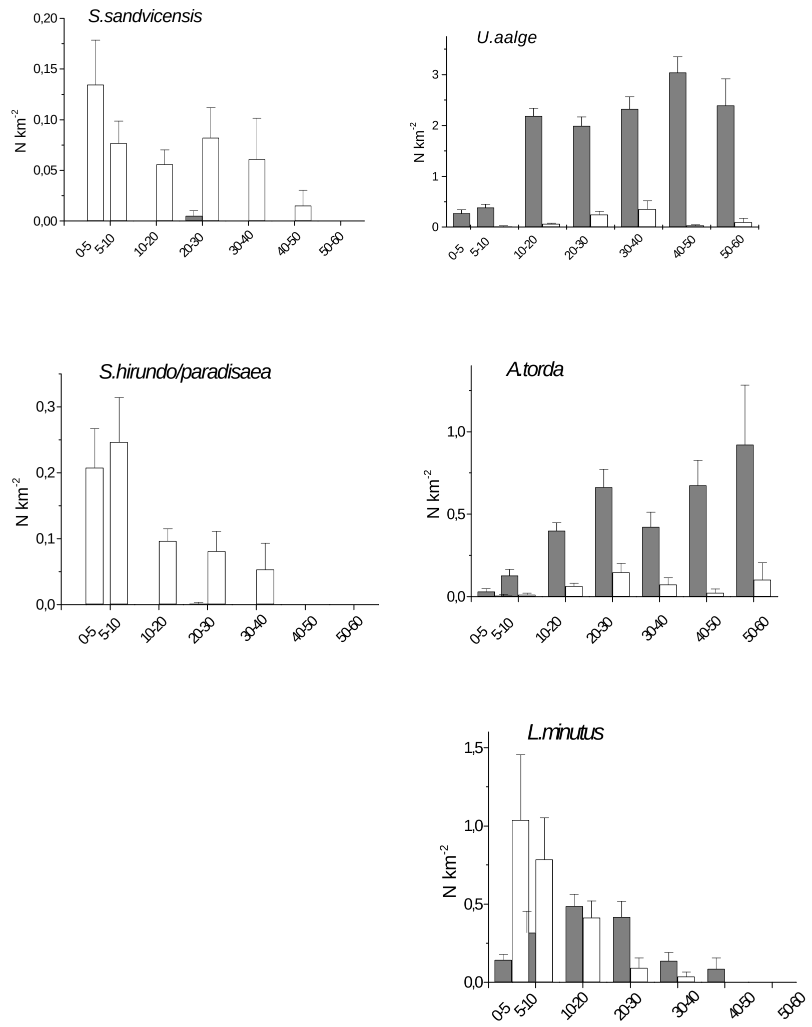
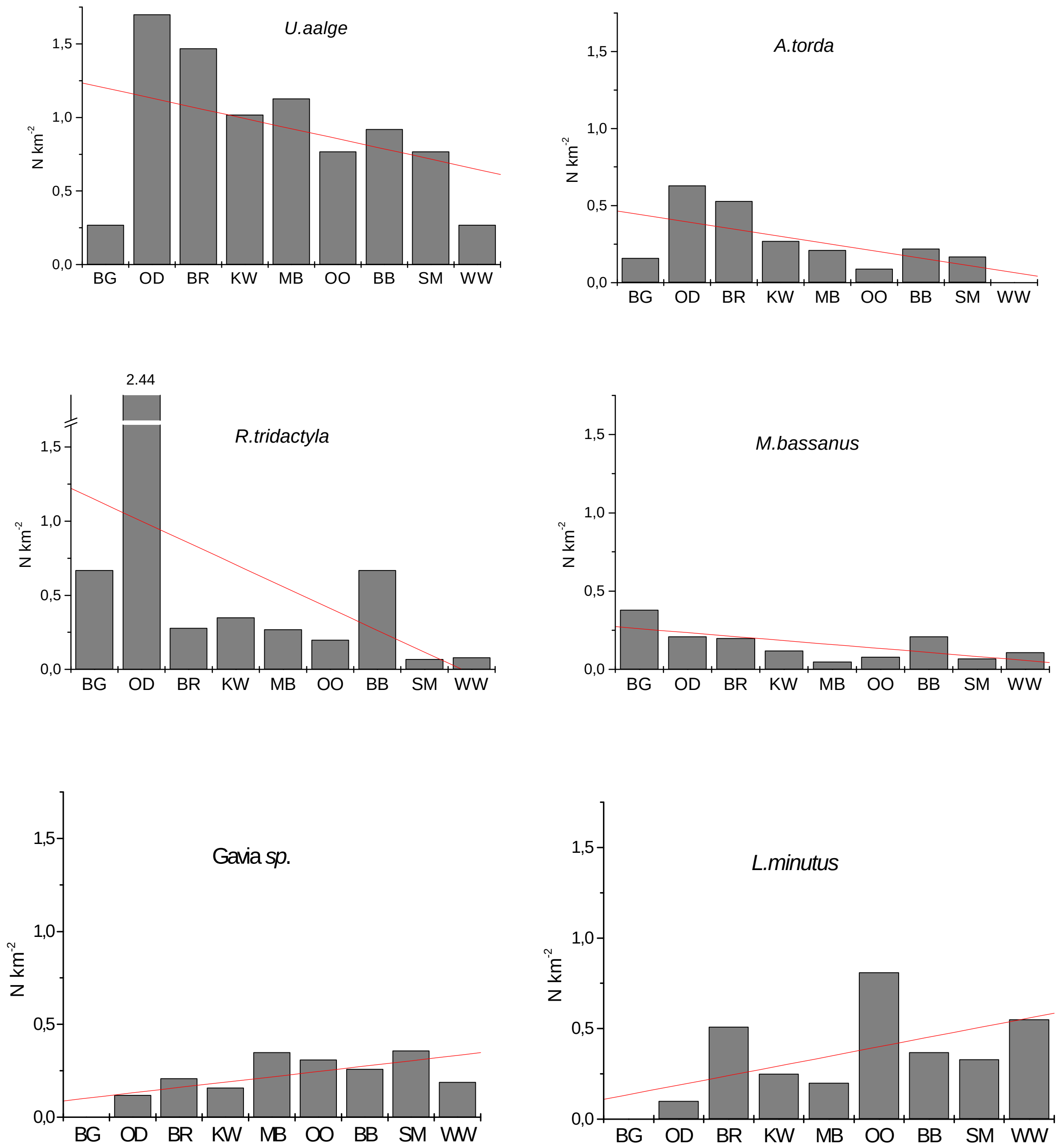



*Fig. 5. Mean density (N km$^{-2}$ ± SE) of 17 dominant species/taxa in Belgian marine waters at various distances to the coast. Values are presented separately for the winter Nov-Mar (grey bars) and the summer period Apr-Oct (white bars).*

The distribution of seabirds in relation to depth (and to a lesser extent also to the underwater topography, classified as 'crest', 'slope' and 'swale') is consistent with the observed gradient in distance to the coast (*Appendices IV, V & VI*). The fact that in a stepwise multiple regression analysis depth and topography appeared of less influence on the distribution of 17 dominant seabird species/taxa than distance to the coast – to which it is obviously related – indicates that other environmental variables (turbidity, currents, food availability, etc...) might play a much more important role. Few species reach their highest densities on the sandbank crests (divers in winter, Lesser Black-backed Gull and Northern Gannet in summer) or in the swales (typical offshore species, including auks). The transition zone ('slope') has the highest overall density in seabirds (*Appendix VI*).

Seabirds are bound to a certain area where they find food, shelter or suitable nesting opportunities. Scoters and other seaducks are concentrated in the coastal strip west of Oostende, where major bivalve populations are found. Flocks of other waterbirds (e.g. Mallard *Anas platyrhynchos* and Wigeon *A. penelope*) often occur in the immediate vicinity of the outer harbour of Zeebrugge, where they concentrate and roost when disturbed in the port or inland. The west-east distribution of terns is primarily caused by the location of the Zeebrugge breeding colony at the east coast and the specific limitations in feeding ranges. Sandwich Terns, who make long feeding trips (in contrast to Common and Little Tern) and take advantage of the rich foraging opportunities in the Westkust- and Vlaamse Banken area, do not show a clear correlation with longitude. Other more widespread species are distributed in response to the gradient formed by the influence of the Channel in the west and the Schelde estuary in the east (*Appendix VII*). Some of these patterns may arise rather artificially. Due to the shape of the Belgian marine waters, longitude is inversely correlated with distance to the coast: the most western longitude strip (2°20-2°30 E) has no inshore component, the most eastern longitude strip (3°10-3°20 E) consists of the harbour of Zeebrugge and the deepwater channels to the Schelde estuary. It is beyond doubt that this has created some of the patterns listed in *Appendix VII*, such as the high densities of gulls and grebes in the easternmost longitude strip. However, that true longitudinal gradients do exist has been observed in the field and can be demonstrated from an analysis of the seabird distribution on the Vlaamse Banken (west-east oriented). Piscivorous species who prefer clear water and mid- to offshore conditions (Common Guillemot, Razorbill, Kittiwake and Northern Gannet) are more abundant on the western Vlaamse Banken, in accordance with the more offshore character, deeper water and smaller distance to the Straits of Dover of these sandbanks. Divers, grebes, scoters and *Larus*-gulls are commoner in the more turbid waters of the eastern Vlaamse Banken (Oostende Bank/ Middelkerke Bank) and on the inshore Smal Bank (Fig. 6).



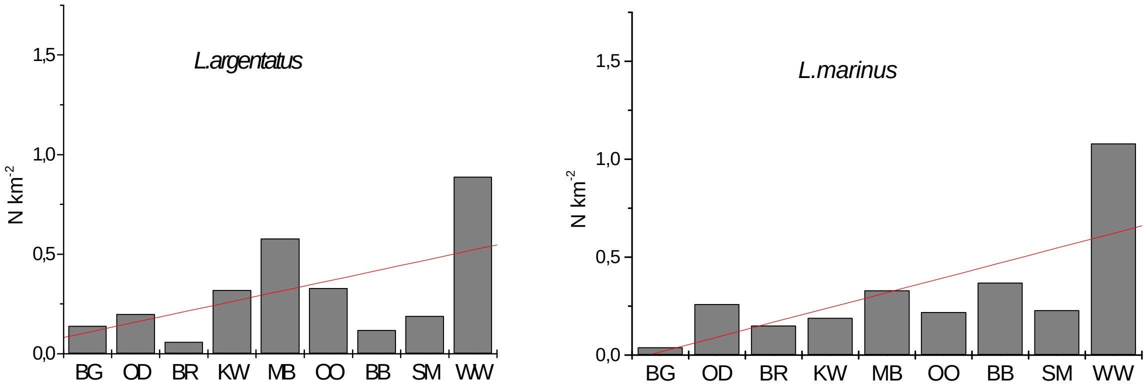



*Fig. 6. Distribution along a west-east gradient of some common seabird species/taxa in the Vlaamse Banken subregion, a midshore area in the Belgian marine waters. Data are derived from ship-based surveys during 1992-1998. Mean year-round densities (N km$^{-2}$) per species are presented by sandbank and sorted along a west-east gradient: BG=Bergues Bank, OD=Oost Dyck, BR=Buiten Ratel, KW=Kwintebank, MB=Middelkerke Bank, OO=Oostende Bank, BB=Breed Bank, SM=Smal Bank, WW=Wandelaar west.*

We conclude that at a species level, season, distance to the coast and longitude (distance to the Schelde estuary and the Straits of Dover) determine the distribution of sea- and coastal birds in Belgian marine waters. Depth and topography seem to be merely derivatives of distance to the coast and are probably subject to some other unknown and dominant variables (currents, turbidity, food availability, etc...).

## COMMUNITY ANALYSIS

### *Coherence of seabird assemblages*

Various multivariate analyses on the density data did not reveal any new pattern that had not yet been shown at the species level. A Canonical Correspondence Analysis confirmed the impact of distance to the coast, season and longitude. The grouping of samples and species appeared to be rather unstable and no distinct communities could be separated. The most significant correlations in distribution between species occurred within the guild of piscivorous birds (Table 4). Highest (Kendall tau) correlation values were found among *Larus*-gulls and within the species assemblage of Common Guillemot, Razorbill, Kittiwake and Little Gull. Divers and grebes were both found in shallow areas during winter and hence correlated well. Offshore, Fulmar and Northern Gannet were often observed within the same ten-minute count unit.

### *Interspecific associations*

That species are observed within a same ten-minute count period does not necessarily imply that they are associated. On the other hand a species may demonstrate a distribution pattern that overlaps only to some extent with that of another species (Table 4), but still ranks high when direct associations are considered (Table 5). In general the chance to observe seabirds in close association with other species is small. From the 17 dominant species/taxa, Razorbill was most likely to be seen associated, most frequently with Kittiwake (34%), Common Guillemot (27%) or Little Gull (23%). Razorbill appeared to be a more attractive ‘target’ than the Common Guillemot (12%). All gulls and Common Tern showed association-rates of 10-15%, and were often seen in mixed flocks while following fishing vessels. Only the Little Gull had a strong focus on the Razorbill (see above), more than on other Laridae. The following species were rarely observed in association with other species: Great-crested Grebe (3%), divers (4%), Sandwich Tern (6%), Fulmar (6%) and Northern Gannet (in 8 % of all the observations in the study-area).

*Table 4. Interspecific correlation (Kendall* tau*) of densities of the 17 most common species/taxa in Belgian marine waters in winter (Nov-March) and summer (April-October). Correlation is based on co-occurrence within ten-minute count periods during ship-based surveys in 1992-98. Significant (*P*<0.05) positive correlations are marked with: +, negative correlations with: -. In addition, significant correlations at* P*<0.01 are highlighted: Light grey: |*t*-values| < 0.10 Grey: |*t*-values| = 0.10.*

| **WINTER** (above diagonal) / **SUMMER** (below diagonal) | *P.cristatus* | *M.nigra* | *S.hirundo/paradisaea* | *S.sandvicensis* | Gavia *sp.* | *L.minutus* | *L.ridibundus* | *L.canus* | *L.argentatus* | *L.fuscus* | *L.marinus* | *R.tridactyla* | *U.aalge* | *A.torda* | *M.bassanus* | *S.skua* | *F.glacialis* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *P.cristatus* | ■ | + | | | + | - | + | + | | - | | - | - | - | - | | - |
| *M.nigra* | | ■ | | | + | | + | | | | | - | - | - | - | | |
| *S.hirundo/paradisaea* | | | ■ | | | | | | | | | | | | | | |
| *S.sandvicensis* | | | + | ■ | | | | | | | | | | | | | |
| Gavia *sp.* | | | | + | ■ | | | | | | + | | + | + | - | + | - |
| *L.minutus* | | + | + | | + | ■ | + | + | + | + | + | + | + | + | | | - |
| *L.ridibundus* | | | + | | + | + | ■ | + | + | + | + | | - | - | - | | - |
| *L.canus* | | + | + | | + | + | + | ■ | + | + | + | + | - | | - | | - |
| *L.argentatus* | | | + | + | | + | + | + | ■ | + | + | + | | | + | | |
| *L.fuscus* | | + | + | + | | + | + | + | + | ■ | + | + | | | + | + | + |
| *L.marinus* | | | + | | + | + | + | + | + | + | ■ | + | + | | + | + | |
| *R.tridactyla* | | | | | | + | | + | | + | + | ■ | + | + | + | + | + |
| *U.aalge* | | | | | + | | | | - | - | | + | ■ | + | + | + | + |
| *A.torda* | | | | | | | | | | - | + | + | + | ■ | | + | |
| *M.bassanus* | | | | | | | - | | | | + | | | + | ■ | + | + |
| *S.skua* | | | + | | | - | | | | | | | + | | + | ■ | |
| *F.glacialis* | | | - | | | - | - | | - | - | | + | + | + | + | + | ■ |

*Table 5. Seabird associations during ship-based surveys in 1992-98. Shown are the proportion of associated sightings on the total number of observations, the number of 'group' observations and the top-2 most associated species for the 17 dominant species/taxa.*

| Species | Frequency of associations with other species (%) | Two most associated species (%) | Nr of 'group' observations (*N*) |
|---|---|---|---|
| *M.nigra* | 16% | *S.mollissima*: 30%, *M.fusca*: 22% | 131 |
| *L.minutus* | 13% | *A.torda*: 23%, *R.tridactyla*: 14% | 331 |
| *F.glacialis* | 6% | *L.fuscus*: 22%, *R.tridactyla*: 18% | 141 |
| *S.skua* | 14% | *L.marinus*: 19%, *R.tridactyla*: 16% | 46 |
| *M.bassanus* | 8% | *L.marinus*: 24%, *R.tridactyla*: 21% | 497 |
| *L.ridibundus* | 12% | *L.canus*: 31%, *L.argentatus*: 24% | 245 |
| *L.canus* | 10% | *L.argentatus*: 26%, *L.marinus*: 17% | 590 |
| *L.fuscus* | 16% | *L.argentatus*: 29%, *L.marinus*: 22% | 916 |
| *L.argentatus* | 15% | *L.fuscus*: 28%, *L.marinus*: 21% | 916 |
| *L.marinus* | 12% | *L.fuscus*: 23%, *L.argentatus*: 23% | 758 |
| *R.tridactyla* | 12% | *L.argentatus*: 15%, *L.marinus*: 15% | 893 |
| Gavia *sp.* | 4% | *P.cristatus*: 23%, *R.tridactyla*: 18% | 68 |
| *P.cristatus* | 3% | *L.canus:* 22%, divers: 19% | 37 |
| *S.sandvicensis* | 6% | *L.fuscus*: 26%, *L.argentatus*: 17% | 35 |
| *S.hirundo/paradisaea* | 12% | *L.fuscus*: 24%, *L.minutus*: 22% | 44 |
| *U.aalge* | 12% | *R.tridactyla*: 43%, *A.torda*: 22% | 997 |
| *A.torda* | 28% | *R.tridactyla*: 34%, *U.aalge*: 27% | 378 |

Skuas are often associated with other species (Great Skua: 14%, Arctic Skua: 17% of the sightings), but merely 2.9% (Great Skua) up to 6.3% (Arctic Skua) of the observed specimens were actually observed while pursuing and kleptoparasiting other birds (Table 6). Main victims were Kittiwake and 'comic' terns in the case of Arctic Skua, and Great Black-backed Gull and Northern Gannet in Great Skua. Observations of kleptoparasiting Pomarine and Long-tailed Skua were scarce and generally in line with what was found in Arctic Skua: twice we saw a Pomarine Skua targeting a Kittiwake, once we observed a Long-tailed Skua during a purchase of an Arctic Tern. Other species rarely attack seabirds in the way skuas do. Fulmar and most gulls showed kleptoparasitic behaviour in less than 0.5% of all the sightings. The species that suffered most from kleptoparasitic attacks from any kind of seabird were the Kittiwake (20%), Great Black-backed Gull (16%), Lesser Black-backed Gull (13%), Herring Gull (10%) and Northern Gannet (8%). In nearly 40% of the pursuits the attack was directed towards a fish held by the cornered bird. In 28% of the observations a bird attacked another bird of the same species.

*Association with fishing vessels*

Larger gulls, Fulmar, Northern Gannet and Kittiwake were most likely to be seen when following fishing vessels (Table 6). Some 65-70% of all Lesser Black-backed, Great Black-backed and Herring Gulls in the study area were seen associated with trawlers. Smaller gulls had a probability of 10-30% to be observed behind a trawler. Due to the dominance of gulls and the intensive fishing activities within the study-area, on average 44% of all sea- and coastal birds were recorded in direct association with fishing vessels. The real impact of trawler activity on the distribution of seabirds in the study area could not be ascertained in more detail since the standard method used in our study is not designed for this purpose. However it looks as if the impact is underestimated, since flocks of gulls at a larger distance but still in the wake of fishing vessels, were considered here as not-associated with fishing activities in this study.

*Table 6. Observations of kleptoparasitism and associations with fishing vessels in 17 dominant seabird species and Arctic Skua during ship-based surveys in the period 1992-98 in the southernmost part of the North Sea.*

| Species | Total number observed | Proportion observed in association with fishing vessels (%) | Kleptoparasitic behaviour (% of observed specimens) | Important 'victims' being kleptoparasited (%) |
|---|---|---|---|---|
| *M.nigra* | 20,697 | 0 | 0 | - |
| *L.minutus* | 7,401 | 6 | 0 | - |
| *F.glacialis* | 5,304 | 29 | 0.04 | - |
| *S.parasiticus* | 174 | 2 | 6.32 | *R.tridactyla*: 36%, *S.hirundo/paradisaea*: 27% |
| *S.skua* | 351 | 3 | 2.85 | *L.marinus*: 50%, *M.bassanus*: 20% |
| *M.bassanus* | 16,344 | 44 | 0 | - |
| *L.ridibundus* | 13,985 | 10 | 0.01 | - |
| *L.canus* | 26,136 | 30 | 0.03 | *L.canus, L.minutus, R.tridactyla*: 22% |
| *L.fuscus* | 64,158 | 69 | 0.02 | *L.fuscus*: 38%, *L.argentatus*: 15% |
| *L.argentatus* | 57,565 | 68 | 0.01 | *L.argentatus:* 50% |
| *L.marinus* | 39,881 | 65 | 0.05 | *L.marinus*: 33%, *R.tridactyla*: 29% |
| *R.tridactyla* | 41,129 | 50 | 0.01 | *R.tridactyla*: 40% |
| Gavia *sp.* | 2,632 | 0 | 0 | - |
| *P.cristatus* | 2,626 | 0 | 0 | - |
| *S.sandvicensis* | 880 | 6 | 0 | - |
| *S.hirundo* | 1,162 | 0.6 | 0 | - |
| *U.aalge* | 12,481 | 0.02 | 0 | - |
| *A.torda* | 2,272 | 0 | 0 | - |
| *TOTAL (all birds)* | 352,549 | 44 | 0.02 | *R.tridactyla*: 20%, *L.marinus*: 16%, *L.fuscus*: 13%, *L.argentatus*: 10%, *M.bassanus*: 8% |

# DISCUSSION

## DISTRIBUTION PATTERNS

Opposing results can emerge when studying seabird distribution at various temporal and spatial scales (HUNT & SCHNEIDER 1987, BEGG & BLOOR 1996, LOGERWELL & HARGREAVES 1996, RIBIC *et al*. 1997). Often seabirds use much finer-scaled cues in exploiting the environment than those that can be detected with large-scale surveys (BEGG & REID 1997, TASKER & REID 1997, WANLESS *et al.* 1997, CAMPHUYSEN & WEBB 1999). Therefore it is essential to study seabird distribution in enough detail in areas of special interest. During seven years of ship-based surveys, we surveyed the small and geomorphologic varied Belgian marine waters intensively. Analysis of the data revealed that spatial and seasonal patterns were more pronounced than year-to-year variations, so that data from several years could be combined. Within two major periods ('winter': Nov-Mar; 'summer': Apr-Oct), most of the 17 dominant species/taxa showed significant variations in density over a 60 km inshore-offshore gradient and many became gradually more abundant over a longitudinal gradient of merely 30-65 km. Scoters, grebes and Black-headed Gull were virtually restricted to the nearest 10 km from the shoreline. Terns, Little Gull and Common Gull are most common inshore but can also be found at a larger distance to the coast. Great Skua and Fulmar are usually observed beyond 30 km and hence can be considered as true offshore species. Auks and Northern Gannet are distributed over a wider front, but clearly avoid inshore waters. Finally all other gulls, Kittiwake and small divers occur throughout the Belgian marine waters and peak at various distances to the coast. Variations in density along a longitudinal gradient are not clear for species that are bound to specific locations to feed (scoters cf. bivalve populations) or to breed (terns). That inshore/midshore species groups (divers, grebes, most *Larus*-gulls) were more common in the eastern part near the mouth of the Schelde estuary and offshore species (Fulmar, Northern Gannet, Great Skua, Great Black-backed Gull, Razorbill) preferred the deeper waters towards the Straits of Dover, is in line with what has earlier been demonstrated by OFFRINGA *et al.* (1996) for the Southern Bight of the North Sea. At larger (North Sea) scales (TASKER *et al*. 1988, CAMPHUYSEN & LEOPOLD 1994, SKOV *et al.* 1995, STONE *et al*. 1995) these patterns are barely detectable.

A remarkable characteristic of the southernmost part of the North Sea is the presence of various sand ridges, aligned in four major groups each with their own strike, steepness and bottom characteristics. Very shallow bank crests (0-5 m below MLLWS) are found next to channels of up to 40 m deep, running in between the sand ridges. Sand waves occur in well defined fields on the slopes and crests of the banks, having a length of several hundreds of metres and heights of 1-8 m (DE MOOR & LANCKNEUS 1988). In the more offshore sand ridges, the bank crests and the north-western, steep slopes are composed of well-sorted sands due to a strong erosion activity. The gentle eastern slopes know a slight sedimentation. In the swales, sediments are not displaced under normal tidal conditions and benthic communities are usually well developed here (HOUTHUYS 1990). Though underwater conditions obviously vary largely in this habitat, topography and depth showed of minor importance in structuring the seabird communities, compared to distance to the coast and seasonality. An explanation can probably be found in the mobility of prey-items (mainly pelagic fish), the changing conditions with tides, the drift of the birds due to currents and the precision of the counting methods (units of 10 minutes, i.e. c. 3 km in terms of travelled distance). The fact that both divers - generally referred to as 'inshore' seabirds - and the 'offshore' auks are particularly common on the Vlaamse Banken at a distance of 10-30 km (i.e. midshore), instead of being spatially separated as in Dutch marine waters (CAMPHUYSEN & LEOPOLD 1994), indicates a remarkable coincidence of different living conditions among these sand ridges. Scanning of the banks with echo sounders often revealed high densities of pelagic fish echos on the slopes of the sand ridges. How the complex geomorphology and hydrography affects availability of prey and how the estuarine plume from the Schelde estuary interferes with it remains yet to be studied. Although there is a wealth of literature on the impact of hydrography on seabird distribution worldwide (e.g. POCKLINGTON 1979, JENSEN & JOIRIS 1983, HANEY 1986, FOLLESTAD 1990, SCHNEIDER 1990, ELPHICK & HUNT 1993, LEOPOLD 1993, SKOV & DURINCK 1995, DECKER & HUNT 1996, BEGG & REID 1997, GARTHE 1997, HUNT 1997, RIBIC & AINLEY 1997, SPRINGER *et al*. 1999), not a single study describes the small-scale structuring impact of currents on seabirds within linear sand ridge complexes. Most of the studies mentioned above concern traditional upwelling zones, large-scale gyres or tidal fronts between mixed and stratified waters (e.g. CAMPHUYSEN & WEBB 1999). Only three studies deal with seabird aggregations at estuarine fronts. In a study of SKOV & PRINS (2001), the distribution of Red-throated and Black-throated Diver in German coastal waters is satisfactorily explained by the Jutland Coastal Current, an estuarine water mass from the Elbe moving northwards along the German coast. The current is distinguished from North Sea water masses by its low surface temperature, high turbidity and a salinity below 34 psu, more or less the way the Schelde estuary outflow affects the Belgian marine waters and the southern part of the Dutch coast (NIHOUL & RONDAY 1976, NIHOUL 1980). SKOV & PRINS (2001) also mention that the highest densities of divers are found where the estuarine surface water mass circulation breaks down in the eddy fields of deeper waters. The way the estuarine plume from the Schelde interferes with the highly structured sand ridges immediately to the west and determines the spatio-temporal availability of food for seabirds warrants further study.

CONSTANCY OF SEABIRD COMMUNITIES

Seabirds are highly mobile organisms and generally do not aggregate in long-lasting communities of coexisting species. They rather occur solitary or in short-lived multi-species feeding associations (MSFA's) around fishing vessels, cetaceans or over fish shoals (HOFFMANN *et al*. 1981, CAMPHUYSEN & WEBB 1999). The first type is common in the North Sea, where fishery activities usually attract large flocks of gulls, Fulmar and Northern Gannet and where fishery waste probably supports 2.5-3.5 million of these scavenging seabirds (FURNESS *et al*. 1992, CAMPHUYSEN 1995, CAMPHUYSEN *et al*. 1995, GARTHE & HÜPPOP 1998). In our study-area we found 65-70% of all Lesser Black-backed, Great Black-backed and Herring Gulls associated with trawlers, and 10-40% of smaller gulls, Northern Gannet and Fulmar. These high values clearly indicate how strongly fishery activities affect the spatio-temporal distribution of seabirds - and particularly of the larger gulls - in this part of the North Sea. This is in accordance with CAMPHUYSEN *et al*. (1995), who pointed out that Great Black-backed Gull, Herring Gull and Lesser Black-backed Gull are the only species of which the overall distribution in the North Sea was clearly positively influenced by the presence of fishing vessels. CAMPHUYSEN *et al*. (1995), GARTHE *et al* (1996), CAMPHUYSEN & GARTHE (1997) and PHILLIPS *et al*. (1999) found that variations in distribution of Fulmar, Northern Gannet, Great Skua and Kittiwake could not be explained by differences in fishing vessel abundance. In the German Bight of the North Sea, GARTHE (1997) describes how seven environmental components explain 71% of the variance in seabird numbers. The occurrence of a land-sea gradient (including distance to the nearest colony/land, water transparency, water depth) turned out to be the most important one and trawler abundance as the second most important explanatory variable. In our small study-area, the high mobility of the large gulls in response to intensive trawling and their numerical dominance at sea and on the shoreline (DEVOS & DEBRUYNE 1990,1991, SPANOGHE 1999) explains at least to some extent the noise that arises when performing multivariate analyses in order to distinguish distinct communities of seabirds.

Natural flocking over fish shoals is described in detail by CAMPHUYSEN & WEBB (1999). They describe how relatively small and diverse MSFA's may suddenly develop and break down over near-front waters off the Scottish east coast and at the frontal zone. It appears that synchronised diving auks most often cause the formation of MSFA's ('producers'), with Kittiwakes being the first to join and instigate other species ('catalysts') to exploit prey chased to the surface by the auks. MSFA's were a very widespread phenomenon and usually broke down rapidly, when auks ceased to drive prey to the surface or when too many scrounging ('suppressors') large gulls moved in. It might well be that the presence of the auks set the limits of the foraging range of Kittiwakes, by making prey available that would normally be out of reach. We observed similar MSFA's in Belgian marine waters during winter, with auks attracting small numbers of Kittiwake or Little Gull. Association rates - including those with other auks - were more than twice as high for Razorbill (28%) compared to Common Guillemot (12%). For both species associations with the other auk species and with Kittiwake amounted to more than 60% of all grouped observations. Little Gull showed the same frequency of associations (13%) with other species as demonstrated by the Kittiwake (12%), but apparently preferred the neighbourhood of Razorbill (23% of all associations) to Common Guillemot (9%). Several authors commented on the feeding association of Little Gulls and auks (MADGE 1965, SCOTT 1972, DATHE 1981, EVANS 1989). The former two authors described how juvenile Little Gulls formed feeding associations with Razorbill, contesting amongst congenerics or other species, which should consort with a particular Razorbill. During winter both Common Guillemot and Razorbill (CAMPHUYSEN 1996,1998a) predominantly feed on small fish in the North Sea, while some data suggest that in the southern North Sea Razorbill might take a higher share of non-clupeid fish. It might well be that slightly different feeding strategies among auk species – resulting from slight differences in prey-choice - result in the observed difference in associations with small gull species.

Our data suggest that associations between seabird species are predominantly triggered by trawling activities and feeding opportunities created over natural fish shoals. Kleptoparasitic behaviour known from skuas is directed towards other gulls and terns. The smaller species focus on small gulls and terns, the Great Skua choose its targets among large gulls and Northern Gannet (see also TASKER *et al*. 1995). In an analysis of associations of Great Skuas with other seabird species in the North Sea, TASKER *et al* (1995) found associations in natural MSFA's and with fishing vessels to account for 65-90% of all grouped observations. Kleptoparasitic behaviour occurred in only 0-21% of all observations, a range that covers the 3-6% we found for skuas in our study-area.

*Recommendations for future research*

Seven years of intensive seabird surveying in the small Belgian marine waters resulted in a good knowledge of general distribution patterns, providing a sound basis for more detailed research in the future. It is clear that seabird communities are mobile and often short-lived assemblages, reacting to local conditions of hydrography and food availability. In order to fully understand the way seabirds interact with their environment in the southernmost part of the North Sea, specific studies should be developed to disentangle how the estuarine front from the Schelde estuary meets the area of sand ridges and how this affects the feeding opportunities for various species of seabirds. Therefore we would suggest to focus research on the complex relationship between seabird distribution and pelagic fish distribution and behaviour. So far there is a serious gap in our knowledge of pelagic fish distribution in this part of the North Sea. There is a need to focus on the temporal and spatial distribution of the fish amid the sand ridges and along the natural gradient from the deep Straits of Dover to the mouth of the Schelde estuary. The data obtained in an indirect way by echosounding during integral campaigns in the period 1994-1998 should be complemented with direct sampling of pelagic fish species. Attention should also go to small-scale temporal distribution patterns in piscivorous birds. Recent studies indicate that self-fishing seabirds tend to target predictable prey concentrations in the winter (SKOV *et al*. 2000) and that tidal and diurnal activity patterns may arise (HANEY & SCHAUER 1994, CAMPHUYSEN 1998b).

The use of focal species is attractive because their use promises to maximize information return from minimal financial commitments to research and monitoring. It definitely makes no sense to monitor only particular species of interest during seabirds at sea surveys. With the standard method all species can be counted without increasing the effort. However, some species provide better research opportunities and behave more as 'umbrella species' than others. These species should get priority in terms of research effort. The correlation- and association rates we calculated for various species may be put forward as one of the potential criteria for selection of 'umbrella-like' seabird species, the way FLEISHMAN *et al.* (2000) used a mean percentage of co-occurring species to select umbrella butterfly species in North-America. Other criteria might be that the species is sufficiently abundant and easy to survey, that its distribution is not influenced thoroughly by human activities (unless you want indicators for these activities), that it is a focal species for conservation purposes or that additional information on mortality and condition can be obtained e.g. through studies at breeding colonies or during beached bird surveys. In Table 7 we ranked the 17 dominant species for Belgian marine waters and the Little Tern according to an 'indicator score'. This score is the sum of scores from 0-2 for five different criteria, considered of major importance in a selection process of focal species. The highest-ranking species in each group are those we consider most appropriate to focus future research upon.

*Table 7. Selection of focal species by feeding guild in Belgian marine waters, based on five criteria: (1) the species should be abundant and easy to survey (abundance classes= maximum numbers in Belgian marine waters, see SEYS* et al., *submitted: 0= <1000; 1=1000-10,000; 2=>10,000; all species are easily surveyed except seaducks and divers); (2) patterns in occurrence are well-delineated (e.g. self-fishing species and benthivores are distributed in a more predictable way than most gulls and other species relying on discards from fisheries activities); (3) the 'umbrella' effect: species often found in association with other species (Table 5); (4) selected as focal species for conservation purposes, i.e. rare and threatened species in Belgian marine waters, or as locally important species, see SEYS* et al.*, submitted; (5) additional information on mortality and condition of the species is available, through studies in the breeding colonies *, or as a result of large beached bird numbers in the 1990s, see SEYS* et al.*, in press: 0= <50 specimens collected, 1=50-150, 2=>150).*

| Species/taxon | Feeding type (season when most abundant/ | (1) | (2) | (3) | (4) | (5) | Total 'Indicator' score |
|---|---|---|---|---|---|---|---|
| *S.hirundo* | self-fishing (summer/inshore) | 2* | 2 | 2 | 2 | 2* | 10 |
| *S.sandvicensis* | self-fishing (summer/inshore) | 2* | 2 | 0 | 2 | 2* | 8 |
| *S.albifrons* | self-fishing (summer/inshore) | 1* | 2 | 0 | 2 | 2* | 7 |
| *P.cristatus* | self-fishing (winter/inshore) | 2 | 2 | 0 | 1 | 1 | 6 |
| *A.torda* | self-fishing (winter/mid-offshore) | 2 | 2 | 2 | 1 | 2 | 9 |
| *U.aalge* | self-fishing (winter/mid-offshore) | 2 | 2 | 2 | 0 | 2 | 8 |
| divers | self-fishing (winter/midshore) | 1 | 2 | 0 | 2 | 1 | 6 |
| *L.ridibundus* | scavenger (yearround/inshore) | 2 | 2 | 2 | 0 | 2 | 8 |
| *L.argentatus* | scavenger (yearround/midshore) | 2 | 1 | 2 | 1 | 2 | 8 |
| *L.fuscus* | scavenger (summer/midshore) | 2 | 1 | 2 | 1 | 2* | 8 |
| *L.marinus* | scavenger (winter/midshore) | 2 | 1 | 2 | 1 | 1 | 7 |
| *L.canus* | scavenger (winter/inshore) | 2 | 1 | 2 | 0 | 2 | 7 |
| *R.tridactyla* | scavenger (yearround/offshore) | 2 | 1 | 2 | 0 | 2 | 7 |
| *F.glacialis* | scavenger (yearround/offshore) | 2 | 1 | 1 | 0 | 2 | 6 |
| *M.bassanus* | scavenger (yearround/offshore) | 2 | 1 | 1 | 0 | 1 | 5 |
| *S.skua* | scavenger (winter/offshore) | 1 | 0 | 2 | 1 | 0 | 4 |
| *L.minutus* | omnivorous (yearround/midshore) | 2 | 1 | 2 | 2 | 0 | 7 |
| *M.nigra* | benthivorous (winter/inshore) | 1 | 2 | 2 | 2 | 1 | 8 |

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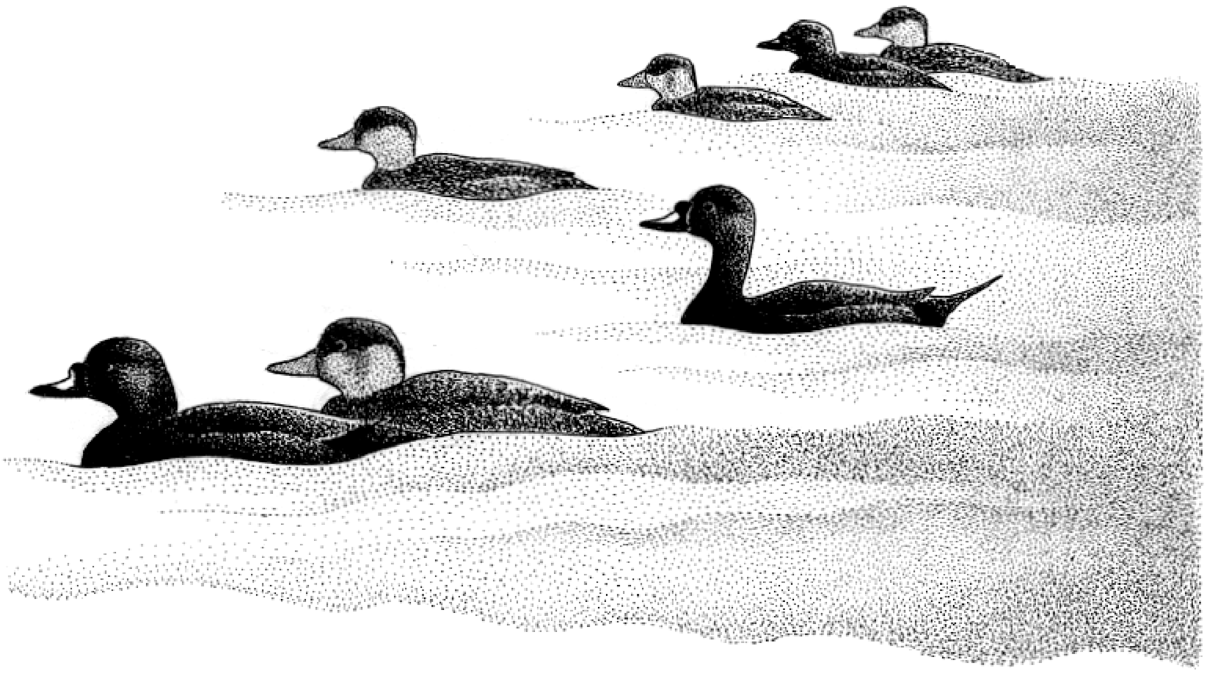
# CHAPTER THREE

## FOCAL SPECIES AND THE DESIGNATION AND MANAGEMENT OF MARINE PROTECTED AREAS: SEA- AND COASTAL BIRDS IN BELGIAN MARINE WATERS



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*Jan Seys[1*], Patrick Meire[2] & Eckhart Kuijken[1]*

*[1] Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
*[2]University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
*[*] present adress: Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

# Focal species and the designation and management of marine protected areas: sea- and coastal birds in Belgian marine waters

J. Seys, J. Van Waeyenberge, P. Meire, M. Vincx & E. Kuijken


## ABSTRACT

The various groups of linear sand ridges off the continental coast of the southernmost part of the North Sea (the 'Flemish Banks') have an important seabird conservation value. During an intensive seabird surveying programme from 1992 till 1998 in the Belgian part of it, eleven species were counted in numbers amounting to 1-5% of the flyway population in an area of merely 3500 $km^2$. Six of them (Red-throated Diver, Common Scoter, Little Gull, Sandwich Tern, Common Tern, Little Tern) are considered as of international conservation value and were selected as focal species. Hotspots are situated on the shallow Westkustbanken, in the neighbourhood of the Zeebrugge outer harbour and on the Vlaamse Banken. In addition, during the 1990s the Zeebrugge harbour accommodated a medium-sized colony of Sandwich Tern (1650 pairs) and some of the largest colonies of Common (2260 pairs) and Little Tern (430 pairs) of NW-Europe. The present conservation status of these areas is insufficient and marine protected areas (in the widest sense) are needed to safeguard the strongholds for Belgian seabirds. Oil-sensitivity maps indicate that the most vulnerable sites are too close to some of the busiest shipping routes of the world to consider any rerouting measure. Weighing the disturbance-sensitivity of different subareas shows that only on the hotspots for divers and scoters there is a need to restrict boating activity during winter. In addition this southernmost part of the North Sea is a very important corridor for seabird migration. An estimated 1-1.3 million seabirds, with one-third being focal species for conservation, may fly through this bottleneck each year. New developments such as wind parks that might have a detrimental impact on resident as well as migrating seabirds must be carefully investigated.


## INTRODUCTION

A worldwide call for environmental protection and installation of marine protected areas has emerged (Bergman *et al*. 1991, Agardy 1994, Eichbaum & Agardy 1996, Conover *et al*. 2000, Salm *et al*. 2000). Fully protected reserves can protect critical habitat for fishery and benthic resources that have been depleted through overharvesting or habitat destruction, or help to conserve marine diversity. Provided the protected area is large enough, they can also enhance the harvest of stocks outside the reserve. Marine protected areas (MPA's) cover the entire range from fully protected marine reserves to areas where management of activities is geared towards conservation needs. In the process of designating marine protected areas, sea- and coastal birds cannot be overlooked and often play an important role. Several seabird species are threatened and need protection measures to save them from a further population decline (Tucker & Evans 1997). Moreover, seabirds as top-predators may act as indicators for pollution or food availability (Becker 1989, Montevecchi 1993, Furness & Camphuysen 1997) and hence reflect the state of the habitat they live in. Compared with fish, marine mammals and other animals that live primarily or exclusively underwater, seabirds are easy to survey. Standard surveying methods for seabirds have been developed (Tasker *et al*. 1984, Komdeur *et al*. 1992), enabling the collection of large amounts of data that can easily be compared and put into an international perspective. Finally, seabirds may enhance the public support for marine protected areas as a conspicuous and attractive part of the ecosystem.

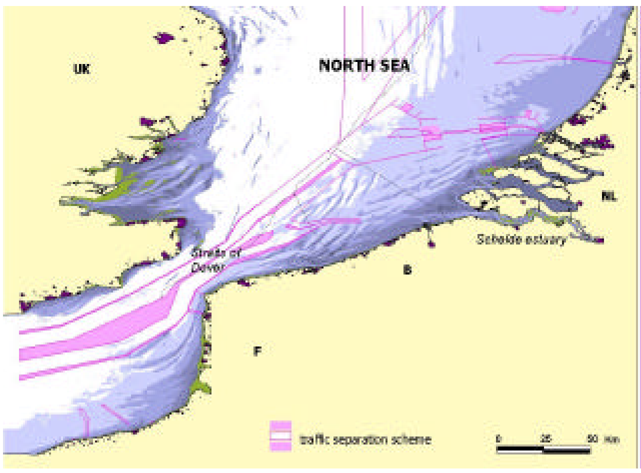
Belgium recently adopted the 'Law on the protection of the marine environment in sea areas under Belgian jurisdiction' (20.01.1999: Official Journal – Belgisch Staatsblad 12.03.1999) that provides a tool for the protection of species and the conservation and management of habitats through the designation of marine protected areas (Cliquet 2000). In order to establish MPA's in Belgian waters and help guiding the management of these areas, a detailed picture of where and when important seabird concentrations occur is essential as well as background information on how various activities may affect their distribution and behaviour. The demarcation of MPA's should aim at maximizing either the number of rare species that will be protected within the MPA or the number of species whose viabilities might suffer from human activities outside the MPA. Although several atlases of seabird distribution in north-west European waters have been produced since the start of regular ship-based surveys in Europe in the 1970s (Baptist & Wolf 1993, Carter *et al*. 1993, Camphuysen & Leopold 1994, Camphuysen *et al*. 1995, Skov *et al*. 1995, Stone *et al*. 1995, Offringa *et al*. 1996), none but one has a scale that can guide regional conservation and management sufficiently. The work of Offringa *et al*. (1996) did focus on the southernmost part of the North Sea, but included data up to February 1995 and therefore urgently needed an update.

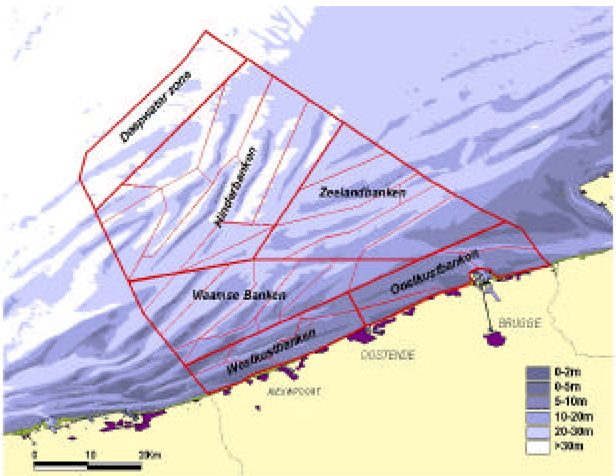
In this paper we give a summary of all seabird data collected in Belgian marine waters during 1992-1998 and evaluate the ornithological conservation value of this part of the North Sea. Species that deserve protection priority (further referred to as focal species, i.e. target species: ZACHARIAS & ROFF 2001) are selected by using criteria of abundance and vulnerability. Maps of the cumulative abundance of these focal species show the hotspots of internationally threatened seabird species in Belgium. In addition vulnerability maps are produced for two direct threats to seabirds at sea, namely oil pollution and shipping disturbance. Oil pollution is widely recognized as one of the major threats to seabirds in North and West European seas (DUNNET *et al*. 1990, FURNESS 1993, TUCKER & EVANS 1997, CAMPHUYSEN & HEUBECK 2001) and beached bird surveying in Europe have demonstrated that the southern North Sea must be regarded as the area most heavily affected by chronic oil pollution (CAMPHUYSEN & VAN FRANEKER 1992). The vulnerability for oil shows important differences between species (KING & SANGER 1979, CAMPHUYSEN *et al*. 1999). Disturbance by shipping activities is generally considered of much less overall influence (TUCKER & EVANS 1997, CAMPHUYSEN & LEOPOLD 1998), but may seriously affect a few disturbance-sensitive species. In order to evaluate the potential impact of new developments on migrating seabirds in this part of the North Sea (e.g. wind parks), we estimated the proportion of the biogeographic population of the most important species that pass through this southernmost part of the North Sea. Shellfishery is not allowed in Belgian marine waters (Royal Decree 1998) and hence the kind of issues arising in The Netherlands and other neighbouring countries (VAN DE KUIP 1991, LEOPOLD 1993, BORCHARDT 1995, SMIT 1995, LEOPOLD & VAN DER LAND 1996, HUNT *et al*. 1999, PIERSMA & CAMPHUYSEN 2001) are not known here. Other impact factors on seabirds are not treated due to lack of specific data or because the impact-effect relationship has not yet been quantified sufficiently. Maps of disturbance sensitivity and oil-vulnerability were produced, using a combination of relative abundance of species and specific vulnerability ratings. We used a methodology similar to the oil vulnerability maps produced by TASKER & PIENKOWSKI (1987), CARTER *et al*. (1993) and maps of important bird areas by SKOV *et al*. (1995). Finally, results are discussed in a context of present conservation tools and implications for future management.

## MATERIAL & METHODS

### STUDY AREA

Belgian marine waters are situated in the funnel-shaped southernmost part of the North Sea, at the entrance to the Channel. They cover an area of approximately 3500 km$^2$ and waters are comparatively shallow (less than 30-40 m). Sediments consist of medium to fine sands, with the smallest median grain-sizes found near the mouth of the Schelde estuary (VANNIEUWENBORGH 1982, HOUTHUYS 1990). The study-area is characterised by the occurrence of four sandbank systems or groups of linear sand ridges, each with their own steepness, strike and distance to the coast (BASTIN 1974, EISMA *et al*. 1979, DE MOOR 1985)(Fig. 1). The *Kustbanken* run parallel and at less than 10 km to the coastline, the mean depth is only 2-3 m and fine sediments are deposited here (particularly at the east-coast near the Westerschelde mouth). The *Vlaamse Banken* and *Hinderbanken* result from sand accumulation and are oriented in an angle of c. 40° to the coastline, with the Hinderbanken situated much further offshore (Fig. 1). The *Zeelandbanken* have a resistant core of older deposits, are partly erosional remnants (HOUBOLT 1968, EISMA *et al*. 1979) and are largely situated in Dutch waters. Based on these sandbank systems, we subdivided Belgian marine waters in six subregions, further split up into a various number of sandbank-units (Fig. 1). Each sandbank-unit consists of at most three topographic strata: swales, slopes and crests, defined as < 10 m deep (crest), 10-20 m (slope) and > 20 m (swale)(except for the inshore Oostkust- and Westkustbanken, where < 5 m, 5-10 m and > 10 m respectively). With 1-3 depth strata in each sandbank-unit, we finally retain 96 bank strata as units for purposes of mapping and analysis.



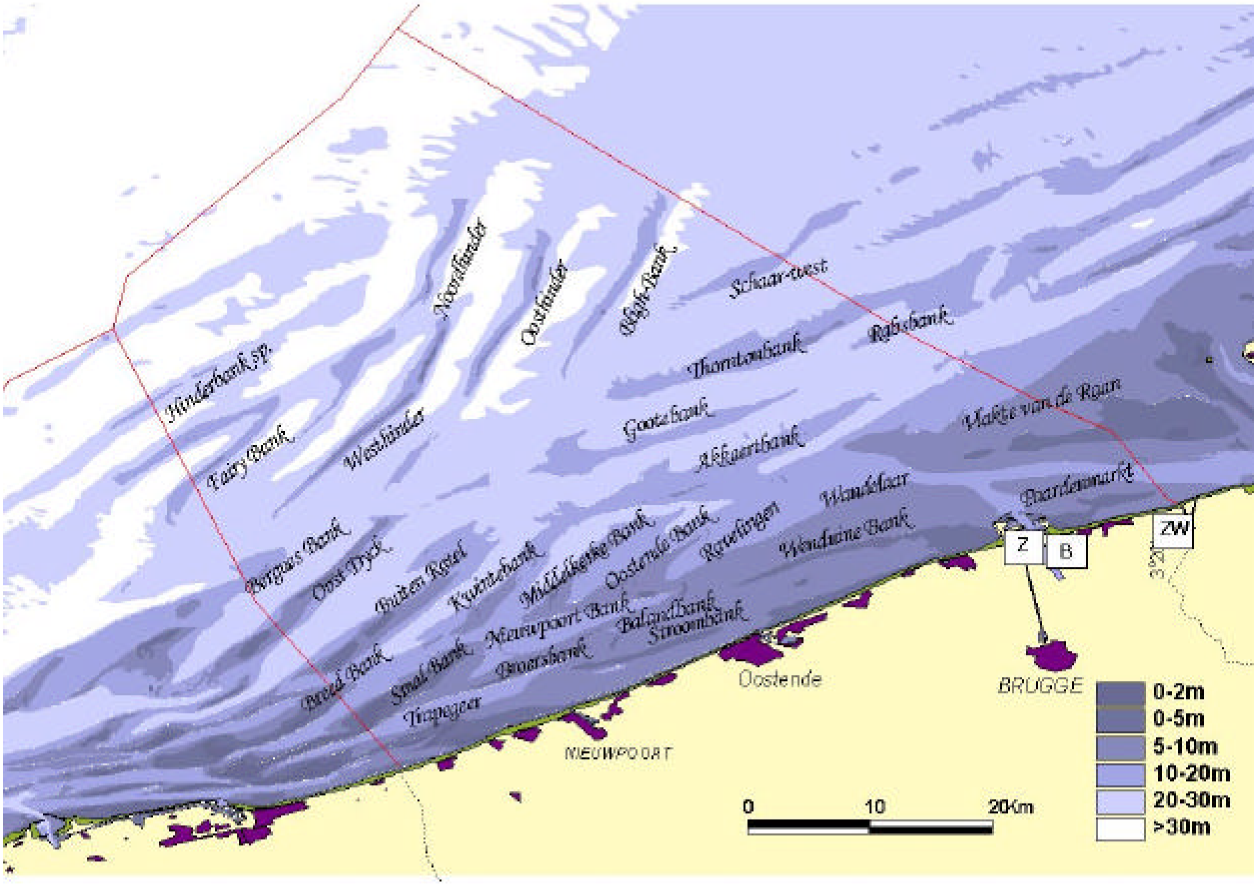



*Fig. 1. Belgian study-area, with: (a) setting within the Southern Bight of the North Sea; (b) subdivision in 6 subregions and 35 sandbanks; (c) most important sandbanks and tern colonies: Z=Zeebrugge, B=Baai van Heist, ZW=Zwin*

Peak flood and ebb currents are directed respectively northeast and southwest. The mean tidal range near the Belgian coast is about 3-5 m. The mean tidal movement corresponds to an elongated current ellipse. The velocity of the surface peak currents attains values of 1m $s^{-1}$ (VAN CAUWENBERGHE 1992). The Belgian coastline measures 65 km and counts three small (Nieuwpoort, Blankenberge, Oostende) and one medium-sized harbour (Zeebrugge). The harbour of Zeebrugge extended seaward in the early 1980s, creating some 150 ha of temporary nesting areas for terns and gulls (SEYS *et al*. 1998). For more details on the study area see OFFRINGA *et al*. (1996) and SEYS *et al.* (submitted).

## SURVEY METHODS

Various methods have been applied to collect seabird data within the study-area:

(1) Ship-based surveys were carried out in the period September 1992 - December 1998, using a standard strip transect method for counting seabirds at sea (TASKER *et al*. 1984). The study-area has been covered as good as possible during regular trips on board of the *Belgica* and the *Ter Streep* and on fixed ferry-routes from Oostende to Ramsgate or Dover. The total effort in Belgian marine waters amounted to 16,000 km or a total transect area of 4817 $km^2$. Every square km has on average been surveyed 1.4 times, with more than twice as much effort during winter and autumn compared to spring-summer. Only the most offshore deepwater zone has been poorly covered (32 $km^2$). Ferry counts on fixed routes accounted for 20% of the total travelled distance. The ferry results will further be used to document seasonal patterns in occurrence of seabirds in the southernmost part of the North Sea.

(2) Land-based winter counts of inshore species (scoters and other seaducks, grebes, divers) in the shallow western coastal bank area (DEVOS 1990, unpublished data IN), held on an irregular base.

(3) Aerial winter counts of scoters. The entire coastal stretch to a distance of approximately 15 km has been counted on a monthly base during winter since 1986, flying at a speed of 100-140 km $h^{-1}$ and at a height of 150 m (MAERTENS *et al*. 1988, 1990, DEVOS *et al*. 1991, OFFRINGA 1997, VAN WAEYENBERGE 1998). The plane flew

along fixed survey lines, which enabled a full count of all birds present in the survey area.

(4) Counts of gulls on beaches, groins and seafronts and in harbours on the entire Belgian coastal stretch of 65 km were performed in December 1989 (DEVOS & DEBRUYNE 1990), July and September 1990 (DEVOS & DEBRUYNE 1991) and on a monthly base during the winter 1998-99 (SPANOGHE 1999).

(5) Census programme of breeding gulls and terns carried out yearly in the main colonies (DE PUTTER & ORBIE 1990, ORBIE 1991, DE PUTTER & WILLEMYNS 1992, DE SCHEEMAEKER 1992, VAN DEN BOSSCHE *et al*. 1995, DEVOS & ANSELIN 1997, SEYS *et al*. 1998).

In addition we assessed the importance of the area as a corridor for migrating seabirds from literature findings. An estimate of peak numbers of seabirds in the study-area on the basis of cumulative densities over a longer period does not tell how many individual specimens of each species may actually migrate through the southernmost part of the North Sea. Particularly those species that tend to migrate in large numbers during a rather short period and restricted to a well-defined corridor may be missed. We roughly estimated, on the basis of literature findings, what proportion of the flyway population of the most abundant seabird species fly through the southernmost part of the North Sea (in between 51° and 52° N), either on migration from or to their wintering grounds, or as residents of this part of the North Sea. We can imagine that some (theoretical) species arrive in the area, stay here and do not move any further. In such a species, the total number will probably approach the estimate based on density data very well. At the other extreme, some seabird species try to migrate through the study-area as quickly as possible. They will probably be missed completely during regular ship-bases surveys, and here the actual number will have to be based entirely upon knowledge of the general migration patterns. In reality, most seabirds demonstrate a mixed pattern, with total numbers to be derived from weighing both resident populations and migration against each other.

## DATA ANALYSIS AND PRESENTATION

### *Estimates of total numbers*

Birds counted during ship-based surveys within a 300 m transect were transformed into densities (N $km^{-2}$), applying a correction factor for small and dark swimming birds (STONE *et al*. 1995). Total counts from aerial-, land-based and breeding colony surveys were added to the database, after converting total numbers for the counted area to densities per sandbank stratum. This method is in line with the way data were processed at a North Sea scale by SKOV *et al*. (1995). Hence density data of terns are largely based on total number of breeding birds spread out over the known feeding range around the major colony of Zeebrugge. The overall maximal densities per 1x1 minute square (each square was counted on average 3.8 times) were then averaged by sandbank stratum and season (with seasons defined as: winter= December-February, spring= March-May, summer= June-August, autumn= September-November). Estimates of maximal total numbers per species in Belgian marine waters were obtained directly from aerial-, land-based- and breeding colony surveys or from ship-based actions after extrapolating the densities to the full extent of the study-area. Total numbers were assessed for the Belgian marine waters as a whole (3500 $km^2$). To compensate for the size of a marine area in determining its international importance, SKOV *et al*. (1995) standardized the values to an area of 3000 $km^2$, a value comparable to the size of our study-area.

### *Selection of focal species*

From the 121 bird species observed above Belgian marine waters, 99 were strictly terrestrial (passerines, swallows, owls, birds of prey, pigeons), aquatic but not marine (waders, rails, grebes other than Great-crested Grebe *Podiceps cristatus*, herons, geese and ducks) or marine but too rare (< 80 specimens observed during entire study-period) to be considered any further. Out of the remaining 23 species, a small set of focal species was selected. In general terms focal species are for ecological or social reasons believed to be valuable for the understanding, management and conservation of natural environments. Collectively, they are species on which our attention is preferentially focussed for one reason or another (ZACHARIAS & ROFF 2001). We took as focal species seabirds that need attention due to an unfavourable international conservation status and are found in internationally important numbers in the Belgian marine waters. They should:

(1) attain 1% of the flyway population in Belgian marine waters (at least in one season), conform the 1% criterion of the 'Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat'

(2) be included in:

* the **EC-Birds Directive** (79/409) on the Conservation of Wild Birds', *Annex I ('Species that are the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution')*,

* the **Bern Convention** on the Conservation of European Wildlife and Natural Habitats, *Appendices I/II* ('*Species which habitats should be protected from deliberate damage or destruction*') or

* the **Bonn Convention** on the Conservation of Migratory Species of Wild Animals, *Appendices I/II ('Species in danger of extinction throughout all or major parts of their range', 'Species which would benefit from international cooperation in their conservation and management' respectively)*(see TUCKER & EVANS 1997).

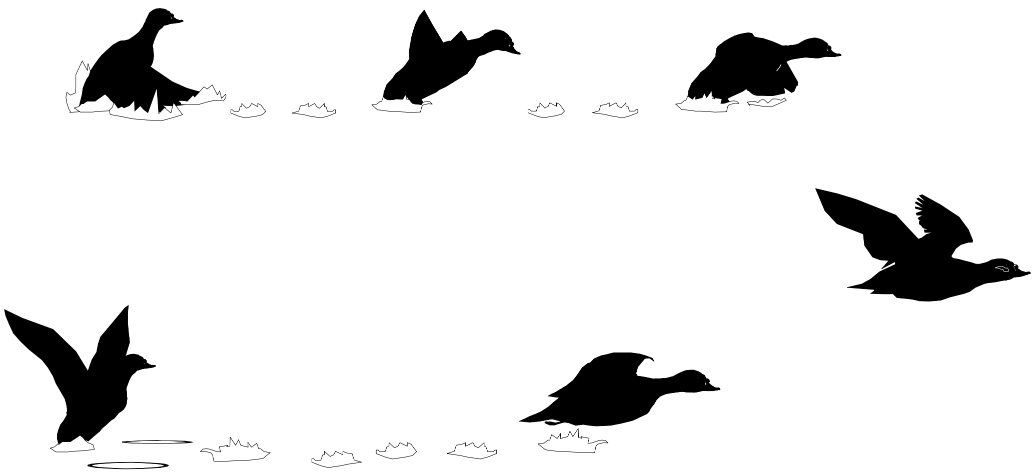
Species that surpass the 1% criterion in Belgian marine waters but are not included in the highest priority lists of the legislative instruments mentioned above, are further referred to as 'locally important species'.

*Hotspots for focal species and areas with high concentrations of oil- and disturbance vulnerable species*

For each of the focal species the distribution in time and space is described and illustrated. A cumulative picture of the hotspots for the focal species is presented, showing where major concentrations of the most threatened birds occur. The 'value' that has been calculated for each bank stratum corresponds to the relative density, times a weight-factor. The weight equals to the log ($x$+1) of the highest observed percentage of the flyway population of that species in Belgian marine waters. The relative density is 0, 1, 2, 3 or 4 depending on whether the species is observed within a bank stratum in density classes of 0%, 1-25%, 25-50%, 50-75% or 75-100% of the maximal value observed for that species in all bank strata in that season.

In a second approach not the rarity of bird species is emphasised, but the vulnerability towards oil pollution. We calculated a value for each bank stratum by multiplying the relative densities of the 23 common seabird species with a weight factor. This weight factor is the oil vulnerability index (OVI), as developed for North Sea waters by CAMPHUYSEN (1998), divided by hundred. This OVI integrates values for various aspects of distribution and behaviour and ranges from <30 (slightly vulnerable) to 50-70 (highly vulnerable).

Disturbance sensitivity maps include a weight-value based on the traffic disturbance index (TDI), as developed for the southern North Sea by CAMPHUYSEN *et al*. 1999. The TDI combines different aspects of occurrence and behaviour on a six-points scale. We simplified the TDI values to four classes: 0 (slightly sensitive: TDI < 35), 1 (moderately sensitive: TDI 35-40), 2 (sensitive: TDI 40-50) or 3 (highly sensitive: TDI:50-65).



## RESULTS

### SELECTION OF FOCAL SPECIES

Out of the 23 more common seabird species observed in Belgian marine waters, 6 species were retained as 'focal species' after applying the criteria described above: Red-throated Diver, Common Scoter, Little Gull, Sandwich Tern, Common Tern and Little Tern (Table 1). Another 5 species exceeded the 1%-criterion but are not mentioned in the highest priority lists of the Bern Convention, the Bonn Convention or the EC-Birds Directive. These species (Great-crested Grebe, Great Skua, Lesser Black-backed Gull, Herring Gull and Great Black-backed Gull) are referred to as 'locally important species'. Another 12 sea- and coastal bird species regularly occur in the area (with total number of specimens observed > 80 during the study-period)(Table1).

*Table 1: Selection of focal seabird species in Belgian marine waters, based on: 1) maximal numbers observed by season during ship-based surveys or additional aerial-and land-based counts (LW= Land-based/winter; AW= Aerial/winter; BS= Breeding numbers/summer-spring); 2) the size of the flyway population; 3) their global status as indicated by international conservation instruments/agreements (EC-BD= Birds Directive; Bern=Bern Convention; Bonn= Bonn Convention). Bold figures outnumber the 1% norm, outlined by ROSE & SCOTT (1997) or 1% of the estimated population as published by: (2) LLOYD* et al*. (1991); (3) HILDÉN & TASKER (1997); (4) HARRIS (1997). Other sources: * DEVOS & DEBRUYNE (1991). Only the 23 sea- and coastal bird species of which more than 80 specimens have been observed in the study-area during 1992-98 are included in the table.*

| Species | Maximal numbers observed in Belgian marine waters (ship-based surveys) | | | | Additional data (land-based, aerial & colony counts) | 1% | Flyway population (ref.) | EC-BD *Ann.* | Bern *App.* | Bonn *App.* |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spr. | Sum. | Aut. | Win. | | | | | | |
| **FOCAL SPECIES** | | | | | | | | | | |
| *Gavia stellata* | 246 | 0 | 183 | **1453** | | 750 | NW-Europe (1) | I | II | II |
| *Melanitta nigra* | 992 | 372 | 771 | 5846 | **15528 AW** | 16000 | NW-Afr., W-Siberia, W/N-Europe (1) | | III | II |
| *Larus minutus* | **3670** | 207 | **2396** | **1861** | | 750 | C/E-Europe (1) | | II | |
| *Sterna sandvicensis* | 274 | 659 | 108 | 0 | **3300 BS** | 1500 | W-Europe, W-Africa (1) | I | II | II |
| *Sterna hirundo* | 60 | 437 | 180 | 0 | **3900 BS** | 1800 | S/W-Europe (1) | I | II | |
| *Sterna albifrons* | 0 | 13 | 0 | 0 | **860 BS** | 340 | E-Atlantic (1) | I | II | II |
| **LOCALLY IMPORTANT SPECIES** | | | | | | | | | | |
| *Podiceps cristatus* | 397 | 0 | 297 | **3736** | **3150 LW** | 1500 | NW-Europe (1) | | III | |
| *Stercorarius skua* | 14 | 88 | **439** | 40 | | 272 | Europe, W-Africa (1) | | III | |
| *Larus fuscus* | **5951** | **5310** | **15608** | 737 | | 4500 | W-Europe, Medit., W-Africa (1) | II | X | |
| *Larus argentatus* | 5159 | 1669 | 6094 | 5158 | **19272 LW (*)** | 14000 | NW-Europe (1) | | III | |
| *Larus marinus* | 628 | 524 | 3517 | **5727** | | 4800 | NE-Atlantic (1) | II | X | |
| **OTHER SEA- & COASTAL BIRD SPECIES (> 80 specimens)** | | | | | | | | | | |
| *Alca torda* | 728 | 0 | 824 | 3791 | | 4820 | NW-Europe (3) | | III | |
| *Fulmarus glacialis* | 933 | 1312 | 1441 | 325 | | 100000 | NE-Atlantic (2) | | III | |
| *Morus bassanus* | 1676 | 641 | 3714 | 619 | | 8920 | NE-Atlantic (2) | | III | |
| *Phalacrocorax carbo* | 381 | 13 | 34 | 5 | | 3200 | NW-Europe (1) | | III | |
| *Anas penelope* | 854 | 0 | 4 | 83 | 7956 LW | 12500 | NW/NE-Europe, W-Siberia (1) | | III | II |
| *Aythya marila* | 0 | 0 | 0 | 0 | 1940 LW | 3100 | NW-Europe (1) | II/III | III | II |
| *Somateria mollissima* | 0 | 0 | 41 | 1421 | 4953 AW | 15000 | Baltic, Denmark, The Netherlands (1) | | III | II |
| *Melanitta fusca* | 0 | 0 | 124 | 11 | 540 LW | 10000 | N-Europe, W-Siberia (1) | II | III | II |
| *Larus ridibundus* | 2122 | 243 | 1245 | 2150 | 4220 LW (*) | 50000 | NW-Europe (1) | | III | |
| *Larus canus* | 5932 | 71 | 2853 | 6927 | | 16000 | NW/C-Europe, Atlantic, Medit. (1) | II | III | |
| *Rissa tridactyla* | 2340 | 569 | 4237 | 5648 | | 84000 | E-Atlantic (1) | | III | |
| *Uria aalge* | 6056 | 255 | 1217 | 13101 | | 19900 | NW-Europe (4) | | III | |

Eleven species have been observed with more than 1% of the flyway population during the 1992-98 study-period. Only two species (Little Gull, Lesser Black-backed Gull) did so in more than one season (Table 1). The highest share (nearly 5%) of an entire sea- or coastal bird population in Belgian marine waters, was observed in the Little Gull (Table 2).

*Table 2: Status and vulnerability of the dominant sea- and coastal bird species of Belgian marine waters. Indicated are: the priority category (see Table 1, with F: focal species, L: locally important species, O: other), the maximal proportion of the flyway population observed within Belgian marine waters and the season when those peak densities occurred, the European SPEC-category and Threat Status (TUCKER & EVANS 1997), the 'oil vulnerability index' (OVI) according to CAMPHUYSEN (1998) and the' traffic disturbance index' (TDI) following CAMPHUYSEN* et al., 1999*. The OVI for* S.albifrons *and* S.sandvicensis *is assumed to be similar to* S.hirundo *(*), for the TDI of* S.albifrons*(**) the mean value of* S.sandvicensis *&* S.hirundo *has been applied. For* Anas penelope *we adopted the same TDI as for* Aythya marila *(***).* Various shadings are used for classes of oil and disturbance vulnerability, with: slightly sensitive (white), moderately sensitive (light grey), sensitive (grey), highly sensitive (dark grey).

| Category | Species | Max.% of population (season) = *x* | SPEC category (1) | European Threat Status (2) | Conservation Value Index (=log(*x*+1)) | Oil Vulnerability Index (OVI) | Traffic Disturbance Index (TDI) |
|---|---|---|---|---|---|---|---|
| F | *Larus minutus* | 4.9% (spring) | 3 | D | 0.77 | 46 | 40 |
| F | *Sterna albifrons* | 2.5% (spring/summer) | 3 | D | 0.54 | 35* | 36** |
| F | *Sterna sandvicensis* | 2.2% (spring/summer) | 2 | D | 0.51 | 35* | 37 |
| F | *Sterna hirundo* | 2.2% (spring/summer) | - | S | 0.51 | 35 | 35 |
| F | *Gavia stellata* | 1.9% (winter) | 3 | V | 0.46 | 50 | 52 |
| F | *Melanitta nigra* | 1.0% (winter) | - | S | 0.30 | 52 | 60 |
| L | *Podiceps cristatus* | 2.5% (winter) | - | S | 0.54 | 45 | 43 |
| L | *Stercorarius skua* | 1.6% (autumn) | 4 | S | 0.41 | 48 | 26 |
| L | *Larus fuscus* | 3.5% (autumn) | 4 | S | 0.65 | 46 | 35 |
| L | *Larus argentatus* | 1.4% (winter) | - | S | 0.38 | 42 | 35 |
| L | *Larus marinus* | 1.2% (winter) | 4 | S | 0.34 | 52 | 37 |
| O | *Alca torda* | 0.8% (winter) | 4 | S | 0.38 | 64 | 47 |
| O | *Uria aalge* | 0.7% (winter) | - | S | 0.26 | 62 | 46 |
| O | *Anas penelope* | 0.6% (winter) | - | S | 0.20 | 19 | 39*** |
| O | *Aythya marila* | 0.6% (winter) | $3^w$ | $L^w$ | 0.20 | 45 | 39 |
| O | *Larus canus* | 0.4% (winter) | 2 | D | 0.15 | 36 | 27 |
| O | *Morus bassanus* | 0.4% (autumn) | 2 | L | 0.15 | 54 | 39 |
| O | *Phalacrocorax carbo* | 0.1% (spring) | - | S | 0.11 | 42 | 34 |
| O | *Somateria mollissima* | 0.2% (winter) | - | S | 0.11 | 56 | 51 |
| O | *Rissa tridactyla* | 0.1% (winter) | - | S | 0.11 | 54 | 40 |
| O | *Larus ridibundus* | 0.1% (winter) | - | S | 0.08 | 36 | 19 |
| O | *Melanitta fusca* | 0.1% (winter) | $3^w$ | $L^w$ | 0.04 | 52 | 52 |
| O | *Fulmarus glacialis* | 0.0% (autumn) | - | S | 0.00 | 50 | 39 |

(1) *The following 'Species of European Conservation Concern' (SPEC) categories are mentioned: category 2= concentrated in Europe but with an unfavourable conservation status; 3= not concentrated in Europe but with an unfavourable conservation status; 4=concentrated in Europe and with a favourable conservation status; $^w$: relates to winter*

(2) *European Threat Status: D(eclining), S(ecure), V(ulnerable), L(ocalized), $^w$: relates to winter populations*

## DISTRIBUTION OF FOCAL SPECIES

Red-throated Diver *Gavia stellata* and Common Scoter *Melanitta nigra* are basically wintering species. Little Gull *Larus minutus* shows important numbers in all seasons except summer. Three tern species breed in the outer harbour of Zeebrugge since the late 1980s in numbers amounting to more than 2% of the flyway population (Table 2).

### LITTLE GULL (LARUS MINUTUS)

Some 75,000 pairs of Little Gull breed in lowland freshwater wetlands of Siberia, Finland, Sweden, Poland and the Baltic states (CRAMP & SIMMONS 1983, ROSE & SCOTT 1997). Outside the breeding season, Little Gulls are mainly coastal and marine in their distribution and concentrate on current lines or fronts, where they feed on small invertebrates by surface-dipping. Each year during spring between 8000 and 20,000 Little Gulls are observed at the Dutch coast (DEN OUDEN & STOUGIE 1990). However, the very high numbers seen in spring 1988-91 by Dutch seabird watchers demonstrate that in some years probably 50-100% of the entire flyway population migrate through the area (CAMPHUYSEN & LEOPOLD 1998). About 90% of the birds in our study-area were identified as adults. The Little Gull has an unfavourable conservation status in Europe (Table 2) and populations are declining (TUCKER & EVANS 1997).

The seasonal pattern shows a peak of sightings in March-April, and to a lesser extent in autumn (September-November). Little Gulls are present in small numbers throughout the winter (Fig. 2).

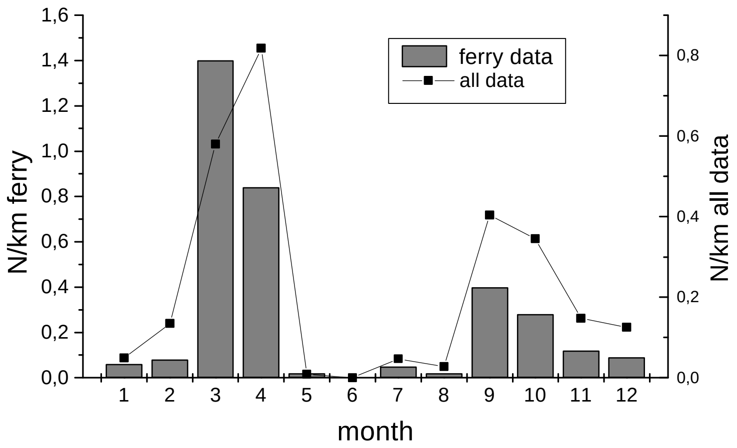



*Fig. 2. Seasonal pattern of occurrence (N km$^{-1}$) of Little Gull* Larus minutus *in the southernmost part of the North Sea during 1992-98. The pattern based on ferry data - collected on fixed routes - is indicated separately.*

Little Gulls at sea are usually seen in small flocks (< 10 birds), although they may form larger groups (CAMPHUYSEN & LEOPOLD 1994, KEIJL & LEOPOLD 1997). The southernmost part of the North Sea appears very attractive for larger flocks (see also VAN IMPE 1966, BULTEEL & VAN DER VLOET 1969). At several occasions flocks of 200-500 birds were encountered on the French side of the Vlaamse Banken. Groups of 50-250 individuals are not rare near the harbour of Oostende. The core-areas for Little Gull in Belgian waters are situated on the Vlaamse Banken in winter and spring, and in the Stroombank-area and the Vlakte van de Raan in autumn (Fig.3).

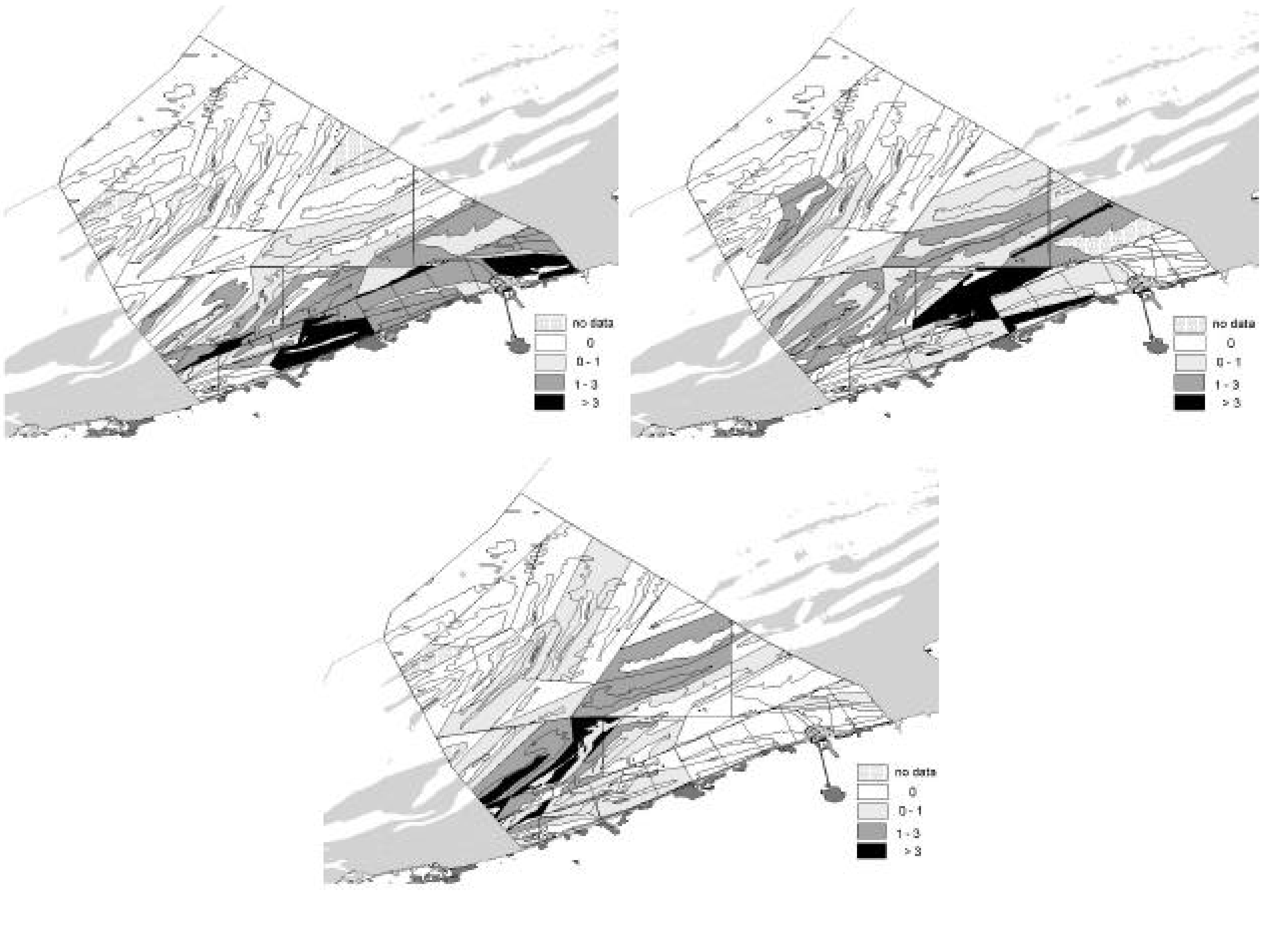



*Fig. 3. Distribution (N km$^{-2}$) of Little Gull* Larus minutus *in Belgian marine waters during 1992-98 in: a) autumn b) spring and c) winter*

<u>*RED-THROATED DIVER (GAVIA STELLATA)*</u>

Over 80% of the European breeding population of Red-throated *Gavia stellata* and Black-throated Diver *G.arctica* breed in Russia and Scandinavia (TUCKER & HEATH 1994, HAGEMEIJER & BLAIR 1997). Closest breeding grounds are in Scotland, Iceland and Fennoscandia. In winter these birds, but also birds from Greenland (OKILL 1994), enter the southern North Sea, forming small flocks in shallow coastal areas. Major concentrations during the non-breeding season occur in the south-eastern North Sea (SKOV *et al*. 1995). They feed on a large variety of small fish, the main prey items being Cod *Gadus morhua*, Herring *Clupea harengus*, Sprat *Sprattus sprattus,* gobies and sticklebacks (MADSEN 1957, CRAMP & SIMMONS 1977, GLUTZ VON BLOTZHEIM & BAUER 1980, LEOPOLD unpubl. data).

Of 2632 divers observed during 1992-98 in the study-area, 54% were identified to species-level. Red-throated Diver is dominant with 92% versus 8% Black-throated Diver (and 3 Great Northern Divers). Two out of three of the Red-throated Divers in our study-area were identified as adults. Divers have an unfavourable conservation status in Europe, with populations considered to be 'vulnerable' according to the European Threat Status (TUCKER & EVANS 1997). They are listed on *Annex I* of the EC Birds Directive 1979, are very vulnerable to oil-pollution and highly sensitive to disturbance by shipping activities.

Red-throated Divers are winter visitors, with highest numbers in November-March (see also CAMPHUYSEN & LEOPOLD 1994). No birds have been observed at sea from May to September (Fig.4).

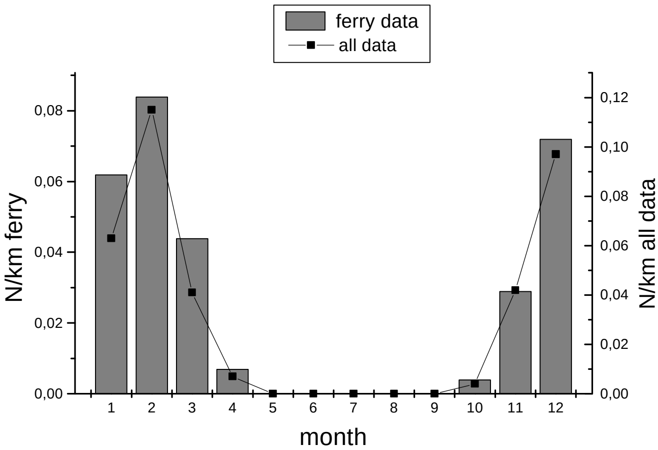



*Fig. 4. Seasonal pattern of occurrence (N km$^{-1}$) of Red-throated Diver* Gavia stellata *in the southernmost part of the North Sea during 1992-98. The pattern based on ferry data - collected on fixed routes - is indicated separately.*

Divers occur solitary or in small flocks in the study-area. The largest group that was observed counted 56 birds, disturbed by a ferry on the Nieuwpoort Bank in March 1996. Groups of 5-20 individuals are not rare at the western Kustbanken (Trapegeer, Smal Bank), on the Vlakte van de Raan and in the Vlaamse Banken area. Larger flocks (100-500 ind.) are described in literature only occasionally from rich feeding areas (GLUTZ VON BLOTZHEIM & BAUER 1980). At the Belgian coast highest densities in winter were recorded on the Middelkerke Bank and the Smal Bank (Fig.5).

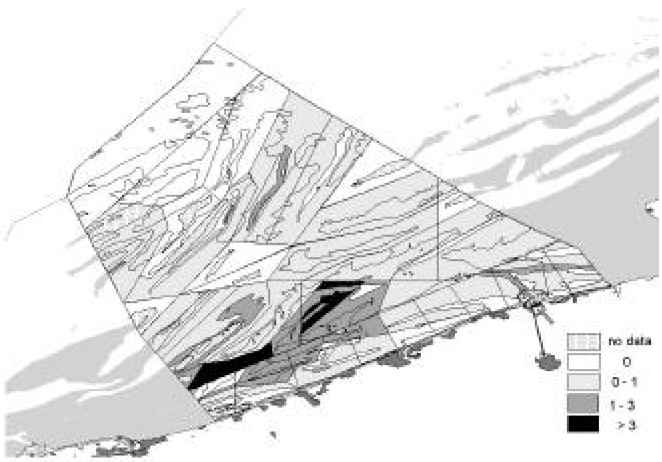



*Fig. 5. Winter distribution (N km$^{-2}$) of Red-throated Diver* Gavia stellata *in Belgian marine waters during 1992-98.*

COMMON SCOTER (*MELANITTA NIGRA*)

Common Scoters have a circumpolar distribution and breed in Iceland, Scotland, Ireland, Fennoscandia and Siberia. Outside the breeding season, Common Scoters are highly gregarious and predominantly feed on various bivalve species (CRAMP & SIMMONS 1977). They concentrate in shallow coastal waters where high densities of prey-items are readily available. In The Netherlands, *Spisula subtruncata* proved to be the dominant prey-item during periods of maximal abundance of the scoters (LEOPOLD *et al*. 1995b). Although Common Scoters are currently not under threat (TUCKER & EVANS 1997), their high vulnerability for oil-pollution and disturbance, and the fact that they rely on undisturbed, relatively shallow coastal waters with dense populations of molluscs, make them a sensitive species (LEOPOLD *et al.* 1995b).

Common Scoters have been observed in the study-area throughout the year, with highest numbers in February-March (Fig. 6). So far there are no summer observations of flocks of moulting and fly-less scoters in Belgium, as has been reported for The Netherlands (LEOPOLD *et al*. 1995b). Major movements of scoters in the southernmost part of the North Sea – as indicated by seabird counts on fixed ferry routes in between Belgium and south-England, i.e. outside the major wintering grounds of scoters – occur in February-April (Fig.6).

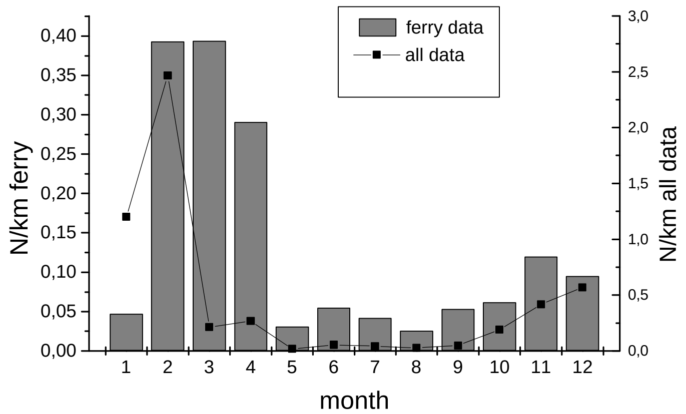



*Fig. 6. Seasonal pattern of occurrence (N km*$^{-1}$*) of Common Scoter* Melanitta nigra *in the southernmost part of the North Sea during 1992-98. The pattern based on ferry data - collected on fixed routes - is indicated separately.*

Belgian coastal waters were already attractive for scoters in a distant past. QUINET (1897) mentions that 'countless numbers covered the sea here as well as the Schelde estuary from Vlissingen to Terneuzen' and that the birds were 'scary and it took great pains to shoot them there'. Since the start of systematic aerial surveys in 1986, total numbers of Common Scoter in Belgian coastal waters fluctuated largely (Fig. 7). These fluctuations may be induced by exchange with nearby feeding sites (the Delta region in The Netherlands, northern France and probably the Thames) or by year-to-year variations in the migration patterns of northern wintering populations (Denmark)(LEOPOLD *et al.* 1995).

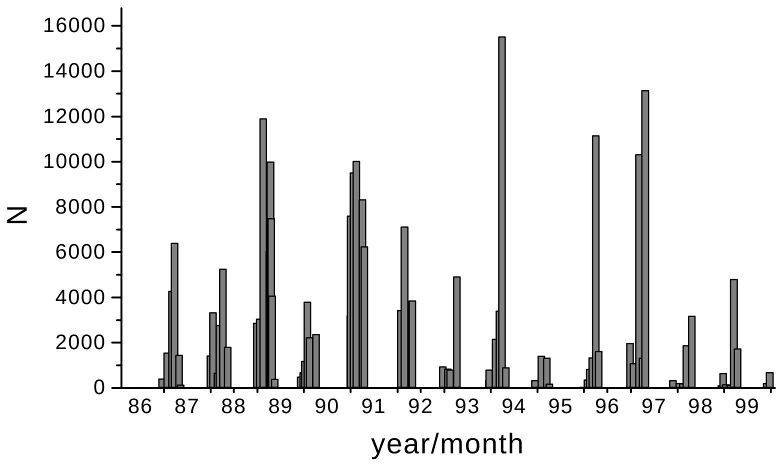



*Fig. 7. Total numbers of Common Scoter counted in Belgian coastal waters during aerial and land-based surveys from 1986 till 1999.*

All major concentrations of scoters in Belgium occur in the western Kustbanken area (Fig. 8). Three strongholds can be identified: 1) the Trapegeer-area (including Den Oever, Westdiep, Broersbank); 2) the Stroombank-Balandbank-Grote Rede area; 3) the Nieuwpoort Bank. The latter held one flock of 12,900 Common Scoters in March 1997, and an excess of 1000 birds on at least six further occasions (in six different winters). The Trapegeer and its immediate neighbourhood is the most inshore wintering site. The largest group of scoters observed here amounted to 8020 in March 1996. Flocks of 1000-5000 individuals are frequent and occurred in the winters 1989-92 and 1996-97. The Stroombank-Balandbank-Grote Rede area (off Oostende) is the most eastern wintering site within Belgian marine waters and the most important one. Peak numbers here were recorded in February 1994, with 15,274 individuals. Flocks of 1000-8500 Common Scoters are counted here annually (except for the winter 1990 and 1998). There are years that Common Scoters concentrate very much inshore (Stroombank), while during other winters they remain further off the coast just south of the Oostende Bank (Grote Rede).

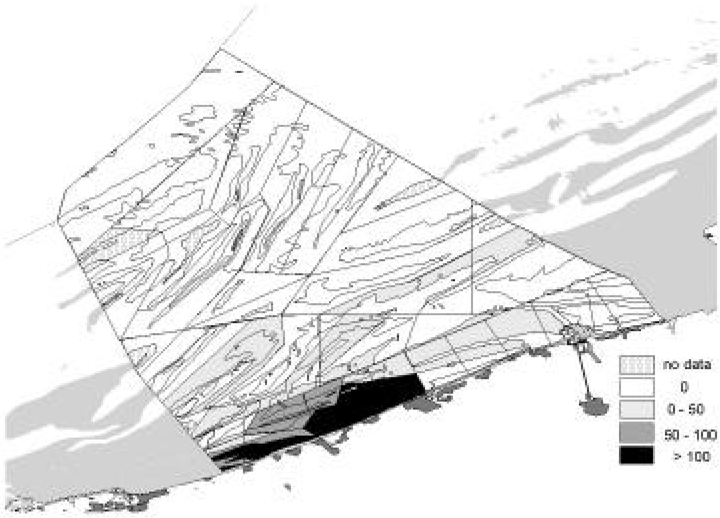



*Fig. 8. Winter distribution (N km$^{-2}$) of Common Scoter* Melanitta nigra *in Belgian marine waters during 1992-98.*

LITTLE TERN (STERNA ALBIFRONS)

With an East-Atlantic flyway population of only 34,000 birds, the Little Tern is a key-species for bird conservation in Europe (TUCKER & EVANS 1997) and hence listed on *Annex I* of the EC Birds Directive. Outside the breeding season most European birds winter between Guinea and Cameroon (MUSELET 1997). The most obvious threat to Little Terns is disturbance at the nesting sites (DEN BOER *et al*. 1993). In Europe it nests in small groups on sand, gravel or shingle beaches or islands or on sparely vegetated or bare, undisturbed artificial habitats. Like other terns, it feeds by plunging to take small fish and invertebrates from near the surface. Little Terns tend to feed very close inshore.

Little Terns have been annual breeders at the Belgian coast before mass-tourism evolved (VAN DEN BOSSCHE *et al*. 1995). At least six locations are known where Little Terns used to nest on beaches, in dunes or near sea-inlets. Reconstruction of the data (Fig. 9) indicates that some 50-75 pairs used these areas as nesting sites in the 1950s, with numbers declining strongly in the early 1960s. The last 3 pairs were recorded in 1973. As for the other tern species, the development of vast, undisturbed areas in the outer harbour of Zeebrugge during the 1980s, created new nesting opportunities (DE SCHUYTER & DE SCHUTTER 1989, DE PUTTER & ORBIE 1990, DE PUTTER & WILLEMYNS 1992, DE SCHEEMAEKER & DEFOORT 1992, DE SCHEEMAEKER & D'HOORE 1994, DE SCHEEMAEKER & LUST 1995, 1996, VAN DEN BOSSCHE *et al*. 1995). The first pair nested in 1985 and the population grew to 425 pairs in 1997, spread over various small subcolonies. Due to constant changes in the availability of suitable nesting area, numbers fluctuated largely (130-425 pairs) during 1994-2001. In 1998 Little Terns nested for the first time (21 pair) in the newly created beach reserve of the 'Baai van Heist' (52 ha), situated next to the eastern pier of the harbour. Numbers increased to 80 pair in 1999, but in 2000 and 2001 no breeding was reported here. It is possible that the in 2000 newly developed 'tern peninsula' of 5 ha inside the eastern part of the outer harbour (as a compensation for loss of breeding ground more to the west) attracted some of the nesting birds from the beach reserve. In 2001 some 120 pair were found nesting at the peninsula, making this area the most important colony of the Zeebrugge harbour at present.

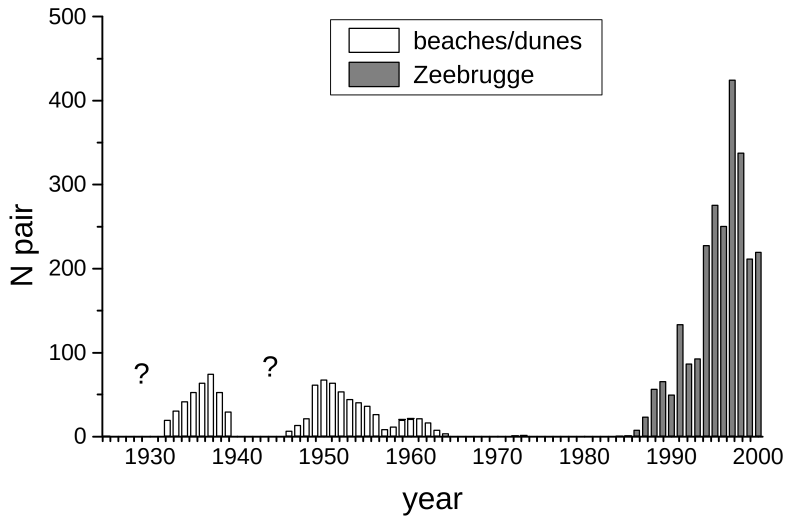



*Fig. 9. Reconstruction of trend in breeding population of Little Tern* Sterna albifrons *in Belgian colonies during 1925-2000 (after* VAN DEN BOSSCHE et al. *1995, supplemented with data from the Institute of Nature Conservation and Filip De Ruwe). Breeding pairs in natural conditions (beaches/dunes) are distinguished from pairs in the Zeebrugge harbour and neighbourhood.*

With 130-425 pairs (1994-2001) the Zeebrugge population ranks among the biggest colonies of Little Tern in the North Sea. In the United Kingdom and The Netherlands, most colonies are small (< 20 pairs) and very few colonies are larger than 100 pairs (DEN BOER *et al*. 1993, SEARS & AVERY 1993). The largest colony described for the U.K. in 1995 was situated at Great Yarmouth and amounted to 197 pairs (THOMPSON *et al.* 1997), and 360 pairs were counted at Foulness in 1983 (LLOYD *et al*. 1991). A historical maximum in The Netherlands is derived from the former area 'De Beer', holding some 500 pairs in the 1930s (MEININGER *et al*. 2000). Nowadays the entire Dutch population counts merely 300-400 pairs, with the largest Little Tern colony (180 pairs) situated at the Hoge Platen in the Schelde estuary (DEN BOER *et al.* 1993). The same applies to France, where less than 100 pair nest along the Channel and Atlantic coasts (CADIOU & LE GISOM 1999). Moreover Little Terns at Zeebrugge have a high hatching success (> 1.5 young per pair)(DE RUWE & DE PUTTER 1999).

The Little Tern arrives at the Zeebrugge colonies at the end of April and leaves the area in July (DE PUTTER & ORBIE 1992). Very few birds are seen at sea, since most Little Terns tend to feed very close inshore or within the harbour of Zeebrugge. Observations near the breeding colonies demonstrated that the majority remains within about 3 km of the nesting location. Therefore the core-areas for Little Tern in Belgium are the immediate vicinity of the harbour of Zeebrugge, in particular the coastal stretch to the east (Paardenmarkt area).

*SANDWICH TERN (STERNA SANDVICENSIS)*

In Europe, Sandwich Terns breed in two distinct regions: in the northwest and the southeast (CRAMP 1985). The NW-European population has its stronghold in the North Sea, with the bulk found in large breeding colonies in undisturbed coastal and island habitats. Sandwich Terns feed exclusively in relatively shallow marine areas, where they feed predominantly by plunge diving on small surface shoaling fish (Herring *Clupea harengus*, Sandeel *Ammodytes* sp., ...). It winters off West-Africa. The species has an unfavourable conservation status, is declining in numbers and hence listed on *Annex I* of the EC Birds Directive.

The creation of suitable breeding habitat in the outer harbour of Zeebrugge in the mid-1980s attracted many Sandwich Terns from Dutch colonies (DERKS & DE KRAKER 1993). After the first (unsuccessful) nesting record for Belgium in 1988 (ORBIE 1991) numbers increased quickly to a maximum of 1650 pairs in 1993, followed by a decrease to 73 pairs in 1998. An active management immediately prior to the breeding seasons of 1999 and 2000 (creating open spots within colonies of Black-headed Gulls) resulted in numbers increasing again gradually to 1550 pairs in 2000 (Fig. 10)(DE SCHEEMAEKER & D'HOORE 1994, DE SCHEEMAEKER & DEFOORT 1992, DE SCHEEMAEKER & LUST 1995, 1996, VAN DEN BOSSCHE *et al*. 1995, data IN, F. De Ruwe, G. De Putter).

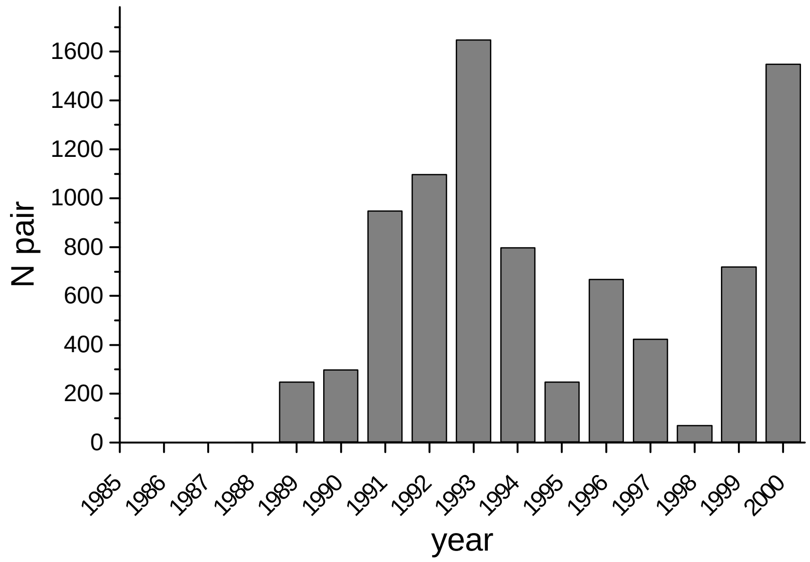



*Fig. 10. Trend in the breeding population of Sandwich Tern* Sterna sandvicensis *in Belgium during 1985-2000 (after* ORBIE *1991,* VAN DEN BOSSCHE et al. *1995, supplemented with data from the Institute of Nature Conservation and F.De Ruwe). All breeding pairs were found in the outer harbour of Zeebrugge.*

With a maximum breeding population of 1650 pair, Zeebrugge ranks amongst the medium-sized colonies in the North Sea. Largest colonies in The Netherlands in the 1990s amounted to c. 8000 pairs (Griend), c. 4000 pairs (Hompelvoet) and c. 3000 pairs (Hoge Platen)(BAPTIST & MEININGER 1996) and historical data (1929-1963) from the former area 'De Beer' mention 11,000 pairs as a maximum (MEININGER *et al.* 2000). By contrast the entire population of France counts merely 6755-6907 pairs, with only 350-435 pairs in the northern part of the country (CADIOU & LE GISOM 1999).

The first birds arrive in March, with migration peaks in April-May and again in July (Fig. 11). The Sandwich Terns that breed at Zeebrugge fly as far as 30-40 km to their feeding grounds situated to the west of the colony, i.e. on the Vlaamse Banken and western Kustbanken.

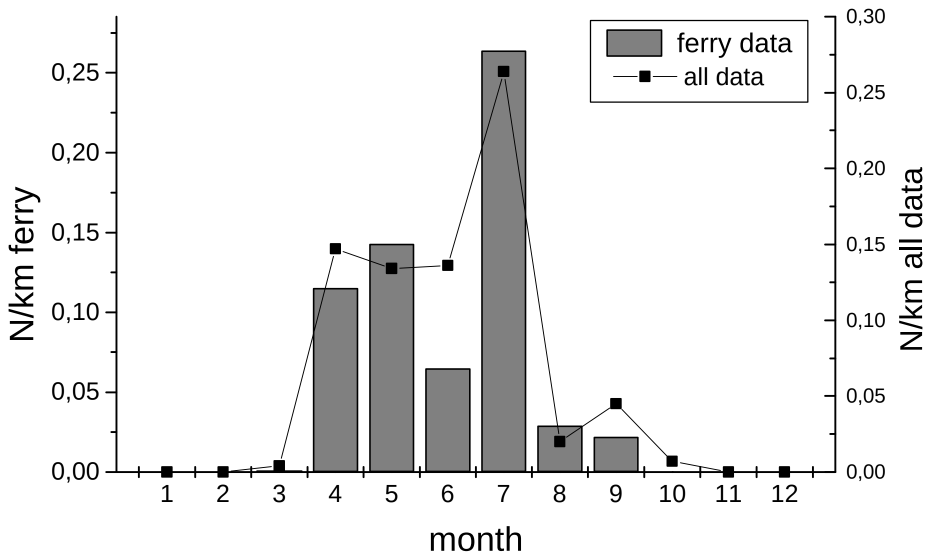



*Fig. 11. Seasonal pattern of occurrence (N km$^{-1}$) of Sandwich Tern* Sterna sandvicensis *in the southernmost part of the North Sea during 1992-98. The pattern based on ferry data - collected on fixed routes - is indicated separately.*

<u>COMMON TERN (STERNA HIRUNDO)</u>

Common Terns nest throughout temperate Europe and Asia. They nest both in coastal and inland sites, and feed on marine and freshwater fish and aquatic invertebrates. Like other terns, they fish by shallow plunge diving. Most Common Terns winter off the West-Africa coast, rather few venture further south across the equator. The European status of the Common Tern is secure (TUCKER & EVANS 1997).

Common Terns first nested at the Belgian coast in 1960, when suitable nesting habitat was created within the Zwin nature reserve (Fig. 12). The Zwin population never exceeded the 375 pairs and has now virtually disappeared (c. 30 pairs in 2000: comm. G.Burggraeve). Meanwhile the vast and sparsely vegetated terrains raised with sand in the outer harbour of Zeebrugge attracted an increasing number of Common Terns (DE SCHEEMAEKER & DEFOORT 1992, ROSSAERT *et al*. 1993, DE SCHEEMAEKER & D'HOORE 1994, DE SCHEEMAEKER & LUST 1995, 1996, VAN DEN BOSSCHE *et al*. 1995, data IN, F. De Ruwe, G. De Putter), with a peak of 2260 pairs in 2000. Smaller numbers have been breeding in the inner harbour as well.

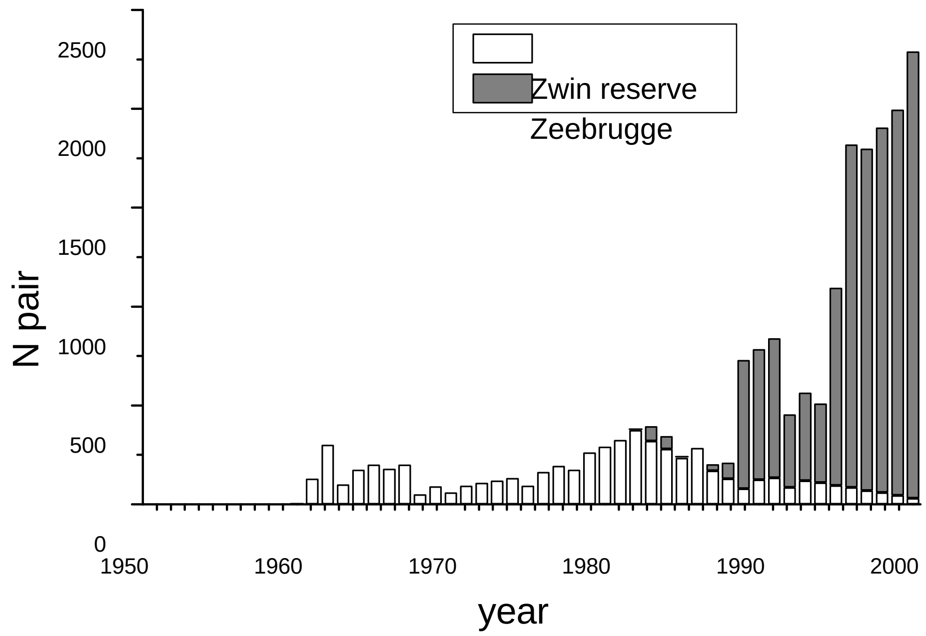



*Fig. 12. Trend in the breeding population of Common Tern* Sterna hirundo *in Belgian coastal colonies during 1925-2000 (after* VAN DEN BOSSCHE *et al. 1995, with additional data from the Institute of Nature Conservation). Breeding pairs from the Zeebrugge harbour are indicated separately from those at the Zwin nature reserve.*

As such, Zeebrugge is currently the largest but one colony of Common Tern in NW-Europe. In comparison, Germany had a total coastal population of 6931 pairs of Common Tern in 1996, with the largest colony at Minserer Oog Island (1800 pairs)(SÜDBECK *et al*. 1998). France counted 4782-4976 pairs in 1998, with only 1546-1644 pairs along the Atlantic and Channel coasts (CADIOU & LE GISOM 1999). The largest colony here was situated in 1958-59 at the northwest coast (c. 1500 pairs: YEATMAN-BERTHELOT & JARRY 1995). The entire population of the U.K. amounted to 14,700 pairs in 1985-87 (LLOYD *et al*. 1991) with only three colonies larger than 1000 pairs (Blakeney Point, maximum of 1800 pairs). And although The Netherlands knew vast colonies in the past (17,500-19,000 at the former 'De Beer': MEININGER *et al.* 2000), nowadays the largest Dutch colony situated at Griend counts merely 1800 pairs. However in some years many more terns may be present, so that Griend must be considered the largest European colony. On the other hand the reproductive success at this colony (0.38-0.80: STIENEN & BRENNINKMEIJER 1998) is much lower than at Zeebrugge (1.20: VAN WAEYENBERGE *et al*. 2000).

The first Common Terns arrive at the end of March – early April (Fig. 13). Resident nesting birds at the Zeebrugge colony cause a peak in the numbers observed per km during ship-based surveys in June. A peak in July during surveys on board ferries to the UK results from important migratory movements. Regular boat-trips in the proximity of Zeebrugge indicate that local Common Terns do not feed beyond 5 km away from the nesting site. Very large flocks (500-1000 birds) are often observed in the wake of in- and outgoing ferries when they manoeuvre within the harbour and stir up large numbers of small prey-items.

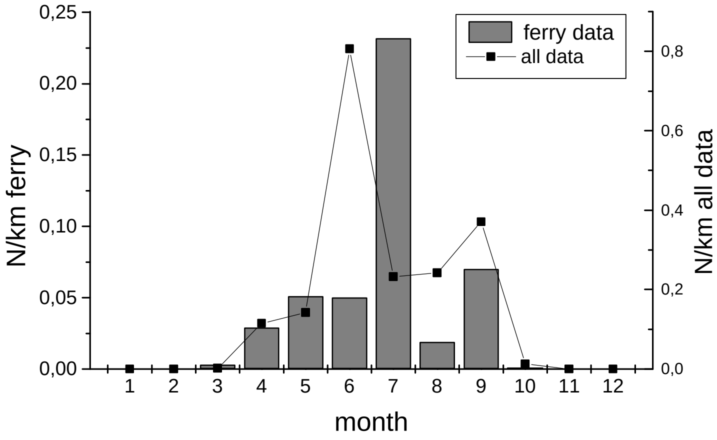
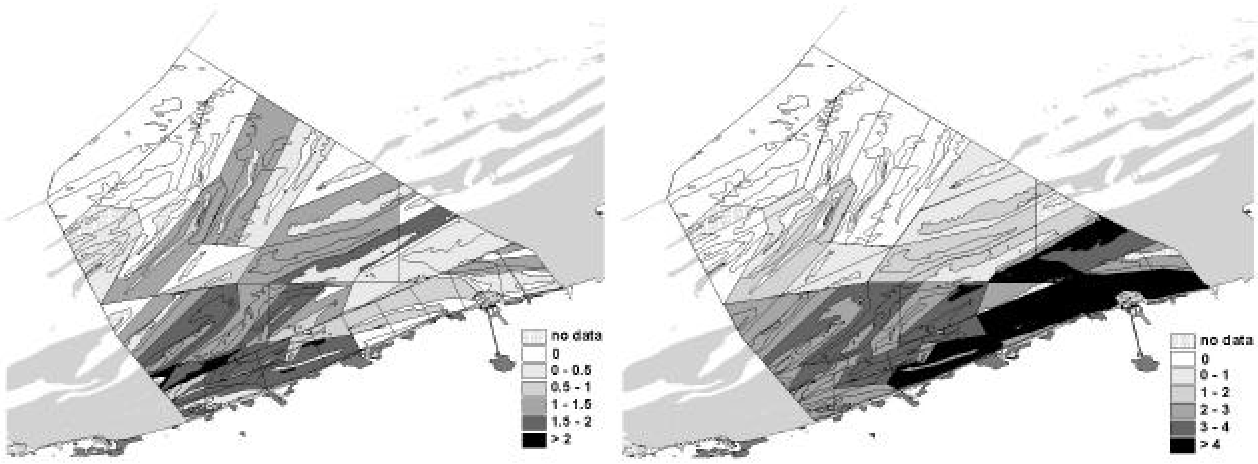



*Fig. 13. Seasonal pattern of occurrence (N km$^{-1}$) of 'Comic Terns' (undifferentiated Common/Arctic Terns)* Sterna hirundo/paradisaea *in the southernmost part of the North Sea during 1992-98. The pattern based on ferry data - counts along fixed routes - is indicated separately.*

## HOTSPOTS FOR SIX FOCAL SEABIRD SPECIES

A cumulative picture of the abundance and weight of focal seabird species in Belgian marine waters (Fig. 14) indicates where major efforts for conservation should focus on. Hotspots in every season are the Westkustbanken (Trapegeer-Broersbank-Den Oever, Nieuwpoort Bank, Stroombank, Balandbank, Smal Bank), the Vlakte van de Raan and most of the Vlaamse Banken. The Oostkustbanken (Paardenmarkt, Wenduinebank, ...) are very important from spring till autumn, mainly as feeding grounds for the three focal tern species. In winter this area has less weight in terms of abundance of focal species than the westcoast. The deep water zone and Hinderbanken area are comparatively poor (Fig.14).



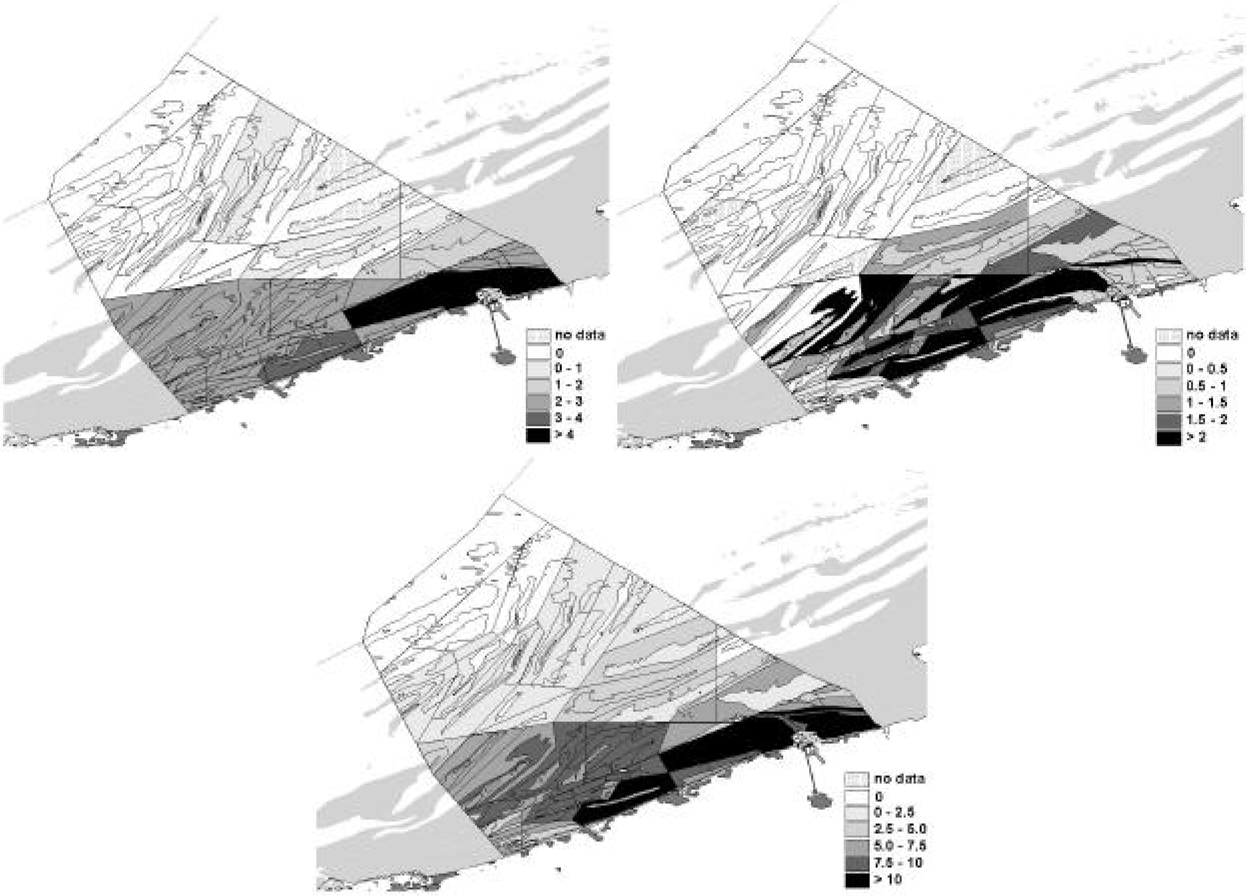



*Fig. 14: Hotspots for six focal seabird species in Belgian marine waters in a) winter b) spring c) summer d) autumn e) overall. Shading is based on the relative abundance of six focal species times a weight factor.*

The period March-May, referred to as 'spring', show the highest concentration of focal species. It combines important winter concentrations of divers and scoters, present till the end of March, with high numbers of terns arriving in the breeding colonies from April/May onwards and staying in the area till late summer. Although autumn is known amongst seabird watchers as an interesting period for rare migrating species, the cumulative densities of focal species are generally low in Belgian waters. Winter and summer show intermediate values.

Generally spoken vulnerable seabird species tend to concentrate on the sandbank slopes in winter and autumn at depths of 5-15 m. In addition the shallower parts of the sandbanks are of great importance to feeding terns in spring and summer. The swales in between the sandbanks show the lowest conservation values. Key-sites for birds situate 5-20 km from the coastline in autumn and winter, and 0-20 km in spring and summer. Beyond 20 km the conservation value gradually declines.

### OIL-SENSITIVE AREAS

By incorporating a measure for oil-vulnerability, sites can be compared in terms of sensitivity for oil-pollution. Winter turns out to be the most delicate period for oil-pollution, immediately followed by spring. The potential impact of oil-slicks on threatened bird species is considerably smaller in autumn and summer. Much higher oil-vulnerability indices for wintering birds (auks, scoters, divers,..) compared to those of terns are the main reason for this difference. Generally spoken, the closer an oil-slick approaches the coastline the worse the presumed impact on seabirds (Fig. 15). Within each season the western sandbank systems Westkustbanken and Vlaamse Banken are highly oil-sensitive (Fig. 15a). During winter, the Oostkustbanken (with the exception of the Vlakte van de Raan) are less vulnerable than the western part of Belgian inshore waters. In spring and summer the Oostkustbanken are most vulnerable (Fig.15b).

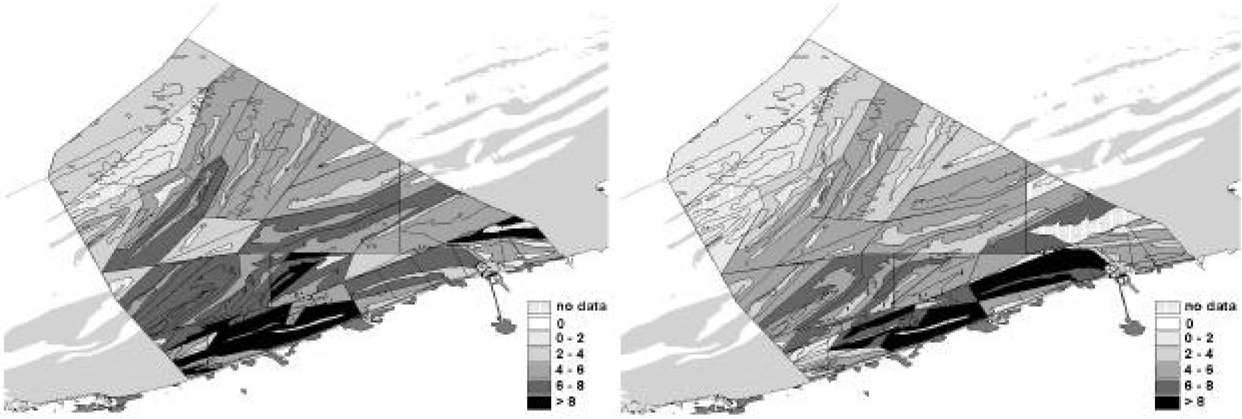



*Fig. 15. The oil-vulnerability for sea- and coastal birds in Belgian marine waters in: a) winter b) spring. Shading is based on an oil vulnerability value, calculated from the relative abundance and the oil vulnerability index of the 23 most abundant species.*

## DISTURBANCE-SENSITIVE AREAS

Disturbance-sensitive species such as scoters, divers and (to a lesser extent) auks and grebes are most abundant in winter and early spring. Higher values in autumn compared to summer are caused by increasing numbers of sensitive species from October onwards. Most vulnerable sites in terms of disturbance are the Westkustbanken and Vlaamse Banken, both in winter and early spring (Fig. 16). There is little reason to worry about disturbance at sea during summer.

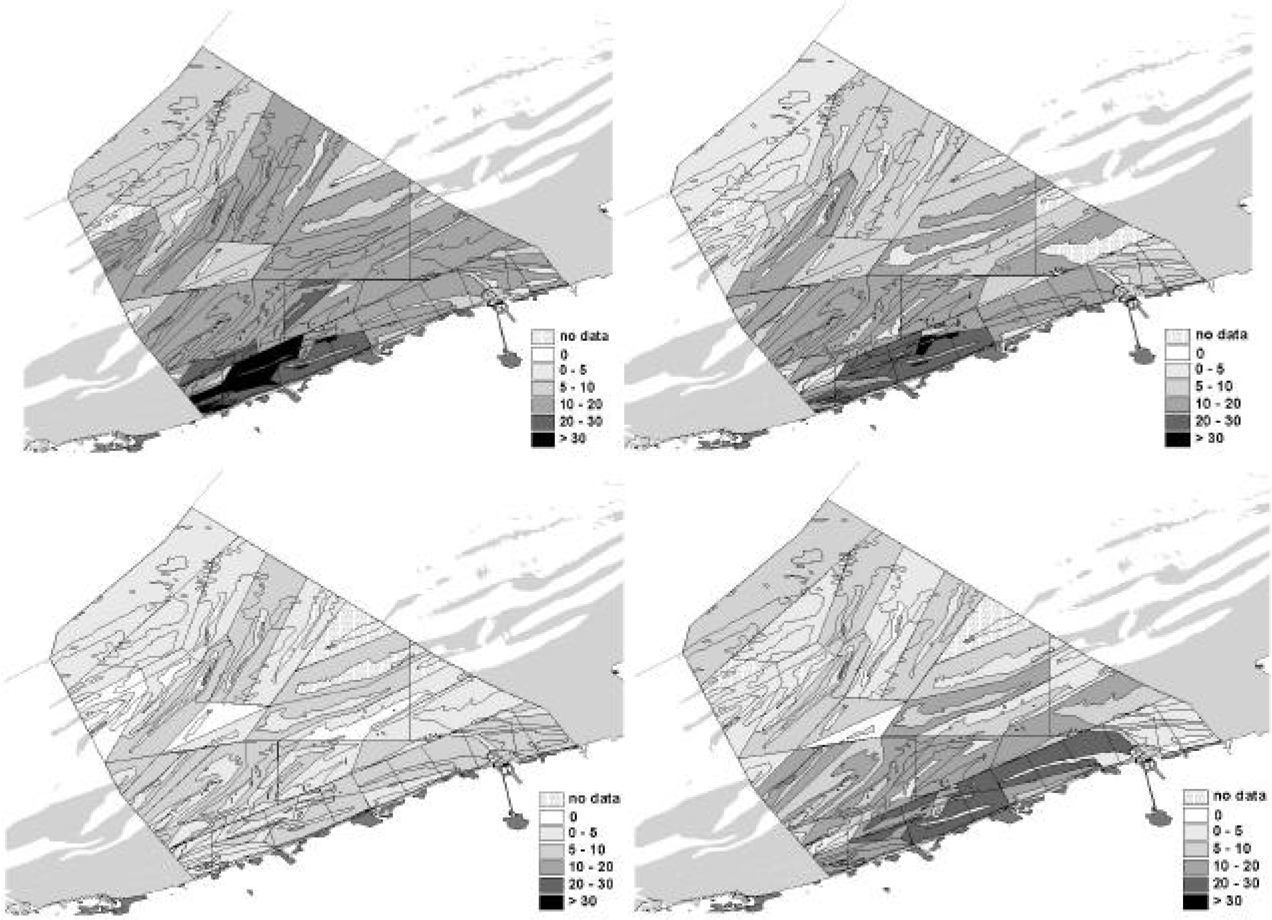



*Fig. 16. The disturbance-sensitivity for seabirds in Belgian marine waters in: a) winter b) spring c) summer d) autumn. Shading is based on a disturbance sensitivity value, calculated from the relative abundance and the disturbance sensitivity of the 23 most abundant species.*

Very sensitive spots (disturbance sensitivity value >30) in winter and/or spring are: Nieuwpoort Bank, Trapegeer-Den Oever-Broersbank, Stroombank and Balandbank, closely followed (values: 20-30) by Ravelingen, Smal Bank-north and Middelkerke Bank (Fig.16a,b).

ROLE AS CORRIDOR FOR MIGRATING SEABIRDS

The southernmost part of the North Sea (between 51° and 52° N) is of great importance as a corridor for migrating seabirds. Table 3 shows rough estimates as compiled from various information sources (Oliver & Davenport 1971, Cramp & Simmons 1977, Glutz von Blotzheim & Bauer 1980, Redman & Milbled 1980, Taylor *et al*. 1981, Camphuysen & van Dijk 1983, Van der Poel 1984, Brown 1985, Furness 1987, Tasker *et al.* 1987, Camphuysen & Derks 1989, den Ouden & Stougie 1990, Platteeuw 1990, Yeatman-Berthelot 1990, Lloyd *et al*. 1991, Boudolf *et al*. 1992, Adriaensen *et al*. 1993, Baillie *et al*. 1994, Camphuysen & Leopold 1994, Meek *et al*. 1994, Platteeuw *et al*. 1994, Sears *et al*. 1995, Skov *et al*. 1995, Stone *et al*. 1995, Barrett & Folkestad 1996, Offringa *et al*. 1996, Barrett & Bakken 1997, Bourne & Whilde 1997, Dunnet 1997, Fjeldså & Lammi 1997, Leopold & Skov 1997, Merne 1997, Pons & Yésou 1997, Camphuysen 1998, Camphuysen & Leopold 1998, Cadiou & le GISOM 1999, Oliver 1999, Seys own observations).

*Table 3: Estimated maximal proportion of the flyway population of 18 common seabird species that cross or reside in the southernmost part of the North Sea (51°-52° N) during an average year. The resident number of birds is based on* Offringa et al. *(1996), adjusted for the Belgian marine waters with results from this study. Notes: *: on average 83% of all identified small divers in the area were Red-throated Divers (*Camphuysen & van Dijk *1983); ** on average 80% of all identified 'comic' terns were Common Tern in* Offringa et al. *(1996); *** Sum of 433 pairs in Essex/Kent (in 1985/87:* Lloyd et al.*, 1991) + 430 pairs in Belgium (this study) + 226 pairs in the Delta region in The Netherlands (in 1992:* den Boer et al. *1993) + 43 pairs in Nord/Pas-de-Calais, France (1998:* Cadiou & le Gisom*, 1999)*

| Species | Flyway population (see *Tab.1*) | Estimated maximal number of 'resident' birds (in relation to flyway population) | | | Estimated maximal number migrating through the Straits of Dover | | | Maximum % of biogeographic population residing in or flying over the southernmost part of the North Sea |
|---|---|---|---|---|---|---|---|---|
| | | N | season | % | N | season | % | |
| *Gavia stellata* | 75,000 | *4,176 | W | 5.6 | 10-15,000 | W | 13-20 | 13-20 |
| *Podiceps cristatus* | 150,000 | 5,826 | W | 3.9 | 15-30,000 | A/W | 10-20 | 10-20 |
| *Fulmarus glacialis* | 10,000,000 | 4,051 | A | 0.0 | - | - | - | <0.01 |
| *Morus bassanus* | 892,000 | 10,024 | A | 1.1 | 40-60,000 | A | 4-7 | 4-7 |
| *Melanitta nigra* | 1,600,000 | 40,028 | W | 2.5 | 60-80,000 | W | 4-5 | 4-5 |
| *Stercorarius skua* | 27,200 | 539 | A | 2.0 | <27,200 | A | <100 | <100 |
| *Larus minutus* | 75,000 | 5,626 | A | 7.5 | 30-75,000 | A/Sp | 40-100 | 40-100 |
| *Larus ridibundus* | >5,000,000 | 6,460 | W | 0.1 | 370-500,000 | A/W/Sp | 7-10 | 7-10 |
| *Larus canus* | 1,600,000 | 20,527 | W | 1.3 | 45-100,000 | A/W/Sp | 3-6 | 3-6 |
| *Larus fuscus* | 450,000 | 28,788 | A | 6.4 | 125,000 | A/Sp | 28 | 28 |
| *Larus argentatus* | 1,400,000 | 64,172 | W | 4.6 | - | - | - | 4.6 |
| *Larus marinus* | 480,000 | 25,117 | A | 5.2 | 6-9,000 | A | 1-2 | 5.2 |
| *Rissa tridactyla* | 8,400,000 | 30,467 | A | 0.4 | - | - | - | 0.4 |
| *Sterna sandvicensis* | 150,000 | 3,970 | S | 2.6 | 100,000 | S | 67 | 67 |
| *Sterna hirundo* | 180,000 | **9,540 | S | 5.3 | 100,000 | Sp | 56 | 56 |
| *Sterna albifrons* | 34,000 | ***2,264 | S | 6.7 | 15,000 | Sp | 44 | 44 |
| *Uria aalge* | 1,990,000 | 29,291 | W | 1.5 | 20-50,000 | W | 1-3 | 1.5-3 |
| *Alca torda* | 482,000 | 6,161 | W | 1.3 | 4-10,000 | A/W | 1-2 | 1.3-2 |

Altogether up to 1-1.3 million seabirds migrate through the Straits of Dover each year, with one-third (315-385,000) being focal species for conservation. The great majority (40-100%) of the flyway population of Great Skua and Little Gull may use the Channel to leave the North Sea, as well as 30-70% of the summer resident terns and Lesser Black-backed Gulls. In addition we estimate that 10-20% of the Red-throated Divers and Great Crested Grebes may pass this bottleneck, and 3-10% of the *Larus*-gulls (except for Little Gull), Northern Gannets and Common Scoters. Pelagic species (Fulmar, Kittiwake, auks) usually have large populations and estimates of dispersing movements are very difficult to make for these species. Hence conservative percentages of < 1-3% were proposed. The 1-1.3 million seabirds passing through the southernmost part of the North Sea compares to a purely theoretical winter maximum (i.e. summing up the maxima of various winters) of c. 200,000 resident seabirds in the area between 51-52° N or c. 100,000 seabirds in Belgian marine waters (Table 3).

## DISCUSSION

### SEABIRD CONSERVATION IN BELGIUM: STATE OF THE ART

The development of a better legal framework, including the installation and management of marine protected areas is an important tool in a proper management and planning of the coastal zone. The 'Law on the protection of the marine environment in sea areas under Belgian jurisdiction' is a new instrument that creates opportunities to install marine protected areas (20.01.1999: OFFICIAL JOURNAL – BELGISCH STAATSBLAD 12.03.1999). Areas can be selected and designated by Royal Decree as 'integral marine reserves', 'special marine reserves', 'special conservation areas', 'closed areas' or 'buffer zones' (Art.7). So far no such marine protected areas have been installed in Belgian marine waters. A Ramsar site of 7,400 ha, called the 'Vlaamse Banken', was proposed in 1971 (KUIJKEN 1971) and installed in 1984 to encompass the favourite habitat of the Common Scoter in the shallow waters extending 3 nautical miles seawards between Oostende and the French-Belgian border. Only the subarea shallower than -6m MLLWS has been included, according to Article 1 of the Ramsar Convention (Fig. 17; MAES *et al*. 2000). No direct and specific management measures have been taken to ensure protection of focal species within this Ramsar area. A larger rectangular area of 17,000 ha (Fig. 17), encompassing the entire Ramsar site and called the 'Trapegeer-Stroombank' site, has been proposed in 1996 as a Special Area of Conservation (SAC) under the EC-Habitats Directive. The proposal of this area fits well into the development of the international Natura-2000 network of SACs and resorts under the habitat of 'sandbanks, which are slightly covered by sea water all the time,' (*Annex I* of the EC-Habitats Directive). The installation of this SAC will hopefully provide for a better habitat protection. However, since birds are not included in the list of species to be protected it does not guarantee that specific measures will be taken for a better protection of these birds.

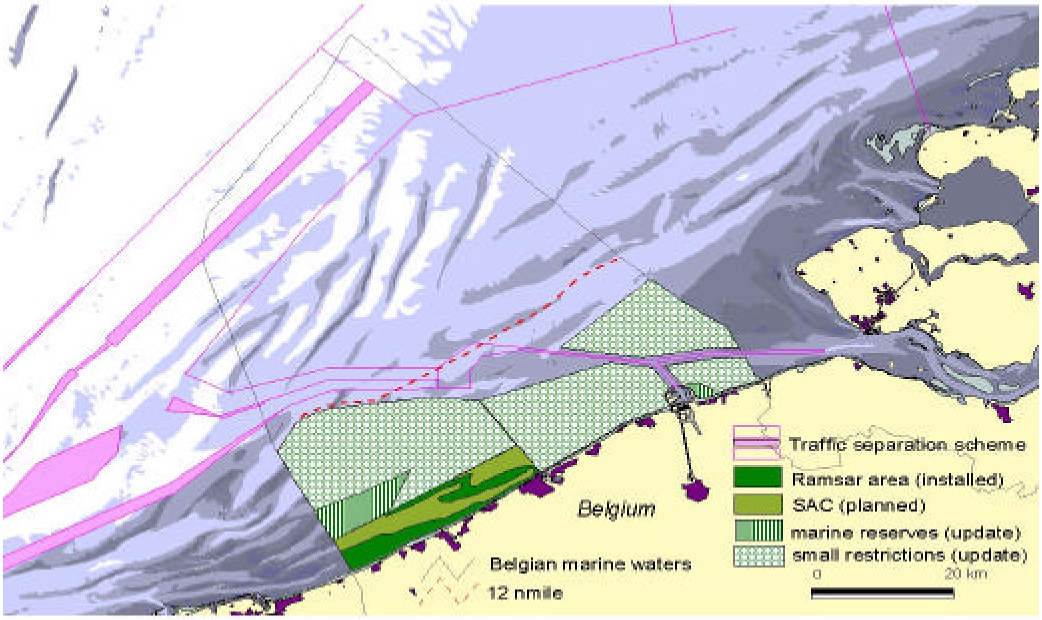



*Fig. 17. Current marine conservation area (Ramsar area 'Vlaamse Banken'), planned Special Area of Conservation ('Trapegeer-Stroombank') and desirable additional MPA's in Belgian marine waters in order to safeguard the focal seabird species. A large area where only minor restrictions will be necessary is differentiated from two strict marine reserves. Also indicated are the the –10 and –20 m depth contours, the boundaries of the Belgian Continental Shelf, the territorial sea (12 nautical mile boundary) and the major shipping routes.*

There is urgent need for an update of the present situation. First of all, the setting and demarcation of the Ramsar area at the westcoast, in charge since 1984, is based merely on the occurrence of the Common Scoter (KUIJKEN 1972). Due to the non-existence of standardized ship-based surveys in Belgium at that time, neither scientists nor policy-makers were aware of the ornithological value of Belgian coastal waters for other seabirds than scoters (divers, auks, ...) and there was no information at all about the abundance of seabirds further offshore. The new data available since 1992 - when seabird surveys on board various vessels were initiated here – and detailed in this paper, show clearly that conservation measures guided by Common Scoters only are not sufficient anymore. Moreover, due to several new population estimates (ROSE & SCOTT 1994, 1997) it becomes more and more difficult for the Common Scoter to attain the 1% threshold (16,000 birds). Ranking the focal and locally important species in

Belgium in terms of the relative proportion of their flyway population, the Common Scoter (1%) is being overtaken by ten other species (Table 2). Furthermore the hotspots for the most threatened species (the four *Annex I* species of the Birds Directive: Red-throated Diver, Sandwich Tern, Little Tern and Common Tern) largely fall outside the proposed Special Area of Conservation (and the Ramsar area). This is in contrast with the requirement for all EC-member states to take protective measures in the most representative areas for those species. The inclusion of the Zeebrugge outer harbour, holding some of the largest European breeding colonies of terns, in the list of Important Bird Areas in Europe (HEATH & EVANS 1999) necessitates further steps to ensure the conservation and protection of these birds.

## CONSERVATION HOTSPOTS: AN UPDATE

### Focal species in a broader context

According to the atlas of important bird areas for seabirds in the North Sea (SKOV *et al*. 1995), the entire shallow coast of The Netherlands, Belgium and northern France is the sixth most important bird area for seabirds in the North Sea, the Channel and the Kattegat. Species occurring in this area of 16,000 $km^2$ in internationally important numbers during 1980-1993 were Red- and Black-throated Diver (average number: 3100), Great-crested Grebe (10,500), Common Scoter (75,000), Little Gull (6700), Herring Gull (53,000), Lesser Black-backed Gull (17,000) and Sandwich Tern (5100). All these bird species have been observed in numbers surpassing the 1%-treshhold in Belgian marine waters as well (Table 1). In addition, Common Tern and Little Tern are focal species for the Belgian coast, resulting from very important colonies in the outer harbour of Zeebrugge. Three other species (Great Skua, Razorbill, Great Black-backed Gull), considered locally important, only occasionally occur with more than 1% of the flyway population in Belgian coastal waters.

With a surface of 3500 $km^2$, Belgian marine waters represent merely 0.6% of the total North Sea area. The comparatively high number of species exceeding the 1% criterion indicates the ornithological conservation value. It forms an important part of the shallow southern North Sea that appears particularly attractive to divers, grebes, seaducks, terns and gulls. CAMPHUYSEN & LEOPOLD (1994) concluded that this area between 51-56° N and 2-7° E is of international importance for wintering Red-throated Divers, Great Crested Grebes, Eider, Common Scoters, Common Gull, Herring Gull, Great Black-backed Gull and Common Guillemot. In summer, the area is of international importance for Lesser Black-backed Gull and Sandwich Tern. In autumn the area is of importance to migrating Northern Gannet, Great Skua, Little Gull and Common Tern and substantial numbers of Fulmar, Arctic Skua, Kittiwake and Razorbill are found here. Our results fit well in this evaluation and show that Belgian marine waters do not have a unique seabird fauna, but are an important stronghold for most shallow water species (Table 4).

*Table 4. Conservation value of Belgian marine waters (this study), compared to The Netherlands and part of the southern North Sea (CAMPHUYSEN & LEOPOLD 1994). Indicated are the peak numbers in terms of % of the flyway populations and the season of maximal abundance of the most abundant species. The size of the flyway populations and the proportions of these flyway populations as used in CAMPHUYSEN & LEOPOLD (1994) have been slightly modified in accordance with: (1) ROSE & SCOTT (1997); (2) HARRIS (1997); (3) HILDÉN & TASKER (1997). The percentage for* S.albifrons *in The Netherlands and the southern North Sea is based on Dutch breeding numbers (DEN BOER* et al. *1993) supplemented with Belgian data (this study).*

| Species | Belgium 3,500 $km^2$ | | The Netherlands 57,000 $km^2$ | | Southern North Sea 130,000 $km^2$ | | Flyway population | |
|---|---|---|---|---|---|---|---|---|
| | % | season | % | season | % | season | N | source |
| *Larus minutus* | 4.9 | sp | 14.3 | au | 18.9 | au | 75,000 | 1 |
| *Sterna albifrons* | 2.5 | sp/su | 1.8 | sp/su | 4.2 | sp/su | 34,000 | 1 |
| *Sterna sandvicensis* | 2.2 | sp/su | 3.9 | sp | 4.7 | sp | 150,000 | 1 |
| *Sterna hirundo* | 2.2 | sp/su | 5.1 | su/au | 5.9 | su/au | 180,000 | 1 |
| *Gavia stellata* | 1.9 | wi | 9.5 | wi | 13.1 | wi | 75,000 | 1 |
| *Melanitta nigra* | 1.0 | wi | 8.4 | wi | 8.4 | wi | 1,600,000 | 1 |
| *Podiceps cristatus* | 2.5 | wi | 9.1 | wi/sp | 14.1 | wi/sp | 150,000 | 1 |
| *Stercorarius skua* | 1.6 | au | 7.4 | su/au | 10.7 | su/au | 27,200 | 1 |
| *Larus fuscus* | 3.5 | au | 12.9 | sp | 18.4 | sp | 450,000 | 1 |
| *Larus argentatus* | 1.4 | wi | 8.4 | wi | 12.2 | wi | 1,400,000 | 1 |
| *Larus marinus* | 1.2 | wi | 7.4 | au/wi | 13.2 | au/wi | 480,000 | 1 |
| *Uria aalge* | 0.7 | wi | 6.7 | wi | 12.2 | au | 1,990,000 | 2 |
| *Alca torda* | 0.8 | wi | 4.5 | wi | 9.1 | wi | 482,000 | 3 |
| *Larus canus* | 0.4 | wi | 3.8 | wi | 5.0 | wi | 1,600,000 | 1 |
| *Morus bassanus* | 0.4 | au | 2.2 | au | 3.0 | au | 892,000 | 1 |
| *Somateria mollissima* | 0.2 | wi | 3.5 | wi | 3.7 | wi | 2,850,000 | 1 |
| *Rissa tridactyla* | 0.1 | wi | 0.9 | wi/sp | 1.8 | au | 8,400,000 | 1 |
| *Larus ridibundus* | 0.1 | wi | 0.4 | au | 0.5 | au | 5,000,000 | 1 |
| *Melanitta fusca* | 0.1 | wi | 1.3 | wi | 1.3 | wi | 1,000,000 | 1 |
| *Fulmarus glacialis* | 0.0 | au | 1.1 | au | 2.3 | au | 10,000,000 | 1 |

Focal areas

The total area of hotspots for threatened seabird species in Belgian marine waters equals 24,700 ha of highest priority (calculated ornithological conservation value of >10) and 37,700 ha of high priority (values 7.5-10), all situated within 25 km from the shoreline (Fig. 14). For a bankstratum to be assigned this highest score, at least five of the focal species must occur at 75-100% of the maximal densities observed in Belgian marine waters. The high priority class includes areas where at least three focal species are found in high densities. In order to provide sufficient protection to the most vulnerable seabird species in Belgian marine waters, a substantial part of both types of areas should be designated as MPA. Depending on the specific conservation needs, fully protected MPA's can be installed ('special marine reserves') or only small restrictions ('closed areas', 'buffer zones') need to be endorsed. These protected areas can then function as part of an international network of protected areas all along the shallow continental coasts of the southern North Sea. At least part of the following three areas should be included (Fig. 17):

(1) The western Kustbanken (Nieuwpoort Bank, Trapegeer, Broersbank, Den Oever and Stroombank) have a high priority in winter and early spring. It is the major wintering site of scoters in Belgian marine waters, and large numbers of Great-crested Grebe and divers can be found here. In spring and summer the area is regularly visited by Sandwich Terns. Though this area is well-covered by the proposed Special Area of Conservation, it will depend largely on the management measures that will be taken, whether the installation of the protected area will be an empty box or a truly effective conservation tool. Because of the high diversity and abundance of focal species and the oil- and disturbance sensitivity of scoters, divers and grebes having their strongholds here, the conservation legislation towards birds should be enhanced. The Ramsar area should be extended to the full range of the SAC (Fig. 17), including the area deeper than –6 m MLLWS (in line with Article 2 of the Ramsar Convention), the SAC should be designated as a Special Protection Area under the EC-Birds Directive and specific measures should be taken to reduce disturbing and destructive activities.

(2) Conservation needs in the vicinity of the harbour of Zeebrugge clearly have two components: the need for save breeding grounds on land (this falls under Flemish jurisdiction), and the necessity to mitigate negative influences on the best feeding grounds at sea near the colonies (under federal Belgian jurisdiction). The immediate vicinity of the Zeebrugge outer harbour has a great value in spring and summer as feeding ground for three tern species. Very little of the nesting sites and of the present feeding areas of the terns are protected these days. All Sandwich Terns nesting in Belgium, more than 95% of all Common Terns and 60-100% of all Little Terns nest in the outer harbour of Zeebrugge, without any legal protection. As a result of the conditions stipulated in the environmental impact assessment study for the northwest part of the outer harbour, a new peninsula was created during the winter of 1999-2000 to compensate for the loss of nesting grounds there (Veen *et al*. 1997). This 'tern-peninsula' measures 5 ha and is situated within the eastern part of the outer harbour. During the first nesting season (2000), 50 pairs of Little Tern used this area, in 2001 numbers increased to 120 pairs (pers. comm. Filip De Ruwe). Even when populations might grow in the future and other species will possibly join the Little Terns here, it does not guarantee the sustainability of the tern colonies along the Belgian coast, since the peninsula has but the legal status of 'waterway'. This is not the case for the 'Baai van Heist' Flemish beach nature reserve, situated next to the eastern pier of the outer harbour. This beach habitat of approximately 52 ha was first closed off for the public in May 1998, leading to the settlement of 21 pairs of Little Tern. In 1999 the reserve accommodated 80 pairs, and no terns managed to nest here in 2000 (due to a storm) and 2001. The major feeding grounds of Little Tern situate at maximal distances of 3 km, those of Common Tern include the harbour and the nearest 5 km (observations Jan Seys, Jeroen Van Waeyenberge, Henk Offringa). A relatively small marine protected area bordering the 'Baai van Heist' nature reserve (situated within the 'Paardenmarkt' bank stratum) would benefit the foraging opportunities of the terns in Zeebrugge and protect the seaward site of the 'Baai van Heist' beach reserve (Fig. 17). The Wenduinebank and Vlakte van de Raan are suitable feeding grounds for terns in spring and summer and meanwhile hold important numbers of grebes and Little Gull in winter and spring/autumn respectively. Here only the most destructing activities on these birds during periods of maximal abundance are needed.

(3) An area of great importance throughout the year that is not legally protected so far is the Vlaamse Banken area (Smal Bank, Kwintebank, Middelkerke Bank, Buiten Ratel, Oost Dyck, Oostende Bank, Ravelingen and Breed Bank). The Smal Bank should be considered an invaluable conservation area, forming a bridge between the shallow western Kustbanken and the more offshore Vlaamse Banken, and having highest densities of Red-throated Diver. It is a sandbank with an interesting and diverse avifauna: Sandwich Terns use the area as feeding ground in spring and summer, Little Gulls are often observed in larger concentrations in autumn and spring (and smaller numbers in winter) and Common Guillemot, Razorbill and Great-crested Grebe are common here. In order to protect the specific seabird fauna of the Vlaamse Banken, at least the Smal Bank should be designated as a Special Protection Area under the EC-Birds Directive, and specific measures should be taken to reduce disturbing activities here. This sandbank area has priority since it is one of the richest seabird sites within the Vlaamse Banken complex, it borders the 'Trapegeer-Stroombank' Special Area of Conservation and it combines high densities of inshore (grebes), midshore (divers) as well as more offshore (auks) species (Fig. 17).

Although the more offshore sandbanks (Hinderbanken, Zeelandbanken) do have interesting seabird populations, their cumulative ornithological conservation value is lower than what is observed at the Westkustbanken, the Vlaamse Banken or in the neighbourhood of Zeebrugge. The need to take measures to reduce seabird disturbance in part of the Zeebrugge marine area (outside the harbour piers), the Westkustbanken and the Vlaamse Banken is largely in line with what has been suggested by OFFRINGA & MEIRE (1997). Due to increasing numbers of Common Tern and Little Tern the Zeebrugge area has become even more important. On the other hand, it must be mentioned that the value of the east coast as demonstrated by the maps with hotspots for threatened bird species, depends largely on the availability of nesting sites on land. Large suitable breeding grounds for the three focal tern species are only found at Zeebrugge. With feeding ranges restricted to a mere 3 km for Little Tern, 5 km for Common Tern and 20-30 km (and more) for Sandwich Tern, the overall 'value' of the sea areas around Zeebrugge is obviously biased. A study of the breeding biology of the terns at Zeebrugge indicates that there is ample of fish in the direct neigbourhood and that reproductive success is high (VAN WAEYENBERGE *et al*. 2000). However even better feeding grounds might be present more to the west, which can not be used by the nesting terns because of the long distance to the colonies. It can be concluded that the value of the inshore areas at the westcoast depends solely on the intrinsic characteristics of the marine habitat. By contrast the neighbourhood of the Zeebrugge harbour obtains its ornithological value largely by the presence of suitable breeding grounds. Therefore from an ornithological point of view, measures in the western marine waters should be taken both to protect habitats and species, whereas near the Zeebrugge harbour conservation of seabirds can better focus on more flexible measures meant primarily to protect the vulnerable seabird species.

## MAPPING AND MANAGEMENT

The collection of large amounts of standardized data on seabird distribution, the availability of estimates of population sizes and the increasing knowledge on their reaction to various impact factors make seabirds a rewarding object for weighing areas or periods to one another. The maps produced to indicate hotspots for focal species, as well as oil-vulnerable and disturbance-vulnerable sites give a comprehensive view of where attention should be focussed upon for various reasons. In a similar way SKOV *et al*. 1995 mapped the important seabird areas in the North Sea on the basis of 30 species which have a population of at least 1% of the species' biogeographic population during parts of the year. They calculated the total value of each geographical area for all those species as the sum of proportions of the total populations of the species occurring in internationally important concentrations within the area. Seabirds generally use much more extensive areas than coastal or terrestrial bird species. Hence, to preclude that almost any larger unit of area in the North Sea would meet the 1%-criterion at any one season, they included a reference area of 3000 km$^2$ (on the basis of average feeding radii of key species from colonies in the North Sea). We used this 'Marine Classification Criterion' to underpin the calculation of international importance on the entire Belgian marine waters, measuring 3500 km$^2$. To further differentiate within this area, we chose smaller sub-units and weighed them against the maximal overall observed densities.

The same technique can be applied to compare areas or periods in terms of vulnerability to various impact factors. CAMPHUYSEN & LEOPOLD (1998) and CAMPHUYSEN *et al.* (1999) identified the most vulnerable periods for boating disturbance, surface pollution with lipophilic substances and impact of flares on migrating species at potential gas-exploitation areas (900 and 405 km$^2$, respectively) off the north coast of The Netherlands. TASKER & PIENKOWSKI (1987) and CARTER *et al*. (1993) identified the most vulnerable seabird concentrations of the North Sea towards surface pollutants. DANIELSEN *et al*. (1986) mapped the conditions in the Danish sector of the North Sea and the Wadden Sea with reference to oil spill impact. In all these exercises the comparisons were based on values obtained by combining (relative) densities and specific impact factors. Depending on the aims of the study, one can choose to use actual densities or densities relative to the total population size or to the numbers in a smaller subarea. Usually either these figures or the vulnerability scores have to be transformed to similar ranges.

## MAJOR THREATS TO BELGIAN SEABIRDS AND MANAGEMENT IMPLICATIONS

### Oil pollution

The negative impact of oil-pollution on sea- and coastal birds is widely recognized (DUNNET *et al*. 1990, FURNESS 1993, TUCKER & EVANS 1997, CAMPHUYSEN & HEUBECK 2001). For the Belgian coast the lethal effects during winter, as demonstrated by beached bird surveying, have been elaborated by SEYS *et al*. (in prep.). Most beached bird survey programmes are confined to winter and it is generally assumed that the impact of oil on seabirds during summer is of less importance. However sublethal effects may have thorough effects on breeding birds, as demonstrated by a pair of breeding Common Terns at the Zeebrugge harbour in 1998 (observation J. Van Waeyenberge).

One parent bird stopped bringing food to its young during three days, while preening himself trying to get rid of the oil that smothered his plumage. The weight of the three young birds declined during this period and started to increase only after the adult bird resumed foraging three days later. The smallest young did not survive this short period of diminished food supply.

It is doubtful that local management measures – other than a strict control to discourage illegal oil discharges – are able to reduce the potential oil risks for seabirds in Belgium. Routing measures are considered to be effective tools to mitigate disturbance effects on wildlife or oil pollution risks. However imposing routing measures in order to reduce the risk of oil-pollution in the southernmost part of the North Sea can hardly be effective. Major shipping routes, that produce most of the oil-slicks and that cannot be rerouted, are very nearby. Oil-slicks travel downwind at 3-4% of the wind speed (CLARK 1992), often affecting areas much further away (CAMPHUYSEN *et al*. 1999). With an average daily wind speed of 20 km $h^{-1}$ during winter (October-March, 1992-1999, Belgian coast: KMI data) it takes at most 2.5 days for an onshore wind to blow the oil discharged in the main shipping routes to major scoter concentrations at the Westkustbanken. With stronger winds and for the Vlaamse Banken that are much closer to the shipping routes, the oil can easily be there in a matter of hours. Moreover the vast majority of illegal discharges of oil cannot be treated efficiently in any way. Provided an oil-slick is detected instantly it is virtually impossible to stop most oil from entering the important bird areas. Therefore all effort should go to aerial surveillance of the shipping routes near the most oil-sensitive seabird areas. By tuning a continuous seabird monitoring to the aerial surveillance programme (at least during winter and early spring), energy can be focussed on the most vulnerable seabird concentrations. When an important oil-slick is detected and wind conditions are not too unfavourable, the oil-combating scheme can use this information to prevent the substance to drift in the direction of major bird concentrations.

*Disturbance*

Disturbance is a major threat to nesting terns (ARTS 2000, ERWIN 1989, LLOYD *et al*. 1991). At sea however, terns, *Larus*-gulls, skuas and Northern Gannet are considered poorly sensitive to disturbance by traffic (ship, airplanes, helicopters)(TUCKER & EVANS 1997, CAMPHUYSEN *et al*. 1999). Some might even be attracted by ship activities. On the other hand, seaducks (KELLER 1991, MIKOLA *et al*. 1994) and divers are highly disturbance-sensitive. These species flush for approaching vessels at distances of 200->1000 m, with an average of 500-600 m (own data). Most scoters and divers stop all activity even earlier (>1 km distance), alert for any further approach of the vessel. During this period of alertness birds cannot forage and loose potential energy-uptake time. When taking off they have to spend additional energy in moving to more quiet places, where food-availability might be much less profitable. Although so far there are no scientific data on differences in disturbance by different types of traffic, it is assumed that fast-moving and noisy crafts (jet-ski, speedboats, large catamarans, formula-1 boats, helicopters) are more harmful than for example sailing boats. In The Netherlands, several examples of temporary or continuous disturbance of large flocks of scoters are documented (LEOPOLD *et al*. 1995a). Divers are winter residents from November to March in shallow coastal waters, with important concentrations in the proposed 'Trapegeer-Stroombank' Natura-2000 site and nearby waters (Smal- and Breed Bank, Middelkerke Bank, Buiten Ratel, Oost Dyck). Smaller concentrations occur on the Vlakte van de Raan and Wenduinebank at the east-coast, and more offshore (Bligh-Bank, Oosthinder,...). Common Scoters have traditional wintering grounds in the inshore shallows of the Trapegeer-area and in the Stroombank-Nieuwpoort Bank-Balandbank-Grote Rede area. Numbers build up slowly in the course of the winter and reach maxima in January-end March. Provided the policy in this area would be the best possible protection of these very vulnerable species, traffic of vessels, low-flying airplanes and helicopters should be restricted by routing measures to a minimum from November to end March in the protected shallow sandbank areas of the westcoast (Westkustbanken and Vlaamse Banken).

*Other activities*

Many other activities may have an impact on the distribution, behaviour or general welfare of seabirds in the Belgian marine waters. Most of these activities affect seabirds in an indirect way, through interactions with their major prey items (all activities destroying or declining shellfish stocks or affecting stocks of small pelagic fish), by changing hydrodynamic characteristics or turbidity of the ecosystem (dredging, sand- and gravel extraction, coastal defence, land reclamation), etc… Some may have a more direct impact on sea- and coastal birds, such as the obvious disturbance created by military activities at Lombardsijde (immediately west of Nieuwpoort). Although the noise made during the exercises has only a local impact, this issue will have to be dealt with when installing a marine protected area in front of the military camp. Own observations demonstrate that all birds (including gulls) in the area fly off when shooting starts and that apparently no habituation takes place. Major problems arise in the period November-end March when large flocks of scoters occur in the area.

Marine birds and mammals may entangle in fishing gear, ropes and plastics. During 1979-89 0.2% of all birds found dead on Dutch beaches got entangled. Northern Gannet (5.4%), Cormorants (2.6%) and Great Black-backed Gull (1.3%) were most affected as victims of entanglement (CAMPHUYSEN 1990). At the Belgian coast entanglement is widespread in Northern Gannet (11.6%) and less frequently observed in divers, grebes, gulls and auks (0.1-2.0%)(SEYS *et al*. in press). Drowning of diving species in monofilament nylon gill nets (drift nets or fixed short nets) may have a dramatic impact on seabirds (and marine mammals) in the North Sea (OLDÉN *et al*. 1986, BOURNE 1989, STRANN *et al*. 1991). Auks are most common as bycatch in fisheries around Iceland (PETERSEN 1994), with records of up to 10,000 auks drowned in cod nets. Auk mortality in fishing gear is of great and perhaps increasing significance, not only in the arctic but also in more temperate waters (MEAD 1993). In northern France gill-nets are widely used and auks are found dead in those nets in substantial numbers during winter (pers. comm.). The extent of the impact of gill nets on seabirds and marine mammals in Belgian waters is poorly documented and should be investigated in more detail in the near future. A further increase in the use of fixed nets in Belgian marine waters is considered incompatible with the protection of vulnerable, diving seabird species such as scoters, grebes, divers, auks and Northern Gannet and coastal marine marmmals.

## THE SOUTHERNMOST PART OF THE NORTH SEA AS A CORRIDOR FOR SEABIRD MIGRATION

We calculated that during winter more than 100,000 seabirds might reside in Belgian marine waters (this study) out of 180,000 in the southernmost part of the North Sea (between 51-52°N)(OFFRINGA *et al.* 1996). This figure is undoubtedly an overestimate since the calculation is based on maximum numbers observed at different months and over more than six years of intensive surveying. Probably maxima in Belgian waters during winter rarely exceed the 50,000. Actual numbers staying at one particular moment cannot be given due to the lack of systematic counts covering the entire study-area in a very short period. The residence time of seabirds is unknown and may vary from several months or years (Herring Gull) to just one hour, i.e. approximately the time to hurry across the area. Moreover many seabirds may pass by during nighttime and stay undetected. A rough estimate of 1-1.3 million seabirds involved in major migratory movements through the bottleneck of the Channel indicates the importance of the area as a corridor for seabird migration. In this context there is a major concern towards plans to develop offshore wind farms in this peculiar area. Wind turbines can have a direct impact when seabirds collide with them, in a more indirect way seabirds might avoid areas where clusters of windmills are located, creating vast areas unsuitable for seabirds (ORLOFF *et al*. 1992, MUSTERS *et al*. 1996, SGS ENVIRONMENT 1996, TUCKER 1996, KETZENBERG & EXO 1997, TULP *et al*. 1999, KRUCKENBERG & JAENE 1999). The most alarming point today is the lack of information on the impact of wind turbines at sea. Very little is known about the nocturnal and concentrated migration of birds in the coastal zone and on how seabirds will react on the installation of new and moving structures in the open sea habitat. Although it is widely accepted that the issue of potential bird collisions and avoidance behaviour should be taken seriously, administrations and project developers often resort to the (most positive) results of terrestrial impact studies to underpin their offshore plans.

There is a need to develop an international network of designated areas important for marine wildlife. In order to safeguard seabird populations this can be achieved by protecting the most important breeding sites on land and by introducing an international network of in- and offshore marine Special Areas of Conservation and Special Protection Areas as required by the EC-Habitats and Birds Directives. At present all the countries in the Northeast Atlantic Marine Region have established some form of marine protected areas. The North Sea and Atlantic coasts of Denmark, Germany, The Netherlands, Belgium, France, Spain, Portugal and Great Britain have about 15 MPA's with an important sublitoral component and half of these areas were designated as MPA's because of important seabird breeding colonies. However the criteria used to select suitable sites, and the degree of protection that is given to the marine wildlife and habitats within these MPA's varies from country to country (GUBBAY 2001). There are examples of Biogenetic Reserves (as part of the Council of Europe's programme for a network of such sites) and Ramsar sites with a marine component in various countries. All countries with the exception of Belgium and Portugal have Special Protection Areas (under the EC-Birds Directive) including a marine component. And the designation of several new MPA's under the Natura 2000 network of the EC-Habitats Directive is still in preparation.

In addition corridors for major migratory movements should be safeguarded from developments threatening the transit of birds (and other organisms such as fish, marine mammals, etc...). At a national level various legal instruments may be developed or applied to achieve this goal. Despite the importance of the seas for birds and other wildlife, conservation of the marine environment lags far behind conservation on land. Though various seabird species are highly dispersive during the non-breeding season and hence probably cannot be protected by setting up such a network, for other species and for particular hotspots it will definitely improve their protection. In such a network, the linear sand ridge complexes off the Belgian (and the Dutch and northern French) coasts deserve special attention (GUBBAY 2001).

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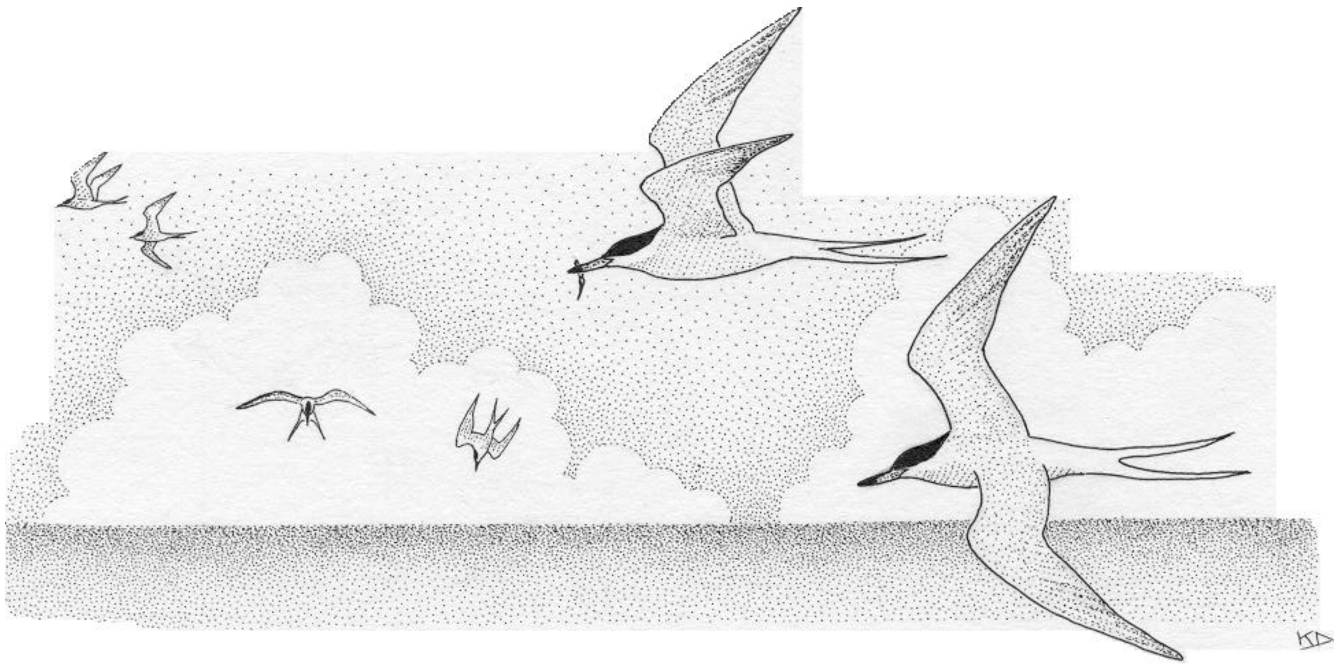
# CHAPTER FOUR

## MONITORING SEABIRDS ON FIXED FERRY ROUTES: A METHODOLOGICAL EVALUATION



*based on the manuscript submitted to:*

***Environmental Monitoring and Assessment***

*Jan Seys[1*], Steven Vantieghem[2], Henk Offringa[3], Patrick Meire[2] & Eckhart Kuijken[1]*

[1] *Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
[2] *University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
[3] *Ministry of Transport, Public Works and Water Management, Directorate General of Public Works and Water Management, North Sea Directorate, P.O.Box 5807, 2280 HV Rijswijk, The Netherlands*
[*] present address*: Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

# Monitoring seabirds on fixed ferry-routes: an evaluation

J. Seys, S. Vantieghem, H. Offringa, P. Meire & E. Kuijken

## ABSTRACT

An analysis of 71 ship-based seabird surveys on fixed ferry routes in the southernmost part of the North Sea revealed that parameters indicating the periodicity of counts (year, season, month) were more influential than those caused by unwanted side-effects (route, observer, wind). With the GLIM tool, we formed minimal adequate log-linear models of the densities of thirteen abundant species/taxa and quantified the impact of route, observer and wind. It was found that a relatively small shift in route (c. 15 km) resulted in significant differences in densities in half of the species. The difference could be as high as a factor 2.4-14.3 times more. Observer effects were considerable in auks (differences in densities of 1.5-3.2x), and really far out for several gull species. These differences might have been caused by slight changes in methodology and demonstrate clearly that interobserver differences need more attention. Finally the wind force affected the observed densities of Kittiwake and Common Gull in such a way that it is recommendable to avoid surveying at strong winds when surveys are part of a long-term monitoring programme. It is concluded that seabird counts on fixed ferry routes are a useful tool to monitor long-term changes in seabird abundance, provided the counting methods are further standardized and the analysis takes the most relevant side-effects into account (e.g. with GLIM).

## INTRODUCTION

Our knowledge of the distribution of seabirds in the North Sea has greatly enhanced since the development of standard surveying methods in the mid-1980s (Tasker *et al.* 1984). Since then, several countries have endeavoured in surveying and producing atlases of the region (Baptist & Wolf 1993, Carter *et al*. 1993, Camphuysen & Leopold 1994, Camphuysen *et al*. 1995, Skov *et al*. 1995, Stone *et al*. 1995, Offringa *et al*. 1996), presenting maps of the distribution at a given moment. In a next step researchers and managers were interested in evaluating the temporal changes in these distribution patterns by setting up a monitoring programme. For this purpose the effort had to be continued and counts had to cover the same area at time intervals in a well-standardized way, an objective that often conflicted with the high costs of shipping time and hence lead to the impracticability of repeated counts.

An alternative could be to count seabirds on fixed ferry routes. The major advantages of this method, i.e. travelling at relatively low cost, at fixed time schedules and always with the same type of vessel, are clear. Moreover it is assumed – though never tested – that ferry surveys are an unbiased and reliable method to monitor temporal changes in seabird abundance. To test whether this is true we made an analysis of standardized seabird counts during ferry transits from the Belgian harbour of Oostende to Dover or Ramsgate (U.K.), carried out by a small group of trained observers in the period 1992–1998. In this paper we focus on the impact of the route (three slightly different routes were used), month, season, year, observer and wind speed on the observed densities of the most abundant seabirds. Our null hypothesis is that route, observer and wind conditions have no effect on the observed numbers of seabirds and that monthly counts are needed to monitor the temporal changes in abundance.

## MATERIAL AND METHODS

### FERRY SEABIRD COUNTS

The study-area is situated in the southernmost part of the North Sea, an area with an interesting variety of sandbanks and swales. Positioned in between the estuarine plume of the Schelde estuary and the Straits of Dover (Offringa *et al*. 1996), it has a rich seabird fauna and an important corridor function for migrating (sea)birds (Seys *et al*. submitted). Seabird surveying has been intensified in this part of the North Sea from September 1992 onwards, when the Institute of Nature Conservation launched a monitoring programme here. In addition to efforts to map the region for seabirds, ferry-based counts were organised on a monthly base in order to monitor the temporal changes.

From September 1992 till December 1998, seabirds were counted on board four ferries using a standard strip 300m transect method, with snapshot count for flying birds (Tasker *et al*., 1984). In order to compensate for missed small and dark birds, the mean density of swimming birds was multiplied with a correction factor (Stone *et al*., 1995). During the study-period we sailed with two companies both leaving in Oostende early in the morning, and reaching Dover or

Ramsgate - situated at 115-120 km distance - within 3-3.5 hours. For further analysis we retained 71 trips that took place under conditions of good visibility and that covered sufficient distance in the various subareas (Belgian and French coastal areas, deep water channel, British coast). To test whether there was a statistical difference between the outward journey and the return trip, 35 day-trips were selected at which seabirds were counted during the outward journey and the return trip on the same route. The average density (N $km^{-2}$) of the thirteen most abundant seabird taxa/species (divers, Fulmar *Fulmarus glacialis*, Northern Gannet *Morus bassanus*, skuas Stercorarius *sp*., Little Gull *Larus minutus*, Black-headed Gull *L.ridibundus*, Common Gull *L.canus*, Lesser Black-backed Gull *L.fuscus*, Herring Gull *L.argentatus*, Great Black-backed Gull *L.marinus*, Kittiwake *Rissa tridactyla*, Sandwich Tern *Sterna sandvicensis*, auks i.e. Common Guillemot *Uria aalge* and Razorbill *Alca torda*) were calculated for each single journey and log-transformed. The difference between the densities during the outward journey and the return trip was tested with a Hotelling $T^2$ multivariate test for differences in means between two groups (STATSOFT 1995).

## STATISTICAL MODEL

*Covariates*

In a second step we analysed the impact of the route (ROUTE), the primary observer (OBS), the wind speed (WIND), the month (MONTH), the season (SEAS) and the year (YEAR) on the observed seabird densities (Table 1). Since the four ferries had a comparable size, speed (15-20 knots) and elevation (c. 20 m) of the observer platform, 'base-type' was not tested as a potential influencing factor. Wind force and wave height were scored on board (meteo-information). An explanatory data analysis revealed that the wave height had less influence than the closely linked factor WIND. As such wave height was dropped fur further analysis. The same applied to the 'number of observers'. In only 10% of the counts a second observer assisted. The four primary observers (OBS), i.e. those who made the majority of the bird observations and were best trained, carried out fieldwork in well-defined periods (Table 1). Three major routes (ROUTE) could be distinguished. In 1992-93 the ferries sailed to Dover, but from 1994 onwards Ramsgate was the harbour of destination. With strong winds (>6 Bf) the southern route to Ramsgate was preferred (Fig.1).

To test at which temporal scale the variability was most important, we included month (MONTH), season (SEAS) and year (YEAR) in our analysis. Clusters of 2-3 months that reflect distinct periods of bird occurrence and migration were formed and referred to as 'season' (SEAS). YEAR was defined as the period Nov-Oct and the study-period was truncated to the ferry-trips carried out between November 1992 and end October 1998, to avoid that differences in effort and an artificial division of the winter period would create misleading results.

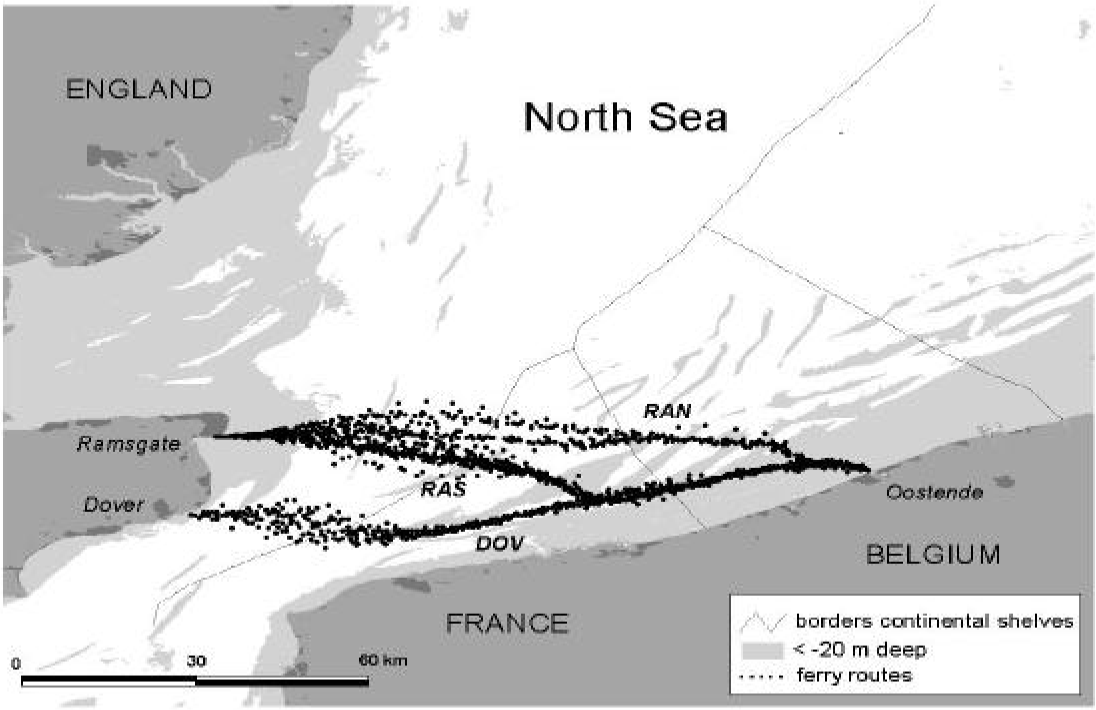



*Fig. 1. The three routes followed by ferries during ship-based seabird surveys between Oostende and Dover/Ramsgate in 1992-98 (DOV=Dover route, RAN=northern route to Ramsgate, RAS=southern route to Ramsgate).*

*Table 1. Summary of the covariates whose impact on the results of seabird surveys on board ferry trips from Belgium to SE-England in 1992-98, we tested.*

| Factor/variable | Code | Categories |
|---|---|---|
| Route | ROUTE | ***DOV*** (Dover), ***RAS*** (Ramsgate south), ***RAN*** (Ramsgate north) |
| Primary observer | OBS | ***A*** (1992-Oct '93; Feb-Dec '98), ***B*** (Nov '93 – Apr '94), ***C*** (Oct '94 – Jul '97), ***D*** (Sep '97 – Jan '98) |
| Wind speed | WIND | ***L*** (0-2 Bf), ***M*** (3-5 Bf), ***H*** (6-9 Bf) |
| Month | MONTH | ***1-12*** (Jan-Dec) |
| Season | SEAS | ***JM*** (Jan-Mar), ***AM*** (Apr-May), ***JJ*** (Jun-Jul), ***AO*** (Aug-Oct), ***ND*** (Nov-Dec) |
| Year (factor) | YEAR | ***1993*** (Nov '92 – Oct '93), etc***. – '98*** |

*GLIM*

The impact of the different parameters was ascertained with Generalized Linear Models (GLIM), using the software package R. GLIM is a development of linear models to accommodate both non-normal response distributions and transformations to linearity in a clean and straightforward way (McCullagh & Nelder 1989). An error function following a Poisson-like distribution has been assumed for our count data. In this case the dispersion of the data is equal to some unknown constant, the so-called dispersion factor, multiplied by the dispersion predicted by the Poisson model. For each species/taxon we developed a log-linear model, relating the density at a certain trip to the effects of ROUTE, OBS, WIND, YEAR, SEAS and MONTH. Interaction effects were not included, since that would have resulted in too many empty cells. This leads to the log-linear model:

$$\log(\mu_{ijklmn}) = \text{cte} + a_i + ß_j + ?_k + d_l + e_m + ?_n$$

with $\mu$ the expected density of the species/taxon at ROUTE *i*, with OBS *j*, WIND *k*, in YEAR *l*, SEAS *m* and MONTH *n*; a constant term or intercept (cte) and $a_i$, $ß_j$, $?_k$, $d_l$, $e_m$, $?_n$ the main effects of ROUTE *i*, OBS *j*, WIND *k*, YEAR *l*, SEAS *m* and MONTH *n*, respectively. Parameter estimates were computed using the quasi-likelihood model as provided by the R-program. The data were not transformed since the regression is transformed through the link function ($?=\log \mu$). To establish a satisfactorily minimal adequate model, we used a forward step-wise selection procedure, starting with the null model (consigning all the variation in ys to the random component) and then proceeding by adding the most significant terms one by one. To find out whether model B was a significant improvement of model A we tested the difference in scaled deviance (i.e. the residual deviance divided by the dispersion factor) with a $?^2$ test at a $p$=0.05 level of significance. This difference has approximately a $?_t{}^2$ distribution, with $t$ being the difference in degrees of freedom of both models. The model selection procedure was stopped as soon as no significant results could be obtained anymore. Provided two parameters had the same significance, the one with the highest mean deviance (deviance divided by the degrees of freedom) was selected. The expected difference in density with various OBS, ROUTE or WIND is calculated with:

$$\mu^{(a)} = \mu^{(b)} * \exp(?_a - ?_b)$$

with:

$^{(a)}$ e.g. ROUTE 1 and $^{(b)}$ ROUTE 2
$?_a$= model estimate of $^{(a)}$, $?_b$= model estimate of $^{(b)}$

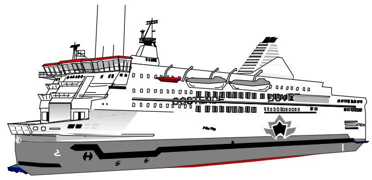
## RESULTS

### A GENERALIZED LINEAR MODEL

A Hotelling $T^2$ multivariate test revealed no significant difference between the densities of the thirteen most abundant seabird species/taxa during the outward and the return part of 35 'complete' ferry-trips ($T^2$ : 18.19, $F_{13,56}$: 1.15, $P$ < 0.338). The forward selection process of parameters for our log-linear models, results in a ranking of the impact of the factors ROUTE, OBS, WIND, YEAR, SEAS and MONTH on the observed seabird densities (Table 2). It follows that parameters indicating the periodicity of counts are more influential than those caused by unwanted side-effects (route, observer, wind). Not surprisingly the densities of all species/taxa are related to the season or month of surveying, whereas only half of the values appear to be affected by the year of the counts. Our null hypothesis that ROUTE, WIND and OBS have no impact on the observed densities applies to merely five out of thirteen species/taxa. Significantly higher densities of Northern Gannet were observed at RAS, more Lesser Black-backed Gull at RAN and significantly less auks at RAN and RAS. More Common Gulls were counted at wind speeds of less than 5 Bf, and most Kittiwakes between 3-5 Bf. There is an observer effect in three gull species and in auks. Observer A counted significantly more Lesser Black-backed Gull and less auks than the others, while observer B saw less Common Gull than the three other primary observers. The four observers detected significantly different numbers of Great Black-backed Gull.

*Table 2. Ranking (1-5) of the impact of the parameters **Y**(ear), **S**(eason), **M**(onth), **R**(oute), **O**(bserver) and **W**(ind) that were considered for a log-linear model of seabird densities observed during ferry counts. For each parameter, values are presented in ascending order. Clusters of values significantly different from the rest are followed/preceded by < or >. Individual values significantly deviating are underlined.*

| Species/taxon | *1* | | *2* | | *3* | | *4* | | *5* | |
|---|---|---|---|---|---|---|---|---|---|---|
| divers | **Y** | *94,93,97,98<96,95* | **M** | *6,9,5,7,8<4,10,3,11,1,2,12* | | | | | | |
| Fulmar | **Y** | *93,96,94,98,95,97* | **S** | *ND,AO,JM,JJ<AM* | | | | | | |
| Northern Gannet | **S** | *AM,JJ,JM<AO,ND* | **R** | *DOV,RAN<RAS* | | | | | | |
| skuas | **S** | *JM,JJ,AM,ND,AO* | | | | | | | | |
| Little Gull | **M** | *6<5,7,1,12,11,8,2,10,4,9,3* | **R** | *RAN,DOV,RAS* | | | | | | |
| Black-headed Gull | **M** | *4,5,12,9,11,1,10,8,7,6,3,2* | **Y** | *97<93,94,95,96,98* | | | | | | |
| Common Gull | **R** | *RAN,DOV,RAS* | **S** | *AO,JJ,AM<ND,JM* | **W** | *H<M<L* | **O** | *D,B,A,C* | **Y** | *97,95,93,96,94,98* |
| Lesser Black-backed Gull | **R** | *DOV<RAS<RAN* | **M** | *8<2,1,11,12,7,5,3,9,10,6,4* | **O** | *B,D,C<A* | | | | |
| Herring Gull | **Y** | *98,97<93,94,95,96* | **R** | *RAS,DOV,RAN* | **S** | *ND,AO,AM,JM,JJ* | | | | |
| Great Black-backed Gull | **M** | *6,4,7,5,3,8,9,2,1,10,12* | **O** | *JW<JS<HO<WB* | | | | | | |
| Kittiwake | **S** | *AM,JJ,AO,ND,JM* | **W** | *M,L,H* | | | | | | |
| Sandwich Tern | **M** | *2,10,11,12,1,8,3,9,6,7,5,4* | **Y** | *95<94,93,96,97,98* | | | | | | |
| auks | **S** | *JJ,AM,AO,ND,JM* | **M** | *8,9,3,11,6,1,2,4* | **R** | *RAN,RAS<DOV* | **O** | *A<B,C,D* | | |



From the general formula, we can derive the model for each individual species/taxon. As an example, densities of auks can be calculated with:

$$\log(\mu_{ijkl}) = \text{intercept} + a_i + ß_j + ?_k + d_l$$

With: $i$ = AM...ND ($a_1$ = AM)
$j$ = 1,2... 12 ($ß_1$ = 1)
$k$ = DOV...RAS ($?_1$ = DOV)
$l$ = 1...4 ($d_1$ = 3)

*Hence*:

log ($\mu$ $_{auks}$)= -4.17 + (3.77)* d(SEAS=*AM*) + (-6.14)* d(SEAS=*AO*) + (5.78)* d(SEAS=*JM*) + (4.61)* d(SEAS=*ND*) +(0.38)* d(MONTH=2) +(-1.19)* d(MONTH=3) +(2.28)* d(MONTH=4) +(-0.28)* d(MONTH=6) +(-0.28)* d(MONTH=8) +(-9.55)* d(MONTH=9) +(-0.46)* d(MONTH=11) +(-1.43)* d(ROUTE=RAN) +(-0.72)* d(ROUTE=RAS) +(-0.91)* d(OBS=1) +(-0.14)* d(OBS=2) +(0.26)* d(OBS=4)

[with: d=0 if false; d=1 if true]

ROUTE EFFECTS

The impact of the OBS, ROUTE and WIND effect on the observed densities of seabirds is substantial. Densities of Northern Gannet observed at the 'best' ROUTE (RAS) were 2.4 times higher than on the ROUTE with lowest densities (DOV). Common Gull was 2.5 times less common at RAN compared to RAS and auks performed 4.2 times better at DOV than at RAN (Fig. 2). Some other gulls showed even larger differences between the best and the worst ROUTE: Little Gull (DOV-RAN: 6.8x), Herring Gull (RAN-RAS: 10.3x) and Lesser Black-backed Gull (RAN-DOV: 14.3x).

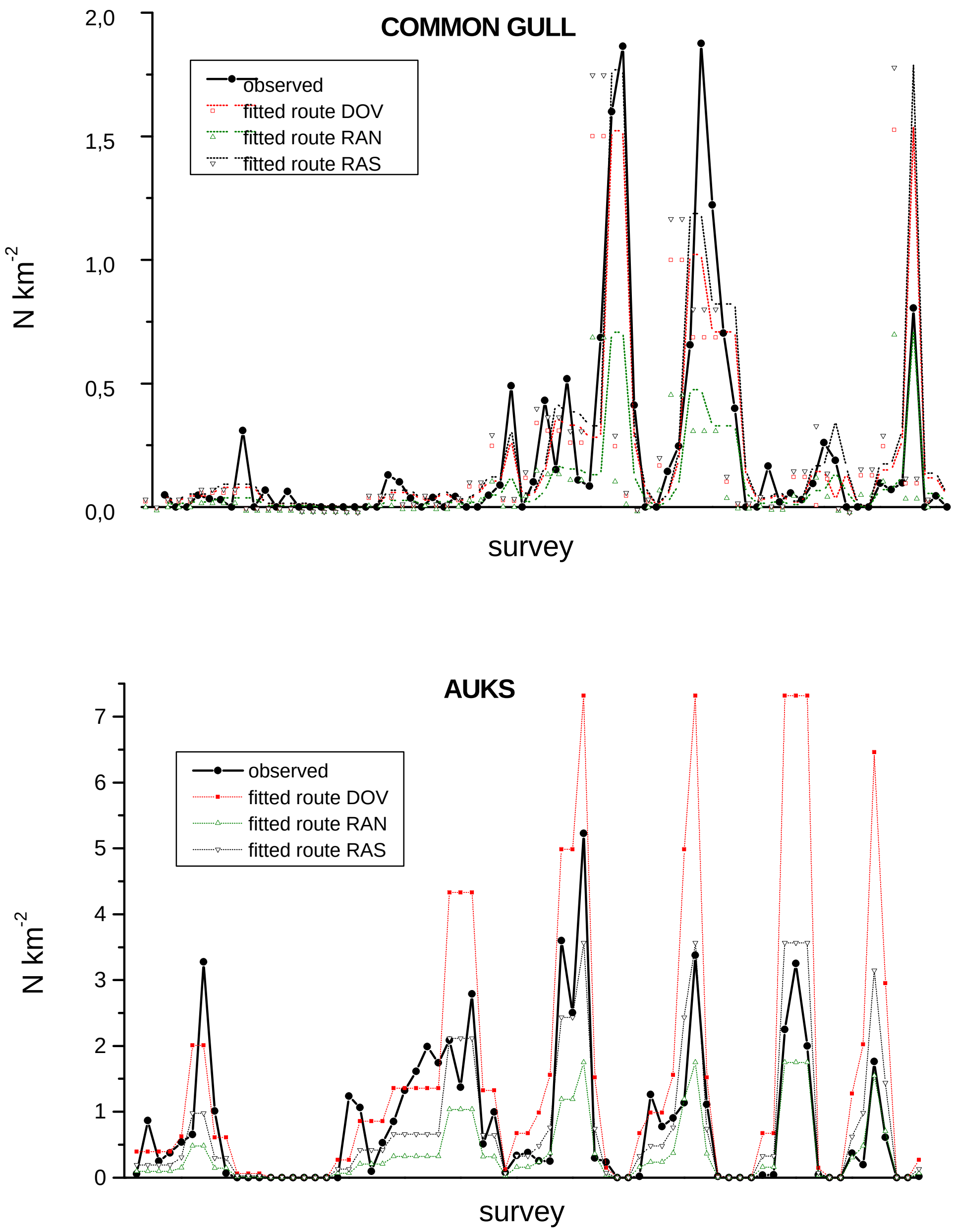
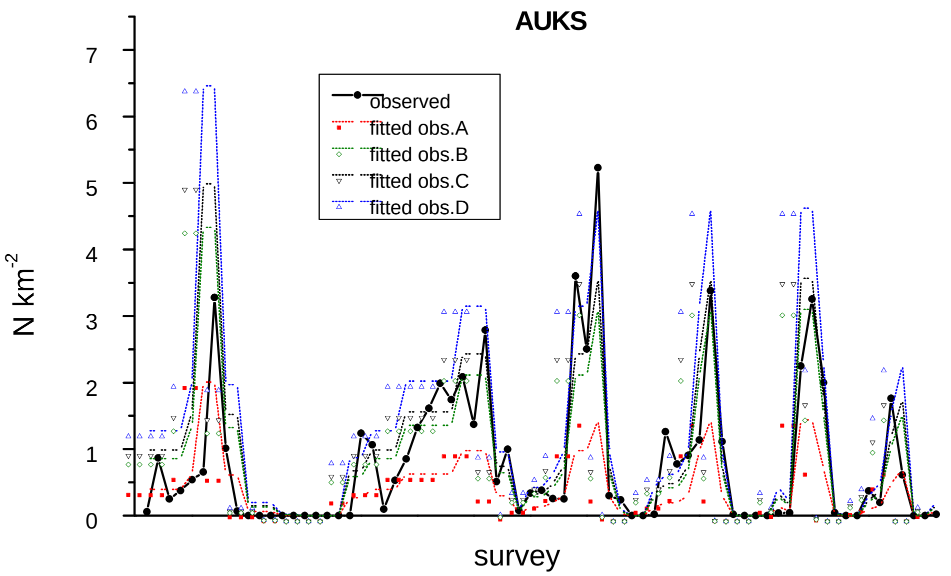



*Fig. 2. Observed and fitted densities of Common Gull and auks at 71 ferry surveys, as found on three slightly different routes (ROUTE): DOV, RAN and RAS (see Fig. 1).*

OBSERVER EFFECTS

The observer effect was relatively small in auks (maximal difference of 1.5x between B-D), except for substantial smaller densities indicated by the model for surveyor 'A' (A-D: 3.2x less)(Fig. 3a). For some scavenging gull species, known to flock around fishing vessels, the differences were really far out. Fitted values for Lesser Black-backed Gull, Great Black-backed Gull and Common Gull (Fig. 3b) maximally deviated with as much as 8.3x (A-B), 26.5x (B-D) and 116.9x (D-C) respectively. In reality the observed maximal densities for these species differed with a factor of 13.3x (A-B), 27.6x (B-D), 19.1x (C-D) respectively.



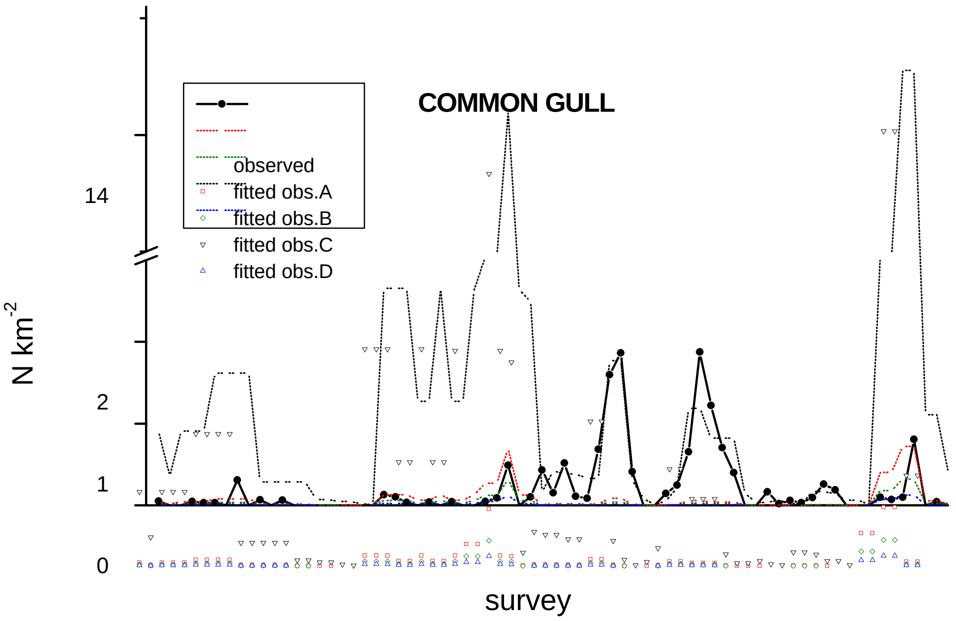




*Fig. 3. Observed and fitted densities of (a) Common Gull and (b) auks at 71 ferry surveys, as found for four different observers (OBS).*

WIND EFFECT

For two out of thirteen seabird species/taxa, we found wind force to be an important factor influencing the observed densities at sea. The model indicates that Kittiwake is most abundant at high wind speed (H: >5 Bf), shows intermediate values at low wind speed (L: 0-2 Bf) and lowest densities in between (M: 3-5 Bf). Densities of Kittiwake observed at H were 2.3 times higher than at M. Common Gull became less and less abundant as wind speed increased: the fitted densities at H were 5.4 times smaller than at L (Fig. 4).

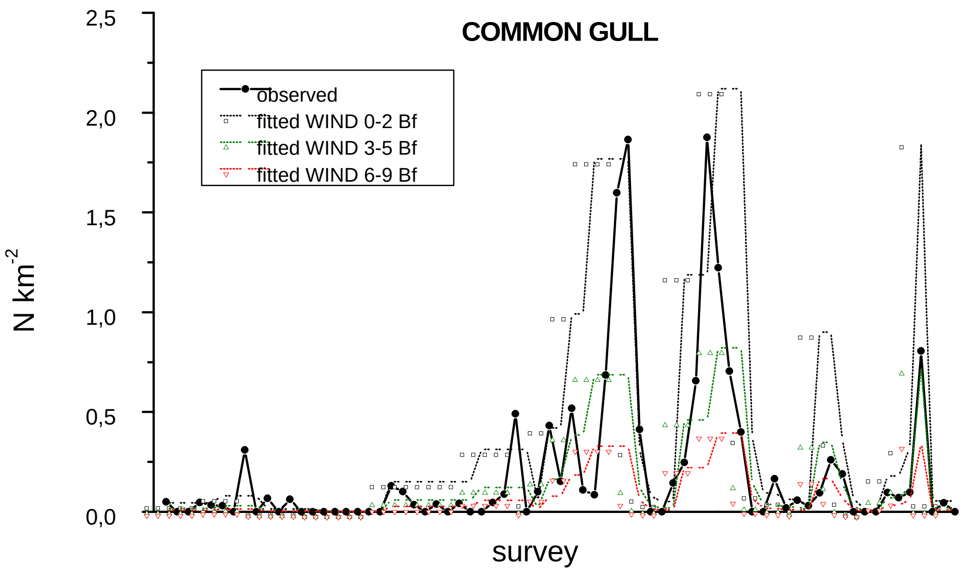



*Fig. 4. Observed and fitted densities of Common Gull at 71 ferry surveys, as found for three classes of wind force: L(ow)=0-2 Bf, M(edium)=3-5 Bf, H(igh)=6-9 Bf (WIND).*

## DISCUSSION

The second part of our null hypothesis, stating that monthly counts are needed to monitor long-term changes in abundance, can be accepted. The densities of the thirteen most abundant seabird species/taxa in our study-area are all highly influenced by the season or month of surveying. In half of the species, 'MONTH' contributed significantly to the minimum adequate model. Consequently a monitoring schedule should try to cover all months. When this is not possible, it is important to keep on surveying in the same months, in order to get comparable data. As a remark we should add that in case one is not only interested in obtaining data on long-term changes in seabirds in an area, but rather wants to follow up short-term fluctuations, it is clear that monthly counts are not sufficient. Seabirds are highly mobile and dispersive and concentrations are often short-lived (CAMPHUYSEN & WEBB 1999). On the other hand, we could illustrate that the overall densities of the most abundant species did not change significantly between the outward and return journey of the ferry. The return journey can thus better be used to concentrate on behavioural aspects or on certain seabird taxa that are thought to be underestimated with the standard count methods (divers, scoters).

Although the parameters indicating the periodicity of the counts (YEAR, SEAS, MONTH) appeared to be of more influence on the densities than those representing certain unwanted side-effects (ROUTE, WIND, OBS), the latter can not be overlooked. Our model suggests that ROUTE affects the observed densities of six taxa, OBS those of four and WIND the densities of two seabird species/taxa. WIND effects were found in Kittiwake and Common Gull and were consistent with known behavioural responses to weather conditions. The Kittiwake is a highly dispersive, pelagic species that can occur in large numbers, particularly during strong winds (GLUTZ VON BLOTZHEIM & BAUER 1980). Common Gull is equally adapted to exposed marine coasts and to inland situations (CRAMP & SIMMONS 1983) and typically seek shelter inland as wind force increases.

That ROUTE had an important impact on the observed densities of half of the species/taxa is not a complete surprise. Although the three routes were close to each other (at most c. 15 km in between), the ferries travelled through an area with plenty of linear sand ridges, each with their own strike, sediment characteristics and current regimes (EISMA *et al*. 1979). The Dover route runs parallel to the Belgian and French coast at a distance of less than 10 km for over 90 km, before crossing the Straits of Dover. By contrast the routes to Ramsgate have a higher share of deep water and enter a shallow zone just east of the harbour of Ramsgate (Fig. 1). As a consequence densities of seabirds show significant deviations with ROUTE (OFFRINGA *et al*., 1996; SEYS *et al*., this volume).

The observer effects we found in three gull species and in auks, are an illustration of an aspect that deserves attention. So far there have been very few investigations on interobserver differences in bird censuses. SAUER *et al*. (1994) found large observer differences in breeding bird surveys and VAN DER MEER &

CAMPHUYSEN (1996) detected considerable observer effects during ship-based seabird surveys. The latter analysed data from four ship-based strip transect surveys, in which six observer teams from several countries cooperated. They found the observed densities of six common seabird species to vary between teams of surveyors by a factor 2.5 (Common Guillemot) to 11 (Razorbill). Although the teams did not work in exactly the same areas at the same time, the effects of area and sea state were filtered by using a log-linear model and are therefore supposed not to have altered the final outcome of the analysis. In our study the interobserver differences in auks (maximal deviations of 3.2 times more for observer D versus A) were comparable with those mentioned above, and substantially higher for the gull species. Although the four primary observers have been operating during different years and partly on other routes, it is plausible to think of real interobserver differences due to slight variations in the interpretation of the methods. A closer look at the data revealed that one observer who contributed largely to the observed differences, always recorded more gull flocks per ferry trip as well as largest group sizes within transect for all gull species. It would be hardly surprising that observers show differences in the ability to estimate the large multi-species flocks of gulls, particularly during ship-based surveys on board fast-sailing ferries (15-20 knots). Slight differences in counting skills, detection ability, interpretation of the transect width, etc. may result in large differences in density estimates. These and the foregoing results indicate that ship-based survey data need to be used with caution and that it makes sense to further standardize and harmonize the practice of seabird surveying at sea. From a viewpoint of long-term seabird monitoring, ferry counts may provide invaluable data when analysed with techniques – such as log-linear models – that can take into account small changes in route, observer or weather conditions (see also TER BRAAK *et al*. 1992, VAN DER MEER *et al*. 1995). As far as possible trips should be organised at regular (monthly) intervals on fixed routes, during normal weather conditions and by a small, well-trained team of observers.

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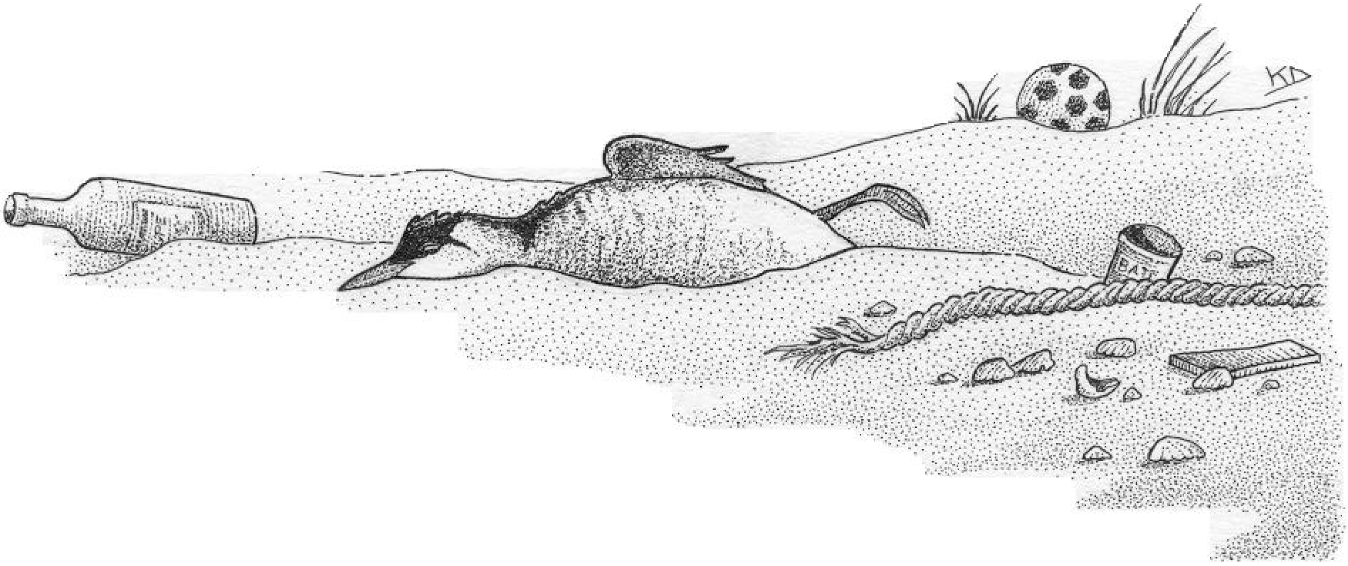
# CHAPTER FIVE

## NUMBERS OF BEACHED BIRD CORPSES AND MORTALITY OF SEABIRDS, HOW DO THEY RELATE: A NORTH SEA STUDY IN A WIDER CONTEXT




*based on the manuscript submitted to:*

***Atlantic Seabirds***

*Jan Seys[1*], Henk Offringa[2], Jeroen Van Waeyenberge[1], Patrick Meire[3] & Eckhart Kuijken[1]*

*[1] Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
*[2] Ministry of Transport, Public Works and Water Management, Directorate General of Public Works and Water Management, North Sea Directorate, P.O.Box 5807, 2280 HV Rijswijk, The Netherlands*
*[3]University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
[*] present adress: *Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

# Numbers of beached bird corpses and mortality of seabirds, how do they relate: a North Sea study in a wider context

J. Seys, H. Offringa, J. Van Waeyenberge, P. Meire & E. Kuijken

## ABSTRACT

This paper summarizes the results of several experiments with bird corpses in the southernmost part of the North Sea and tries to fit this information in the current knowledge of how mortality at sea relates to densities of beached birds on the shoreline. During thirteen drift experiments off the Belgian coast between February 1996 and March 1999, a total of 634 sea- and coastal tagged bird corpses were dropped at sea. Bird corpses were found to drift by the wind at 2.2-3.1% of its own velocity, a value in line with earlier published reports of 2.2-4%. Recovery rates averaged 12%, which is smaller than an overall mean of 22% for thirty published drift experiments worldwide but conform an older 'standard' to multiply the number of birds found dead on the beach with ten to arrive at an estimate of total mortality. Despite many complicating factors and a large variability (recovery rates ranging from 0 to 75%) some general patterns appear, useful for the interpretation of beached bird numbers in the Southern North Sea. Recovery rates depend primarily on the dropping location (distance to the coast) and on the size of the bird. An evaluation of bird strandings during 1992-99 at the Belgian coast demonstrates a significant correlation with the cumulative onshore wind speeds of the ten days prior to the survey. Offshore species are much more dependent on enough onshore winds to strand and are found more evenly distributed on the shoreline. Temporal patterns of beached birds usually follow those of seabirds at sea with a time-lag of at least one month. Persistence experiments during three winters with 562 tagged corpses confirm the picture of short residence times in the Southern North Sea. A mean persistence time of merely 5.8-13.3 days and the fact that 50-80% of all birds cannot be recovered anymore after 9 days, indicate how strongly persistence must affect the results of beached bird surveys and drift experiments. Small-sized corpses have persistence times of only 0.7 days, medium-sized birds 5.5 days and large birds persist on average 13 days. Heavily oiled birds are more persistent than other corpses. This and other complicating factors are further discussed in the context of the interpretation of beached bird numbers. We conclude that: (1) beached numbers can be useful and indicate interesting patterns if interpreted with care and in an international context; (2) there is a need for more drift-, persistence- and floating experiments in order to fully understand what a bird corpse does from the moment it dies until it is being found on the beach; (3) special attention should go to differences in 'behaviour' of oiled versus unoiled corpses and to what happens with corpses once they have sunk; (4) models should be developed to help predicting patterns of seabird strandings, not to replace drift experiments at incidents or mass strandings.

## INTRODUCTION

Since the onset of beached bird surveying in the 1920s, its methods and value have been food for many discussions. Disputes could be attributed to a number of factors, the emphasis on beached numbers rather than on relative measures such as the oil rate (the proportion of complete corpses that are oiled) being the most important one (Camphuysen & Heubeck 2001). Nowadays it is generally acknowledged that beached bird monitoring is an appropriate method to indicate spatial and temporal patterns in oil pollution - through the calculation of oil rates - and several examples have been given in support of this thesis (Camphuysen & van Franeker 1992). As a tool for monitoring seabird mortality rates or in order to estimate total mortality among seabirds due to oil pollution, beached bird surveying appears inadequate (Furness & Camphuysen 1997) because numbers of dead seabirds recorded on the beach are highly subject to factors such as wind, currents, predation, etc. As a consequence scientists do detemine numbers of stranded birds as part of the standard procedure in all beached bird programs but treat these density values merely as background information. On the other hand, the public at large, the media and the policy-makers are primarily interested in the total number of casualties after a major oil incident or in an annual number of victims of chronic pollution in our seas. To estimate the total mortality at sea, we need to know the entire pathway a seabird follows from the moment it dies, until a surveyor finds it on the beach (Fig. 1). This includes the drifting 'behaviour' of the corpse in relation to currents and wind, the process of decay affecting buoyancy and attractiveness to scavengers, the movement of the carcass when it has sunk before reaching the coast and the final probability to be washed ashore (dependent on local beach conditions in terms of bathymetry, presence of breakwaters and accessible beaches, ports, piers and beach fronts)(Piatt *et al*. 1990; Wiese & Ryan 1999). Furthermore, we need to assess the chance a corpse is actually detected after beaching. It may wash up on inaccessible shorelines and not be discovered, wash up on accessible beaches but get buried, scavenged or taken back by the sea or by beach cleaning operators before discovery, or wash up on a beach but be overlooked. In general, the numbers of birds dying at sea relates to the number found on the beach times the probability to strand and to be detected once they have beached. These probabilities in turn are affected by many unknown factors:

$N^{\dagger}_{sea} = N^{\dagger}_{beach} * (\text{beaching probability}^{-1} * \text{detection probability}^{-1})$

Provided we can quantify this wide spectrum of variables and relationships and we know the search effort, it should be possible to quantify (and model) the number of birds killed at sea from the number recovered on beaches. To understand the entire pathway will require much more research – drifting-, floating- and persistence experiments - and data will have to be gathered for various locations.

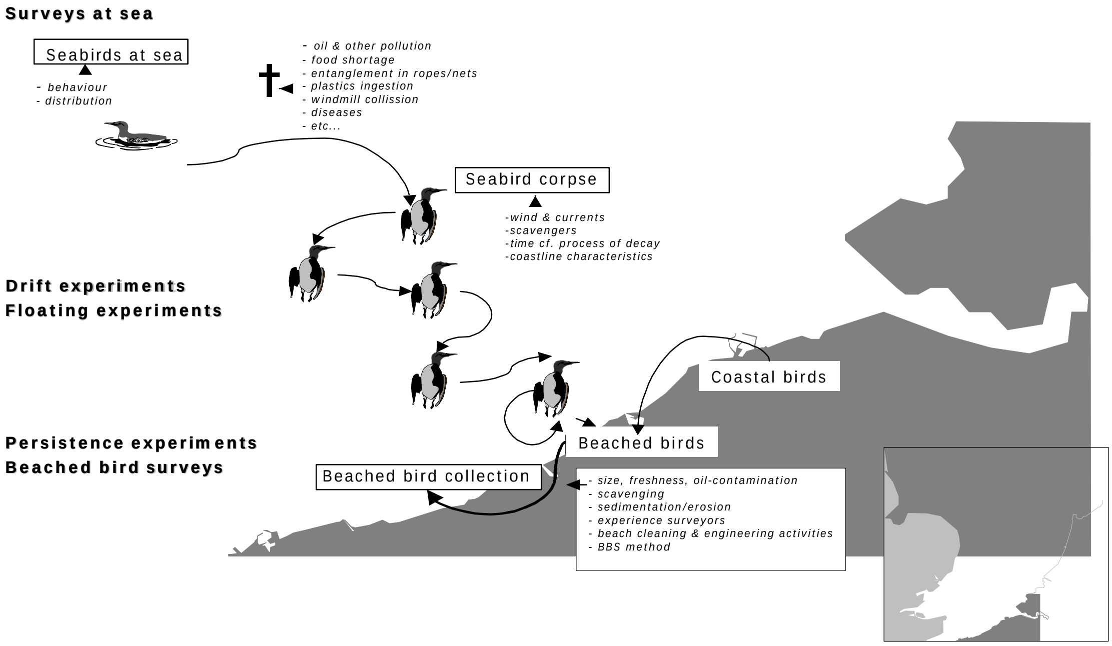



*Fig. 1. Conceptual pathway of a sea- and coastal bird dying in Belgian coastal waters.*

So far, information of this kind has been particularly scanty for the southernmost part of the North Sea. No floating experiments have been published in detail. Only few drift experiments can be traced in literature that focussed on the southern part of the North Sea (STOWE 1982b,c; KEIJL & CAMPHUYSEN 1992), while most studies were carried out in the 1960s and 1970s in the Irish Sea or the English Channel (BEER 1968; JONES *et al*. 1970; LLOYD *et al*. 1974; BIBBY & LLOYD 1977; JONES *et al*. 1978; COLOMBÉ *et al*. 1996), the central or northern North Sea (LLOYD & DIXON in CADBURY 1978; BIBBY 1981) and more recently in northern America (PAGE *et al*. 1982; THRELFALL & PIATT 1983; PIATT *et al*. 1990; FORD *et al*. 1991; HLADY & BURGER 1993; CHARDINE & PELLY 1994). Where it concerns persistence experiments the situation is somehow better, with about half of the studies being conducted in the southern North Sea, i.e. on Belgian (HOUWEN 1968; KUIJKEN 1978; VERBOVEN 1978), Dutch (TANIS & MÖRZER-BRUYNS 1962; CAMPHUYSEN 1989), French (RAEVEL 1992) and British beaches (STOWE 1982). The other half concerns more recent studies in northern America (BAILEY 1989; JONES 1989; PAGE *et al*. 1990; BODKIN & JAMESON 1991; BURGER 1991; ECI 1991; VAN PELT & PIATT 1993).

In this paper we present available information and new data that may help to unravel the complex relationship between the mortality of seabirds at sea and what can be observed of this mortality on the beach. First we focus on how numbers of beached birds in Belgium correlates with the presence of seabirds at sea and with wind conditions. Next we present results of: (1) thirteen drift experiments between February 1996 and March 1999 off the Belgian and northern French coast, with 634 bird corpses dropped at various locations; (2) persistence experiments with a total of 562 birds on Belgian beaches during three successive winters (1996-99). These results are compared to the available literature on the subject and fitted in the general framework sketched above. Finally we discuss the repercussions for the use of beached bird surveying as a tool to determine mortality at sea and make suggestions for additional future research.

## METHODOLOGY

STUDY AREA & -PERIOD

Belgian marine waters are part of the southernmost tip of the North Sea and are situated in the middle of what is internationally referred to as the 'Flemish Banks' (OSPAR COMMISSION 2000). Near to the Straits of Dover (55-75 km to the west) and adjacent to the mouth of the Schelde estuary, shipping traffic is very intense and ever increasing (OSPAR COMMISSION 2000). The structural variation in topography, with four major complexes of sand ridges, is the result of sediment and melt water displacements during glacial periods (DE MOOR 1985). Tidal currents are strong and oriented parallel to the coast. They attain maximal velocities of 1.7 knots at spring tide and 0.6 knots at neap tide. There is a small net residual NE-circulation through the Straits of Dover. With persistent strong winds however, the wind-driven induced currents may approach, or even exceed, the rate of tidal streams. Persistent W or SW gales can produce observed overall movement of surface water as strong as 35 miles over a period of 24 hours. Maximal tidal current velocities become gradually more important from the west (1.0-1.2 knots) to the east (1.7-1.8 knots)(ANONYMOUS 1992). The prevailing wind direction in Oostende (compiled from meteorological data 1941-1992) is S or SW (BELL 1994). During the winters (October-March) 1992-93/1998-99, 47% of all winds blew offshore (SE-SW and ENE-SE), 28% onshore (WSW-NNE) and 25% parallel with the coastline (NNE-ENE and SW-WSW). Mean wind speed amounted to 20 km $h^{-1}$, and peaked in the sector SW-NW (23-28 km $h^{-1}$)(calculated from data KMI). Mean surface water temperature in the southernmost part of the North Sea in February amounts to 4-6 °C (OTTO *et al*. 1990).

The Belgian shoreline measures 65.4 km, of which 3.3 km lies between the moles of the outer harbour of Zeebrugge (Fig. 2). The 62.1 km of sandy beaches are easy of access, and count groins on average every 200-400 m (except for the major part of the west coast French border-Nieuwpoort, Bredene-De Haan and in front of the Zwin nature reserve on the Belgian-Dutch border). More than half of the entire length of the coast is bordered with buildings and boulevards. The tidal range at the Belgian coast amounts to 3-5 m. The beach slope increases in eastern direction (DUFOURMONT 1979) and hence beaches are generally broader in the west. Stranding of carcasses is virtually impossible on a stretch of 5 km, due to the presence of dykes and beaches submerged at high tide. For analysis purposes the Belgian coast is divided in four sections: FRNP, NPOO, OOZB and ZBNL (Fig.2).

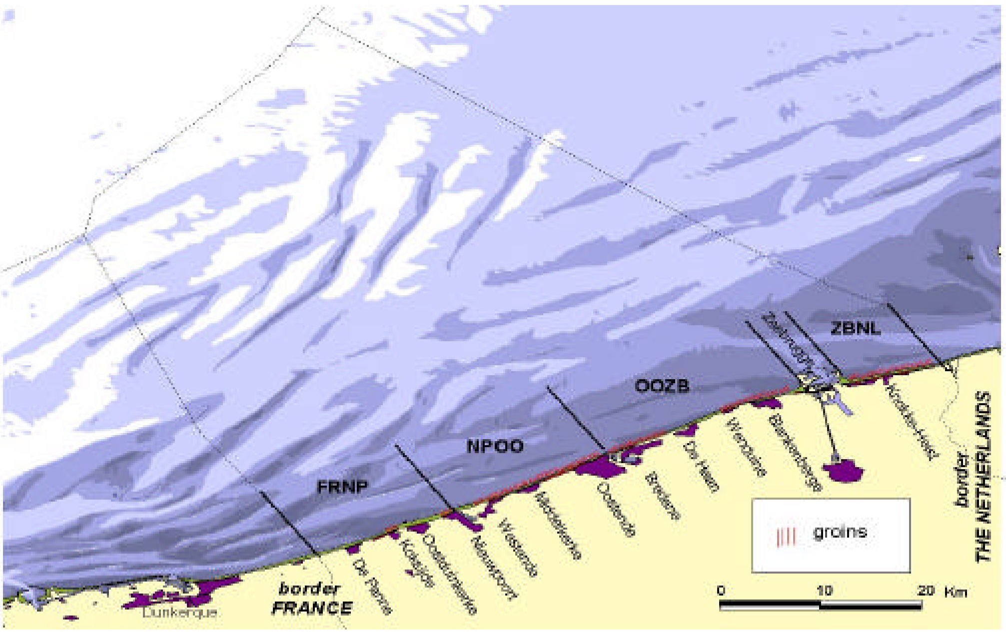



*Fig. 2. The Belgian shoreline divided in four major beach sections*.

Winters were 'normal' during the study period 1993-1999 (Table 1), with severe frost restricted to early 1996 and 1997 and a short cold spell at the end of December 1992. We applied the IJnsen factor as a measure for the severity of the winter (V= v2/363 + 2/3 y + 10/9 z, with v=number of frost days, i.e. with minimum temperature < 0°C, y=number of ice days, i.e. with maximum temperature < 0°C, z=number of very cold days, i.e. with minimum temperature< -10°C: IJNSEN 1991). For this purpose we made a new classification following the frequency distribution of values as found for the Belgian coast during 1961-99 (based on meteorological data for Oostende-Middelkerke: source: KMI). The occurrence of strong onshore winds (WSW-NNE) equals the number of days per winter (October–March) with an average wind speed of at least 30 km $h^{-1}$ and is inversely correlated with winter severity.

*Table 1. Winter severity (IJnsen factor) and frequency of strong onshore wind during the winters 1992-93/1998-99 at the Belgian coast (data KMI).*

| Winter | Winter severity | | Strong onshore winds (days) |
|---|---|---|---|
| | IJnsen factor (Belgian coast) | Category (classification Belgian coast) | |
| 1993 | 7.4 | cold | 31 |
| 1994 | 4.0 | normal (cold) | 39 |
| 1995 | 2.7 | normal (mild) | 39 |
| 1996 | 15.3 | severe | 11 |
| 1997 | 17.7 | severe | 12 |
| 1998 | 4.2 | normal (cold) | 18 |
| 1999 | 5.7 | normal (cold) | 23 |

## CORRELATION OF BEACHED DENSITIES WITH WIND CONDITIONS AND ABUNDANCE OF SEABIRDS AT SEA

Densities of beached birds have been recorded at the Belgian coast since 1962. Initially most effort went to annual surveys in February, later on additional monthly counts of the entire coastline were carried out as well. Since January 1992, the Belgian beached bird survey programme consists of weekly surveys (on average every 9.3 days) of the 16.7 km beach section NPOO, and monthly surveys of all beaches during winter months (October-March)(SEYS *et al*. accepted). We correlated the density of birds collected during weekly surveys with the 'wind-index' of the ten preceding days. This 'wind-index' is defined here as the sum of wind speeds (km $h^{-1}$) of the ten days prior to the survey, attributing a positive sign to onshore winds (WSW to NNE), a negative one when winds were blowing in offshore direction (SSW to ENE).

The abundance of seabirds at sea is assessed during ship-based surveys, carried out by the Institute of Nature Conservation in the southernmost part of the North Sea since September 1992 (SEYS *et al*. in prep.). The focal area includes the Straits of Dover and the Belgian marine waters. During the study-period September 1992 – December 1998, more than 20,000 km had been surveyed in winter time (55% within Belgian marine waters). We applied a standard strip-transect method with snapshot counts for flying birds (TASKER *et al*. 1984). Densities (N $km^{-2}$) are calculated after applying correction factors for small and dark swimming birds (STONE *et al*. 1995). We investigated whether differences in beaching numbers are in line with the seasonal distribution of seabirds at sea, as observed during ship-based surveys (SEYS, unpublished data). We defined as inshore species/taxa those who are dominant within 0-10 km from the Belgian coast (scoters, grebes, terns, Eider), as midshore species/taxa those who occur in a wide front being not particularly less common at 10-20 km distance from the coast compared to further offshore (*Larus*-gulls, divers, auks) and as offshore species that are very rarely found at 0-10 km and are obviously most common beyond 20 km from the coast (skuas, Fulmar, Kittiwake, Northern Gannet).

## DRIFT EXPERIMENTS

At thirteen occasions during the period February 1996 - March 1999, a total of 634 bird corpses has been dropped at various locations off the Belgian coast (Table 2, Fig. 2). The sample consisted for more than 90% of auks (62%), waterbirds (16%) and *Larus*-gulls (15%). The great majority (97%) was medium-sized, defined here as 25-60 cm in body-length (JONSSON 1993). Most corpses were recovered from the freezers at the Ecomare rehabilitation centre (Texel, The Netherlands). They were all defrosted, measured and labelled with a plastic wing-tag and a ring. Bird corpses were dropped at sea usually in batches of ten specimens each, at various distances from the shoreline. Beached bird surveyors at the Belgian and Dutch coast were informed to look carefully for stranded tagged specimens. The label indicated the importance of the experiment and the need to contact the national Ringing Service (KBIN) in case of a finding. Bodies found by the general public were reported through the normal channels for ringed birds. For analysis purposes the birds were grouped in wing-length classes of <150 mm (a single woodpecker), 150-250 mm (e.g. auks, seaducks, grebes, waders), 250-350 mm (e.g. Eider, small *Larus*-gulls, Fulmar, Cormorant) 350-450 mm (large *Larus*-gulls) and > 450 mm (Northern Gannet, Great Black-backed Gull).

### PERSISTENCE EXPERIMENTS

During weekly winter surveys in 1997, 1998 and 1999 on the beach section Oostende-Nieuwpoort, 562 bird corpses were tagged (with an inconspicuous label around the leg) and searched after at consecutive surveys. Birds were recovered from the beach thus reflecting the actual local species-composition (226 auks, 151 gulls, 77 waders, 44 Fulmars *Fulmarus glacialis* and smaller numbers of other taxa). We defined persistence time as the mean number of days a corpse could be recovered on the beach, before washing away, getting buried by sand or being discarded by predators or men. Since time intervals between subsequent surveys were rather large (on average 9.3 days), mean minimal (from date of marking to day of last recovery) as well as maximal (to first survey after the last recovery) persistence times were calculated. Although weekly controls do not allow defining persistence time more precisely, we believe the first and lowest value gives a more reliable picture. Therefore for further analysis only values of minimal persistence time have been used. Corpses were grouped in classes of oiling, with: 1) unknown; 2) no oil; 3) 1-5% covered; 4) >5-50%; 5) >50-100%; in size classes, with: 1) large = minimal length (bill top – tail end) > 60 cm (JONSSON 1993) (with Pomarine Skua *Stercorarius pomarinus* treated as medium-sized instead of large: cf. tail-streamers); 2) medium-sized = < 60 & > 25 cm; 3) small = ? 25 cm; and in classes of state of decay (estimated on sight) with: 0) very fresh; 1) fresh; 2) rotten; 3) carcasses with wings, feet and furculum only. Differences in persistence time according to the winter, oil-rate, size and freshness were calculated with an ANOVA on minimal persistence times, after log ($x$+1) transformation of the original data.

## RESULTS

### FACTORS DETERMINING THE DENSITY OF BEACHED BIRDS

Densities of beached bird species/taxa do not correlate well with weather characteristics (IJnssen factor, frequency of strong onshore winds) when winters are compared. Only the density of dead waders (Kendall *tau* 0.727, $N$=11, $P$<0.001) and seaducks other than *Melanitta/Somateria* (Kendall *tau* 0.539, $N$=11, $P$<0.05) significantly increase with severe winter weather. At this level, total numbers of auks, *Larus*-gulls and scoters are correlated neither with the IJnsen factor nor with the frequency of strong onshore winds.

However, when comparing densities of beached corpses by date instead of by winter, total numbers of beached seabirds are well correlated with the wind direction and –speed. Considering only those seabird taxa that are entirely marine during winter (auks, Kittiwake *Rissa tridactyla*, Fulmar, Northern Gannet, divers, Eider, scoters, skuas), we find a highly significant correlation ($R$= 0.447; $N$= 87; $P$<0.0001) between numbers of birds collected per 16.7 km (during weekly surveys in the winters 1993-1999 at the beach section NPOO) and the ‘wind-index’ of the ten preceding days (Fig. 3). All densities higher than 2 birds km$^{-1}$ were recorded in the months January-March, most of them when the net wind speed of the ten preceding days shows a positive sign (i.e. has been blowing in onshore direction).

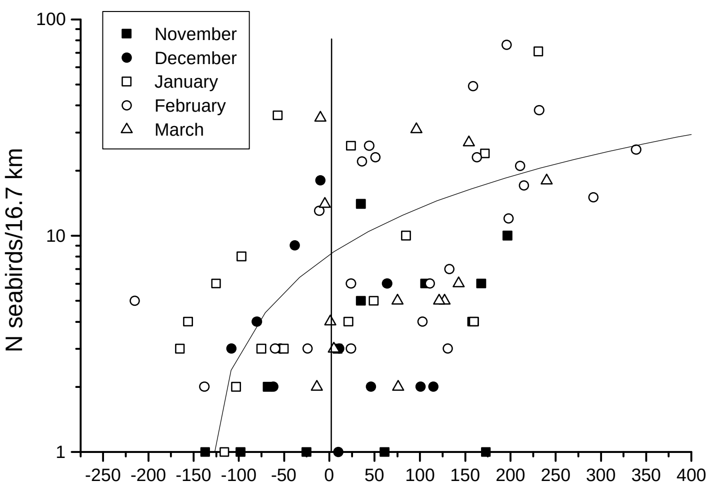



*Fig. 3. The impact of wind force and direction (translated in a wind-index: see Methodology) on densities of beached seabird corpses during weekly surveys.*

The further offshore seabirds live, the more they depend on the occurrence of (strong) onshore winds to get beached (Fig. 4). Inshore taxa (grebes and seaducks) are not correlated with the cumulative onshore wind speed of the ten preceding days (Spearman $R$=0.100; $N$=89; n.s). The taxa that have a midshore distribution in Belgian marine waters show a significant correlation ($R$=0.240; $N$=89; $P$<0.05) and offshore species such as Fulmar, Northern Gannet, Kittiwake and Great Skua *Stercorarius skua* are highly significantly correlated in winter ($R$=0.410; $N$=89; $P$<0.001).

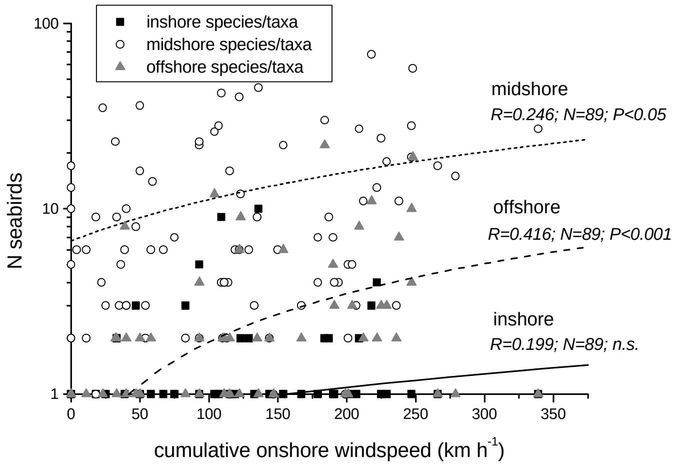



*Fig. 4. Relationship between the cumulative onshore wind speed in a ten-days period before a beached bird survey and the number of inshore, midshore and offshore seabirds found at a 16.7 beach section at the Belgian coast.*

COMPARISON OF SEABIRD DISTRIBUTION AT SEA AND DENSITY OF BEACHED BIRDS

In most species we observed that the relative density of beached birds on the Belgian shoreline followed the temporal pattern of occurrence at sea, as noticed during ship-based surveys along fixed ferry routes (Fig. 5). Often a time lag of at least one month between both peak densities could be discerned.

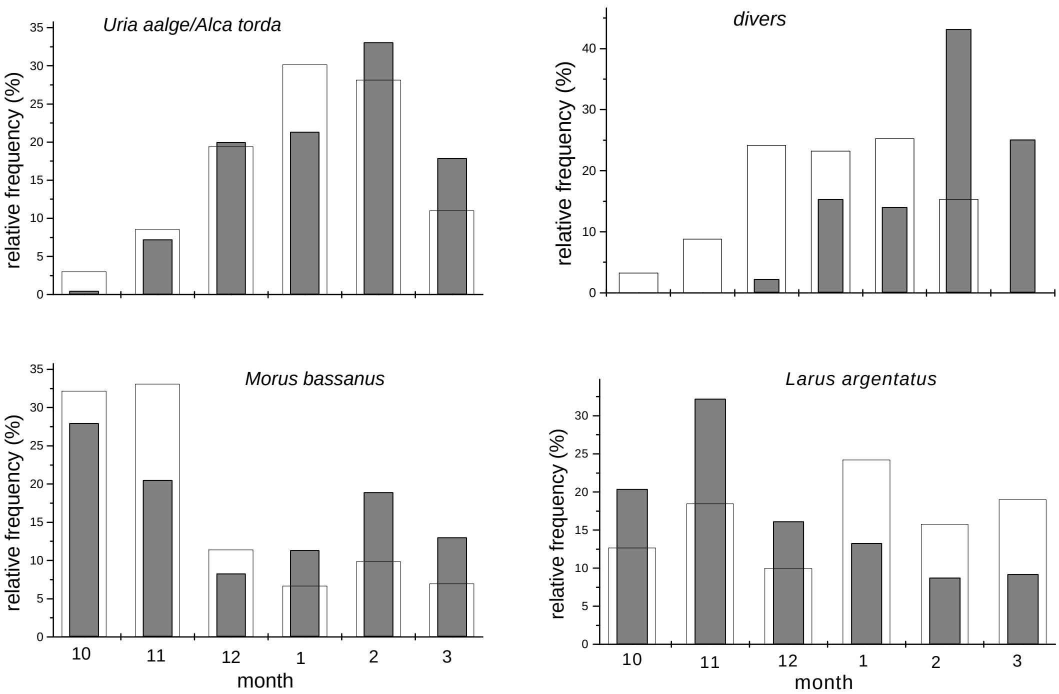



*Fig. 5. Relative monthly abundance of four seabird taxa during ship-based surveys (hollow bars) in the southernmost part of the North Sea, compared to relative density at beached bird surveys (grey bars) in Belgium.*

Though the Belgian shoreline measures hardly 65 km and looks like one uniform and straight habitat, there are significant differences in the beaching intensity of birds ($?^2$=9.8, *N*=4, *P*>0.05). In case of a homogeneous distribution we would expect each of the four beach sections to contribute 25% of the summed, overall density. Densities are higher than the expected 25% at OOZB (37.7%) and lower at NPOO (20.3%) and at beach section ZBNL (17.2%)(Table 2).

*Table 2. Spatial variation in density (N km$^{-1}$) of beached bird corpses at the Belgian coast, based on a comparison of observed (columns FRNP/NPOO/OOZB/ZBNL) versus expected densities of beached birds on four transects during monthly surveys with full coverage in the 1990s ($?^2$, df=3; ns: not significant; * P>0.05; ** P>0.01; *** P>0.001). Distribution at sea is indicated for each taxon as: I: inshore/beach; M: midshore; O: offshore (see Methodology and* OFFRINGA *et al. 1996).*

| Taxon/species | At sea | FRNP | NPOO | OOZB | ZBNL | $?^2$ | *P* |
|---|---|---|---|---|---|---|---|
| skuas – Stercorarius *sp*. | O | 0.002 | 0.002 | 0.003 | 0.003 | 4.0 | ns |
| Fulmar - *Fulmarus glacialis* | O | 0.069 | 0.043 | 0.090 | 0.090 | 7.0 | ns |
| Kittiwake - *Rissa tridactyla* | O | 0.067 | 0.070 | 0.093 | 0.041 | 7.6 | ns |
| Northern Gannet - *Morus bassanus* | O | 0.020 | 0.009 | 0.017 | 0.009 | 13.0 | ** |
| Great Black-backed Gull - *L.marinus* | M/O | 0.027 | 0.018 | 0.020 | 0.012 | 8.1 | * |
| Common Guillemot - *Uria aalge* | M | 0.498 | 0.344 | 0.638 | 0.252 | 11.6 | ** |
| Razorbill - *Alca torda* | M | 0.091 | 0.077 | 0.081 | 0.023 | 15.1 | ** |
| Lesser Black-backed Gull - *L.fuscus* | M | 0.004 | 0.007 | 0.014 | 0.009 | 15.2 | ** |
| divers – Gavia *sp*. | M | 0.009 | 0.002 | 0.024 | 0.003 | 88.9 | *** |
| Herring Gull - *L.argentatus* | I/M | 0.085 | 0.088 | 0.168 | 0.084 | 11.4 | ** |
| Common Gull - *L.canus* | I/M | 0.038 | 0.023 | 0.042 | 0.014 | 14.2 | ** |
| Little Gull - *L.minutus* | I/M | 0.000 | 0.004 | 0.006 | 0.003 | 47.0 | *** |
| waders | I | 0.056 | 0.106 | 0.206 | 0.107 | 21.1 | *** |
| grebes – Podiceps *sp*. | I | 0.053 | 0.038 | 0.080 | 0.017 | 23.4 | *** |
| Eider - *Somateria mollissima* | I | 0.004 | 0.000 | 0.012 | 0.003 | 84.1 | *** |
| scoters – Melanitta *sp*. | I | 0.022 | 0.016 | 0.069 | 0.014 | 54.3 | *** |
| Black-headed Gull - *Larus ridibundus* | I | 0.062 | 0.043 | 0.072 | 0.064 | 3.1 | ns |
| ALL | | 1.154 | 0.945 | 1.753 | 0.799 | 9.8 | * |

Species and taxa are more likely to have a random distribution in beaching when they occur further offshore (Table 2). Offshore species/taxa such as Fulmar, Kittiwake and skuas do not show significant deviations from the expected evenly distributed patterns; inshore species are predominantly found in the neighbourhood of their major wintering sites. The Black-headed Gull is an exception to this trend, probably due to its homogenous distribution along the entire Belgian coast (SPANOGHE 1999) and its main occurrence on beaches and further inland.

## DRIFT EXPERIMENTS

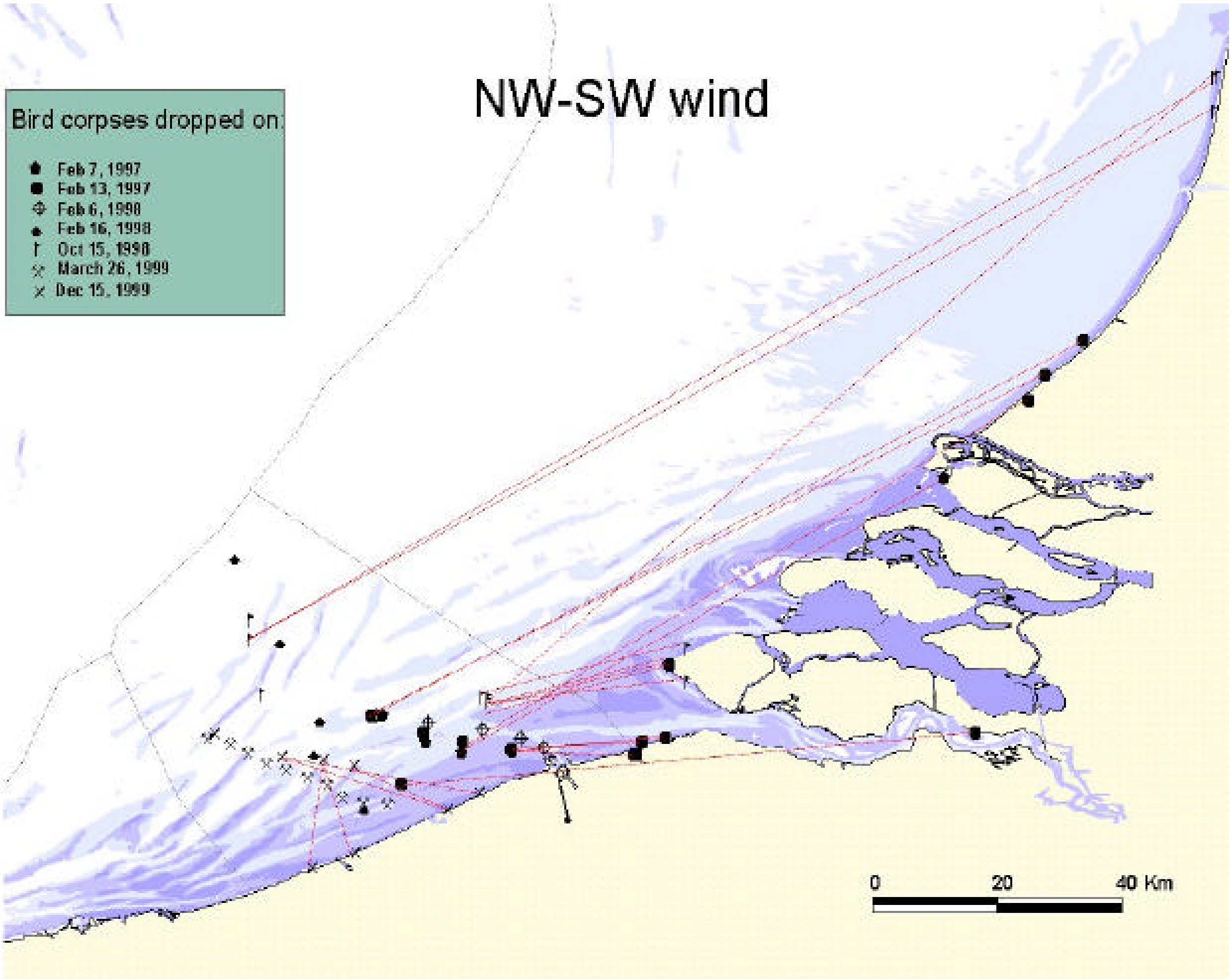
Overall, 12% of all 634 bird corpses dropped off the Belgian coast were recovered on Belgian, French or Dutch beaches (Table 3). A single gull corpse released on February 23, 1996 at c. twelve km off De Panne, was recovered from a lost fishing net on the beach of Felixtowe (U.K.) one and a half month later.

*Table 3. Summary of the results of drift experiments carried out off the Belgian coast during the winters of 1996-1999. The total number of corpses per date includes all batches dropped that same day, thus including various dropping sites.*

| Dropping date | Wind direction & force (Beaufort) at the date of dropping | Total N corpses dropped | Total N corpses recovered | Median interval between dropping and finding (days) | Recovery rate (%) |
|---|---|---|---|---|---|
| Feb 23, 1996 | S 0-3 | 26 | 1 | (78) | 4 |
| Feb 25, 1996 | S 8 | 10 | 0 | - | 0 |
| Feb 26, 1996 | S 0-3 | 20 | 1 | (8) | 5 |
| Feb 27, 1996 | still | 10 | 1 | (7) | 10 |
| Feb 28, 1996 | NE 4-5 | 34 | 20 | 2 | 59 |
| March 20, 1996 | NE 4 | 100 | 26 | 16 | 26 |
| Feb 7, 1997 | SSW 5 | 40 | 1 | (9) | 3 |
| Feb 13, 1997 | W 8 | 53 | 13 | 6 | 25 |
| Feb 6, 1998 | SSW 4 | 55 | 0 | - | 0 |
| Feb 16, 1998 | SW 4-5 | 52 | 0 | - | 0 |
| Oct 15, 1998 | W 4 | 76 | 8 | 5 | 11 |
| March 26, 1999 | W 4 | 121 | 0 | - | 0 |
| Dec 15, 1999 | NW 7 | 37 | 6 | 10 | 14 |
| OVERALL | | 634 | 77 | 8 | 12 |

Recovery rates were highly variable. We did not recover a single bird corpse from four out of thirteen batches; from another four batches only one corpse had been recovered. Generally the drift pattern is in accordance with the wind climate (direction and velocity) in the first week after the dropping. Three major patterns can be distinguished:

(1) During normal or mild winter weather in this part of the North Sea - with winds blowing for several days parallel with the shoreline (Feb 7th, 1997; Feb 6th, 1998) or at least not in onshore direction (Feb 16th, 1998; March 26th, 1999) – virtually no recoveries were made.
(2) A comparable wind climate with a major SW-component, but turning onshore for at least a few days shortly after the corpses have been released (Feb 13th, 1997, Oct 15th, 1998; Dec 15th, 1999) gives rise to recovery rates of 11-25% on Belgian (43%) or Dutch (57%) beaches (Fig. 6a). The fate of the birds dropped at October 15th is probably a good illustration of what might be a more general pattern of northeastern drift and 'step-stone' stranding of floating objects along the coast of the Southern North Sea: as soon as the wind turned W-NW (October 17th-20th), a first batch of corpses was recovered (in the most southern part of The Netherlands). Then the wind blew SSW again and no recoveries were made. On October 25th-26th, the wind strengthened from the west and two new recoveries followed in the northern part of The Netherlands.
(3) The results of the drift experiments carried out between Feb 23rd and March 20th, 1996 reflect what happens during periods with breezes blowing predominantly from northern and eastern directions (Fig. 6b). As soon as the wind turned NE-E on February 27th-28th, corpses started washing ashore, most of them (75%) in northern France. Recovery rates were fairly large (10-59%) and as high as 75% for smaller subsets of birds put out (one batch of 24 birds dropped at only 1-2 km off the Belgian shoreline).



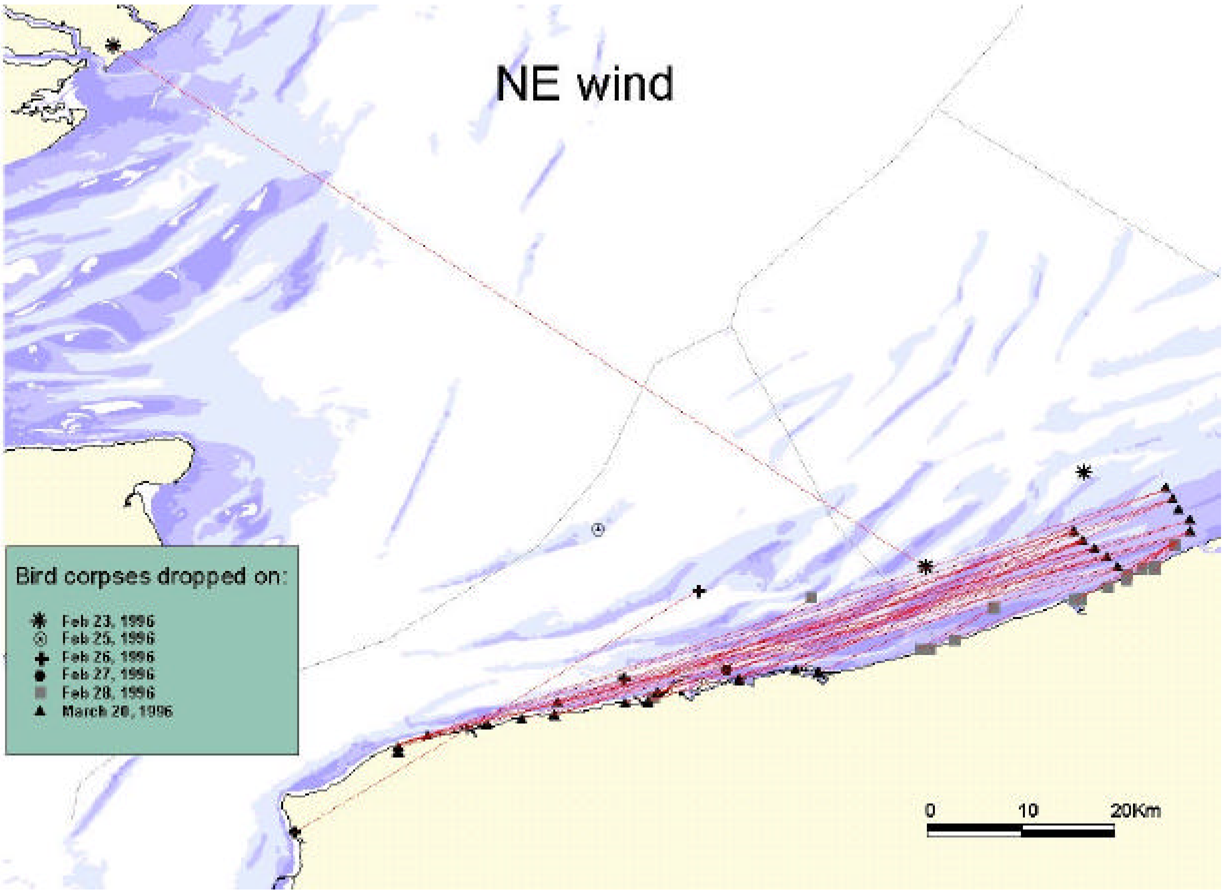



*Fig. 6. Positions where bird corpses were dropped and recovered during various drift experiments off the Belgian coast, under: (a) NW-SW wind conditions, (b) NE wind conditions (aberrant observation refers to corpse trapped in fishing net)*

The closer to the coast the corpses are released, the higher the probability that they will wash ashore (Fig. 7). On average 45-50% are recovered when dropped at 1-2 km, 0-30% at 2-25 km offshore and virtually none will ever reach the shore beyond a distance of 25 km.

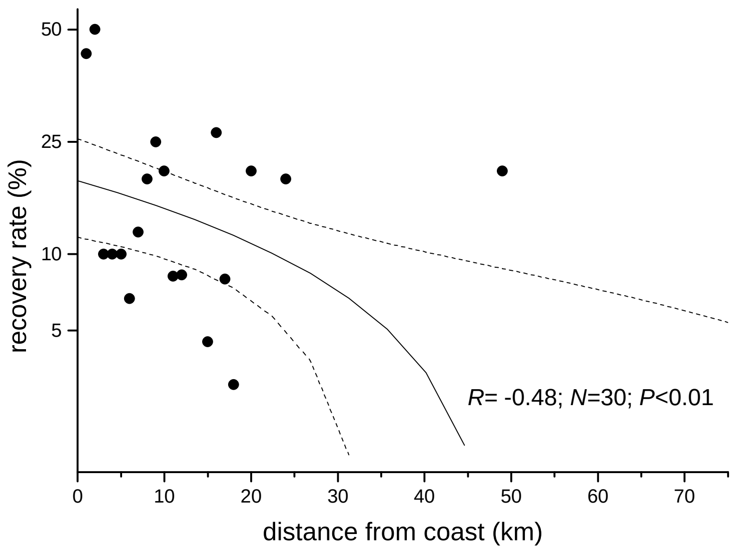



*Fig. 7. Relationship between the recovery rate of bird corpses during drift experiments and the distance to the coast at which they were dropped (linear regression with 95% confidence intervals). The null recovery rates were included to calculate the regression but are not presented on the figure*

The more offshore a bird carcass is dropped, the more likely that it will make a long journey (Fig. 8). The size of the bird - expressed in terms of wing-length - doesn't seem to have an impact on the travelled distance. Two corpses were retrieved in the northern part of The Netherlands (Schoorl-Bergen, De Kerf) at a distance of 175-200 km. One bird was flushed into the Schelde estuary and recovered at Valkenisse (Fig. 6a).

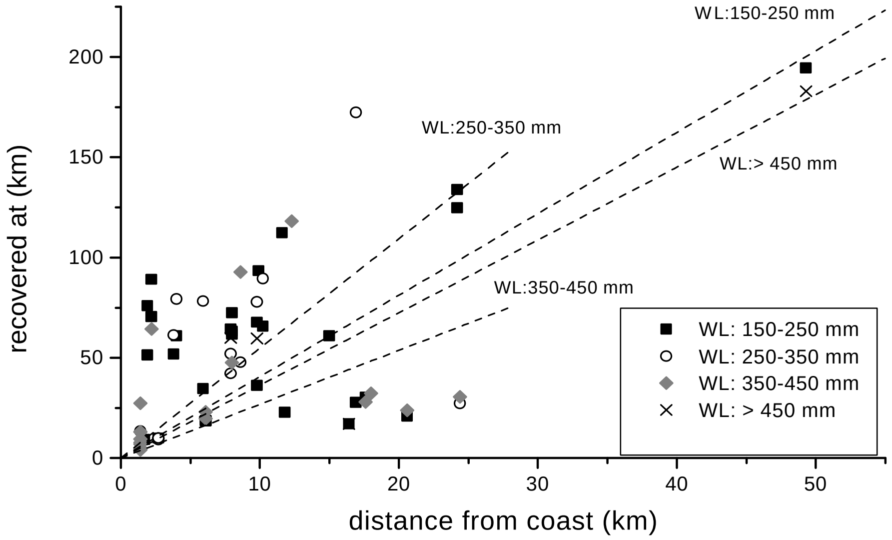



*Fig. 8. Relationship between the distance to the coast at which a bird corpse is dropped and the distance it has travelled at recovery. The results are presented for four size-classes (expressed in terms of wing-length).*

Longer-winged birds have a much higher probability to be recovered on the beach (Fig. 9). Recovery rates for the short-winged auks, scoters, grebes and waders are merely 8.3%. Eider *Somateria mollissima*, small *Larus*-gulls, Fulmar, Great Cormorant *Phalacrocorax carbo* and other waterbirds have a probability twice as high (16.3%) to be recovered, while large *Larus*-gulls (25.3%) and Northern Gannets *Morus bassanus* (44.4%) demonstrate the highest recovery rates. Other characteristics of the species or the degree of contamination with oil do not affect the recovery rate in our experiments.

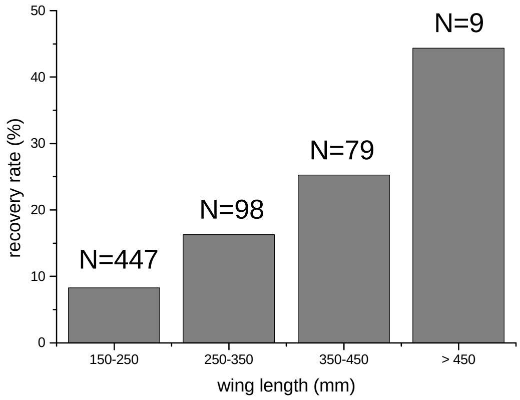



*Fig. 9. Impact of the size of a bird (in terms of wing-length) on the recovery rate during drift experiments (N=number of corpses dropped).*

Some corpses that drifted for several days with winds blowing from one major direction enabled us to calculate maximal velocities of drifting. One Northern Gannet corpse released on October 15, 1998 was recovered ten days later at Egmond aan Zee (The Netherlands) at 183 km northeast of the site of dropping. This means that the bird must have moved at 3.1% of the actual wind speed (measured at Oostende). A Velvet Scoter *Melanitta fusca* made a trip to Schoorl (172 km to the northeast) in twelve days, i.e. at 2.2% of the wind speed.

PERSISTENCE EXPERIMENTS

Once a bird corpse strands, it depends on many factors whether it will or won't be found by a beached bird surveyor. On average a bird corpse remains on the beach for 5.8 – 13.3 days. Although weekly controls do not allow defining persistence time more precisely, the minimal value is probably the more realistic one. About 50% of all corpses (277 of 562 specimens) have never been recovered and are most likely to have disappeared in the very first days after being left behind; 50-80% are not recovered anymore after only 9 days (Fig.10).

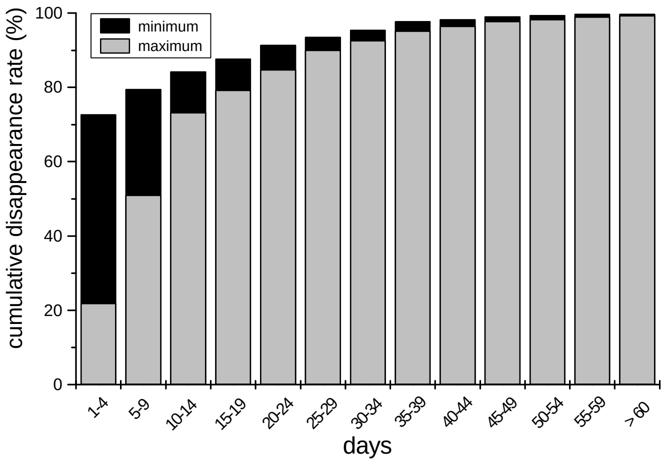
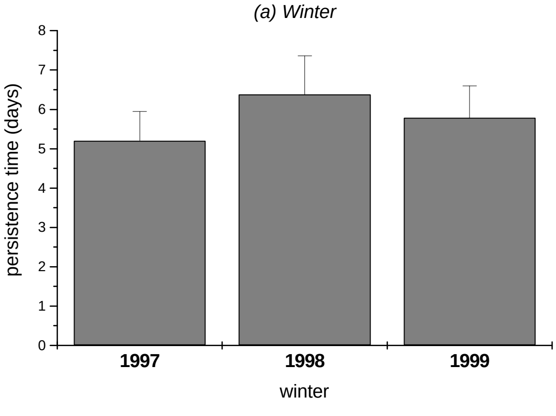
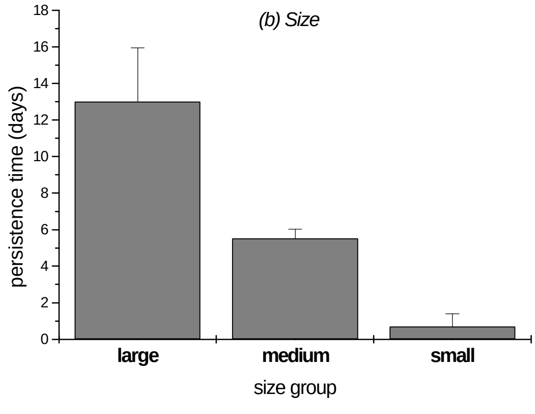



*Fig. 10. Cumulative disappearance rate of corpses (N=562) on Belgian beaches during persistence experiments. Since time intervals between subsequent surveys were rather large, mean minimal (from date of marking to day of last recovery) as well as maximal (to first survey after the last recovery) disappearance rates are presented.*

We did not find a significant difference between the winters 1997, 1998 or 1999 (One Way ANOVA, $F_{2,562}$=0.170, $P$<0.05); minimal values ranged from 5.2 to 6.4 days (Fig. 11a). Persistence time is primarily determined by the size of the bird (Fig. 11b,c), with small birds having much shorter persistence times ($F_{2,562}$= 9,715; $P$<0.001). A small-sized corpse has a minimal persistence time of only 0.7 days, medium-sized birds 5.5 days, large birds persist on average 13 days. Consequently bird groups with smaller-sized representatives will disappear much faster from a beach than for instance divers, herons or gannets (Fig. 11d). Oiled seabird corpses appear to have a higher but non-significant chance to disappear earlier than un-oiled birds ($F_{3,440}$=0.673; $P$<0.05). In fact only very heavily (>50%) oiled birds will remain on the beach markedly longer (12.3 days), than all other bird corpses (6.4 days)(Fig. 11e). There is a non-significant trend ($F_{3,562}$= 0.470; $P$<0.05) towards higher persistence times in fresher corpses (Fig. 11f), although this trend is not consistent for medium-sized birds.



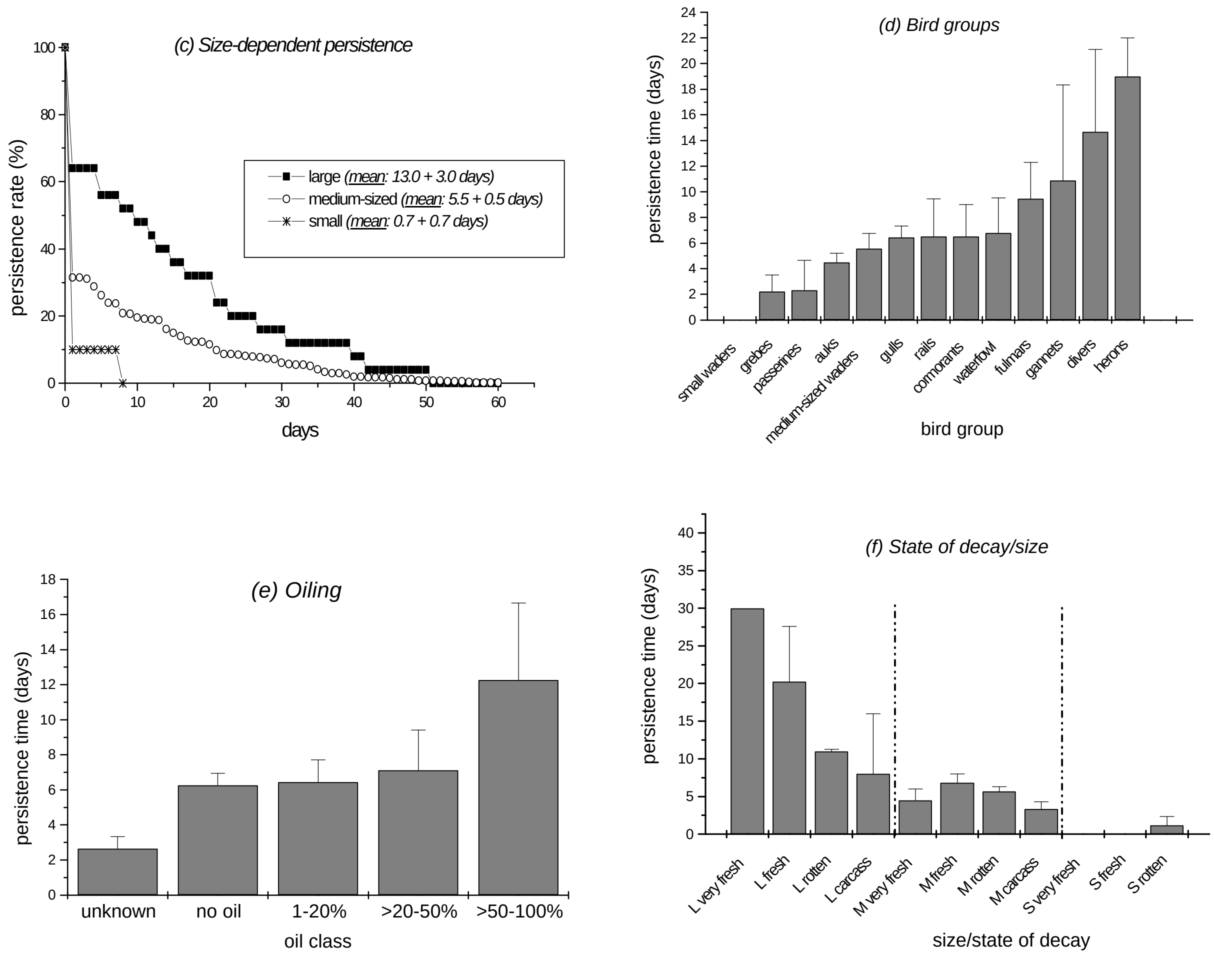



*Fig. 11. Minimal persistence time (in days ? SE) of bird corpses on Belgian beaches (N=562) in relation to (a) winter, (b,c) size, (d) bird group, (e) cover with oil, and (f) state of decay.*

## DISCUSSION

DRIFT OF BIRD CORPSES

During our experiments we observed bird corpses to drift by the wind at 2.2-3.1% of its own velocity. This result is consistent with other published values: 2.2% (auks, JONES *et al.* 1970), 2.55% with maxima of over 4% (gulls, BIBBY & LLOYD 1977), 3.1% (shearwaters, WOOD, 1996) and 4% (gulls, BIBBY 1981). These drift velocities do not differ substantially from those of oil (3-4%: SMITH 1968; SAMUELS & LANFEAR 1982; CLARK 1992), buoys (2.9%: STOMMEL in TOMCZAK 1964) or drift cards/floats (4.2-5%: TOMCZAK 1964; WOOD 1996). The average recovery rate of 12% calculated from our drift experiments is in line with an older 'internationally accepted standard' to multiply the number of birds found dead with ten to arrive at an estimate of total mortality, and lower than the overall mean of 22% calculated from about thirty drift experiments carried out worldwide (*Appendix II*). However, taking into account the complete range in recovery rates of 0-100% (*Appendix II*) and the known impact of various complicating factors, it would be silly to use this or another value as 'the one and only magic factor' (STOWE & UNDERWOOD 1984; CAMPHUYSEN 1991).

Still, we believe that these data have a value in extracting drift patterns of bird corpses for a specific location such as the Southern North Sea. Provided the wind blows onshore for a few consecutive days, we may expect to find over 40-50% of all corpses dropped at less than 2 km (up to 100% when dropped from the beach with onshore wind: STOWE 1982A), up to 25% of those put out at 2-25 km and only marginal numbers of offshore droppings. The trivial fact that the further offshore a floating object is put out, the less likely it is to wash ashore was also observed by PAGE *et al*. (1982), BODKIN & JAMESON (1991) and WOOD (1996). Translated towards live birds it can be derived that offshore species are much more dependent on the occurrence of strong onshore winds to beach, a result we could also demonstrate from our data: inshore taxa (grebes and seaducks) were not correlated with the cumulative onshore wind speed of the ten preceding days, taxa with a midshore distribution in Belgian marine waters showed a significant correlation and offshore species such as Fulmar, Northern Gannet, Kittiwake and Great Skua were highly significantly correlated. Alike, over a 10-year period with daily surveys on a beach section along the Dutch coast, CAMPHUYSEN & HEUBECK (2001) found positive correlations between deposition rates and the frequency of onshore winds in offshore seabirds in winter. For coastal and migratory land birds, and for offshore species in summer, the abundance at sea explained most of the observed variation in deposition. At the Belgian coast we could demonstrate that species/taxa are more likely to have a random distribution in beaching when they occur further offshore. Offshore species/taxa do not show significant deviations from the expected evenly distributed patterns; inshore species are predominantly found in the neighbourhood of their major wintering sites. Generally spoken, the more offshore a species occur the more likely it is it has been drifting for a while and originates from remote areas.

Another factor that affects the probability of recovery is the size of the bird. During the drift experiments off the Belgian coast, longer-winged birds had a much higher probability to be recovered on the beach. Short-winged taxa (auks, scoters, grebes, waders) were recovered at only 8.3%, whereas small *Larus*-gulls, Fulmar, Great Cormorant, other waterbirds (16.3%), large *Larus*-gulls (25.3%) and Northern Gannet (44.4%) showed markedly higher recovery rates. From our results and from literature findings it is not clear to which underlying factor(s) this difference should be attributed. PIATT *et al*. (1991) mention buoyancy, wind profile, size and colour as possible explanations for higher recovery rates in gull carcasses compared to auk corpses. Accordingly BIBBY & LLOYD (1977) relate the high recovery rates they found for Laridae corpses to their long wings, that enable gulls to float better (than auks) and aid their discovery once ashore. From experiments with wooden drift blocks (three sizes simulating three bird species), HLADY & BURGER (1993) found no significant effect of block size on the distances travelled, suggesting that weight and length of a floating object is not a prime factor. In addition, drift velocities for various bird groups are not that different (see above) and do not seem to explain the important variations in recovery rates. The same applies for methodological influencing factors. BIBBY & LLOYD (1977) mention the strong tendency for birds to be found at weekends and STOWE (1982) found significant differences in recovery for tagged versus ringed corpses. However, since our experiments were all carried out using one single method and since most experiments were performed prior to a longer holiday period, methodological aspects are probably of minor importance in explaining different recovery rates for small versus large birds. We feel the major contributing factors should be looked after on the beach, rather than at sea. Although a better buoyancy and a smaller chance to get scavenged upon might play a role while drifting, the higher detectability and persistence on the beach are possibly much more important.

PERSISTENCE

During winter a bird corpse remains on a Belgian beach for 5.8-13.3 days. This value is similar to results of previous experiments at the Belgian coast in the 1970s: 10 days (KUIJKEN 1978) and 5.8-12.8 days (recalculated from VERBOVEN 1978). This and other persistence experiments in various parts of the world (*Appendix* III) show that mean persistence times are always less than a month and that daily disappearance rates can be as high as 50-60% (PAGE *et al*. 1990; ECI 1991). It follows that the outcome of drift experiments are undoubtedly highly affected by the detection rate and disappearance rates on beaches, probably more than by the drifting behaviour of the corpses at sea. It is also clear that beached bird survey programs carried out at monthly intervals will miss large numbers of birds, having already disappeared before the next count takes place. In a comparison of counts at a mean interval of 9.3 days and 30 days along the Belgian coast, we found that the former resulted in 6.6 times more corpses (a figure in line with a mean persistence time of about 5 days). The fact that small-sized birds persist on average for only 0.7-6.5 days on the beach, medium-sized ones (including auks, seaducks, Fulmar, most gulls) for 5.5-13.1 days and large birds (Northern Gannet, Great Cormorant, divers, Great Black-backed Gull, Grey Heron *Ardea cinerea*) for 13.0-20.8 days, means that beached bird surveys that are carried out at a higher frequency will automatically result in a relatively higher share of small-sized birds (SEYS *et al.* accepted).

Predation (besides detection rate and probability of relocating) is probably the dominant factor leading to the short persistence of small birds (STOWE 1982). Large gulls, Carrion Crows *Corvus corone*, Jackdaws *Corvus monedula* and Magpies *Pica pica* are common scavengers at Belgian flood marks (pers. observations). In Orkney, also Great Skua and Common Rat *Rattus norvegicus* are heavily involved (JONES 1980). CAMPHUYSEN (1988) attributes the discrepancy in persistence of passerines to the swallowing capacity of the larger gulls (to a maximum prey-size of 20 cm). There are indications that scavengers prefer terrestrial, non-marine birds (waders, ducks, passerines), adding to the difference in persistence time between larger (mainly marine) beached birds and small (mainly non-marine) species (SEYS unpublished data). RAEVEL (1992) also indicates a relationship between persistence time and size, and found that the speed and rate of disappearance is greater for unoiled birds through scavenging. Our results can only show a difference between heavily (> 50%) oiled corpses (persistence time: 12.3-20.3 days) and slightly or unoiled birds (6.3-15.6 days), a result also mentioned by TANIS & MÖRZER-BRUIJNS (1962) and BOURNE (1976). An inverse relationship between persistence rate and freshness, as indicated by VAN PELT & PIATT (1995), can not be demonstrated: in our study very fresh and old incomplete corpses seem to have a tendency to shorter persistence times but the relationship is not significant. VAN PELT & PIATT (1995) demonstrated that a corpse of less than four days old has a 6% probability of being encountered four days later, whereas corpses older than two weeks had a much higher probability (86%) to be detected. Probably the important impact of scavengers in their study area is not so much of influence at North Sea coasts (JONES 1980).

There are other factors than removal of corpses by scavengers that affect the outcome of persistence experiments. First of all, the duration of persistence experiments should be long enough (at least 100 days, with controls once a week or more) to avoid artificially low persistence rates. Since fresh corpses tend to disappear rapidly in the first few days of study, studies of longer duration report substantially higher persistence rates (VAN PELT & PIATT 1995). Corpses might be there but remain unnoticed, they can be buried by sand or debris, disappear in rock crevices or be removed by the tides before a surveyor is able to record it. Up to one fifth of the birds present on a rocky beach in Orkney were missed by an observer who was looking hard for beached birds (JONES 1980). VAN PELT & PIATT (1995) indicates burial in beach debris and sand to be the second most important cause of corpses not being rediscovered and JONES (1980) reports 12% of 56 corpses set out on tidelines to be hidden under seaweed after one week. The presence of seaweeds, debris and crevices on rocky substrates result in corpses or wooden drift blocks being found less frequently here than on sand and gravel tidelines (BODKIN & JAMESON 1991; HLADY & BURGER 1993). STUTZENBAKER *et al*. (in HLADY & BURGER 1993) found that only 12% of fifty waterbird corpses placed in exposed positions on vegetation was found by teams of searchers, whereas none of the fifty which were concealed in vegetation was found. Also the colour of the experimental object will influence the detection rate. THRELFALL & PIATT (1982) recovered significantly more orange/yellow drift blocks than black and white ones. An unknown share of corpses gets buried by sand and it seldom occurs that they surface again after stormy weather (VERBOVEN 1978). Moreover, all bird corpses relocated were found at or very near their original position on subsequent days (VERBOVEN 1978; BODKIN & JAMESON 1991). Once deposited, they tend to be static or to be removed altogether (CAMPHUYSEN 1989; VAN PELT & PIATT 1995). Removal of corpses by currents might be more difficult for larger-sized animals.

## OTHER COMPLICATING FACTORS

### *Decomposition*

The decaying process of a bird corpse clearly has an impact on the buoyancy and on how scavengers will deal with it at sea as well as on the beach. Nevertheless, these interrelationships have been poorly studied so far. Corpses that had stayed longer in sea than 28 days in a drift experiment in The Netherlands (KEIJL & CAMPHUYSEN 1992) were in various stages of decomposition, those that were recovered after two weeks were still fresh and complete. At the Belgian coast, offshore species are on average in a more advanced stage of decomposition than inshore taxa when they beach and beached corpses of Common Guillemot become gradually more rotten in the course of the winter. Tests with shearwater corpses in a floating cage in an Australian lake at water temperatures of 20°C resulted in disarticulation of carcasses in 7-10 days (WOOD unpubl. data in WOOD 1996) and JONES (1980) found 89% of the auks arriving on the beach as whole corpses, compared to 25% for Kittiwake. He attributed a gradually smaller share of juveniles of Kittiwake away from their natal Orkney colonies as an indication for a more rapid disintegration of juvenile corpses. All these data suggest that most bird corpses decompose in seawater in a few weeks time. How temperature affects this decomposing process and hence the buoyancy is unknown. Experiments in northern America indicate that buoyancy of heavily oiled auks decreases with time, with freshly oiled alcid carcasses sinking at rates of 15% per day (BURGER 1991; FORD *et al*. 1987). These results suggest that they stop floating rather early in the decaying process.

Once on the beach, decomposition continues, making corpses less attractive for scavengers. TANIS-MÖRZER-BRUIJNS (1962) performed a comprehensive study of the persistence of sea- and coastal bird corpses in The Netherlands and found differences in persistence time to depend largely on size. Considering one single species (Common Scoter), they found humidity to be a prime factor in the persistence of a corpse. Persistence was shortest in a stormy and rainy winter (18 days) or summer (20 days) and longest during frost periods (39 days) or in dry, hot summers (47 days). Under optimal conditions, bird corpses can remain identifiable for months, sometimes even years (CADBURRY 1978; JONES 1980; BIBBY 1981; STOWE 1982, SEYS *et al* this study), but only if left almost completely undisturbed (JONES, 1980). WOOD (1996) reports on deterioration tests with shearwater corpses on an Australian beach in a hot (18-25°C) and rainy climate. In three weeks time all sixteen corpses could still be identified and only one was partly broken into pieces. Certain taxa might be more prone to decomposition than others. Divers and Northern Gannet often seem hardly to change, perhaps because their feather structure and tough skin slows the process of decay (JONES 1980).

### *Numbers of seabirds at sea*

Many researchers tried to correlate beached bird numbers with various measures of intensity and/or frequency of onshore winds. Some were quite succesful (BIBBY & LLOYD 1977; KUIJKEN 1978; VERBOVEN 1979; STOWE 1982; CAMPHUYSEN & HEUBECK 2001; SEYS *et al* this study), others failed (JONES 1980). The best results are obtained when densities of seabird corpses on the beach are correlated with wind conditions in a 12-15 days period before the beached bird survey. That the results are not even better should be attributed to small-scale variations in beach exposure and currents, and to continuous variations in the stock of live and dead seabirds at sea. Provided a delay between the death of a bird and its subsequent stranding on the beach is taken into account, consistent temporal patterns can be found (CAMPHUYSEN & VAN FRANEKER 1992; SEYS *et al* this study). On a spatial scale, correlations are much harder to demonstrate due to the time-lag between the moment a bird gets sick and the time it washes ashore. Contaminated seabirds (JOENSEN & HANSEN 1977; CAMPBELL *et al*. 1978; STANDRING & STOWE 1981) or birds that suffer from food-shortage (SEYS 1993) often wander long distances before dying. In addition to the wind climate, variability in currents and beach exposition may contribute to the final distribution of beached corpses (VAUK *et al*. 1989; STRATFORD & PARTRIDGE 1993; SKOV *et al*. 1996; WOOD 1996). Particularly near to the shore, the effects of tides and currents are likely to be greater, and probably act to delay beaching (STOWE 1982). At the short Belgian coast, VERBOVEN (1979) linked the spatial distribution of beach-cast birds with the current velocity at 4-6 km from the shoreline. He found that small-scale differences in beaching intensity could be explained by a gradual increase in current velocity towards the Schelde estuary in the east (reducing the number of beached corpses) and very local conditions inforcing (low densities at NPOO due to a 5 km beach section entirely submerged at every high tide) or counteracting (high densities at OOZB, because of the accumulating effect of the piers of the outer harbour of Zeebrugge) this general pattern. In addition the increasing beach slope at the east coast (DUFOURMONT 1979) possibly hampers stranding of corpses here. These small-scale effects should be taken into account when a beached bird programme is developped or when a persistence experiment is set up. Unpublished results of a detailed persistence experiment in February-March 2000 (observations F. Bauwens & J. Seys) demonstrate how important it is to choose the experimental site properly and to spread the experiment over a longer beach section. Daily controls of corpses on a 1 km beach section near Lombardsijde (clearly a 'sink' rather than a 'source') were interrupted after one and a half month, with more than 90% of the corpses still on the spot.

## IMPLICATIONS FOR THE USE OF BEACHED BIRD SURVEY DATA

Bird corpses can travel hundreds, even thousands of kilometres before they wash ashore (BIBBY 1981). Off the Belgian coast a dead bird drifts on average at a speed of 12 km a day, taking into account it moves at 2.5-3% of the wind speed and wind speeds in winter amount to 20 km $h^{-1}$ here. With stronger winds blowing from one direction, displacements of 200 km a week should not be exceptionally. Considering the short Belgian shoreline and the prevailing frequency distribution of winds, probably only 10% of all birds washing ashore died in Belgian marine waters. With a dominant SSW circulation and a net residual current in northeastern direction, many birds must end up on Dutch, German or Scandinavian beaches. More generally, floating objects released in the Southern North Sea and along the eastern coast of the United Kingdom have a high probability to be drifted to the east (unless they sink)(TOMCZAK 1964; CLARK 1984; CAMPHUYSEN *et al.* 1988; CARLBERG & STAHRE 1994; DAHLMANN *et al*. 1994). Accordingly, there is a higher probability that Belgian beaches receive birds that died in northern France or south-England than from other North Sea border states. At the Belgian coast there are on average five days with winds blowing offshore or parallel to the shoreline in between every period of onshore wind. During this period and under average wind contions (SW-W 20 km h-1) a bird corpse will be displaced over 60 km in northeastern direction. Therefore, trying to monitor the impact of local activities on birds (such as hunting, the use of gill-nets or the development of wind parks) will definitely fail if there is not enough ommunication with other beached bird programmes in neighbouring countries.

Furthermore, we believe that there is a need for more drift and persistence experiments and more detailed modelling exercises in order to fully understand what a bird corpse does from the moment it dies until a surveyor is finding it on the beach. Some general patterns are known already and these results indicate that at least on a local scale, a computer-based model might usefully be developed to predict densities of corpses on beaches using wind data. Such a model should include chances of sinking, scavenging upon by gulls and other animals, beaching and loss of corpses from the beach before they can be counted (STOWE 1982; PIATT *et al*. 1991; WIESE & RYAN 1999). In particular it should pay attention to differences in behaviour of oiled and unoiled corpses (probably affecting oil-rates recorded on beaches) and to sinking behaviour. We know that after several weeks a bird corpse sinks, where it might be recovered caught in trawls or lost nets (JONES *et al*. 1970; SEYS *et al* this study). We also have evidence from corpses washing ashore although wind is blowing strongly offshore (KEIJL & CAMPHUYSEN 1992), a phenomenon well-known among beachcombers. However, we do not know how important these bottom streams are in bringing (older) carcasses to the beach. Floating experiments should be developed to find out at which critical stage a corpse sinks, how deep it sinks and what happens with it on the bottom of the sea. Working with artificial corpses (preferably radio-tagged) should further be explored to enhance the capacity of experimental work and contribute to our understanding of bird corpse drift. Once an operational model is developed and calibrated, it can be tested in case of mass strandings of seabirds. However it is advisable to organise a drift experiment at any larger incident, the way it happened at events of exceptional mortality in the past (COULSON *et al*. 1968; LLOYD *et al*. 1974; JONES *et al*. 1978; PIATT *et al*. 1990; COLOMBÉ *et al*. 1996) in order to check the drift results against the predicted results (BURGER 1993).

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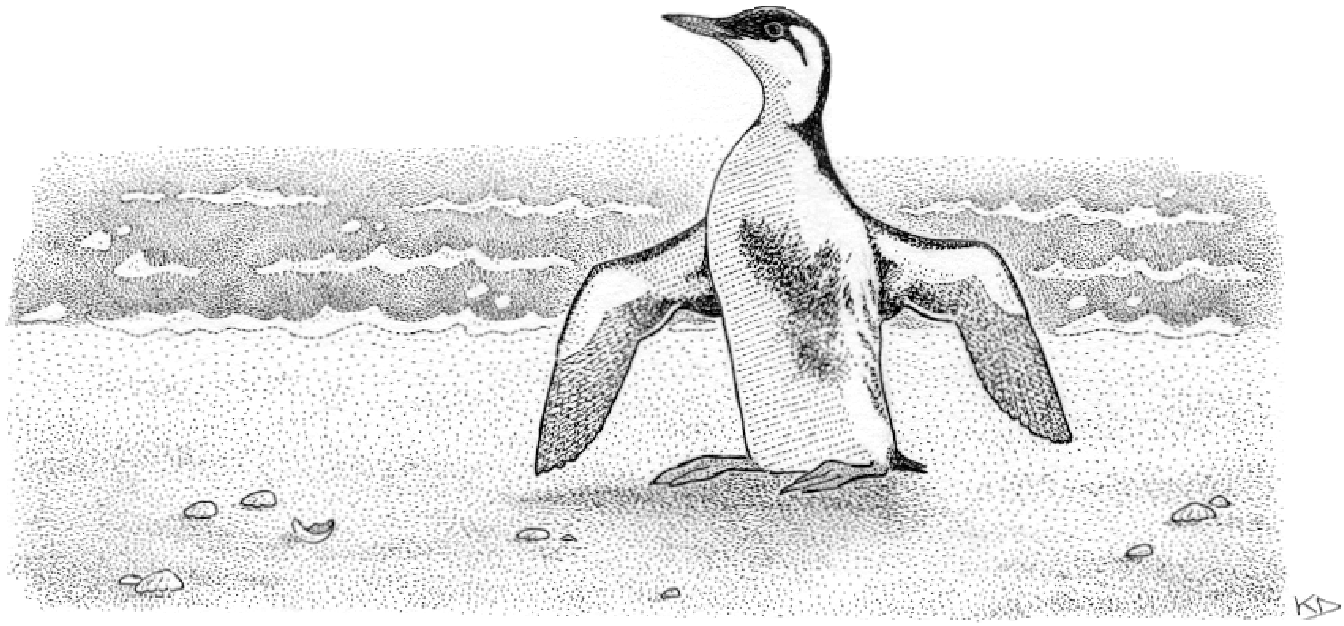
# CHAPTER SIX

## LONG-TERM CHANGES IN OIL POLLUTION OFF THE BELGIAN COAST: EVIDENCE FROM BEACHED BIRD MONITORING



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*Jan Seys[1*], Henk Offringa[2], Jeroen Van Waeyenberge[1], Patrick Meire[3] & Eckhart Kuijken[1]*

*[1] Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
*[2] Ministry of Transport, Public Works and Water Management, Directorate General of Public Works and Water Management, North Sea Directorate, P.O.Box 5807, 2280 HV Rijswijk, The Netherlands*
*[3]University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
*[*] present adress: Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

# Long-term changes in oil pollution off the Belgian coast: evidence from beached bird monitoring

J. Seys, H. Offringa, J. Van Waeyenberge, P. Meire & E. Kuijken

## ABSTRACT

Trends in oil pollution in the southernmost (Belgian) part of the North Sea were analysed using a dataset of 37 years (1962-99) of annual national beached bird surveys in February. The most abundant seabird groups were auks (31%), gulls (28%), scoters (17%) and Kittiwake (9%). Oil rates of most bird species/taxa indicate a decline in oil pollution, though only *Larus*-gulls, Common Guillemot and Razorbill show significant reductions. For the other taxa no significant decrease in proportion of oiled birds could be demonstrated, often due to the relatively small study-area and hence insufficient number of birds collected. The slope in the linear decreasing trend is steeper in inshore and midshore species, than in offshore species. A power analysis of the results demonstrated that statistical significant trends were expected with annual indices within 17 years for Razorbill, 29 years for *Larus*-gulls and 31 years for Common Guillemot. For other species/taxa, at least 50 years of surveying would be required. In terms of densities of beached birds four separate periods, coinciding with the decades, can be distinguished. In both the 1960s and 1980s large numbers washed ashore. Divers, Northern Gannet, Eider/scoters and gulls, dominated the 1960s whilst the latter period was characterised by high densities of Common Guillemot and Kittiwake. In the 1970s, the total densities of all species remained surprisingly low. Likewise, after a peak in 1990, numbers levelled off in the following years, except for some important wrecks of Common Guillemot and Fulmar. Over the entire study period densities declined for most species, but only significantly for divers, Northern Gannet, scoters, Coot, skuas and *Larus*-gulls. The Common Guillemot is the only species that increased significantly in density throughout the study period. We conclude that long-term oil pollution monitoring in Belgium should be continued but only in an international context and with a major focus on a set of abundant bird taxa, sensitive to oil-pollution and occurring in various marine habitats. Most appropriate for this purpose are grebes (inshore), *Larus*-gulls, Common Guillemot, Razorbill (midshore), Kittiwake and Fulmar (offshore).

## INTRODUCTION

Seabirds are highly vulnerable to surface pollutants. The sporadic occurrence of large numbers of sea- and coastal bird corpses on North Sea beaches had been noted over a century ago (GRAY 1871, ANONYMOUS 1876). Nowadays estimates of illegal oil input in the North Sea range from 15,000 tonnes per year to as much as 60,000 tonnes (PEET 1993). The governments of North Sea countries endeavoured to seize the contamination of the marine environment by subscribing international agreements (OILPOL, MARPOL 73/78 and Bonn 1983), in which they agreed to take measures for prevention and surveillance. Despite the execution of the accompanying laws (MARPOL was extended with an act of enforcement in Belgium in 1995), important numbers of oiled birds continued to wash ashore on North Sea beaches during the 1980s and early 1990s (DUNNET 1987, CAMPHUYSEN 1989, CHRISTENSEN 1989, SKOV *et al*. 1989, VAUK *et al*. 1990, HEUBECK *et al*. 1992, RAEVEL 1992). Oil slicks are particularly common in the shipping corridor between the Straits of Dover and the German Bight (OSPAR COMMISSION 2000), including the Belgian marine waters. As from 1 August 1999, the North Sea has been established as a Special Area under MARPOL *Annex I* (oil), meaning that every discharge of oil is illegal.

Oil pollution at sea is basically monitored in two different ways: beached bird surveying and aerial surveillance of oil slicks. Both methods have some drawbacks and should be considered complementary. However airborne surveillance catches only a small fraction of the shortly exposed oil slicks (SCHALLIER *et al*. 1996), is costly and seriously hampered in adverse weather conditions. Counting stranded birds and scoring the proportion of the corpses that are oiled is an indirect but effective method. Beached bird surveys provide relatively cost-effective and 'all-weather' additional information on the occurrence of oil and the frequency of illegal spills that could not be collected from the air. Hence beached bird surveying was acknowledged at the 4th International ministerial Conference on the Protection of the North Sea (8-9 June 1995) at Esbjerg (Denmark) as a useful oil-monitoring tool. In Belgium aerial surveillance started in 1991 (JACQUES *et al*. 1991). In this short period of monitoring no trends could be discerned so far (DI MARCANTONIO 1999). Beached bird surveying has a much longer tradition here and first standardized data go back as far as 1962. With Belgian data obtained at the annual International Beached Bird Surveys (IBBS) in February 1962-1999, we will investigate whether trends in densities and oil rates of sea- and coastal birds can be demonstrated and if any policy action undertaken under MARPOL or Bonn has resulted in less pollution so far. An analysis of oil rates in various taxa of seabirds can shed light on the impact of oil pollution in onshore versus offshore marine waters.

## MATERIAL AND METHODS

### STUDY AREA

The part of the sea under Belgian jurisdiction (further referred to as the Belgian marine waters) is heavily exploited by various users (MAES *et al*. 2000). Situated at the entrance of the Channel, this area is characterised by a very intensive and still increasing shipping traffic (OSPAR COMMISSION 2000) and by high densities of sea- and coastal birds, migrating to and from the Channel (SEYS *et al*. submitted).

The Belgian shoreline has a length of 65.4 km, of which 3.3 km is situated in between the moles of the outer harbour of Zeebrugge (constructed in 1974-86). Narrow, sandy beaches prevail, with broad beaches restricted to the west coast near De Panne (± 3 km) and at both sides of the Zeebrugge harbour piers (± 1 km). Breakwaters are a characteristic feature at the Belgian shoreline (on average at every 200-400 m). More than half of the entire length of the coast (34 km) is bordered with buildings and boulevards (Fig. 1) and many beaches are frequently cleaned, particularly during summer. The tidal range amounts to 3-5 metres. Tidal currents are oriented parallel to the coast and attain maximal velocities of 1.7 knots at spring tide and 0.6 knots at neap tide. There is a small net residual NE-circulation through the Straits of Dover. With persistent strong winds however, the wind-induced currents may approach or even exceed the rate of tidal streams. Persistent W or SW gales can produce an overall movement of surface water as high as 35 miles over a period of 24 hours. The prevailing wind direction in Oostende (as compiled from meteorological data in the period 1941-1992) is S-SW (BELL 1994).

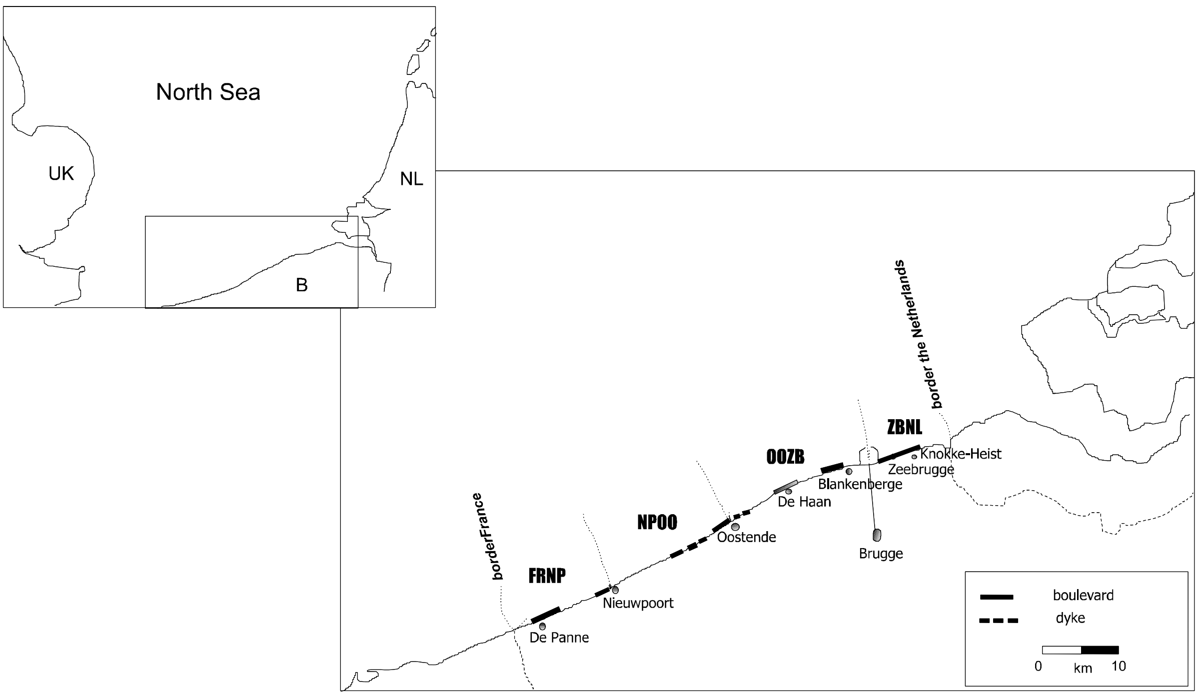


*Fig. 1. Study-area showing the boundaries of the beach sections used in Belgian beached bird surveys.*

### HISTORY

In Belgium the first occasional counts of beached birds go back as far as the 1950s and early 1960s (KESTELOOT 1953, HAUTEKIET 1955, 1956, 1961, 1965, DE RIDDER 1961, HOUWEN 1968). Counts of the entire Belgian coastline were coordinated by Kuijken from 1962 onwards and extended to substantial parts of the Dutch and northern French coasts in 1965 (BLANKENA & KUIJKEN 1967). This was the earliest step towards the International Beached Bird Surveys (IBBS), at first supervised by Belgian and Dutch Youth Organisations for Nature Studies (BJN and NJN). Pioneers as KUIJKEN & ZEGERS (1968), KUIJKEN (1978a,b) and VERBOVEN (1978, 1979) published early reviews of time series on Belgian data. A period of centrally governed counts was concluded with counts coordinated by MEIRE (1978a,b). The 1980s were characterised by many individual actions, instigated by several large seabird strandings (DE WAELE 1981, VAN GOMPEL 1981, 1984, 1987, VERBOVEN 1985, SHERIDAN & PAMART 1988). From the winter 1991-92 onwards, beached bird surveys were centralised again, now by the Institute of Nature Conservation (SEYS & MEIRE 1992). Since then, annual updates are available (SEYS & MEIRE 1993, SEYS *et al*. 1993,1999, OFFRINGA & MEIRE 1995, OFFRINGA *et al*. 1995,1997.

## DATA COLLECTION AND ANALYSIS

In many countries bordering the North Sea, the Channel, the Bay of Biscay and the Baltic, IBBS are organised annually in late February. Beached bird corpses are searched for at the high water mark and bodies are checked for species, age, condition and (for complete corpses) the presence of oil. The output of the surveys is a list of birds, containing information on the distance covered and the number of oiled and clean birds. All results have been centralized by the Royal Society for the Protection of Birds (Sandy, England; 1972 to 1985) and later by Ornis Consult (Copenhagen, Denmark; from 1992 onwards) to be included in an international database. For the study-period 1962-99, the Belgian IBBS database includes a surveyed overall distance of 1976 km. From 1962 till 1979, and again from 1990 onwards, the February counts covered a major part of the entire coastline. During the 1980s the effort decreased and ranged from 7.1 km to 50.5 km (*Appendix VIIIa-d*). Although the effort in 1981 was small, the results are considered not unreasonable and retained. No results for 1980 were available. Throughout the entire study period the coastal villages and towns served as boundaries for different beach sections (Fig. 1). Despite the expected strong coherence among the relatively short and close sections, local differences in strandings exist (SEYS *et al*. 1993, OFFRINGA *et al*. 1995). The problem manifested in years with incomplete coverage when surveys were biased to specific beach stretches (1980s). A correction factor for every section was calculated by comparing the section density with the mean density of the entire Belgian coast ($d_{coast}/d_{transect}$). The factors are mean values of 20 years of IBBS in Belgium, in which all beach sections were covered (Table 1). They were applied to the density values in years with incomplete coverage, by taking the average of the factors of corresponding (combinations of) beach sections.

*Table 1. Correction factors for Belgian beach sections, based on 20 complete IBB surveys during 1962-1999.*

| Beach section | Code | Correction factor |
|---|---|---|
| French border - Nieuwpoort | FRNP | 0.69 |
| Nieuwpoort – Oostende | NPOO | 1.14 |
| Oostende - Zeebrugge | OOZB | 0.90 |
| Zeebrugge – Dutch border | ZBNL | 2.14 |

Grouping of species in taxa roughly follows STOWE (1982) and CAMPHUYSEN (1989). We focus on birds that occupy different habitats and are unequally vulnerable for oil pollution: divers (Red-throated Diver *Gavia stellata* and Black-throated Diver *G.arctica*), grebes (Great-crested Grebe *Podiceps cristatus*), Fulmar (*Fulmarus glacialis*), Northern Gannet (*Morus bassanus*), Eider (*Somateria mollissima*), scoters (Common Scoter *Melanitta nigra* and Velvet scoter *M.fusca*), Coot (*Fulica atra*), waders, skuas (Great Skua *Stercorarius skua*, Pomarine Skua *S.pomarinus*, Arctic Skua *S.parasiticus*), *Larus*-gulls, Kittiwake (*Rissa tridactyla*), Common Guillemot (*Uria aalge*) and Razorbill (*Alca torda*). Total numbers are of little value when comparing years with different effort, change in environmental conditions, etc. This is accounted for by using 'N $km^{-1}$' (density), and 'oil rate' (the proportion of complete bird corpses with oil: $N_{oiled}/N_{all\ birds}$ * 100%). The latter is widely accepted as a good condition indicator of oil pollution (SKOV 1991, CAMPHUYSEN 1993, 1995, 1998), and is presumably only influenced by post mortal contamination or rejection by scavengers. Oil rates were calculated on less than 10 complete bird corpses (SKOV *et al*. 1996). Trends in oil rates were calculated after logit-transformation of the data by means of linear regression (by least-squares estimation), conform CAMPHUYSEN (1995). The power (*1-ß*) or the probability that a trend, if present, will be detected as statistically significant, is studied by means of a power analysis (NETER *et al.* 1990). The power depends on the size of the trend (slope *b*), the error variance (*rms*), the sample size (number of years, *N*) and the size of the test (*a*). Clusters of closely related years or taxa are revealed with multidimensional scaling (KRUSKAL & WISH 1978), which was applied on bird densities by mapping distances in pairs of Bray-Curtis similarities between years. The hypothesis for a priori defined groups is tested with ANOSIM (CLARKE & WARWICK 1993). The overall association in densities and oil rates over the years is ascertained by Kendall's Coefficient of Concordance (SIEGEL 1959).

## RESULTS

OVERALL TREND IN DENSITY AND OIL RATE OF BEACHED BIRDS

The total (non-corrected) numbers, effort and oil rates are summarized in *Appendices VIIIa-d* and Table 2. A total of 6743 birds of 80 different species have been recorded at Belgian IBB surveys during 1962-99. The Shannon-Wiener diversity index decreased significantly over the years (Kendall $t$ =-0.285, $N$=37, $P$<0.05), whilst the effort did not go down significantly ($t$ =-0.221, $N$=37, $P$=0.051).

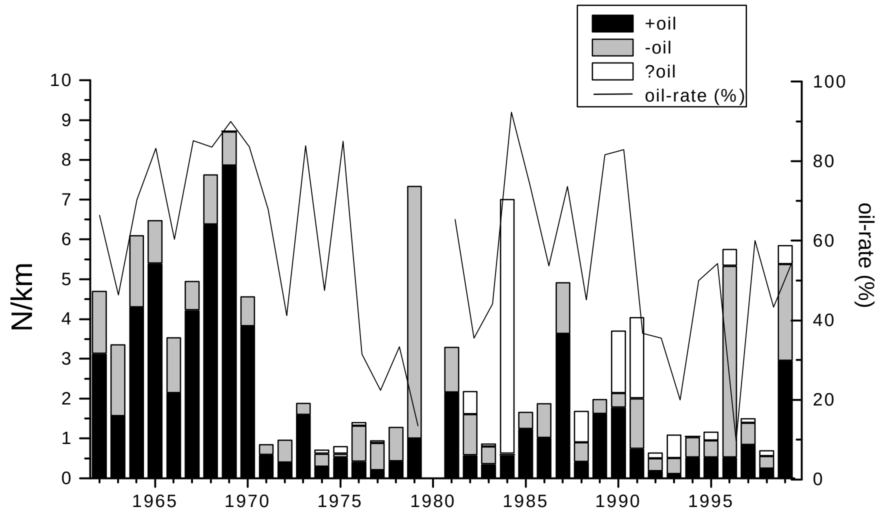


*Fig. 2. Densities (bars) and oil rates (line) of all beached birds collected during IBB surveys in Belgium during 1962-99. Densities are subdivided into 'oiled', 'unoiled' and 'not scored' specimens.*

The total density of beached birds does not show a significant linear trend during the study-period ($R^2$=0.041, *rms*=11.7, $b$=-0.06, $N$=37, $P$=0.23). However four discrete periods can be demonstrated, coinciding more or less with the four decades: group 1: 1962-69, group 2: 1970-79, group 3: 1981-89 and group 4: 1990-99 (Fig. 2). The 1960s were characterised by high densities (average 5.7, *SD* 1.9 birds km$^{-1}$) and high oil rates (average 73.2, *SD* 15.0%). In the 1970s the situation had changed impetuously (2.1, *SD* 2.2 birds km$^{-1}$ and 51.0, *SD* 27.1%), but by the end of that decade numbers slowly increased again. The agony of the 1960s was repeated in the 1980s, but now the birds came in pulses (2.8, *SD* 2.0 birds km$^{-1}$ and 62.8, *SD* 19.2%). The densities were slightly reduced again in the 1990s (2.6, *SD* 2.1 birds km$^{-1}$) and oil rates markedly declined (44.7, *SD* 20.8%).

*Table 2. Total number of birds collected per taxon during IBBS in Belgium and mean oil rates (calculated as the cumulative N+oil/Ntot *100 for the entire period 1962-99).*

| Taxon | *N* | oil rate (overall) |
|---|---|---|
| auks | 1641 | 84 |
| *Larus*-gulls | 1465 | 53 |
| scoters | 887 | 88 |
| Kittiwake | 450 | 74 |
| waders | 454 | 4 |
| grebes | 330 | 67 |
| Coot | 348 | 26 |
| Fulmar | 268 | 48 |
| others | 527 | 6 |
| divers | 124 | 94 |
| other waterbirds | 139 | 32 |
| Northern Gannet | 71 | 91 |
| Eider | 23 | 76 |
| other seaducks | 9 | - |
| skuas | 5 | - |
| Cormorant/Shag | 2 | - |

A MDS of Bray-Curtis similarities between densities with 18 taxa in 37 years confirmed this global picture (stress=0.141). Ignoring some odd data from severe winters with lots of cold victims, we find four clusters that agree for the greater part with our postulation (Fig. 3). Taxa are clustered according to their sensitivity to severe winter weather (e.g. Coot, waders) and the likelihood to occur in 'wreck'-conditions (e.g. Kittiwake, Common Guillemot, Fulmar)(Fig. 4). Pair-wise comparison of groups in 5000 random labelling, showed in all but one case significant greater distances between groups than within groups (ONE-WAY ANOSIM, group 1 *vs.* 2: $R$=0.537**, 1 *vs.* 3: $R$=0.424**, 1 *vs.* 4: $R$=0.557***, 2 *vs.* 3: $R$=0.288**, 2 *vs.* 4: $R$=0.426*** and 3 *vs.* 4: $R$=0.002 $^{n.s}$., with: ***$P$<0.001, ** $P$<0.01, * $P$<0.05, $^{n.s.}$ non significant). In other words: based on density data the a priori defined groups are not unlikely. Only the difference between the 1990s and 1980s in terms of densities is not significant. These two periods however are clearly different in the proportion of oiled versus unoiled birds. Best discriminating taxa between the assumed clusters were scoters, *Larus*-gulls, Kittiwake and Common Guillemot. They account for most of the dissimilarity between subsequent periods (Table 3). Scoters and *Larus*-gulls were most abundant as beached birds during the 1960s; Kittiwake and Common Guillemot were particularly common in the 1980s (and 1990s for the Common Guillemot).

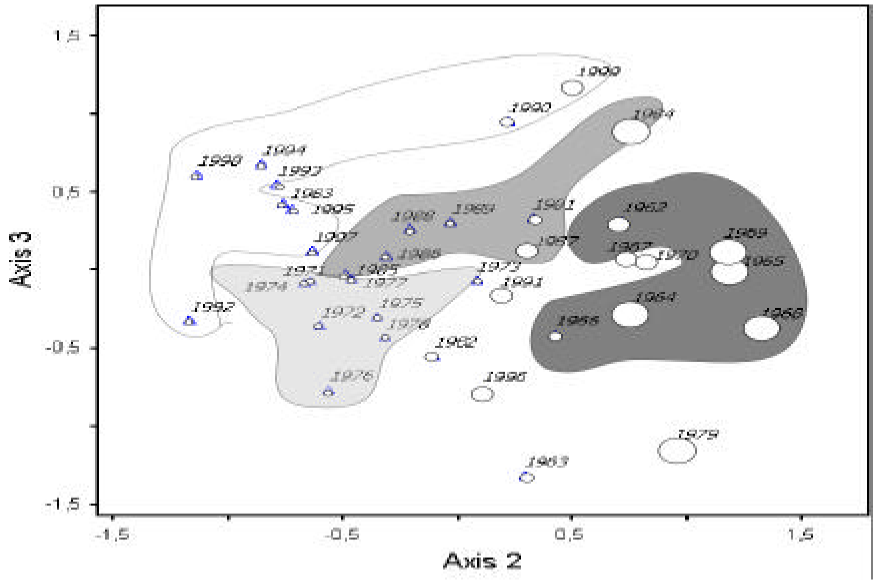


*Fig. 3. MDS ordination of total densities of beached birds during 1962-99, indicating clusters of winters (fitted by eye). Circle sizes reflect total densities.*

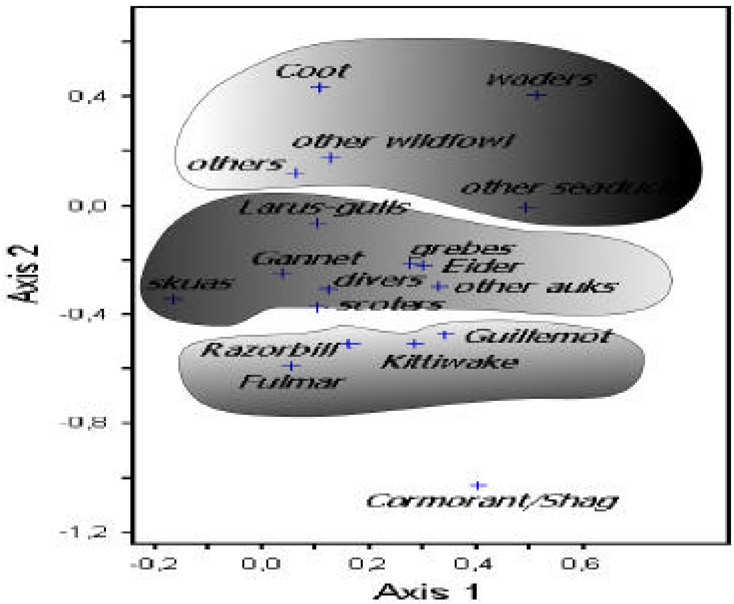


*Fig. 4. MDS ordination of total densities of beached birds during 1962-99, indicating clusters of taxa (fitted by eye).*

*Table 3. Average abundance per group of most distinctive species in BBS. The ? denotes a contribution of > 10% to the total dissimilarity between subsequent periods. Average dissimilarities (Bray-Curtis) between 1 and 2: 65.93, between 2 and 3: 59.08, between 3 and 4: 55.42.*

| Taxon | 1 (1962-69) | 2 (1970-79) | 3 (1981-89) | 4 (1990-99) |
|---|---|---|---|---|
| divers | 0.16 | 0.03 | 0.03 | 0.02 |
| grebes | 0.19 | 0.16 | 0.21 | 0.10 |
| Fulmar | 0.27 | 0.03 | 0.10 | 0.18 |
| Northern Gannet | 0.10 | 0.02 | 0.02 | 0.01 |
| Eider | 0.02 | 0.00 | 0.02 | 0.02 |
| scoters | 1.23 ? | 0.22 | 0.21 | 0.07 |
| Coot | 0.29 | 0.20 | 0.03 | 0.01 |
| waders | 0.12 | 0.13 | 0.14 ? | 0.46 |
| skuas | 0.01 | 0.00 | 0.00 | 0.00 |
| *Larus*-gulls | 1.52 ? | 0.65 ? | 0.44 ? | 0.29 |
| Kittiwake | 0.42 | 0.11 ? | 0.48 ? | 0.14 |
| Common Guillemot | 0.56 | 0.10 ? | 0.78 ? | 1.00 |
| Razorbill | 0.48 | 0.20 | 0.28 | 0.16 |

## ONSHORE VERSUS OFFSHORE BIRD TAXA

*Larus*-gulls, Northern Gannet, scoters and divers significantly decreased in densities at IBB surveys during 1962-99. The Common Guillemot is the only common species that became significantly more abundant during the study-period (Table 4, Fig. 5). Taxa or species that do not show significant trends appear to be either offshore species (Fulmar, Kittiwake, skuas) or birds known to be sensitive to cold winter weather (Coot, grebes, waders).

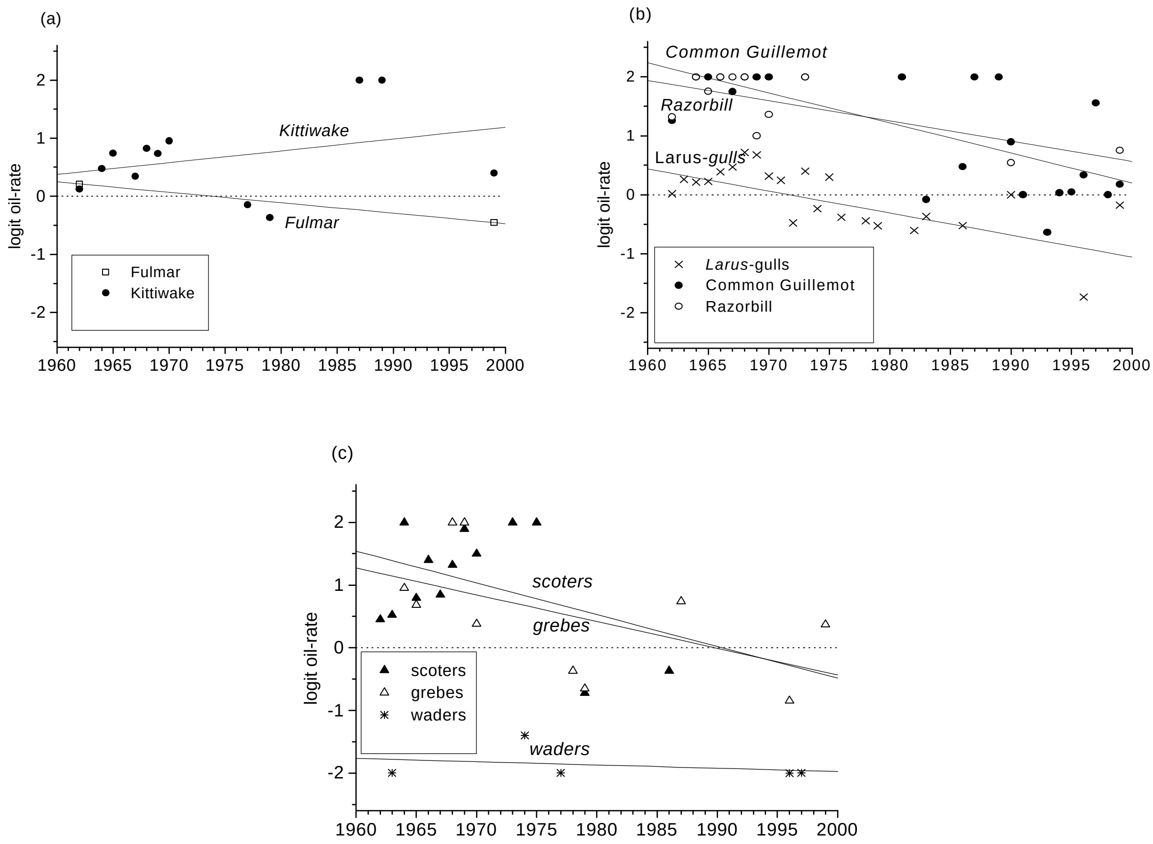


*Fig. 5. Trends in oil rate of sea- and coastal bird groups in Belgium based on results of February IBB surveys during 1962-99. Trends for an offshore (a), midshore (b) and inshore group of species are shown.*

Oil rates of two typically offshore species, the Fulmar and the Kittiwake did not change significantly during the 37 years of study, although lowest values were recorded for both species in the 1990s (Table 4). Two groups of birds that are very common at 10-30 km from the shoreline, the *Larus*-gulls and the Common Guillemot, show significant declines in oil rate. The oiling among gulls was heaviest in the 1960s (70%) and decreased to 12% in the 1990s. The average oil rate in the Common Guillemot was higher, both in the 1960s (99%) and in the 1990s (66%). The decline in oil rate in the Razorbill – a species occurring in the same wintering areas as the Common Guillemot - was less pronounced but still significant (1960s: 96%, 1960s: 72%). Inshore and coastal species all show lower oil rates now than some forty years ago, though none of the trends were significant (Table 4). That this should be attributed to the sample size, being too small to reveal trends, can be demonstrated with a power analysis. For waders, grebes and scoters we need at least 50 years of surveying to get a 90% probability to find an existing trend (Fig. 6). Only for Razorbill (17 years), *Larus*-gulls (29 years) and Common Guillemot (31 years), the international BB surveys can already produce significant trends at a 90% probability.

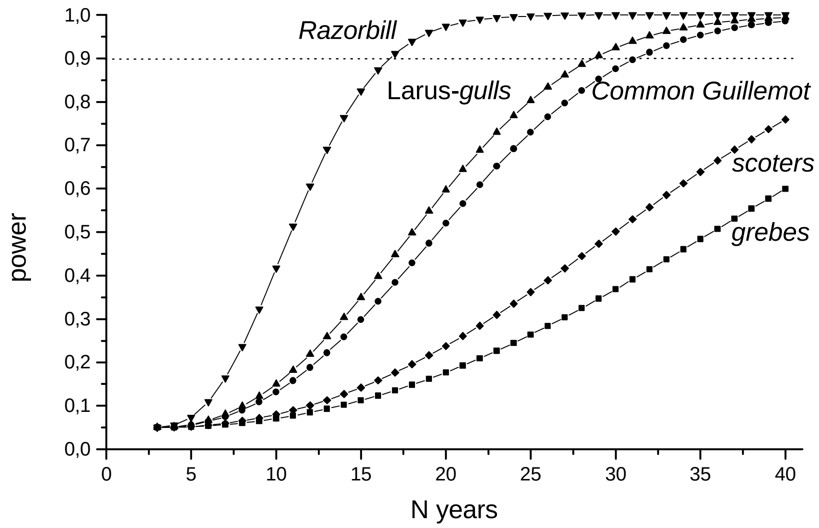


*Fig. 6. Power of trend test of oil-rates in seabird taxa versus number of years sampled based on IBB surveys at the Belgian coast in February during 1962-1999.*

The slopes of the linear regression in various species confirm the general pattern of oil rates for offshore birds decreasing less quickly than for inshore and midshore species. It can be concluded that densities of most beached bird species are much smaller now than in the past, and that oil rates show consistent declines that are more prominent in coastal, inshore and midshore bird species than in offshore taxa.

*Table 4. Trends in (a) densities (N km$^{-1}$) and (b) logit-transformed oil rates of sea- and coastal bird taxa at the Belgian coast during the winters of 1962-99. Shown are mean values of densities and non-transformed oil rates by decade and linear trends (*rms*= residual variance;* b*=slope of regression;* $R^2$*;* N*=number of winters; significance= n.s.: non significant, *: P<0.05, **: P<0.01, ***: P<0.001).*

| (a) | Density (N km$^{-1}$) by decade | | | | trend | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Taxon | 1960s | 1970s | 1980s | 1990s | *rms* | slope *b* | $R^2$ | *N* | *P* |
| divers | 0.19 | 0.05 | 0.05 | 0.03 | 0.008 | -0.004 | 0.228 | 37 | ** |
| grebes | 0.19 | 0.17 | 0.27 | 0.10 | 0.053 | -0.003 | 0.020 | 37 | n.s. |
| Fulmar | 0.31 | 0.04 | 0.13 | 0.23 | 0.118 | -0.001 | 0.002 | 37 | n.s. |
| Northern Gannet | 0.11 | 0.03 | 0.05 | 0.02 | 0.002 | -0.002 | 0.276 | 37 | *** |
| scoters | 1.23 | 0.22 | 0.21 | 0.08 | 0.411 | -0.029 | 0.212 | 37 | ** |
| Coot | 0.33 | 0.33 | 0.08 | 0.02 | 0.249 | -0.009 | 0.040 | 37 | n.s. |
| waders | 0.12 | 0.17 | 0.21 | 0.57 | 0.312 | 0.011 | 0.045 | 37 | n.s. |
| skuas | 0.02 | 0.02 | 0.03 | 0.00 | 0.000 | -0.000 | 0.075 | 37 | n.s. |
| *Larus*-gulls | 1.52 | 0.65 | 0.44 | 0.29 | 0.444 | -0.035 | 0.268 | 37 | ** |
| Kittiwake | 0.42 | 0.11 | 0.54 | 0.16 | 0.189 | -0.004 | 0.009 | 37 | n.s. |
| Common Guillemot | 0.56 | 0.10 | 0.78 | 1.00 | 0.456 | 0.021 | 0.110 | 37 | * |
| Razorbill | 0.48 | 0.20 | 0.32 | 0.18 | 0.136 | -0.009 | 0.074 | 37 | n.s. |

| (b) Taxon | Oil rate (%) by decade 1960s | 1970s | 1980s | 1990s | trend *rms* | slope *b* | $R^2$ | *N* | *P* |
|---|---|---|---|---|---|---|---|---|---|
| divers | 99 | 93 | 50 | - | - | - | - | 2 | - |
| grebes | 88 | 55 | 76 | 42 | 0.755 | -0.043 | 0.305 | 10 | n.s. |
| Fulmar | 53 | 75 | 40 | 45 | - | - | - | 2 | - |
| Northern Gannet | 99 | 75 | - | - | - | - | - | 2 | - |
| scoters | 89 | 71 | 83 | 55 | 0.746 | -0.051 | 0.153 | 13 | n.s. |
| Coot | 47 | 3 | - | - | 0.079 | -0.100 | 0.902 | 4 | n.s. |
| waders | 18 | 10 | 0 | 1 | 0.088 | -0.005 | 0.082 | 5 | n.s. |
| *Larus*-gulls | 69 | 41 | 22 | 20 | 0.315 | -0.037 | 0.318 | 24 | ** |
| Kittiwake | 76 | 59 | 93 | 62 | 0.527 | 0.020 | 0.105 | 12 | n.s. |
| Common Guillemot | 99 | 84 | 82 | 61 | 0.474 | -0.051 | 0.492 | 23 | *** |
| Razorbill | 98 | 88 | 92 | 64 | 0.163 | -0.034 | 0.521 | 11 | * |

## DISCUSSION

### QUALITY OF THE DATA

In IBB surveys during the 1980s the Belgian beaches were not completely covered. Hence, geographical differences may influence the outcome of the survey. RAEVEL (1992) demonstrated that a minimum of 25-30% of the (Nord-Pas-de-Calais to Picardie) coastline must be surveyed to get reliable densities and oil rates for the whole coast. Accordingly SEYS *et al* (accepted) found oil rates of Common Guillemot to stabilize above a sample of 10-15 bird corpses, a figure corresponding to a mean surveyed distance of 25-30 km (or 40-50% of the entire Belgian coast). More than half of the coast, some 65%, (RAEVEL 1992, SEYS *et al.* accepted) must be covered to approach the actual species richness. These figures underscore the necessity to put substantial effort in the beach surveys. This is normally met in Belgian BBS, but put the results of years with low effort (1981, 1984, 1985, 1987) in question.

### OIL POLLUTION TRENDS IN THE NORTH SEA

In many countries bordering the North Sea, long-term trends in oil pollution have been described, as derived from the proportion in beached birds with oil (STOWE 1982, AVERBECK *et al*. 1992, HEUBECK 1995, SKOV *et al*. 1996, FLEET & REINEKING 2000, CAMPHUYSEN & HEUBECK 2001). Measurable declines have been observed in several species along the north-east English and Scottish coasts, in south-east England, in parts of Denmark (see SKOV *et al*. 1996), in The Netherlands (CAMPHUYSEN 1998, CAMPHUYSEN & HEUBECK 2001) and in Germany (AVERBECK *et al*. 1992, FLEET & REINEKING 2000). The Belgian coast borders the southernmost part of the North Sea, an area heavily affected by chronic oil pollution (NORTH SEA TASK FORCE 1993, OSPAR 2000). Our data show downward trends in oil rate for most species, trends that are highly significant for the two most abundant taxa (Common Guillemot, *Larus*-gulls) only. STOWE (1982) and SKOV *et al*. (1996) showed that in the countries around the Southern Bight, the proportions of oiled Common Guillemots – an important target species - were higher than in other West European countries. That the proportion of oiled Common Guillemots in the late 1980s and early 1990s in Belgium is relatively low (approximately 50%) compared to surrounding countries (more than 75%, CAMPHUYSEN 1995) can partly be attributed to a different approach: CAMPHUYSEN (1995) considered data collected on Dutch beaches during ten winters (1985/86-1994/95) and used extensive material of six monthly surveys for each winter. For Belgian beaches however, only data from IBB February surveys (1986-1995)(SKOV *et al*. 1989, SKOV 1991) and additional information from January 1992 up to March 1995 were used (SEYS & MEIRE 1992, 1993, OFFRINGA & MEIRE 1995, OFFRINGA *et al*. 1995). Several important Common Guillemot wrecks in the early 1990s (with small proportions of bird corpses oiled) caused oil rates to be lowered quite drastically. When all existing Common Guillemot data from Belgian beaches (i.e. including monthly and weekly winter surveys) would be used, a mean oil rate of 65% for the period 1986-1995 is found, a value intermediate between the 50% mentioned above and the 75% recorded on Dutch beaches.

In our data offshore species such as Fulmar and Kittiwake do not show significant changes in oiling. These species occur around the offshore shipping lanes, where most oil slicks were recorded over the past eight years (DI MARCANTONIO 1999, SCHALLIER *et al*. 1996). Both species are not considered particularly vulnerable here for oil since they winter in small numbers (approximately 250 Fulmars and 3800 Kittiwakes, OFFRINGA *et al*. 1996) in Belgian offshore waters and spend much time on the wing. Nevertheless it is surprising that no downward trend can be discerned as found in The Netherlands, Germany, England and Scotland in the period 1984-1995 (CAMPHUYSEN 1995, SKOV *et al*. 1996). The smaller slope in the downward trend (Fig. 5) – as found in The Netherlands as well (CAMPHUYSEN 1998) – probably explains why the trend is not (yet) significant for the Fulmar. The same applies to waders. They were often found oiled during the 1960s (indicating the beaching of oil slicks or post-mortal contamination) but now clearly have a smaller chance to get oil-fouled. That we don't find significant downward trends in oil rate yet, must be ascribed to the relatively slow decrease and hence the need for a high number of sampling years (58 years to have a power of 90%). The very low numbers of most sea- and coastal birds beaching these days in combination with the exceedingly high number of surveying years needed to find a trend, necessitates the focus on the most common taxa (auks, *Larus*-gulls) and the collection of additional data during the rest of the winter.

TARGET SPECIES FOR OIL MONITORING

Future research should focus on several species and/or groups of species simultaneously to avoid problems caused by certain mortality incidents in individual species and to sample different subregions (inshore vs. offshore). For The Netherlands, CAMPHUYSEN (1995) selected Common Guillemot, Razorbill, Kittiwake, Fulmar, Northern Gannet, scoters and *Larus*-gulls as target species for beached bird surveying. A power analysis on Dutch data reveals that trends should be demonstrable – even for species showing linear trends with high residual variance and small slope – within 13-17 years. The trends we find by using only IBB surveys have a much lower power, meaning that at least some 30 years are needed before an existing trend will be detected with a chance of 90%. Considering the small length of the Belgian coastline and hence the comparatively small total number of beached birds that can be collected on each February IBB survey, oil impact monitoring should: (1) focus on abundant species/taxa that occur throughout the winter, are sensitive to oil-pollution and preferably include species typical for each of the different marine habitats (inshore, midshore, offshore); (2) always be organised synchronic with counts in neighbouring countries; (3) be complemented with monthly surveys at least during winter.

In designing future beached bird surveys, one of the main considerations in relation to analysing trends in the proportion of oiled corpses, should be the limited number of beached birds (SKOV *et al*. 1996). Due to decreasing densities of beaching corpses, it might become more and more difficult to collect large enough samples (and keep the numerous volunteers motivated). Assuming that a sample of at least ten complete corpses is required to calculate reliable oil rates, only the Common Guillemot (as species) and auks (as taxon) can provide the necessary data in Belgium these days. The beach environment and adjacent surf zone can probably be monitored much better during winter by scoring oil rates on living birds, such as Sanderlings *Calidris alba* (a small coastal wader, pale in colour and intensively foraging near the water mark). For the inshore zone, the most suitable potential target species is the Great-crested Grebe *Podiceps cristatus* (common in February in inshore waters), for the midshore area the Common Guillemot, Razorbill and several *Larus*-gull species can fulfil the role of oil indicators. For the offshore zone probably only Kittiwake and Fulmar can do. Although the IBB surveys may have some drawbacks compared to repeated monthly or weekly beached bird surveys (SEYS *et al*. accepted) they provide invaluable information, can build on large historical datasets collected in a standardized way over a vast area and hence should be continued and strengthened in the future.

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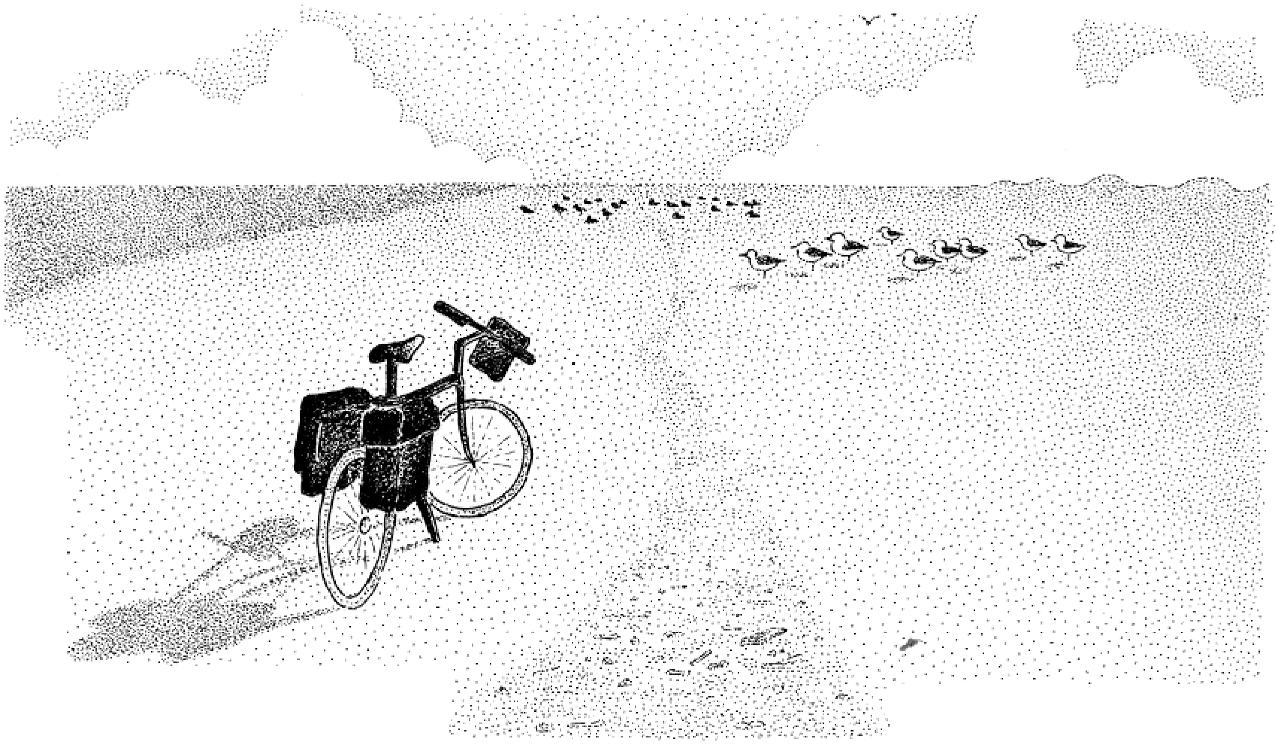
# CHAPTER SEVEN

## AN EVALUATION OF BEACHED BIRD MONITORING APPROACHES



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*Jan Seys[1*], Henk Offringa[2], Jeroen Van Waeyenberge[1], Patrick Meire[3] & Eckhart Kuijken[1]*

*[1] Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
*[2] Ministry of Transport, Public Works and Water Management, Directorate General of Public Works and Water Management, North Sea Directorate, P.O.Box 5807, 2280 HV Rijswijk, The Netherlands*
*[3] University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
present address*: Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

# An evaluation of beached bird monitoring approaches

J. Seys, H. Offringa, J. Van Waeyenberge, P. Meire & E. Kuijken

## ABSTRACT

Oil-pollution monitoring at sea through beach bird surveying would undoubtedly benefit from a further standardisation of methods, enhancing the efficiency of data collection. In order to come up with useful recommendations, we evaluated various approaches of beached bird collection at the Belgian coast during seven winters (1993-1999). Data received in a passive way by one major rehabilitation centre were compared to the results of targeted beach surveys carried out at different scales by trained ornithologists: 'weekly' surveys - with a mean interval of 9 days – restricted to a fixed 16.7 km beach stretch, 'monthly' surveys over the entire coastline (62.1 km) and an annual 'international' survey in Belgium over the same distance at the end of February. Data collected through Belgian rehabilitation centres concern injured, living birds collected in a non-systematic way. Oil rates derived from these centres appear to be strongly biased to oiled auks and inshore bird species, and are hence of little use in assessing the extent of oil pollution at sea. The major asset of rehabilitation centres in terms of data collection seems to be their continuous warning function for events of mass mortality. Weekly surveys on a representative and large enough section rendered reliable data on oil rates, estimates of total number of bird victims, representation of various taxonomic groups and species-richness and were most sensitive in detecting events quickly (wrecks, oil-slicks, severe winter mortality,...). Monthly surveys gave comparable results, although they overlooked some important beaching events and demonstrated slightly higher oil rates, probably due to the higher chance to miss short-lasting wrecks of auks. Since the monthly surveys in Belgium were carried out by a network of volunteers and were spread over a larger beach section, they should be considered as best performing. Single 'international beached bird surveys' in February gave reliable data on total victim number (once the mean ratio between numbers in various months is known) and oil rate (provided a sufficiently large sample can be collected), but failed in tracking events. It is a particularly attractive approach because of its long tradition, resulting in invaluable long-term databases, and the uniformity in which these surveys are organised on a large scale. The minimal distance for a monthly survey amounts to 25-30 km (40-50% of Belgian coastline) up to 40 km (65%) in order to attain sound figures for oil rate and species-richness respectively. These distances are primarily determined by the number of bird corpses that may be collected and are hence a function of beaching intensity and corpse detection rate.

## INTRODUCTION

Beached bird surveys have been set up worldwide to establish the patterns of occurrence of dead seabirds along coastlines and the proportions of the different species that are oiled (CAMPHUYSEN & HEUBECK 2001). It is a rather cost-effective method that allows to demonstrate long-term changes in oil-pollution (AVERBECK *et al*. 1992; MEISSNER 1992; CAMPHUYSEN 1998, SEYS *et al*. submitted), to evaluate changes in policy (AVERBECK 1991, HEUBECK 1995) or to assess the scale of oiling incidents (BOURNE *et al*. 1967, JONES *et al*. 1970, 78, SWENNEN 1978, BOURNE 1979, LINDÉN *et al*. 1979, HEUBECK & RICHARDSON 1980, CAMPHUYSEN *et al*. 1988, PIATT *et al*. 1990, HEUBECK *et al*. 1995, CAMPHUYSEN 1996, REINEKING 1998). However, due to an overall lack in structural funding and a reliance on volunteers, beached bird surveying has been subject to large temporal and spatial fluctuations. The frequency and survey distance often differ considerably in time and from country to country, ranging from an effort restricted to single occasions on only a few sections up to full monthly coverage of entire coastlines (HEUBECK & CAMPHUYSEN 1992).

It is widely accepted that beached bird surveying should be designed according to an internationally harmonized standard methodology, as to enable comparisons between countries, continents, seasons and years (CAMPHUYSEN & VAN FRANEKER, 1992, HEUBECK & CAMPHUYSEN, 1992). Although several manuals and papers indicate how to organise beached bird monitoring in order to obtain reliable data (AINLEY *et al*. 1980, JONES *et al*. 1982, PAGE *et al*. 1982, POWESLAND & IMBER 1988, CHRISTENSEN 1989, CAMPHUYSEN & DAHLMANN 1995, CAMPHUYSEN 1999) at minimal cost and effort, very little has been published to underpin these suggestions (CAMPHUYSEN 1991a, RAEVEL 1992a,b,c). The minimal requirements are that it provides: (1) reliable oil-rates for target species and; (2) estimates of densities and/or minimal total numbers of birds washed ashore (particularly in oil incidents). The value of the programme further improves when: (3) it helps detecting specific short- as well as long-lasting events (wrecks, severe frost, oil incidents); (4) it provides a large and varied sample of bird corpses, that can be used for an additional post-mortem necropsy (STEPHEN & BURGER 1994), drift-, sink- or persistence experiments or the analysis of contaminants in body (DEBACKER *et al*. 2000) or feathers (DAHLMANN *et al*. 1994). A scheme of monthly sampling of the abundance of beached birds and the percentage of these birds which are oiled, at least in the winter period (i.e. October-April) has been put forward. Counts should be made on a selected, representative fraction of the coast, providing a sufficiently large sample of beached birds of the most common species, that enables the calculation of reliable oil rates (CAMPHUYSEN 2001). As a rule of thumb, it has been suggested that all dead beached birds should be recorded over at least 10% of the coastline of each subregion (ANONYMOUS 1996).

Over the past 30 years beached bird surveys have been particularly intense in Britain (JONES 1980, STOWE 1982a,b, HEUBECK *et al.* 1992, HEUBECK 1995), Belgium (KUIJKEN 1978a,b, OFFRINGA *et al*. 1997, SEYS *et al*. submitted), The Netherlands (CAMPHUYSEN 1989, 1997), Germany (VAUK & REINEKING 1980, AVERBECK *et al.* 1992) and France (DEBOUT 1984, RAEVEL 1990) (in CAMPHUYSEN & HEUBECK 2001). A constant and high survey effort on 65 km of sandy beach in Belgium during the winters of 1993-1999 provides data for a critical analysis of various monitoring approaches. Data of beached birds collected at one major rehabilitation centre and on the beach during weekly, monthly and February surveys are compared. Furthermore we look into the impact of the sampling effort (distance, frequency) and the method (rehabilitation centre versus beached bird surveys) used on oil-rate, species composition and total number of beached birds and try to answer questions such as: 'How frequent does one have to survey in order to avoid unacceptable deviations in the variables mentioned above?', 'What is the minimal distance that should be surveyed?', 'Is distance determining the quality of the resulting data or other dependent parameters?', 'How can rehabilitation centres contribute to beached bird data collection?'. Finally current guidelines for beached bird surveying are evaluated and recommendations are made – under the precondition of an acceptable data quality – for a minimal cost, maximal output beached bird monitoring programme.

## STUDY AREA AND METHODS

### STUDY AREA AND STUDY PERIOD

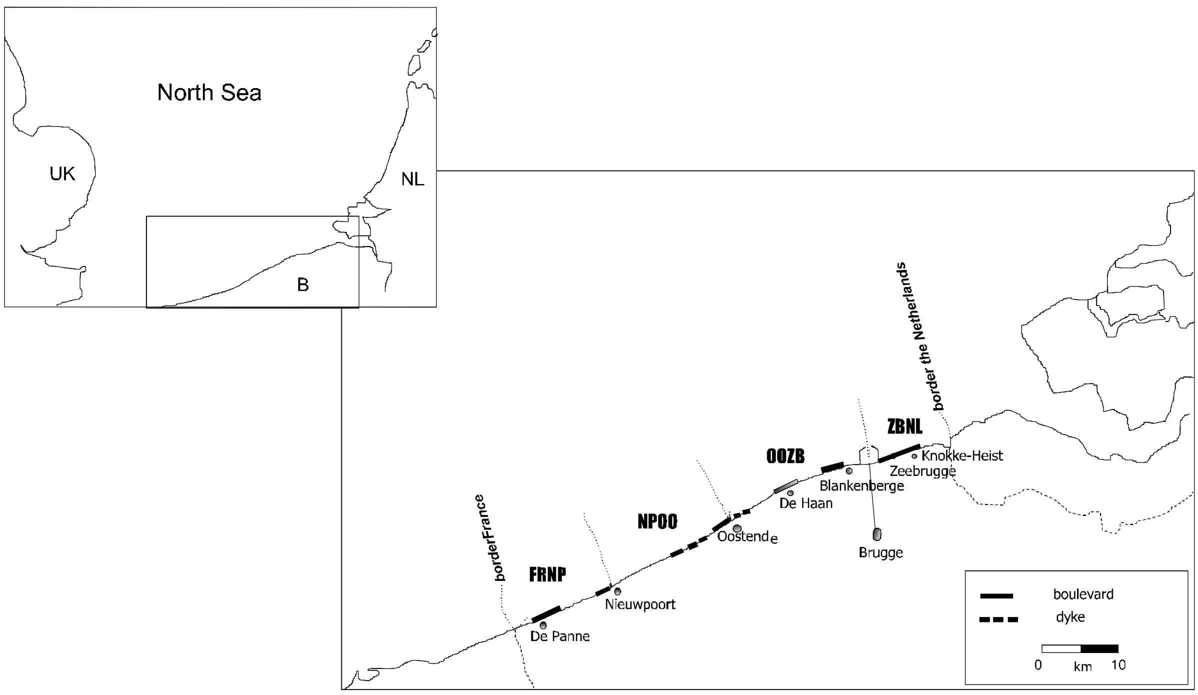



*Fig. 1. The Belgian coast divided in four major beach sections.*

The Belgian coastal strip consists of 62.1 km of easily accessible, sandy beach that is only interrupted at Zeebrugge port (Fig. 1). Four major beach sections are distinguished for further analysis: French border-Nieuwpoort (FRNP), Nieuwpoort-Oostende (NPOO), Oostende-Zeebrugge (OOZB) and Zeebrugge-Dutch border (ZBNL). Breakwaters are a common feature (on average every 200-400 m) and are only absent at the west coast (FRNP), at Bredene-De Haan and near the Belgian-Dutch border. The tidal amplitude measures 3-5 metre and beaches are generally narrow. Broad beaches are restricted to the western part (De Panne: ± 3 km) and the immediate neighbourhood of Zeebrugge port (± 1 km). Currents are predominantly oriented parallel to the coast and attain maximal velocities of 1.7 knots at spring tide and 0.6 knots at neap tide. There is a small net residual NE-circulation through the Straits of Dover. The prevailing wind direction in Oostende is S or SW (BELL 1994). During persistent westerly gales, the velocity of surface water can be as high as 35 miles within twenty-four hours.

During the study period 1993-1999, winters were not particularly cold, with severe frost restricted to early 1996 and 1997, and a short cold spell at the end of December 1992. Frequency of strong onshore winds was high in 1994 and 1995 and low in 1996 and 1997. The occurrence of strong onshore winds is inversely correlated with the IJnsen factor (unpublished data), a measure for winter severity (IJNSEN 1991).

## BEACHED BIRD SURVEY APPROACHES

Four different approaches were compared. Rehabilitation centres received debilitated or moribund, live birds in a mostly passive and continuous way. During beached bird surveys, trained ornithologists collected bird corpses on the beach, identified and measured them and checked the complete corpses on the presence of oil. Bird corpses obtained from the harbour area of Zeebrugge or during occasional surveys (organised in the wake of claimed incidents or massive beaching of corpses) were excluded from the analysis.

*Beached bird surveys*

A 16.7 km section (NPOO) has been surveyed 'weekly' (i.e. with an average interval of 9 days) from mid-October to the end of March. In addition the entire Belgian coast (62.1 km) has been surveyed monthly from October to March, with only poor coverage in October 1992-1994 (Table 1). The results of the February surveys were also used as the annual International Beached Bird survey (IBBS).

*Table 1. Frequency and effort of various beached bird monitoring methods applied at the Belgian coast during seven winters October-March 1993-1999. Interval=the mean interval between successive 'weekly' surveys (days ? SE).*

| Winter | 'weekly surveys' *N* | Interval (days ? *SE*) | 'monthly surveys' Effort (% surveyed of 62.1 km coast) Oct | Nov | Dec | Jan | Feb | Mar | overall | 'IBB surveys' Date |
|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | 22 | 8.2 ? 0.6 | 47 | 100 | 100 | 100 | 96 | 100 | 91 ? 9 | 13 Feb |
| 1994 | 18 | 7.7 ? 0.6 | 0 | 100 | 96 | 96 | 100 | 95 | 81 ? 16 | 5 Feb |
| 1995 | 14 | 12.1 ? 2.3 | 0 | 100 | 95 | 88 | 77 | 61 | 70 ? 15 | 18-24 Feb |
| 1996 | 16 | 11.5 ? 1.7 | 75 | 84 | 84 | 100 | 100 | 95 | 90 ? 4 | 9-18 Feb |
| 1997 | 19 | 8.3 ? 1.7 | 76 | 76 | 90 | 85 | 93 | 85 | 84 ? 3 | 21-27 Feb |
| 1998 | 18 | 9.6 ? 1.5 | 74 | 78 | 91 | 93 | 82 | 82 | 83 ? 3 | 13-23 Feb |
| 1999 | 17 | 9.3 ? 0.7 | 85 | 89 | 89 | 100 | 100 | 100 | 94 ? 3 | 11-15 Feb |
| Overall | 124 | 9.3 ? 0.5 | 51? 14 | 90? 4 | 92? 2 | 95? 2 | 93? 4 | 88? 5 | 85 ? 3 | |

*Rehabilitation centre of Oostende*

The data collected during beached bird surveys were compared to information on debilitated or moribund, living birds received at the Marine Ecological Centre (MEC) at Oostende from October 1992 till end March 1999. This rehabilitation centre proved to maintain the most detailed casualty lists, accommodates about 40% of the rehabilitated birds of the Belgian coast (SEYS *et al*. 1999) and is centrally located, adjacent to the weekly surveyed beach section. Most birds received at the MEC rehabilitation centre were collected on the beach section Westende-De Haan. Hence for further analysis it was assumed that the search area corresponded with a distance of approximately 20 km. The dataset included live birds that died in care and excluded taxa considered to be essentially terrestrial (rails, passerines). The number of birds was summed for periods of ten days (period 1= day 1-9, period 2= day 10-19, period 3= day 20-31).

## DATA HANDLING AND ANALYSIS

*Total number of beached birds*

The total number of birds that could theoretically be collected with each of the approaches during one winter at the Belgian coast was calculated by extrapolating and adjusting the field data for the frequency and distance surveyed. First, missing values were estimated by inputting data according to consistent spatial differences in overall densities of corpses in three ways: (1) Incompletely covered sections in weekly, monthly or IBB surveys were extrapolated to the full distance of the section; (2) In 8 out of 168 sections (< 5%) that were not surveyed during specific monthly or IBB surveys, section-correction factors were applied to obtain better estimates of the real number of beached birds. These factors (for the beach sections FRNP, NPOO, OOZB and ZBNL values of 1.43, 2.48, 0.79 and 1.86 respectively) were obtained by comparing the number of beached birds on these sections during 34 monthly surveys covering the entire Belgian coastline in the period January 1992 – March 1999; (3) Two months during which there was no surveying effort at all (October 1993 and October 1994) were adjusted for by adding the mean value of all October months of the period 1993-1999.

In a next step these results were extrapolated to the full distance of the Belgian coast and to the entire winter period (October-March): (1) The results of 'weekly' surveys carried out on the section NPOO were multiplied by the section-correction factor 2.48 (see above) to obtain estimated total numbers for the entire Belgian coast; (2) Total numbers resulting from the 'IBB February surveys' were extrapolated to a full winter by applying a month-correction factor of 2.82. This factor was obtained in a similar way as described above for the section-correction factors and amounted to 15.08 (October), 10.61 (November), 8.68 (December), 4.31 (January), 2.82 (February) and 7.25 (March). This means that an analysis of 34 complete monthly surveys during 1992-99 revealed consistent temporal patterns in stranding and that during e.g. December on average only 1/8.68 of the total number of bird corpses of an entire winter is found. In these recalculations temporal or spatial differences between species were not considered.

The final result is an estimate of the total number of beached birds per winter on the entire coastline, obtained for each of the approaches that has been used. By excluding the impact of travelled distance and variation in beaching intensity along sections, differences can be attributed entirely to variations in monitoring frequency.

*Oil rates, number of species and occurrence of events*

The oil-rate is the fraction of complete bird corpses oiled of the total number found. For the purpose of this article two major taxa of beached birds were considered: auks (Common Guillemot *Uria aalge* and Razorbill *Alca torda*) and *Larus*-gulls. We assumed that, for both groups, a minimum of 10 specimens is required to calculate an oil-rate. The small size of the sample of *Larus*-gulls in February did not allow including the International Beached Bird Survey in the comparison of methods. Species richness was scored for each method as the total number of species found, equivalent to the Hill number $N_0$ (HILL 1973). The sensitivity of each method in detecting events of important bird stranding on the beach (wrecks, increased stranding due to oil-slicks and winter mortality of frost-sensitive species) is analysed by ranking the top-12 densities for Common Guillemot, Fulmar *Fulmarus glacialis*, Kittiwake *Rissa tridactyla* or waders (as taxon) over the entire study period, grouping these high densities for each species into well-demarcated periods (events) and checking which of the four methods was able to detect the event. Data from the MEC rehabilitation centre were grouped in ten-day periods and expressed as N $km^{-1}$ (the majority of the birds of which their origin was documented appeared to originate from a 20 km beach section).

## RESULTS

### TOTAL NUMBER OF BEACHED BIRDS

With 'weekly' surveys it is possible to collect on average 2687 corpses along the entire Belgian coastline each winter (Table 2). This is 6.6 times more than can be found during monthly surveys of the entire coast, a ratio corresponding quite well with the known minimal persistence time of corpses on Belgian beaches (5.8 days) during the same study period (unpublished data). At a single annual February (IBB) survey, the number of corpses that is collected is 3.0 times smaller than on six monthly surveys (135 vs. 406), a ratio well in line with the month-correction factor of 2.88 needed to extrapolate February results to a full winter. Hence, once the ratio in number of corpses between several winter months is well documented, results of an IBB survey can be used to estimate total number of beached birds by winter roughly. Annual mean total number of victims for monthly, IBB and weekly surveys divided by 6.6 are not significantly different from each other (Kruskal-Wallis test: $H_{(3,28)}$=3.47; $N$=7; $P$<0.05).

According to the results of 'weekly surveys' from 1993 to 1999, an average yearly number of 2687 birds washed ashore (range: 1500-4,000). This number has to be increased with 400-500 weakened, living birds collected through rehabilitation centres each winter (assuming an overall share of 40% by the MEC in the total number of Belgian coastal rehabilitated birds: SEYS *et al.* 1999, or assuming the MEC rehabilitation centre targets about 20 km of the 62 km of Belgian beaches). Annual fluctuations become more important when frequency of surveying decreases: the proportion of maximal versus minimal yield amounts to 2.0 (MEC), 2.4 (weekly surveys), 3.0 (monthly surveys) and 7.7 (IBB surveys) respectively. The disproportionately high total number of birds estimated during the IBB survey in 1999 results from an important wreck of Common Guillemot and Fulmar in February 1999 (SEYS *et al*. 1999).

This rough estimate of the total number of casualties does not give the full picture of how many birds really strand each year. Taking into account that during persistence experiments at the Belgian coast (unpublished data) 50-80% of the corpses disappeared already within the first nine days (the mean interval between succeeding weekly surveys), many bird corpses must have been lost in between successive 'weekly' surveys. Therefore we estimate that the real number of bird corpses beaching on the Belgian coast each winter might be as high as 5000-10,000 birds.

*Table 2. Estimates of total number of beached bird corpses and debilitated living birds that can be collected by winter at the Belgian coast, using different approaches. Actual numbers of corpses collected each year in the field during weekly (W), monthly (M) or IBB (I) surveys are tabulated as well as the estimated number of corpses for an entire winter, based on a single February IBB survey multiplied by the correction factor 2.88 ($I_x$). As an estimate of the total number of living sea- and coastal birds that are collected annually by all Belgian coastal rehabilitation centres, data from the MEC rehabilitation centre were extrapolated (RehC).*

| Winter/method | W | M | I | Ix | MEC | RehC |
|---|---|---|---|---|---|---|
| 1993 | 3301 | 256 | 68 | 192 | 123 | 382 |
| 1994 | 1655 | 216 | 66 | 188 | 171 | 531 |
| 1995 | 2067 | 307 | 56 | 158 | 139 | 432 |
| 1996 | 3921 | 644 | 234 | 661 | 132 | 410 |
| 1997 | 2338 | 465 | 90 | 254 | 134 | 416 |
| 1998 | 1935 | 297 | 49 | 140 | 132 | 410 |
| 1999 | 3592 | 654 | 381 | 1075 | 251 | 779 |
| 1993-99: mean | 2687 | 406 | 135 | 381 | 155 | 480 |
| 1993-99*: SE* | 340 | 69 | 48 | 134 | 17 | 53 |

## OIL-RATE

Oil-rates of auks and *Larus*-gulls differ significantly when using other approaches (Kruskal-Wallis test: $H_{(3,28)}=13.76$; $N=28$; $P<0.01$ for auks; $H_{(2,21)}=8.58$; $N=21$; $P<0.05$ for *Larus*-gulls). Post-hoc comparisons demonstrate the MEC rehabilitation centre results differ significantly from all beached bird survey methods ($P<0.05$). Auks have much higher oil-rates (on average 28% higher) at the MEC rehabilitation centre. *Larus*-gulls arriving at the rehabilitation centre are virtually free of oil, compared to mean oil-rates of 15% in beached bird surveys (Table 3). There are no significant differences between the oil-rates of Alcidae and *Larus*-gulls for the beach surveys at different frequency (though oil-rates of Alcidae are about 10% lower in weekly, compared to monthly and IBB surveys).

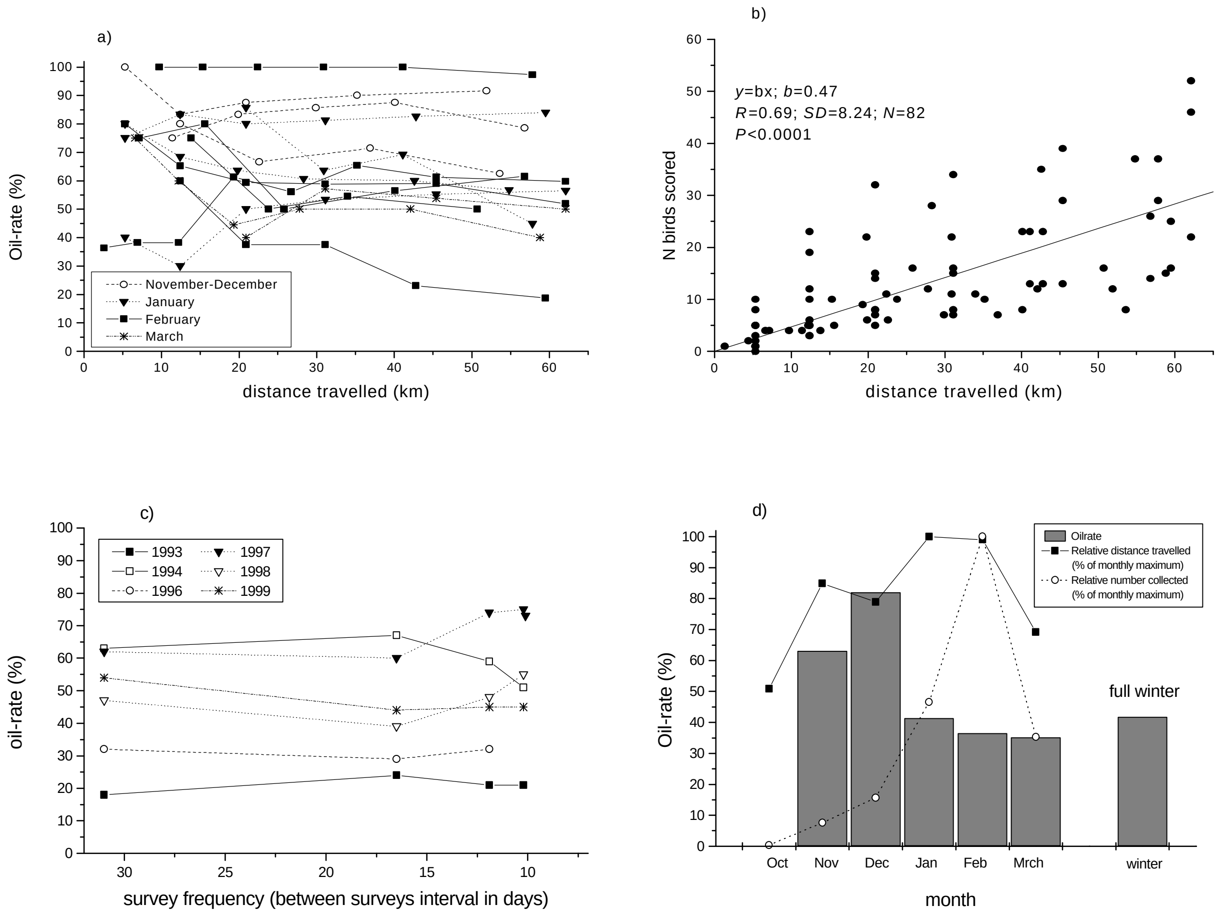



*Fig. 2. Relationship between survey distance & frequency and oil-rate of Common Guillemot* Uria aalge*, with a) survey distance vs. oil-rate in monthly surveys; b) average 'yield' of Common Guillemots vs. distance; c) survey frequency vs. oil-rate Common Guillemot in weekly surveys; d) oil-rate by month vs. distance surveyed and number of Common Guillemots collected.*

When sections are added stepwise to the shortest section that was surveyed every month (Fig. 2a), oil-rates in Common Guillemot stabilize from a travelled distance of 25-30 km onwards (40-50% of entire Belgian coast), which is equivalent to an average of 10-15 Common Guillemots found (Fig. 2b).

*Table 3. Oil rates (%) (and N birds scored) of beached auks (Alcidae) and Larus-gulls, as found in the period 1993-1999 at the Belgian coast using different approaches. W= weekly surveys, M=monthly surveys, I=IBB surveys, MEC=rehabilitation centre.*

| Method | W | | M | | I | | MEC | |
|---|---|---|---|---|---|---|---|---|
| Winter | *Alcidae* | *Laridae* | *Alcidae* | *Laridae* | *Alcidae* | *Laridae* | *Alcidae* | *Laridae* |
| 1993 | 21 (*152*) | 21 (*44*) | 51 (*84*) | 3 (*36*) | 27 (*18*) | (*3*) | 77 (*60*) | 2 (*45*) |
| 1994 | 56 (*92*) | 4 (*27*) | 70 (*104*) | 9 (*22*) | 52 (*54*) | (*3*) | 88 (*109*) | 0 (*23*) |
| 1995 | 59 (*24*) | 31 (*32*) | 61 (*75*) | 15 (*40*) | 55 (*20*) | (*4*) | 75 (*83*) | 14 (*22*) |
| 1996 | 31 (*59*) | 6 (*145*) | 46 (*102*) | 3 (*188*) | 53 (*51*) | 2 (*55*) | 74 (*27*) | 2 (*53*) |
| 1997 | 68 (*43*) | 2 (*32*) | 73 (*83*) | 11 (*104*) | 95 (*43*) | (*9*) | 96 (*50*) | 0 (*34*) |
| 1998 | 53 (*60*) | 19 (*34*) | 52 (*85*) | 11 (*47*) | 57 (*18*) | (*3*) | 84 (*76*) | 0 (*33*) |
| 1999 | 46 (*161*) | 3 (*38*) | 63 (*300*) | 19 (*47*) | 63 (*207*) | 44 (*10*) | 89 (*180*) | 0 (*21*) |
| 1993-99: mean | 48 | 12 | 59 | 10 | 57 | 24 | 83 | 3 |
| 1993-99: *SE* | 6 | 4 | 30 | 2 | 8 | | 3 | 2 |

Data from 118 'weekly surveys' in the period 1993-1999 with a minimal distance travelled of 10 km indicate that annual oil-rates of Common Guillemot do not change substantially when the frequency of surveys is increased from 1 up to 3-5 times a month (Fig. 2c). However a clear difference in oil-rate in the various months of each winter (Fig. 2d), with high values (60-80%) in early winter and low oil-rates from January onwards, strongly emphasize the need to spread beached bird surveying effort over the entire winter period. Since most Common Guillemots were collected in January-March (Fig. 2d), average oil-rates by winter reflect the situation of this period.

## SHARE OF MAJOR TAXA AND SPECIES RICHNESS

The choice of a beached bird monitoring method has an impact on the observed species composition. Weekly and monthly surveys show comparable results in terms of species richness and relative abundance of taxa (Table 4). The IBB survey, traditionally organised at the end of February, has a comparatively high share of auks (Kruskal-Wallis test: $H_{(3,28)}$=5.63; $N$=28; not significant at $P$ 0.05) and significantly lower numbers of *Larus*-gulls (Kruskal-Wallis test: $H_{(3,28)}$=9.05; $N$=28; $P$< 0.05). This is consistent with the occurrence of auk wrecks mainly in late winter and gull mortality particularly distinct in early winter. Live birds collected for the MEC-rehabilitation centre are more likely to belong to the Alcidae and typical offshore bird species (Fulmar, Kittiwake) are underrepresented here. Among the Laridae, the MEC rehabilitation centre receives relatively more Black-headed Gull, and less Herring/Lesser Black-backed and Great Black-backed Gulls (Table 5). This shift towards more 'land-oriented' gulls can be explained by the input of substantial numbers of gulls from inland polders. The number of species collected by winter (and over the entire study period 1993-1999) is significantly influenced by the distance travelled and the time-span covered (Kruskal-Wallis test between methods: $H_{(3,28)}$=16.30; $N$=28; $P$< 0.01). As a consequence February surveys (IBBS) produce only half the number of species compared to 'weekly' and 'monthly surveys' (15 vs. 27-30: Table 4).

*Table 4. Share of major taxonomic groups in the density of beached birds (mean % ? SE) and species richness ($N_0$ ? SE) during the winters 1993-1999 at the Belgian coast using different approaches. W= weekly surveys, M=monthly surveys, I=IBB surveys, MEC=rehabilitation centre. Significant differences (Kruskal-Wallis: P<0.05) are in italic, with significant post-hoc comparisons indicated at the bottom of the table.*

| Method | grebes | Fulmar | *Northern Gannet* | seaducks | waders | *Larus-gulls* | *Kittiwake* | auks | *Species richness* |
|---|---|---|---|---|---|---|---|---|---|
| W | 2.9 ? 1.7 | 4.5 ? 1.8 | 1.5 ? 0.3 | 3.0 ? 0.6 | 9.7 ? 4.7 | 25.3 ? 3.7 | 5.7 ? 1.6 | 41.9 ? 5.8 | 27 ? 3 |
| M | 3.7 ? 0.9 | 5.9 ? 2.2 | 1.8 ? 0.3 | 3.4 ? 0.4 | 8.6 ? 3.8 | 24.0 ? 3.2 | 6.4 ? 1.5 | 40.3 ? 5.1 | 30 ? 3 |
| I | 3.6 ? 0.7 | 7.0 ? 3.3 | 0.4 ? 0.2 | 3.0 ? 0.6 | 8.6 ? 5.0 | 12.0 ? 2.8 | 5.6 ? 1.2 | 57.1 ? 7.0 | 15 ? 2 |
| MEC | 4.7 ? 1.0 | 1.1 ? 0.5 | 0.7 ? 0.2 | 2.4 ? 0.6 | 7.2 ? 2.3 | 26.7 ? 4.7 | 0.7 ? 0.4 | 53.9 ? 6.7 | 19 ? 1 |
| | | | *I-W* | | | *I-W* | *MEC-W* | | *I-W* |
| Post-hoc | | | *I-M* | | | *I-M* | *MEC-M* | | *I-M* |
| comparisons | | | *MEC-W* | | | *I-MEC* | *MEC-I* | | *MEC-W* |
| | | | | | | | | | *MEC-M* |

*Table 5. Species-composition of beached Larus-gulls at the Belgian coast (1990s) and at the MEC rehabilitation centre (1988-99).*

| Species | Proportion beach 1990s (%) | Proportion MEC 1988-99 (%) |
|---|---|---|
| *L.minutus* | 0.7 | 0.0 |
| *L.ridibundus* | 22.5 | 43.6 |
| *L.canus* | 11.2 | 10.3 |
| *L.argentatus/fuscus/cachinnans* | 57.5 | 39.7 |
| *L.marinus* | 8.1 | 6.5 |

Assuming that at the maximum travelled distance of 50-62 km during a monthly survey one obtains a reliable figure for the species-richness of the Belgian coast, a minimum distance of 40 km (or 65% of the entire coast) is needed to avoid deviations of more than 10% from this value (Fig. 3a). It is evident that the number of specimens that is collected - and not the surveyed distance in itself - determines the final value of the species-richness (Fig. 3b). It can be demonstrated that on average 50-100 birds should be collected to have a good sample of the species diversity found on the beach.

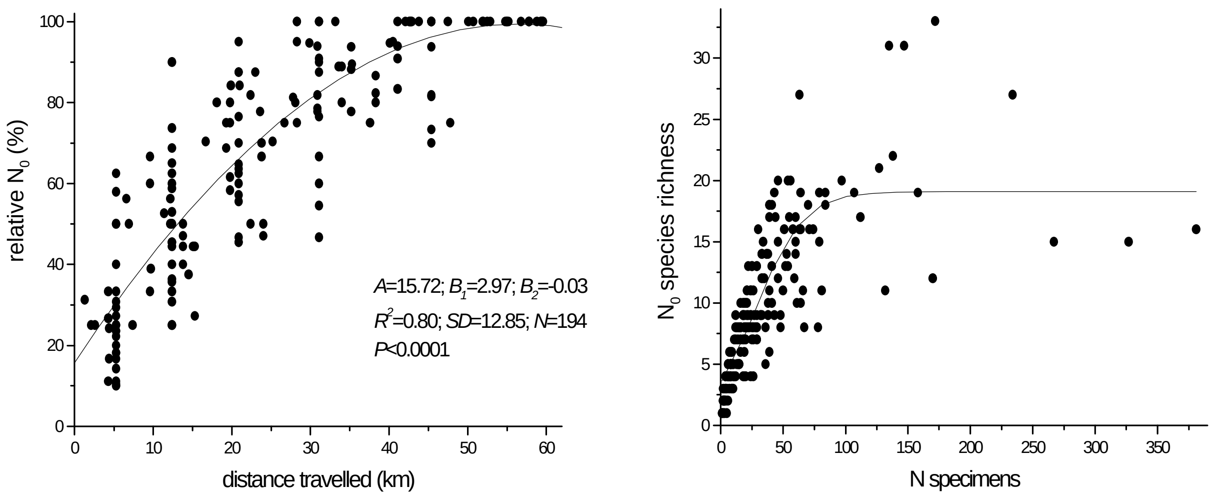



*Fig. 3. Relationship between the collected number of beached birds, the distance surveyed and the species-richness at monthly surveys, with a) relative species-richness vs. distance surveyed; b) species-richness vs. number of birds collected. Curves were fitted by eye.*

## OCCURRENCE OF EVENTS

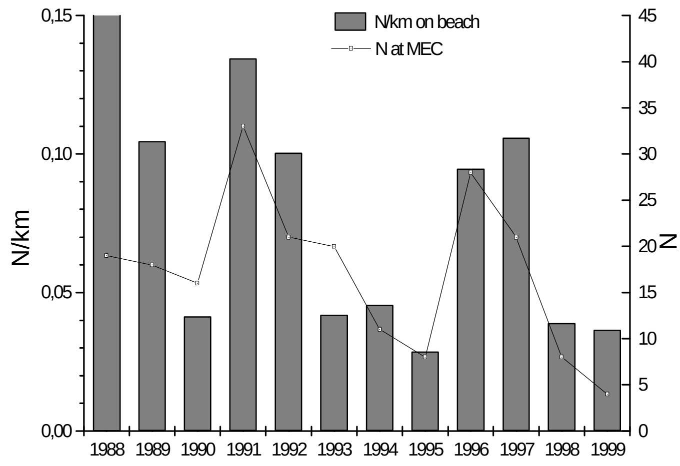
A detailed screening of the data shows that ‘weekly surveys’ are most sensitive in detecting events of mass occurrence of corpses on the beach (Table 6). In 84% of the important beaching events of Fulmar, Common Guillemot, Kittiwake and waders, the event was revealed from weekly surveys. For monthly (63%), IBB surveys (32%) and the MEC rehabilitation centre (16%) sensitivity was (much) lower. Monthly surveys were as useful in some species (Fulmar, Kittiwake, waders) but missed three out of four Common Guillemot wrecks observed in the period 1993-1999. Increased mortality of waders due to cold winter spells in 1996 and 1997 was detected by most approaches. Smaller numbers of dead waders at the turn of the year 1992 were missed by all methods except for the ‘weekly surveys’.

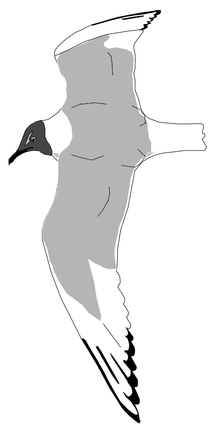
The main reason why the MEC rehabilitation centre fails to detect the events in Table 6 is the small number of birds that is received compared to what is found during topical beach surveys. The temporal patterns in number of birds found dead on the beach and received alive at the rehabilitation centre are very much in line. All taxa that were regularly hosted at the rehabilitation centre (with at least forty birds during 1988-99: grebes, scoters, waders, *Larus*-gulls, auks) show significant correlations with beached corpse numbers, both at a winter-to-winter and month-to-month level (unpublished data). Fig. 4 shows convergent patterns for Black-headed Gull *Larus ridibundus* and Common Guillemot in the MEC rehabilitation centre, compared to beach data. The remarkable peak of Common Guillemot in December probably arises from a large number of tourists on the beach during Christmas holidays.

*Table 6. Sensitivity of different beached bird monitoring approaches (I='IBB surveys', M='monthly surveys', W= 'weekly surveys', MEC= rehabilitation centre) in detecting events with high densities of corpses of Fulmar, Kittiwake, Common Guillemot or waders on Belgian beaches during 1993-1999. The sensitivity of each approach is tested by ranking the top-12 densities for each species(group) over the entire study period, grouping these densities for each species into events (periods) and scoring how many of these events were tracked by each approach. The sensitivity of each approach is the proportion of the events that could be signalled.*

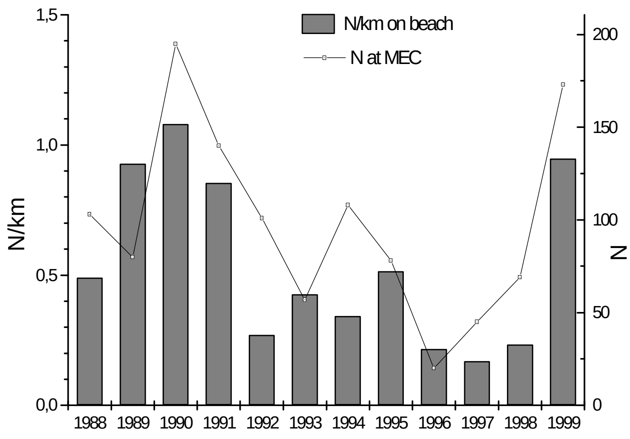
| | Event | | | | Sensitivity of method (%) | | | |
|---|---|---|---|---|---|---|---|---|
| Species | Events (period) | N $km^{-1}$ | Oil-rate (*N*) | Detected by | W | M | I | MEC |
| *F.glacialis* | | | | | 67 | 83 | 33 | 0 |
| | 21/1/95 | 0.40 | | M | | | | |
| | 18-20/10/97 | 0.24- 0.41 | 23 (13) | W M I | | | | |
| | 21-25/1/98 | 0.24 | | W M | | | | |
| | 23/2/98 | 0.30 | | M I | | | | |
| | 30/3/98 | 0.30 | | W | | | | |
| | 15/2-3/3/99 | 0.24-1.67 | 29 (115) | W M I MEC | | | | |
| *R.tridactyla* | | | | | 83 | 67 | 17 | 0 |
| | 27/1/93 | 0.84 | | W | | | | |
| | 28/2/93 | 0.36 | | W | | | | |
| | 21/1/95 | 0.39 | | W M | | | | |
| | 25/11/95 | 0.24 | | M | | | | |
| | 19/12/97-25/1/98 | 0.24-0.48 | 50 (28) | W M | | | | |
| | 15/2/99 | 0.44-0.48 | 69 (29) | W M I | | | | |
| *U.aalge* | | | | | 100 | 25 | 25 | 25 |
| | 27/1-12/3/93 | 1.86-2.81 | 15 (124) | W | | | | |
| | 1-11/2/94 | 1.44 | 39 (61) | W | | | | |
| | 9-15/1/95 | 1.89-3.58 | | W | | | | |
| | 15/2-14/3/99 | 1.40-3.67 | 51-92 (367) | W M I MEC | | | | |
| waders | | | | | 100 | 67 | 33 | 33 |
| | 6/1/93 | 1.20 | 0 (20) | W | | | | |
| | 1/2-24/3/96 | 1.40-2.38 | 1 (159) | W M I | | | | |
| | 5-30/1/97 | 0.48-2.98 | 0 (158) | W M MEC | | | | |
| Summary for all 19 events | | | | | 84 | 63 | 32 | 16 |

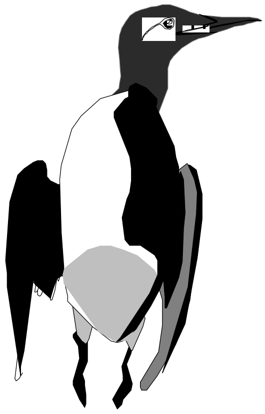
a)



b)



c)

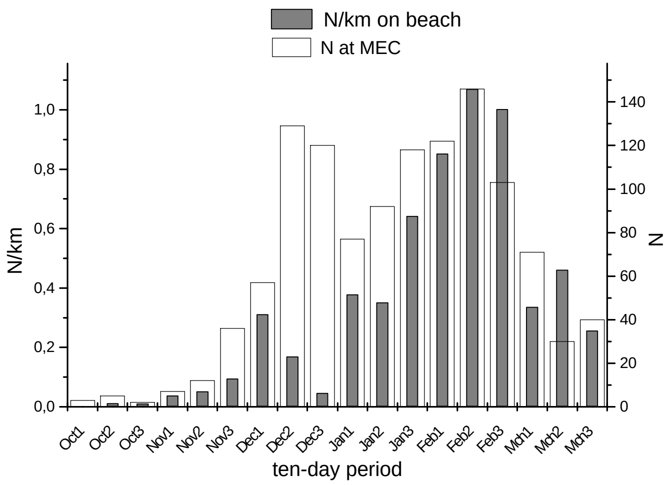



*Fig. 4. Temporal pattern in the number of (moribund) seabirds received at the MEC rehabilitation centre and in the numbers found dead on the beach, with: a) year-to-year variation in Black-headed Gull; b) year-to-year variation in Common Guillemot; c) monthly variation in Common Guillemot.*

## DISCUSSION & CONCLUSION

The major objective of any beached bird monitoring scheme should be to obtain accurate data of the abundance of beached birds and the percentage of these birds that are oiled or contaminated with lipophilic compounds. Depending on whether one deals with an oil incident or with the effects of chronic pollution, either the assessment of total number of casualties or oil-rates is emphasized. In addition beached bird monitoring may provide useful information on the occurrence of mortality events (mass stranding due to oil-pollution, food-shortage or severe winter weather, e.g.: CLARK 1982, UNDERWOOD & STOWE 1984, PIATT & VAN PELT 1993, PIERSMA & CAMPHUYSEN 2000) or indicate changes in relative abundance of bird species occupying the same habitat at sea. And it is undoubtedly a valuable source of background information on species characteristics (biometry, colour-phases, age, sex, e.g.: ANKER-NILSSEN *et al*. 1988, CAMPHUYSEN & VAN FRANEKER 1992, STRATFORD & PARTRIDGE 1996), diet (through stomach analysis, e.g.: BLAKE 1983, CAMPHUYSEN & KEIJL 1994 or stable-isotope techniques, e.g.: HOBSON *et al*. 1994) and mortality factors other than oil, such as parasites (BROSENS *et al*. 1996, CAMPHUYSEN 2000), entanglement (TEXEIRA 1986, MEISSNER 1992, CAMPHUYSEN 2001b), plastic ingestion (VAN FRANEKER 1985, RYAN 1988), hunting (RAEVEL 1990), heavy metals (DEBACKER *et al*. 2000).

## REHABILITATION CENTRES

The information on sea- and coastal birds obtained through a coastal rehabilitation centre is different from that collected during beached bird surveys. The former might be a good source of information on debilitated or moribund, living coastal and inshore seabirds and function as a first alert. However rehabilitation centres do not provide reliable data on oil-rates, a key factor in oil-monitoring programmes. Oil-rates in auks are significantly higher in the rehabilitation centre (83%) and lower in *Larus*-gulls (3%), probably due to a bias towards specimens that can easily be caught and be transferred alive. Oiled gulls are not easily taken alive, unless they have broken wings of legs. The latter are the main 'recorded' victims among gulls in rehabilitation centres at the Belgian coast. Lower oil-rates in auks seemed to be linked to the probability of getting the bird in the rehabilitation centre in time (once it has died, as happens very often with exhausted 'wrecked' auks, the finder often decides not to bring the corpse to the centre). Similarly RAEVEL (1992c) concludes that oil-rates are systematically higher in the centres of Northern France compared to those determined on the beach (e.g.: Razorbill: 99% versus 65%; Common Guillemot: 98% versus 73%).

The number of living birds that is received at Belgian coastal rehabilitation centres every winter is estimated at 400-500 specimens and is thus small compared to the numbers of corpses found on the beach (on average 2700). RAEVEL (1992c) mentions even smaller relative numbers of live birds collected through rehabilitation centres in N-France, amounting to 90-400 'centre' birds by winter, compared to 370-3500 beached corpses at IBB surveys. As to prevent an underestimation of numbers and oil-rates, RAEVEL suggests including live birds from rehabilitation centres. We suggest to keep the data from rehabilitation centres separate from data on beached corpses, since the former are much more effort-dependent than beach surveys (and thus related to weather conditions, occurrence of events, etc..) and can usually not rely on the same degree of data quality as for BBS. Although oil-rates in the most common taxa differ for both methods, general temporal patterns in relative densities and oil-rates at the beach and in rehabilitation centres are comparable. It does not come as a surprise that the species richness recorded at the MEC rehabilitation centre and during IBB surveys is significantly smaller than during weekly or monthly surveys. In addition the species composition is also markedly different. Late February IBB surveys have a comparatively high share of auks (most auk wrecks in second half winter) and low numbers of *Larus*-gulls (mortality in this group concentrated in early winter). Offshore species such as Fulmar and Kittiwake are largely underrepresented at rehabilitation centres.

## COMPARISON OF BEACHED BIRD SURVEY APPROACHES

In order to obtain reliable data from beached bird surveys in the most efficient way, one should ensure a high enough surveying frequency, a spacing over the entire winter period and a large enough distance as to make sure a sufficient number of corpses can be collected (CAMPHUYSEN & HEUBECK 2001). The advantages of increasing the frequency of surveying from once a month to 'weekly' are comparatively small. The four beach monitoring approaches we applied all led to reliable estimates of total number of beached birds. Data from IBB surveys can be translated into very rough total winter estimates provided the average contribution in numbers of beached birds by month is known, and both monthly and IBB surveys will approach the total estimates shown at weekly surveys when multiplied by a persistence correction factor.

Oil-rates of auks are slightly, but not significantly reduced at weekly surveys (48%) compared to monthly (59%) or IBB surveys (57%), a difference resulting neither from the higher frequency of the surveys, nor from the spatial variation in beaching along the Belgian: oil-rates are reduced from 57 to 55% when considering only the section at monthly surveys coinciding with the weekly surveyed stretch of beach (Oostende-Nieuwpoort). Probably the slightly reduced oil-rates in auks in 'weekly surveys' are caused by the higher probability to include wreck-events into the figures as the frequency of monitoring is increased. The two winters with values in 'weekly surveys' deviating most distinctly from results of 'monthly' and 'IBB surveys' are those with typical wreck conditions (1993 & 1999). Three out of four peak-densities in Common Guillemot during the 7 winters of study were not detected by monthly surveys. All of those peak values were due to massive strandings or 'wrecks', i.e. events with low oil-rates. It appears the major advantages of increasing the frequency from monthly to 'weekly' be the higher probability to detect events or the additional number of corpses that can be collected for further analysis (or for drift- or other experiments).

More important than a very high frequency is a large enough spacing of the surveys throughout the winter (and when possible, throughout the year). A homogenous distribution of surveys over an entire winter season (October-March) is essential due to marked differences in oil-rate throughout the year. Wrecks with high numbers of unoiled beached seabirds were frequent at the Belgian coast during the period 1993-1999 and typically occurred in the second half of the winter. Common Guillemot showed peak densities (> 2.5 $km^{-1}$) in February 1993, January 1995 and February-March 1999, Fulmar knew only one important mass stranding i.e. in February-March 1999. If one decides to carry out only one beached bird survey a winter, it is essential to organise it in the same month each year, which in fact is the basic idea behind the IBB surveys. Spatial variation in beaching intensity even on a small scale (such as the Belgian coast: unpublished data) urges to space surveying effort over the entire length of the coastline. To be statistically representative, survey beaches need to be randomly distributed. This is in accordance with CAMPHUYSEN & HEUBECK (2001), who propose a selection of subregions covering the entire coastline, and in response to local conditions.

## IMPACT DISTANCE

The number of species collected by winter is largely influenced by the distance travelled (function of the number of specimens that can be collected) and the time-span covered. Single surveys such as the IBB survey produce only half of the species richness observed at weekly or monthly surveys. That species composition for weekly surveys is similar to monthly surveys is also mentioned by BODKIN & JAMESON (1991). For the Belgian coast (62.1 km of sand beaches) a reliable species richness deviating not more than 10% of the maximal species spectrum at every monthly survey is obtained at c. 40 km coverage (=65%). This corresponds with a total number of 50-100 birds collected. Both weekly and monthly surveys meet these requirements when data are cumulated up to winter scale. Comparable results were obtained by RAEVEL (1992b). Although RAEVEL indicates that species richness has not reached its upper limit at the maximal distance of 173 km under study, some 65% of this distance (i.e. 112 km) will already produce about 85% of the species richness.

We found a minimum of 25-30 kms (40-50% coverage) is needed to attain stable oil-rates in the Common Guillemot. RAEVEL (1992b) mentions 25-30% coverage (i.e. about 50 km out of a 173 km shoreline) as a minimum, but according to figures presented in his paper a survey on only 10% of the study area (i.e. 17 km) will give oil-rates with deviations of only 10%. This corresponds with the 10% minimum suggested by CAMPHUYSEN (1991b) to obtain reliable figures for various subsectors at the Dutch coast. However it is not distance in se, but a sufficiently large sample that will lead to stable oil rates (see also CAMPHUYSEN & HEUBECK 2001). As a consequence in every other study-area the distance that should minimally be travelled will vary with the density of beached target species and therefore depend on season, occurrence of events etc.. At the Belgian coast, the proposed 25-30 kms corresponds with an average ‘yield’ of 10-15 Common Guillemots. Assuming one needs at least 10 specimens to get reliable annual oil-rate figures for the Belgian coast for a species/taxon, only Common Guillemot provides sufficient corpses each winter in weekly, monthly as well as IBB surveys. *Larus*-gulls meet this criterion only in weekly and monthly surveys, Razorbill only with ‘weekly’ effort. For the much longer Dutch coast, CAMPHUYSEN (1995) selects seven taxa/species that are sufficiently common and widespread to be used as ‘key-species’ for oil-monitoring: Common Guillemot, Razorbill, Kittiwake, Fulmar, Northern Gannet, Common & Velvet Scoter and *Larus*-gulls. The need to cover 25-30 kms (oil-rates) up to 40 kms (species richness) of beach at the Belgian coast in order to obtain reliable oil-monitoring data put a further intensification of mechanical beach cleaning activities during winter into question.

## CONCLUSION

Essentially time investment and hence the cost of the various approaches is dependent on the travelled distance and on the frequency of the surveys. Assuming that professionals carry out all surveys, monthly surveys are slightly more expensive and time-consuming than weekly surveys (Table 7). However, since monthly surveys in Belgium and The Netherlands are largely carried out by a well-trained network of volunteers, monthly surveys turn out here to be the most cost-effective ways to get accurate information on beached birds.

As a general conclusion it is clear the set-up of a beached bird surveying programme depends on the objectives one has in mind. To meet the minimal requirements in terms of oil-pollution data collection, a single IBB survey on 10% (long coastlines) to 50% (short ones cf. Belgium) of the targeted coastline satisfies, preferably synchronic with other neighbouring countries. IBB surveys restricted to a single action in February give reasonable results for density and oil-rate but fail where it comes to signalling events and share of different taxonomic groups. Its main value is the international character of the scheme and its long history (and hence important databases). For at least the Belgian and Dutch situation (CAMPHUYSEN 2001) a survey in February coincides with the period of maximal beaching. If one is also interested in quantifying the number of debilitated or moribund, live birds that come ashore and wants to point out problems at sea in a more or less continuous ways, data from rehabilitation centres should be added. However these data can not be used directly to indicate oiling in seabirds due to an important bias of the data. Moreover the numbers of birds collected are proportionally small, collection takes place in a non-standardized way and important strandings with no or only few living victims might be missed completely. Most satisfactory results (lowest effort versus best results) are obtained by monthly surveys on a large enough part of the shoreline. They give reliable data on oil-rates and total numbers, represent all species and taxa and are reasonably sensitive in detecting events such as wrecks, small oilslicks, winter mortality, etc. Increasing the effort to 'weekly' surveys will increase the sensitivity in detecting short-lasting events and improve the yield of bird corpses substantially (to be used for necropsy examinations, etc.). Alternatively monthly surveys can be combined with data collection through at least one well-runned rehabilitation centre. When important stranding events are signalled by the centre, additional beached bird sampling can then be organised.

*Table 7. Evaluation of various beached bird monitoring approaches applied at the Belgian coast during the winters 1993-1999. Score: ++ = good results; + = fairly good results; - = unreliable results. Remarks: *: needed as additional information; **: good as to signal most but not all events, effort-dependent and hence biased; ***: no manpower needed to comb the beaches, but personnel essential to run the rehabilitation centre. The total field time investment per winter at the Belgian coast amounts to 36 man days (survey methods partly overlapping, see Methods). A rough estimate of the financial input for each BBS-method does not take into account the data analysis phase and assumes all fieldwork is done by professionals.*

| Method | 'weekly surveys' | 'monthly surveys' | 'IBB surveys' | MEC rehabilitation centre |
|---|---|---|---|---|
| - oil-rate | ++ | ++ | ++ | - |
| - total number | ++ | ++ | ++ | * |
| - events | ++ | + | - | -/+ ** |
| - species richness | ++ | ++ | - | - |
| - consistent data since | 1992 | 1986 | 1962 | 1984 |
| - taxonomic groups | ++ | ++ | - | - |
| - yield of corpses 1993-99 | 1916 | 2673 | 910 | 1082 |
| - time investment field work per winter (man days) | 18 | 24 | 4 | - *** |
| - financial input (ratio) | 4.6 | 6 | 1 | - |

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# CHAPTER EIGHT

## SUMMARY

# Summary

## OUTLINE

In this thesis we present a state of the art of seabird research in Belgium (*Chapter one*), with a more detailed analysis of two major datasets. First we try to get insight into the temporal and spatial distribution patterns of seabirds in the southernmost part of the North Sea, on the basis of an intensive seabird survey programme of ship-based (since 1992), aerial (since 1986) and occasional land-based counts. Next we focus on almost forty years of beached bird surveys: from 1962 onwards, sea- and coastal bird corpses have been collected on Belgian beaches during winter in order to assess the scale and causes of their mortality. Both datasets were analysed with a general focus on the relevance for policy and management - as this was also the prime reason to set up the programmes - and approached from three different points of view. Notice that aspects of seabird migration, pathology, ecotoxicology and breeding biology are only dealt with briefly. In a first and analytical/descriptive part we try to distinguish seabird communities in relation to environmental variables (*Chapter two*) and kind of review how bird mortality at sea relates to observed densities of beached corpses (*Chapter five*). In addition some general characteristics of the most common beached bird species are described in *Appendix X*. In a second, management-oriented part we evaluate the results of forty years of beached bird surveying as a monitoring instrument for marine oil pollution (*Chapter six*) and translate the data on seabird distribution at sea into maps with hotspots of threatened species and areas sensitive to oil pollution or disturbance by shipping activities (*Chapter three*). In a third and methodological part we critically evaluate the methods that we applied for beached bird surveying (*Chapter seven*) and bird counting at sea (*Chapter four*) and suggestions for improvements are being made. Finally we formulate an answer to the question whether seabirds can be used as focal species ('indicators') in Belgian waters and make recommendations for future research.

## SEABIRD DISTRIBUTION *(Chapter 2)*

About 16,000 km has been traveled in the Belgian part of the southern North Sea during intensive ship-based seabird surveying in the period 1992-98. Overall we observed 124 bird species and found the highest diversity during the migration periods (spring, autumn). The more offshore Hinderbanken and the deepwater subregion showed the poorest bird communities in terms of number of species. Averaged over the entire study-period and study-area, the density of birds amounted to 6.89 $km^{-2}$ (range: 0-1151 $km^{-2}$), of which 98.1% can be catalogued as seabirds. *Larus*-gulls were most common (3.48 $km^{-2}$), then auks (1.34 $km^{-2}$), Kittiwake (0.57 $km^{-2}$), scoters (0.48 $km^{-2}$) and grebes (0.29 $km^{-2}$). At a species level, the Common Guillemot attained the highest mean densities (1.06 $km^{-2}$), higher than those of Lesser Black-backed Gull (0.92 $km^{-2}$), Herring Gull (0.74 $km^{-2}$), Common Gull (0.71 $km^{-2}$), Kittiwake (0.57 $km^{-2}$), Common Scoter (0.48 $km^{-2}$), Great Black-backed Gull (0.44 $km^{-2}$), Little Gull (0.39 $km^{-2}$), Great Crested Grebe (0.29 $km^{-2}$), Black-headed Gull (0.28 $km^{-2}$), Razorbill (0.25 $km^{-2}$), Northern Gannet (0.15 $km^{-2}$) and Red-throated Diver (0.12 $km^{-2}$). Furthermore the data revealed the existence of an inshore-offshore and a longitudinal gradient in seabird distribution from the Schelde estuary in the east to the deeper, less turbid waters in the west. Piscivorous species preferring clear water and mid- to offshore conditions (auks, Kittiwake and Northern Gannet) were more abundant in the west. Divers, grebes and *Larus*-gulls were commoner in the murky waters near the mouth of the Schelde estuary. In a multiple regression analysis, depth and topography appeared less dominant than distance to the coast, season and longitude as explanatory variables for the distribution of most of the 17 dominant species/taxa. Multivariate and correlative analysis of the abundance of seabird species could not demonstrate strong temporal or spatial coherence of seabirds in communities. Highest correlations were found among *Larus*-gulls scavenging at trawlers, and in the group consisting of auks, Kittiwake and Little Gull. The auks (Razorbill, Common Guillemot) and both gull species were often seen in short-lived multi-species feeding associations over (presumed) fish shoals. Razorbill was the species that associated most frequently with other seabirds (in 28% of all observations). It appeared to be a more 'attractive' target for Kittiwake (34%) and Little Gull (23%) than the Common Guillemot. Associations based on kleptoparasitic behaviour were rarely observed (2.9-6.3% of the observations in skuas). The impact of fishery activities on the distribution of scavenging seabirds (8 of the 17 dominant species) turned out to be large. Some 65-70% of all large gulls in the study area were seen in association with trawlers.

## DESIGNATION AND MANAGEMENT OF MARINE PROTECTED AREAS BASED ON SEABIRD DATA *(Chapter 3)*

The various groups of linear sand ridges off the continental coast of the southernmost part of the North Sea (often misleadingly referred to as the 'Flemish Banks') form a unique area with an important seabird conservation value. Eleven seabird species have been counted in numbers amounting to 1-5% of the entire flyway population in the Belgian part of it that measures merely 3500 $km^2$ or 0.6% of the total North Sea area. Six of them (Red-throated Diver, Common Scoter, Little Gull, Sandwich Tern, Common Tern, Little Tern) are considered as focal or target species for conservation.

Their spatial and temporal distribution is described in more detail. Hotspots, i.e. sites where highest cumulative concentrations of focal species can be found, are situated on the shallow Westkustbanken, in the neighbourhood of the Zeebrugge outer harbour and on the Vlaamse Banken. In addition, during the 1990s the Zeebrugge harbour accommodated an - according to West-European standards - medium-sized colony of Sandwich Tern (1650 pairs), one of the largest colonies of Little Tern (150-430 pairs) and the largest but one colony of Common Tern (2260 pairs) of NW-Europe. The present conservation status of these seabird strongholds is insufficient and marine protected areas (in the widest sense and as foreseen by the 'Law on the protection of the marine environment in sea areas under Belgian jurisdiction') are needed to safeguard these areas of interest. Suggestions are being made to accommodate these conservation needs and to manage Belgian marine waters in a seabird-friendly way. Oil-sensitivity maps indicate that the most vulnerable sites are too close to some of the busiest shipping routes of the world to consider any rerouting measure as an effective management tool. A weighing of the disturbance-sensitivity of different subareas shows that only in the hotspots for divers and scoters and restricted to the winter period, there is a need to regulate boating activities. In addition this southernmost part of the North Sea is a very important corridor for (sea)bird migration. An estimated 1-1.3 million seabirds, with one-third being focal species for conservation, may fly through this bottleneck each year. The great majority (40-100%) of the flyway population of Great Skua and Little Gull may use the Channel to leave the North Sea, as well as 30-70% of the summer resident terns and Lesser Black-backed Gulls. In addition we estimate that 10-20% of the Red-throated Divers and Great Crested Grebes may pass this bottleneck, and 3-10% of the *Larus*-gulls (except for Little Gull), Northern Gannets and Common Scoters. The impact of new developments (such as the installation of wind parks) on resident as well as migrating seabirds here must therefore be carefully investigated.

### MONITORING SEABIRDS ON FIXED FERRY ROUTES: HOW APPROPRIATE IS THE METHOD? *(Chapter 4)*

Superficially, surveying along fixed ferry-routes might look as the perfect tool to monitor seabirds. We analysed a set of 71 ship-based seabird surveys on a fixed ferry route between the Belgian harbour of Oostende and the British harbours Dover and Ramsgate in order to assess the importance of the periodicity of the counts (year, season, month) and of some unwanted side-effects (route, observer, wind) on the resulting densities. There were no significant differences between densities during the outward journey and the return trip. With a GLIM tool, we formed minimal adequate log-linear models of the densities of thirteen abundant species/taxa and quantified the impact of the various factors with a forward selection procedure. In half of the species, 'month' contributed significantly to the model and when 'month' and 'season' were considered, all species responded significantly. Hence it is advisable to cover the major seasons and include as many months as possible in a monitoring programme. When this is not possible, it is important to keep on surveying in the same months. It was also found that a relatively small shift in route (over a distance of c. 15 km) resulted in significant differences in densities in half of the species, with extreme values deviating with as much as a factor 2.4-14.3. Observer effects were considerable in auks (differences in densities of 1.5-3.2x) and really far out for several gull species. The latter might have been caused by slight differences in the interpretation or application of the methodology and these results emphasize the importance of interobserver differences. Finally the wind force affected the observed densities in two species (Kittiwake and Common Gull). It is therefore recommendable to avoid surveying at strong winds when surveys are part of a long-term monitoring programme. We conclude that seabird counts on fixed ferry routes are a useful tool for monitoring long-term changes in seabird abundance, provided the counting methods are further standardized and the analysis takes the most relevant side-effects into account (e.g. with GLIM).

### HOW DOES BIRD MORTALITY AT SEA RELATE TO DENSITIES OF BEACHED CORPSES? *(Chapter 5)*

Birds dying at sea may eventually wash ashore. As such, beached bird surveys can be an important source of information concerning mortality of seabirds in the marine environment. However there has been a lot of debate on the question how numbers of casualties on beaches relate to the actual mortality at sea and which factors affect this relationship. This paper summarizes the results of several experiments carried out with bird corpses in the southernmost part of the North Sea that may help to answer this question. It also tries to fit this information in the current knowledge on this subject. During thirteen drift experiments off the Belgian coast between February 1996 and March 1999, a total of 634 sea- and coastal tagged bird corpses were dropped at sea. Bird corpses were found to drift by the wind at 2.2-3.1% of its own velocity, a value in line with earlier published reports of 2.2-4%. That means that at an average wind speed of 20 km $h^{-1}$ during winter, bird corpses will drift at a speed of 12 km a day. As a result of the prevailing wind conditions here, one expects that merely 10% of all birds washing ashore in Belgium really died in Belgian marine waters. Accordingly, there is a high chance that Belgian beaches receive birds that died in northern France or south-England. Our experiments show mean recovery rates of 12%, which is smaller than an overall mean of 22% for thirty published drift experiments worldwide but conform an older 'standard' to multiply the number of birds found dead on the beach with ten to arrive at an estimate of total mortality. Despite many complicating factors and a large variability (recovery rates ranging from 0 to 75%) some general patterns appear, useful for the interpretation of beached bird numbers in the Southern North Sea. Recovery rates depend primarily on the dropping location (distance to the coast) and on the size of the bird. On average 45-50% of all corpses may be recovered when dropped at 1-2 km from the shore, 0-30% at 2-25 km and virtually none will ever reach the beach when dropped beyond 25 km. Longer-winged (larger) birds are more likely to be recovered on the beach. Recovery rates for the short-winged auks, scoters, grebes and waders amount to 8.3%. Eider, small *Larus*-gulls, Fulmar, Great Cormorant and other waterbirds have a probability twice as high (16.3%) to be recovered, while large *Larus*-gulls (25.3%) and Northern Gannets (44.4%) reveal the highest recovery rates. An evaluation of bird strandings during 1992-99 at the Belgian coast demonstrates a significant correlation of the numbers of beached corpses with the cumulative onshore wind speeds of the ten days prior to the survey. Corpses of offshore birds are much more dependent on sufficient onshore wind to strand and are found more evenly distributed on the shoreline. Temporal patterns of beached birds usually follow those of seabirds at sea with a time lag of at least one month. Persistence experiments during three winters with 562 tagged corpses confirm the picture of short residence times in the Southern North Sea. A bird corpse persists on average for only 5.8-13.3 days on a Belgian beach, with 50-80% of all corpses not recovered anymore after 9 days. It is clear from these results that the short persistence time must have an important impact on the results of beached bird surveys and drift experiments. Small-sized corpses have persistence times of only 0.7 days, medium-sized birds 5.5 days and corpses of large birds remain on the beach for 13 days. Heavily oiled specimens are more persistent than all other corpses. This and other complicating factors are further discussed in the context of the interpretation of beached bird numbers. We conclude that: (1) beached numbers may indicate the extent of the mortality at sea provided the results are interpreted with care and in an international context; (2) there is a need for more drift-, persistence- and floating experiments in order to fully understand what a bird corpse does from the moment it dies until it is being found on the beach; (3) special attention should go to differences in ‘behaviour’ of oiled versus unoiled corpses and to what happens with corpses once they have sunk; (4) models should be developed to help predicting patterns of seabird strandings, not to replace drift experiments at incidents or mass strandings.

**LONG-TERM CHANGE IN OIL POLLUTION OFF THE BELGIAN COAST** *(Chapter 6)*

Oil rates of beached bird corpses are an appropriate condition indicator of oil pollution at sea. Trends in oil pollution in the southernmost part of the North Sea were analysed using a dataset of 37 years (1962-99) of annual Belgian beached bird surveys in February. The most abundant seabird groups were auks (31%), gulls (28%), scoters (17%) and Kittiwake (9%). Oil rates of most bird species/taxa indicate a decline in oil pollution, though only *Larus*-gulls, Common Guillemot and Razorbill show significant reductions. For the other taxa no significant decrease in proportion of oiled birds could be demonstrated, often due to the relatively small study-area and hence the insufficient number of birds that has been collected. The slope in the linear decreasing trend is steeper in inshore and midshore species than in offshore species. A power analysis of the results demonstrates that statistical significant trends are expected with annual indices within 17 years for Razorbill, 29 years for *Larus*-gulls and 31 years for Common Guillemot. For other species/taxa, at least 50 years of surveying is required. In terms of densities of beached birds four separate periods coinciding with the decades can be distinguished. In both the 1960s and 1980s large numbers washed ashore. Divers, Northern Gannet, Eider/scoters and gulls dominated the 1960s whilst the 1980s were characterised by high densities of Common Guillemot and Kittiwake. In the 1970s, the total densities of all species remained surprisingly low. Likewise, after a peak in 1990, numbers levelled off in the following years, except for some important wrecks of Common Guillemot and Fulmar. Over the entire study period densities declined for most species, but only significantly for divers, Northern Gannet, scoters, Coot, skuas and *Larus*-gulls. The Common Guillemot is the only species that increased significantly in density throughout the study period. We conclude that long-term oil pollution monitoring in Belgium should be continued but only in an international context and with a major focus on a set of abundant bird taxa, sensitive to oil-pollution and occurring in various marine habitats. Most appropriate for this purpose are grebes (inshore), *Larus*-gulls, Common Guillemot, Razorbill (midshore), Kittiwake and Fulmar (offshore).

**AN EVALUATION OF BEACHED BIRD MONITORING APPROACHES** *(Chapter 7)*

Oil-pollution monitoring at sea through beach bird surveying would undoubtedly benefit from a further standardization of methods, enhancing the efficiency of data collection. In order to come up with useful recommendations, we evaluated various approaches of beached bird collection at the Belgian coast during seven winters (1993-1999). Data received in a passive way by one major rehabilitation center were compared to the results of targeted beach surveys carried out at different scales by trained ornithologists: ‘weekly’ surveys - with a mean interval of 9 days – restricted to a fixed 16.7 km beach stretch, ‘monthly’ surveys over the entire coastline (62.1 km) and an annual ‘international’ survey in Belgium covering the same distance at the end of February. Most birds collected by the rehabilitation centre were injured and still alive. Oil rates derived from these centres appeared to be strongly biased to oiled auks and inshore bird species, and were therefore of little use in assessing the extent of oil pollution at sea. The major asset of rehabilitation centres in terms of data collection seemed to be their continuous warning function for events of mass mortality. Weekly surveys on a representative and large enough section rendered reliable data on oil rates, estimates of total number of bird victims, representation of various taxonomic groups and species-richness and were most sensitive in detecting events quickly (wrecks, oil-slicks, severe winter mortality,...). Monthly surveys gave comparable results, although they overlooked some important beaching events and demonstrated slightly higher oil rates, probably due to the higher chance to miss short-lasting wrecks of auks. Since the monthly surveys in Belgium were carried out by a network of volunteers and were spread over a larger beach section, they should be considered as the overall best performing approach. Single 'international beached bird survey' in February gave reliable data on the total number of casualties (once the mean ratio between numbers in various months is known) and oil rate (provided a sufficiently large sample can be collected), but failed in tracking events. It is a particularly attractive approach taking into account its long tradition, resulting in invaluable long-term databases, and the uniformity in which these surveys are organised on a large scale. The minimal distance for a monthly survey amounts to 25-30 km (40-50% of Belgian coastline) up to 40 km (65%) in order to attain sound figures for oil rate and species-richness respectively. These distances are primarily determined by the number of bird corpses that may be collected and are hence a function of beaching intensity and corpse detection rate.

### 'BELGIAN' SEABIRDS AS FOCAL SPECIES

Focal species or taxa are those which, for ecological or social reasons, are believed to be valuable for understanding, managing or conserving natural environments and which our attention is preferentially focussed upon for one reason or another. In this sense, it coincides (excluding 'flagship species') with what is described as an 'indicator species' ('an organism whose characteristics – e.g. presence/absence, population density, dispersion, reproductive success – are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest'). In broad terms we can distinguish five major types: keystones, composition indicators, condition indicators, umbrella species and flagships.

From the results summarized above we must conclude that seabirds can indeed play an important role as focal species of Belgian marine waters. Undoubtedly they perform as flagships, in the sense that they may be tools to garner public support and aim at the protection of their habitats. Good examples are oiled Common Guillemots (and in general all oiled seabirds) who for decades have been some of the most effective symbols in the fight against oil pollution at sea, and species such as Common Scoter and the three tern species, being subjects for many discussions on the need to conserve natural values offshore. We could find no good arguments to consider seabirds here as keystones or umbrellas for ecosystems or other species. Seabirds are probably too mobile to be critical to the ecological function of an entire community or habitat, and associations among species are by no means long lasting and widespread. However, as condition-indicators they perform well and we could demonstrate how oil-rates in beached seabirds may be used to monitor long-term changes in marine oil pollution ('environmental indicators'). Most appropriate for this purpose are grebes (inshore), *Larus*-gulls, Common Guillemot, Razorbill (midshore), Kittiwake and Fulmar (offshore).
In addition there are reasons to believe that scoters and divers may be useful as 'management indicators' for boating disturbance. Furthermore we selected six vulnerable seabird species as targets for conservation and ranked the 18 dominant species in terms of their indicator value as representatives for specific communities. For the latter we used several criteria such as: (1) the degree to which it associates with other species, (2) the species must be sufficiently abundant and easy to survey, (3) its distribution is not influenced thoroughly by human activities, (4) it is a focal species for conservation purposes, (5) additional information on mortality and condition can easily be obtained e.g. through studies at breeding colonies or during beached bird surveys. Some of the best performing species, each within a specific feeding guild and season, are Common Tern, Great-crested Grebe, Razorbill, most *Larus*-gulls and Common Scoter. Both the target species for conservation and the representatives of bird communities can be regarded as composition-indicators and may help to channel research and conservation priorities.

### RECOMMENDATIONS FOR FUTURE RESEARCH

Finally we would like to summarize briefly what we feel should get priority in terms of research effort in the future, in order to further upgrade and optimize the use of seabirds in the understanding, the policy and the management of our marine waters. Major efforts should go to:

1) the interaction between <u>*hydrography*</u> (Channel water vs. Schelde estuarine front), <u>*prey-availability*</u> (pelagic fish, molluscs, floating debris), the specific <u>*geomorphologic characteristics*</u> of the study-area (sand ridges) and the way it determines seabird distribution; existing data of integral campaigns should be worked out, new information has to be collected

2) the development of a <u>*standard monitoring route*</u> in which the entire Belgian marine waters can be 'sampled' in a short time-span and whose data can be quickly made available for management purposes (e.g. oil combating schemes)

3) the continuation of seabird <u>*surveys on fixed ferry routes*</u> for long-term monitoring purposes; these surveys should be organised at least once a season (in the same months) and care should be taken to further standardize the methodology, particularly where it concerns the count of large flocks of gulls

4) studies on <u>*behaviour*</u> (movements, activity, ...), <u>*associations*</u>, <u>*feeding ecology*</u> of seabirds with a focus on terns, grebes, auks, *Larus*-gulls and scoters

5) studies on the *impact of disturbance, entanglement and wind mills* on seabirds; in addition techniques should be developed to further differentiate casualties (found during BBS) of entanglement and collision with wind mills from birds killed through other activities

6) the development of a *comprehensive database on the migration of birds* within the funnel-shaped southernmost part of the North Sea; existing data that were collected by local ornithologists should be combined into one single database and analysed in conjunction with data from The Netherlands, northern France and southern England; additional observations from offshore platforms should be considered seriously; radar studies are essential to provide data on nocturnal migration (cf. development of wind parks), vertical distribution and impact of weather conditions

7) the continuation of *beached bird surveys* during winter, particularly the international February and the monthly surveys; in addition data from *rehabilitation centres* should be incorporated into one single quality-controlled database

8) new *drift-, persistence- and floating experiments* with seabird corpses in order to develop a functional *model* that can predict beaching intensity out of data on seabird distribution at sea, weather conditions, topography, oiling, predation, etc...

# Samenvatting

## ALGEMENE OPZET

In deze thesis wordt dieper ingegaan op het zeevogelonderzoek in België, en meer in het bijzonder op twee belangrijke gegevensbestanden. Enerzijds proberen we op basis van intensief telwerk vanop schepen (sinds 1992) en vanuit vliegtuigjes (sinds 1986), aangevuld met occasionele tellingen vanop het land, een beeld te krijgen van hoe zeevogels zich verspreiden in ruimte en tijd. Anderzijds willen we iets meer te weten komen over de mortaliteit onder zee- en kustvogels aan de hand van een dataset van bijna veertig jaar wintertellingen van aangespoelde vogelkadavers (‘beached bird surveys’, BBS). Beide gegevenssets werden aangemaakt ten behoeve van het beleid en beheer van onze kustwateren, wat inhoudt dat dit ook de rode draad zal zijn doorheen de doorgevoerde analyses. Resultaten van zeetrektellingen, broedbiologisch werk en ecotoxicologisch/pathologisch onderzoek komen slechts sporadisch aan bod. In beide luiken (levende vogels op zee, op het strand vastgestelde mortaliteit) zijn telkens drie invalshoeken te onderscheiden. Vanuit een analytisch-beschrijvende opzet proberen we eerst zeevogelgemeenschappen te onderscheiden en te koppelen aan omgevingsvariabelen (*Hfdst. 2*) en maken we een ruime analyse van hoe de mortaliteit op zee zich verhoudt tot wat uiteindelijk hiervan daadwerkelijk op het strand zichtbaar wordt (*Hfdst. 5*). Aanvullend worden op soortsniveau de belangrijkste aspecten uit veertig jaar BBS beschreven in *Appendix X*. In een tweede beleidsgericht deel evalueren we op basis van de BBS-dataset hoe het gesteld is met de olieverontreiniging op zee (*Hfdst. 6*) en maken we een vertaalslag vanuit de verspreiding van zeevogels in de Belgische wateren naar de aanduiding van aandachtssoorten, kerngebieden voor bedreigde zeevogels, oliegevoelige zones en gebieden extra gevoelig voor verstoring door scheepvaart (*Hfdst. 3*). In een derde methodologische luik zoeken we naar een optimaal BBS-programma (*Hfdst. 7*) en gaan we kritisch in op het gebruik van zeevogeltellingen langs ‘vaste’ ferryroutes t.b.v. lange-termijn monitoring (*Hfdst. 4*). Tenslotte brengen we een korte synthese van hoe zeevogels kunnen fungeren als aandachtssoorten (‘indicatoren’) van de Belgische kustwateren en doen we een aantal aanbevelingen voor toekomstig noodzakelijk geacht onderzoek.

## ZEEVOGELGEMEENSCHAPPEN EN –VERSPREIDING (*Hfdst. 2*)

Tussen 1992 en 1999 werd bij intensieve zeevogeltellingen vanop schepen in het Belgisch deel van de zuidelijke Noordzee zowat 16.000 km afgevaren. In totaal werden 124 vogelsoorten waargenomen. De hoogste diversiteit werd vastgesteld gedurende de trekperiodes (lente, herfst). De meest zeewaarts gelegen Hinderbanken en de diepwaterzone kenden steevast de laagste soortendiversiteit. Gemiddeld over de ganse studieperiode bedroeg de vogeldichtheid in de Belgische mariene wateren 6,89 ex. per km$^2$ (bereik: 0-1151 ex. per km$^2$), waarvan 98,1% kan worden beschouwd als zeevogels. De *Larus*-meeuwen waren het talrijkst (3,48 ex. per km$^2$), gevolgd door alkachtigen (1,34 ex. per km$^2$), Drieteenmeeuw (0,57 ex. per km$^2$), zee-eenden (0,48 ex. per km$^2$) en futen (0,29 ex. per km$^2$). Op soortsniveau was de Zeekoet het talrijkst (1,06 ex. per km$^2$), talrijker dan de Kleine Mantelmeeuw (0,92 ex. per km$^2$), Zilvermeeuw (0,74 ex. per km$^2$), Stormmeeuw (0,71 ex. per km$^2$), Drieteenmeeuw (0,57 ex. per km$^2$), Zwarte Zee-eend (0,48 ex. per km$^2$), Grote Mantelmeeuw (0,44 ex. per km$^2$), Dwergmeeuw (0,39 ex. per km$^2$), Fuut (0,29 ex. per km$^2$), Kokmeeuw (0,28 ex. per km$^2$), Alk (0,25 ex. per km$^2$), Jan-van-Gent (0,15 ex. per km$^2$) en Roodkeelduiker (0,12 ex. per km$^2$). Verder kon een kust-zee en een west-oost gradiënt worden aangetoond vanaf het Schelde-estuarium tot aan de diepere en minder troebele zeegebieden op Frans grondgebied. Visetende soorten met een voorkeur voor helder water en mid- tot offshore omstandigheden (alkachtigen, Drieteenmeeuw en Jan-van-Gent) waren talrijker in het westen. Duikers, futen en *Larus*-meeuwen zijn prominenter aanwezig naarmate men het slibrijke water in het mondingsgebied van de Schelde nadert. Een multiple regressie toonde aan dat diepte en topografie ondergeschikt waren aan afstand tot de kust, seizoen en lengtegraad in het verklaren van de verspreiding van de 17 dominante zeevogelsoorten/taxa. Met multivariate en correlatieve technieken konden geen verdere consistente gemeenschappen worden aangetoond. Soorten die het best onderling correleerden in hun verspreiding waren *Larus*-meeuwen (achter vissersschepen) enerzijds en alkachtigen, Drieteenmeeuw en Dwergmeeuw anderzijds. De alkachtigen (Alk, Zeekoet) werden hierbij vaak waargenomen in kortstondige associatie, vermoedelijk ter hoogte van aanwezige visscholen. De Alk werd het vaakst in gezelschap waargenomen (in 28% van alle waarnemingen) en bleek een ‘aantrekkelijker’ doelwit voor Drieteenmeeuw (34%) en Dwergmeeuw (23%) dan de Zeekoet. Kleptoparasitisme, een andere vorm van associaties tussen zeevogels, werd slechts zelden waargenomen (2,9-6,3% van de waargenomen jagers). De impact van visserijactiviteiten bleek van groot belang voor de verspreiding van opportunistische zeevogels (8 van de 17 talrijkste soorten). Zowat 65-70% van alle grotere meeuwen in het studiegebied werden waargenomen in de directe buurt van vissersschepen.

**INSTELLING EN BEHEER VAN MARIEN BESCHERMDE GEBIEDEN A.D.H.V. ZEEVOGELGEGEVENS** (*Hfdst. 3*)

De zandbankcomplexen aan de continentale kusten van het zuidelijkste deel van de Noordzee (vaak misleidend 'Vlaamse Banken' genoemd) zijn een uniek gebied met een belangrijke beschermingswaarde voor zeevogels. Van elf soorten werd in dit gebied van nauwelijks 3500 km$^2$ of 0,6% van de volledige Noordzee oppervlakte, 1-5% van de volledige biogeografische populatie waargenomen. Zes van de elf (Roodkeelduiker, Zwarte Zee-eend, Dwergmeeuw, Grote Stern, Visdief, Dwergstern) worden ook internationaal beschouwd als kwetsbare soorten die bescherming vereisen. Van deze zeevogels bespreken we de ruimtelijke en temporele verspreiding in meer detail en worden kaartjes gepresenteerd die de cumulatieve waarde aangeeft. Deze hotspots blijken zich te situeren op de ondiepe Westkustbanken, in de omgeving van de Zeebrugse voorhaven en op de Vlaamse Banken. Daarenboven herbergde de Zeebrugse voorhaven het laatste decennium een – naar Europese maatstaven – middelgrote kolonie van de Grote Stern (1650 paar), één van de grootste kolonies Dwergsternen (150-430 paar) en de op één na omvangrijkste NW-Europese Visdieven kolonie (2260 paar). De huidige beschermingsstatus voor zeevogels is ontoereikend en marien beschermde gebieden zijn dan ook nodig, zoals voorzien in de 'Wet ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België'. Daarenboven is er nood aan beheersmaatregelen die deze beschermingsmodaliteiten dienen te ondersteunen. De olie-kwetsbaarheidskaarten die in deze thesis worden voorgesteld geven te kennen dat routeringsmaatregelen voor de scheepvaart zo dicht bij één van de drukst bevaren routes ter wereld weinig zinvol zijn ter bescherming van de aanwezige zeevogels. Wel is er behoefte aan beperking van scheepvaartverstoring tijdens de winter en enkel in de kerngebieden voor zee-eenden en duikers. Daarenboven vormt het zuidelijkste, trechtervormige deel van de Noordzee een zeer belangrijke corridor voor (zee)vogeltrek. Naar schatting 1-1,3 miljoen zeevogels, waarvan een derde dient te worden aanzien als aandachtssoort naar bescherming toe, kunnen jaarlijks doorheen deze flessenhals migreren. Het betreft o.a. de grote meerderheid (40-100%) van de biogeografische populatie Grote Jagers en Dwergmeeuw, 30-70% van de populatie van drie sternensoorten en van de Kleine Mantelmeeuw, 10-20% van de Roodkeelduikers en Futen alsook 3-10% van de *Larus*-meeuwen (voor Dwergmeeuw zie hoger), Jan-van-Genten en Zwarte Zee-eenden. De mogelijke impact van nieuwe ontwikkelingen, zoals de aanleg van windmolenparken, op residente en doortrekkende zeevogels dient dan ook ten gronde te worden onderzocht.

**KAN ZEEVOGEL MONITORING VANOP FERRY-SCHEPEN: HOE BETROUWBAAR IS DE METHODE?** *(Hfdst. 4)*

Op het eerste zicht lijkt het monitoren van zeevogels vanaf ferry-schepen op vaste routes een gedroomde methode. Is dit wel zo? Wij analyseerden een gegevensset bestaande uit 71 tellingen uitgevoerd tussen de haven van Oostende en de Britse havens Dover en Ramsgate, en onderzochten in hoeverre de periodiciteit van de tellingen (jaarlijks, per seizoen, per maand) en ongewenste neveneffecten (kleine route-verschuivingen, waarnemersverschillen, wind) een invloed hadden op de waargenomen dichtheden aan zeevogels. In een eerste analyse bleek dat er geen significant verschil optrad tussen heen- en terugvaarten op dezelfde dag. Met Generalized Linear Models berekenden we log-lineaire modellen van de densiteiten van dertien talrijke soorten/taxa en kwantificeerden de impact van de verschillende factoren door middel van een voorwaartse selectieprocedure. We vonden dat bij de helft van de soorten 'maand' significant bijdroeg aan het model, en dat – als ook seizoen werd mee beschouwd – de dichtheden van alle soorten door minstens één van beide variabelen werden bepaald. Dit betekent dat een monitoringsprogramma minimaal elk seizoen en bij voorkeur elke maand dient plaats te grijpen. Indien dit laatste niet haalbaar is, dient telkens gedurende dezelfde maand binnen één seizoen te worden geteld. We vonden ook dat een relatief kleine wijziging in de route (over een afstand van nauwelijks 15 km) reeds kan resulteren in significante verschillen bij de helft van de soorten (in extreme gevallen leidend tot densiteiten die verschillen met een factor 2,4-14,3). Waarnemerseffecten traden op bij alkachtigen (tot een factor 1,5-3,2 x verschillend) en waren onaanvaardbaar hoog bij verschillende meeuwensoorten. We vermoeden dat dit laatste veroorzaakt werd door kleine verschillen in interpretatie of toepassing van de standaardmethode en in elk geval geeft het aan dat waarnemersverschillen belangrijk genoeg zijn om ze degelijk te bestuderen. Ook windkracht had een effect op de waargenomen densiteiten bij twee soorten (Drieteenmeeuw en Stormmeeuw), in die mate dat het in het kader van een lange-termijn monitoringsprogramma aan te bevelen is niet te tellen bij harde wind. Als algemeen besluit zien we wel degelijk een toekomst weggelegd voor lange-termijn monitoring van zeevogels vanop ferry-schepen, maar dan enkel als de telmethodes verder worden bijgeschaafd en de verwerking van de gegevens rekening houdt met de belangrijkste neveneffecten (bijv. d.m.v. GLIM).

**HOE VERHOUDT DE STERFTE VAN VOGELS OP ZEE ZICH TOT DE WAARGENOMEN GESTRANDE AANTALLEN?** *(Hfdst. 5)*

Voor elke vogel die sterft op zee bestaat er een kans dat hij op het strand aanspoelt en dus informatie kan verschaffen over de mortaliteit in de mariene omgeving. Toch is er reeds lang discussie over de vraag of aangetroffen aantallen kadavers op het strand wel kunnen worden gebruikt als maatstaf voor die sterfte en welke factoren hierop inspelen. In deze bijdrage vatten we de resultaten samen van experimenteel werk dat werd uitgevoerd in het zuidelijkste deel van de Noordzee en mogelijk een antwoord kan helpen bieden op deze vragen. Vervolgens wordt aan de hand van een literatuurstudie nagegaan hoe het gesteld is met de huidige kennis op het terrein. Bij dertien verschillende verdriftingsexperimenten vóór de Belgische kust tussen februari 1996 en maart 1999 werden in totaal 634 gemerkte

vogelkadavers op zee gedropt. De kadavers bleken zich te verplaatsen aan 2,2-3,1% van de windsnelheid, wat overeenstemt met de literatuurgegevens ter zake (2,2-4%). Rekening houdend met een gemiddelde windsnelheid aan onze kust van 20 km $h^{-1}$ tijdens de winter, verplaatst een kadaver zich dus gemiddeld 12 km per dag. Als ook de overwegend ZW-W windrichting in rekening wordt gebracht kan worden afgeleid dat vermoedelijk slechts 10% van alle kadavers die op Belgische stranden worden aangetroffen ook daadwerkelijk gestorven zijn in Belgische mariene wateren, en dat de kans groot is dat vooral Noord-Franse en Zuid-Engelse vogels hier aanspoelen.
Wij vonden 12% van alle op zee gedropte exemplaren terug, wat minder is dan het gemiddeld terugmeldcijfer van 22% voor een dertigtal gelijkaardige experimenten uitgevoerd wereldwijd, maar aansluit bij de vroeger wel eens gehanteerde norm om de gevonden aantallen op het strand met tien te vermenigvuldigen om de werkelijke sterfte te kennen. Ondanks vele complicerende factoren en een grote variabiliteit (terugmeldpercentages fluctueren van 0 tot 75%) blijven een aantal algemene patronen overeind die het mogelijk maken gestrande aantallen in de Zuidelijke Noordzee te interpreteren. Zo blijkt de terugmeldkans vooral bepaald door de afstand tot de kust waarop de vogel wordt gedropt en door de grootte. Gemiddeld wordt 45-50% teruggemeld als er gedropt wordt op 1-2 km uit de kust, 0-30% als op 2-25 km offshore en vrijwel niets bij droppings voorbij de 25 km. Grotere vogels (met langere vleugels) hebben een grotere kans te worden teruggevonden, wat blijkt uit de toenemende terugmeldkans voor respectievelijk de kortvleugelige alkachtigen, zee-eenden, futen en steltlopers (8,3%), Eidereend, kleine *Larus*-meeuwen, Noordse Stormvogel, Aalscholver en andere watervogels (16,3%), grote *Larus*-meeuwen (25,3%) en Jan-van-Genten (44,4%).
Een evaluatie van de strandingen aan de Belgische kust tussen 1992 en 1999 leert verder nog dat de aantallen significant gecorreleerd zijn met de cumulatieve aanlandige windsnelheden over een periode van tien dagen vóór de survey. Kadavers van offshore soorten spoelen pas aan als de aanlandige wind meerdere dagen aanhoudt en verdelen zich gelijkmatiger over de volledige kustlijn. Doorgaans is het aanspoelingspatroon analoog aan het seizoenaal verspreidingspatroon op zee, maar dan met een tijdsverschil van één tot meerdere maanden.
Ligduurexperimenten gedurende drie winters met in totaal 562 gemerkte kadavers bevestigen het beeld van de zeer korte ligduren op stranden van de Zuidelijke Noordzee. Gemiddeld blijft een vogel tijdens de winter slechts 5,8-13,3 dagen liggen op een Belgisch strand en worden 50-80% niet meer teruggevonden na amper 9 dagen, resultaten die aangeven hoezeer de ligduur van belang is bij de interpretatie van resultaten van 'beached bird surveys' (BBS) en verdriftingsexperimenten. Kleine kadavers verdwijnen het snelst (ligduur: 0,7 dagen), middelgrote (5,5 dagen) en grote vogels (13 dagen) blijven significant langer liggen. Zwaar met olie besmeurde exemplaren zijn ook persistenter dan alle andere kadavers. Vanuit een globale benadering van deze en andere resultaten besluiten we dat: (1) gestrande aantallen wel degelijk iets te vertellen hebben over de schaal van mortaliteit op zee, op voorwaarde dat de resultaten voorzichtig en binnen een internationale context worden geïnterpreteerd, (2) er nood is aan bijkomende verdriftings-, ligduur- en zinkexperimenten, (3) er bijzondere aandacht moet gaan naar verschillen in 'drijf-, zink- en ligduurgedrag' tussen vogels met en zonder olie en naar wat met kadavers gebeurt nadat ze zinken, (4) er modellen dienen te worden ontwikkeld om de karakteristieken van zeevogelstrandingen te helpen voorspellen, als aanvulling bij verdriftingsexperimenten uit te voeren bij massale strandingen.

### LANGE-TERMIJN TRENDS IN OLIEVERONTREINIGING VÓÓR DE BELGISCHE KUST *(Hfdst. 6)*

Oliebesmeuringspercentages van gestrande zeevogels zijn een geschikte conditie-indicator voor olieverontreiniging op zee. Hierop gebaseerd onderzochten we trends in olieverontreiniging in het zuidelijkste deel van de Noordzee, aan de hand van 'beached bird surveys' die sinds 1962 elk jaar in februari werden uitgevoerd aan de Belgische kust. Talrijkst waren alkachtigen (31%), meeuwen (28%), zee-eenden (17%) en Drieteenmeeuw (9%). Over de bestudeerde 37 jaar vertonen de besmeuringspercentages van de meeste vogelsoorten/taxa een dalende trend, hoewel – ten gevolge van onze korte kustlijn en dus een soms te beperkt aantal gevonden kadavers voor analyse - deze trends enkel significant waren voor *Larus*-meeuwen, Zeekoet en Alk. Een power-analyse geeft dan ook aan dat significante trends, indien aanwezig, pas zullen gevonden worden a.d.h.v. jaarlijkse indices (met een 90% kans) na 17 jaar (Alk), 29 jaar (*Larus*-meeuwen), 31 jaar (Zeekoet) en voor andere soorten ten vroegste na 50 jaar monitoren. De meer kustgebonden soorten vertonen een sterkere daling in oliebesmeuring dan de offshore soorten.

Qua aanspoelingsintensiteit (densiteiten) kunnen vier periodes worden onderscheiden: grote aantallen in de zestiger (veel duikers, Jan-van-Genten, zee-eenden en meeuwen) en tachtiger jaren (Zeekoet, Drieteenmeeuw), wisselden af met lage aantallen in de zeventiger en negentiger jaren. Na een piek in 1990 namen de aantallen globaal af, hoewel er soms belangrijke sterfte van Zeekoet en Noordse Stormvogel optrad. De Zeekoet is overigens de enige soort waarvan de aantallen kadavers op de stranden in de tijd zijn toegenomen. Significante dalingen werden waargenomen bij duikers, Jan-van-Gent, zee-eenden, Meerkoet, jagers en *Larus*-meeuwen.

We besluiten dat een lange-termijn monitoring naar olieverontreiniging zoals de voorbije 37 jaar uitgevoerd in België heel waardevol is en moet worden verder gezet, vanuit een internationale context en met speciale aandacht voor talrijke, voor olie gevoelige taxa uit verschillende deelhabitats (kustnabije zone: futen; middengebied: *Larus*-meeuwen, Zeekoet en Alk; meest zeewaartse deel: Drieteenmeeuw en Noordse Stormvogel).

**EEN EVALUATIE VAN VERSCHILLENDE MONITORINGSTECHNIEKEN VAN GESTRANDE VOGELS** *(Hfdst. 7)*

In het licht van een optimalisatie van de methode om a.d.h.v. gestrande zee- en kustvogels mariene olieverontreiniging te monitoren, analyseerden we een gegevensset verzameld aan de Belgische kust (1993-99). Data verkregen via het vogelopvangcentrum te Oostende (Marien Ecologisch Centrum – MEC) werden vergeleken met de resultaten van gerichte strandtellingen uitgevoerd door professionele ornithologen en verzameld over uiteenlopende afstanden en volgens een wisselende periodiciteit: ‘wekelijkse’ tellingen (interval van gemiddeld 9 dagen) op een vast traject van 16,7 km, ‘maandelijkse’ tellingen van alle Belgische stranden (62,1 km) en een éénmalige ‘internationale’ survey telkens in februari en eveneens over de volledige 62,1 km. De resultaten geven aan dat gegevens van veelal gewonde en nog levende vogels die op onregelmatige basis worden binnengebracht in het kustopvangcentrum een vertekend beeld leveren voor wat betreft de oliebesmeuringspercentages. Voor alkachtigen waren de percentages met olie besmeurde vogels opvallend veel hoger, voor kustgebonden soorten significant lager dan bij strandtellingen. De belangrijkste troef van opvangcentra naar het leveren van gegevens toe lijkt dan ook hun ‘early-warning’ functie te zijn. Wekelijkse strandtellingen uitgevoerd op een representatief deel van de kustlijn, geven de beste resultaten voor oliebesmeuringspercentages, schattingen van totaal aantal strandende kadavers, vertegenwoordiging van verschillende taxonomische groepen en soortenrijkdom en zijn het gevoeligst voor wat betreft het signaleren van belangrijke strandingen (‘wrecks’, olievlekken op zee, strenge winterperiodes, ...). Vermits maandelijkse tellingen in België kunnen worden uitgevoerd door vrijwilligers en de volledige kustlijn dekken enerzijds, en anderzijds qua resultaten niet echt moeten onderdoen voor de wekelijkse surveys (iets minder gevoelig voor detecteren van strandingen en lichtjes hogere besmeuringspercentages opleverend), kunnen ze beschouwd worden als de meest kost-efficiënte methode. De éénmalige internationale survey in februari geeft wel nog bevredigende schattingen van het aantal slachtoffers per winter (eens de verhouding in gevonden aantallen tussen maanden is gekend) en van het oliebesmeuringspercentage (als voldoende exemplaren worden gevonden), maar missen heel wat belangrijke strandingen. Toch blijft het een bijzonder waardevolle methode, gezien zijn lange traditie, dito databestanden en uniformiteit waarmee deze tellingen op internationaal niveau worden uitgevoerd. We berekenden ook dat de minimale afstand die moet worden afgelegd bij maandelijkse tellingen om betrouwbare oliebesmeuringspercentages te verkrijgen en voldoende soorten te behappen, 25-30 km (40-50% van de Belgische kust) tot respectievelijk 40 km (65%) bedraagt. Deze afstand wordt bepaald door het aantal kadavers dat kan worden gevonden en hangt dus vooral af van de intensiteit van het aanspoelen en de terugvindkans.

**‘BELGISCHE’ ZEEVOGELS ALS AANDACHTSOORTEN**

Aandachtsoorten of –taxa zijn soorten/taxa die worden geacht, omwille van ecologische of sociale redenen, waardevol te zijn bij het begrijpen, beheren of beschermen van natuurlijke leefomgevingen en die dus primair onze aandacht opeisen. In die zin valt het begrip samen met het begrip ‘indicator’ (met uitsluiting van ‘symboolsoorten’), dat omschreven wordt als: ‘een organisme waarvan de kenmerken – bv. aan/afwezigheid, populatiedichtheid, dispersie, reproductief succes, ... – kunnen worden gebruikt als een index voor kenmerken die anders te moeilijk, onhandig of té duur zouden zijn om gemeten te worden bij andere soorten of omgevingsvariabelen’. In algemene termen kunnen vijf klassen worden onderscheiden: hoeksteensoorten, compositie-indicatoren, conditie-indicatoren, paraplusoorten en symboolsoorten.

Uit de hierboven samengevatte resultaten kunnen we concluderen dat zeevogels wel degelijk een belangrijke rol kunnen vervullen als aandachtsoorten voor Belgische mariene wateren. Ongetwijfeld zijn het symboolsoorten die de publieke opinie kunnen bespelen en bescherming van habitats kunnen stimuleren. Voorbeelden zijn de mate waarin met olie besmeurde zeevogels reeds jaar en dag worden gehanteerd als mascottes in de strijd tegen verontreiniging van de zeeën en de symboolwaarde van de Zwarte Zee-eend en de drie hoger genoemde sternensoorten in de discussies rond de bescherming van het marien milieu. We konden geen goede redenen vinden om zeevogels te beschouwen als hoeksteensoorten of paraplusoorten voor ecosystemen of andere soorten, deels omdat zeevogels nu eenmaal té mobiel zijn om onmisbaar te zijn in het functioneren van volledige ecosystemen en omdat associaties veelal van korte duur blijken. Als conditie-indicatoren zijn ze echter wel bruikbaar, zoals kon worden aangetoond aan de hand van de bepaling van trends in olieverontreiniging over een periode van 37 jaar. Meest geschikt voor dit doel zijn futen (kustgebonden), *Larus*-meeuwen, Zeekoet, Alk (middengebied), Drieteenmeeuw en Noordse Stormvogel (offshore). Verder lijken zee-eenden en duikers geschikte ‘beheersindicatoren’ voor het fenomeen verstoring door scheepvaart. Zes kwetsbare zeevogelsoorten werden geselecteerd als aandachtsoorten voor beschermingsmaatregelen en we suggereren een rangorde in indicatorwaarde voor de 18 talrijkste zeevogelsoorten als vertegenwoordigers voor bepaalde trofische gemeenschappen. Gebruikte criteria zijn: (1) de mate waarin ze associëren met andere soorten, (2) hun talrijkheid en het gemak waarmee ze geteld kunnen worden, (3) een verspreiding die zo min mogelijk beïnvloed wordt door menselijke activiteiten, (4) of ze aandachtsoorten zijn voor het natuurbehoud, (5) de mate waarin bijkomende informatie over mortaliteit en conditie kan worden verzameld, bv. d.m.v. studies in broedgebieden of bij ‘beached bird surveys’. Samengevat beantwoorden – elk binnen hun trofische gemeenschap en voor een bepaald seizoen – volgende soorten best aan deze criteria: Visdief, Fuut, Alk, de meeste *Larus*-meeuwen en Zwarte Zee-eend. Zowel deze vertegenwoordigers als de aandachtsoorten voor het natuurbehoud op zee kunnen beschouwd worden als compositie-indicatoren en mogen dus bijzondere aandacht krijgen bij het vastleggen van toekomstig onderzoek en beschermingsprioriteiten.

**AANBEVELINGEN VOOR TOEKOMSTIG ONDERZOEK**

Samengevat zijn volgende onderzoeksnoden aanwezig om zeevogels nog beter te laten functioneren in het begrijpen en het beheren van ons marien milieu:

1) Om de interactie tussen *hydrografie* (Kanaalwater vs. Schelde estuarien front), *prooi-beschikbaarheid* (pelagische vis, schelpdieren, drijvend afval) en de specifieke *geomorfologische karakteristieken* van het studiegebied met zijn vele zandbanken te kunnen begrijpen, dienen de resultaten van de reeds uitgevoerde integrale campagnes te worden verwerkt en moet nieuw onderzoek worden opgezet.
2) De ontwikkeling van een *standaard monitoringsroute* voor zeevogels moet toelaten het volledige gebied van de Belgisch mariene wateren op een kort tijdsbestek te bemonsteren en de hieruit voortvloeiende data moeten zo snel mogelijk kunnen worden vrijgemaakt ten behoeve van het beleid (bv. oliebestrijding)
3) Lange-termijn monitoring van zeevogels kan best worden gecontinueerd m.b.v. *ferrytellingen op vaste routes*; deze tellingen dienen minimaal éénmaal per seizoen te gebeuren (telkens in zelfde maand) en de methode moet verder geüniformiseerd worden, met name bij het tellen van grote groepen meeuwen
4) Er is nood aan onderzoek met betrekking tot het *gedrag* (bewegingen, activiteit, ...), bestaande *associaties* en *voedselecologie* van sternen, alkachtigen, *Larus*-meeuwen en zee-eenden
5) Er dient te worden geanticipeerd op noden vanuit het beleid, in het bijzonder rond het mogelijke probleem van *verstoring door de scheepvaart, verstrikking in netten en aanvaring/verstoring door windmolens*; technieken moeten worden verfijnd om doodsoorzaken van gestrande vogels nog beter te kunnen thuiswijzen (bv. verstrikking in staande want, aanvaring met windmolens, ...)
6) Het is wenselijk dat alle *zeetrektelgegevens* verzameld in het trechtervormige, zuidelijkste deel van de Noordzee, worden samengebracht in één *databank*; daarbovenop is er nood aan waarnemingen vanop offshore platforms en aan radarstudies om een zicht te krijgen op de nachtelijke trekbewegingen, de verticale verspreiding en de impact van het weer op de trek
7) *Beached bird surveys* dienen te worden gecontinueerd tijdens de winter, zeker ter gelegenheid van de jaarlijkse internationale februaritelling en de maandelijkse surveys; ook is het wenselijk de gegevens van *vogelopvangcentra* efficiënter te verzamelen en te incorporeren in een kwaliteitsgecontroleerde databank
8) Er moet gestreefd worden naar het opstellen van een functioneel *model* dat de aard en de grootte van zeevogelstrandingen kan voorspellen vanuit de verspreiding op zee, het weer, de onderwatertopografie, predatie, besmeuring met olie, etc....; in dit verband zijn nieuwe *verdriftings-, ligduur- en zinkexperimenten* essentieel.

# APPENDICES

## LIST OF APPENDICES

# APPENDIX I

*Bird species observed during: (1) ship-based, land-based and aerial surveys in Belgian marine waters and the southernmost part of the North Sea during 1992-1998, and (2) at regular beached bird surveys at the Belgian coast during 1962-1999 (nomenclature following* JONSSON *1993). Indicated are: the international EURING code; the scientific, English, Dutch and French name; family; group (according to* STOWE *1982); whether we consider them as S(eabirds), C(oastal birds) or T(errestrial birds); their presence during (A) Seabird at Sea (SAS) surveys in Belgian waters, (B) idem in the southernmost part of the North Sea, (C) Beached Bird Surveys (BBS) at the Belgian coast, and in which Annex of the EC-Birds Directive (BD), the Bern Convention (Bern) and the Bonn Convention (Bonn) they are included.*

| EURING | Scientific name | English name | Dutch name | French name |
|---|---|---|---|---|
| 20 | *Gavia stellata* | Red-throated Diver | Roodkeelduiker | Plongeon catmarin |
| 30 | *Gavia arctica* | Black-throated Diver | Parelduiker | Plongeon arctique |
| 40 | *Gavia immer* | Great Northern Diver | IJsduiker | Plongeon imbrin |
| 70 | *Tachybaptus ruficollis* | Little Grebe | Dodaars | Grèbe castagneux |
| 90 | *Podiceps cristatus* | Great Crested Grebe | Fuut | Grèbe huppé |
| 100 | *Podiceps grisegena* | Red-necked Grebe | Roodhalsfuut | Grèbe jougris |
| 110 | *Podiceps auritus* | Slavonian Grebe | Kuifduiker | Grèbe esclavon |
| 120 | *Podiceps nigricollis* | Black-necked Grebe | Geoorde Fuut | Grèbe à cou noir |
| 220 | *Fulmarus glacialis* | Fulmar | Noordse Stormvogel | Fulmar boréal |
| 400 | *Puffinus gravis* | Great Shearwater | Grote Pijlstormvogel | Puffin majeur |
| 430 | *Puffinus griseus* | Sooty Shearwater | Grauwe Pijlstormvogel | Puffin fuligineux |
| 460 | *Puffinus puffinus* | Manx Shearwater | Noordse Pijlstormvogel | Puffin des Anglais |
| 520 | *Hydrobates pelagicus* | European Storm-petrel | Stormvogeltje | Océanite tempête |
| 550 | *Oceanodroma leucorhoa* | Leach's Storm-petrel | Vaal Stormvogeltje | Océanite culblanc |
| 710 | *Morus bassanus* | Northern Gannet | Jan van Gent | Fou de Bassan |
| 720 | *Phalacrocorax carbo* | Great Cormorant | Aalscholver | Grand Cormoran |
| 800 | *Phalacrocorax aristotelis* | Shag | Kuifaalscholver | Cormoran huppé |
| 950 | *Botaurus stellaris* | Great Bittern | Roerdomp | Butor étoilé |
| 1220 | *Ardea cinerea* | Grey Heron | Blauwe Reiger | Héron cendré |
| 1520 | *Cygnus olor* | Mute Swan | Knobbelzwaan | Cygne tuberculé |
| 1570 | *Anser fabalis* | Bean Goose | Rietgans | Oie des moissons |
| 1580 | *Anser brachyrhynchus* | Pink-footed Goose | Kleine Rietgans | Oie à bec court |
| 1590 | *Anser albifrons* | White-fronted Goose | Kolgans | Oie rieuse |
| 1610 | *Anser anser* | Greylag Goose | Grauwe Gans | Oie cendrée |
| 1660 | *Branta canadensis* | Canada Goose | Canadese Gans | Bernache du Canada |
| 1670 | *Branta leucopsis* | Barnacle Goose | Brandgans | Bernache nonnette |
| 1680 | *Branta bernicla* | Brent Goose | Rotgans | Bernache cravant |
| 1700 | *Alopochen aegyptiacus* | Egyptian Goose | Nijlgans | Ouette d'Egypte |
| 1730 | *Tadorna tadorna* | Common Shelduck | Bergeend | Tadorne de Belon |
| 1780 | *Aix galericulata* | Mandarin Duck | Mandarijneend | Canard mandarin |
| 1790 | *Anas penelope* | Eurasian Wigeon | Smient | Canard siffleur |
| 1820 | *Anas strepera* | Gadwall | Krakeend | Canard chipeau |
| 1840 | *Anas crecca* | Common Teal | Wintertaling | Sarcelle d'hiver |
| 1860 | *Anas platyrhynchos* | Mallard | Wilde Eend | Canard colvert |
| 1890 | *Anas acuta* | Northern Pintail | Pijlstaart | Canard pilet |
| 1910 | *Anas querquedula* | Garganey | Zomertaling | Sarcelle d'été |
| 1940 | *Anas clypeata* | Northern Shoveler | Slobeend | Canard souchet |
| 1980 | *Aythya ferina* | Common Pochard | Tafeleend | Fuligule milouin |
| 2030 | *Aythya fuligula* | Tufted Duck | Kuifeend | Fuligule morrilon |
| 2040 | *Aythya marila* | Greater Scaup | Toppereend | Fuligule milouinan |
| 2060 | *Somateria mollissima* | Common Eider | Eidereend | Eider à duvet |
| 2120 | *Clangula hyemalis* | Long-tailed Duck | IJseend | Harelde boréal |
| 2130 | *Melanitta nigra* | Common Scoter | Zwarte Zeeëend | Macreuse noire |
| 2150 | *Melanitta fusca* | Velvet Scoter | Grote Zeeëend | Macreuse brune |
| 2180 | *Bucephala clangula* | Common Goldeneye | Brilduiker | Garrot à oeil d'or |
| 2200 | *Mergus albellus* | Smew | Nonnetje | Harle piette |
| 2210 | *Mergus serrator* | Red-breasted Merganser | Middelste Zaagbek | Harle huppé |
| 2230 | *Mergus merganser* | Goosander | Grote Zaagbek | Harle bièvre |
| 2600 | *Circus aeruginosus* | Marsh Harrier | Bruine Kiekendief | Busard des roseaux |

| | | | | |
|---|---|---|---|---|
| 2690 | *Accipiter nisus* | Eurasian Sparrowhawk | Sperwer | Epervier d'Europe |
| 2900 | *Buteo lagopus* | Rough-legged Buzzard | Ruigpootbuizerd | Buse pattue |
| 3040 | *Falco tinnunculus* | Common Kestrel | Torenvalk | Faucon crécerelle |
| 3100 | *Falco subbuteo* | Hobby | Boomvalk | Faucon hobereau |
| 3200 | *Falco peregrinus* | Peregrine Falcon | Slechtvalk | Faucon pélerin |
| 3670 | *Perdix perdix* | Grey Partridge | Patrijs | Perdrix grise |
| 3940 | *Phasianus colchicus* | Common Pheasant | Fazant | Faisan de Colchide |
| 4070 | *Rallus aquaticus* | Water Rail | Waterral | Râle d'eau |
| 4240 | *Gallinula chloropus* | Moorhen | Waterhoen | Gallinule poule-d'eau |
| 4290 | *Fulica atra* | Common Coot | Meerkoet | Foulque macroule |
| 4500 | *Haematopus ostralegus* | Oystercatcher | Scholekster | Huîtrier pie |
| 4560 | *Recurvirostra avosetta* | Avocet | Kluut | Avocette élégante |
| 4690 | *Charadrius dubius* | Little Ringed Plover | Kleine Plevier | Petit Gravelot |
| 4700 | *Charadrius hiaticula* | Great Ringed Plover | Bontbekplevier | Grand Gravelot |
| 4770 | *Charadrius alexandrinus* | Kentish Plover | Strandplevier | Gravelot à collier interrompu |
| 4850 | *Pluvialis apricaria* | European Golden Plover | Goudplevier | Pluvier doré |
| 4860 | *Pluvialis squatarola* | Grey Plover | Zilverplevier | Pluvier argenté |
| 4930 | *Vanellus vanellus* | Northern Lapwing | Kievit | Vanneau huppé |
| 4960 | *Calidris canutus* | Red Knot | Kanoetstrandloper | Bécasseau maubèche |
| 4970 | *Calidris alba* | Sanderling | Drieteenstrandloper | Bécasseau sanderling |
| 5100 | *Calidris maritima* | Purple Sandpiper | Paarse Strandloper | Bécasseau violet |
| 5120 | *Calidris alpina* | Dunlin | Bonte Strandloper | Bécasseau variable |
| 5170 | *Philomachus pugnax* | Ruff | Kemphaan | Combattant varié |
| 5180 | *Lymnocryptes minimus* | Jack Snipe | Bokje | Bécassine sourde |
| 5190 | *Gallinago gallinago* | Common Snipe | Watersnip | Bécassine des marais |
| 5290 | *Scolopax rusticola* | Woodcock | Houtsnip | Bécasse des bois |
| 5320 | *Limosa limosa* | Black-tailed Godwit | Grutto | Barge à queue noire |
| 5340 | *Limosa lapponica* | Bar-tailed Godwit | Rosse Grutto | Barge rousse |
| 5380 | *Numenius phaeopus* | Whimbrel | Regenwulp | Courlis corlieu |
| 5410 | *Numenius arquata* | Eurasian Curlew | Wulp | Courlis cendré |
| 5460 | *Tringa totanus* | Common Redshank | Tureluur | Chevalier gambette |
| 5480 | *Tringa nebularia* | Common Greenshank | Groenpootruiter | Chevalier aboyeur |
| 5610 | *Arenaria interpres* | Turnstone | Steenloper | Tournepierre à collier |
| 5640 | *Phalaropus lobatus* | Red-necked Phalarope | Grauwe Franjepoot | Phalarope à bec étroit |
| 5650 | *Phalaropus fulicarius* | Grey Phalarope | Rosse Franjepoot | Phalarope à bec large |
| 5660 | *Stercorarius pomarinus* | Pomarine Skua | Middelste Jager | Labbe pomarin |
| 5670 | *Stercorarius parasiticus* | Arctic Skua | Kleine Jager | Labbe parasite |
| 5680 | *Stercorarius longicaudus* | Long-tailed Skua | Kleinste Jager | Labbe à longue queue |
| 5690 | *Stercorarius skua* | Great Skua | Grote Jager | Grande Labbe |
| 5750 | *Larus melanocephalus* | Mediterranean Gull | Zwartkopmeeuw | Mouette mélanocéphale |
| 5780 | *Larus minutus* | Little Gull | Dwergmeeuw | Mouette pygmée |
| 5790 | *Larus sabini* | Sabine's Gull | Vorkstaartmeeuw | Mouette de Sabine |
| 5820 | *Larus ridibundus* | Black-headed Gull | Kokmeeuw | Mouette rieuse |
| 5890 | *Larus delawarensis* | Ring-billed Gull | Ringsnavelmeeuw | Goéland à bec cerclé |
| 5900 | *Larus canus* | Common Gull | Stormmeeuw | Goéland cendré |
| 5910 | *Larus fuscus* | Lesser Black-backed Gull | Kleine Mantelmeeuw | Goéland brun |
| 5920 | *Larus argentatus* | Herring Gull | Zilvermeeuw | Goéland argenté |
| 5926 | *Larus cachinnans* | Yellow-legged Gull | Geelpootmeeuw | Goéland leucophée |
| 5990 | *Larus hyperboreus* | Glaucous Gull | Grote Burgemeester | Goéland bourgmestre |
| 6000 | *Larus marinus* | Great Black-backed Gull | Grote Mantelmeeuw | Goéland marin |
| 6020 | *Rissa tridactyla* | Kittiwake | Drieteenmeeuw | Mouette tridactyle |
| 6050 | *Gelochelidon nilotica* | Gull-billed Tern | Lachstern | Sterne hansel |
| 6110 | *Sterna sandvicensis* | Sandwich Tern | Grote Stern | Sterne caugek |
| 6150 | *Sterna hirundo* | Common Tern | Visdief | Sterne pierregarin |
| 6160 | *Sterna paradisaea* | Arctic Tern | Noordse Stern | Sterne arctique |
| 6240 | *Sterna albifrons* | Little Tern | Dwergstern | Sterne naine |
| 6270 | *Chlidonias niger* | Black Tern | Zwarte Stern | Guifette noire |
| 6340 | *Uria aalge* | Common Guillemot | Zeekoet | Guillemot de Troïl |
| 6350 | *Uria lomvia* | Brünnich's Guillemot | Kortbekzeekoet | Guillemot de Brünnich |
| 6360 | *Alca torda* | Razorbill | Alk | Pingouin torda |

| | | | | |
|---|---|---|---|---|
| 6470 | *Alle alle* | Little Auk | Kleine Alk | Mergule nain |
| 6540 | *Fratercula arctica* | Puffin | Papegaaiduiker | Macareux moine |
| 6655 | *Columba livia domestica* | Feral Pigeon | Postduif | Pigeon voyageur |
| 6680 | *Columba oenas* | Stock Dove | Holeduif | Pigeon colombin |
| 6700 | *Columba palumbus* | Wood Pigeon | Houtduif | Pigeon ramier |
| 6840 | *Streptopelia decaocto* | Collared Dove | Turkse Tortel | Tourterelle turque |
| 7350 | *Tyto alba* | Barn Owl | Kerkuil | Effraie des clochers |
| 7610 | *Strix aluco* | Tawny Owl | Bosuil | Chouette hulotte |
| 7680 | *Asio flammeus* | Short-eared Owl | Velduil | Hibou des marais |
| 7950 | *Apus apus* | Common Swift | Gierzwaluw | Martinet noir |
| 9720 | *Galerida cristata* | Crested Lark | Kuifleeuwerik | Cochevis huppé |
| 9760 | *Alauda arvensis* | Sky Lark | Veldleeuwerik | Alouette des champs |
| 9810 | *Riparia riparia* | Sand Martin | Oeverzwaluw | Hirondelle de rivage |
| 9920 | *Hirundo rustica* | Barn Swallow | Boerenzwaluw | Hirondelle rustique |
| 10010 | *Delichon urbica* | House Martin | Huiszwaluw | Hirondelle de fenêtre |
| 10090 | *Anthus trivialis* | Tree Pipit | Boompieper | Pipit des arbres |
| 10110 | *Anthus pratensis* | Meadow Pipit | Graspieper | Pipit farlouse |
| 10140 | *Anthus petrosus* | Rock Pipit | Oeverpieper | Pipit maritime |
| 10170 | *Motacilla flava* | Yellow Wagtail | Gele kwikstaart | Bergeronnette printanière |
| 10190 | *Motacilla cinerea* | Grey Wagtail | Grote Gele Kwikstaart | Bergeronnette des ruisseaux |
| 10200 | *Motacilla alba* | Pied Wagtail | Witte kwikstaart | Bergeronnette grise |
| 10840 | *Prunella modularis* | Hedge Accentor | Heggemus | Accenteur mouchet |
| 10990 | *Erithacus rubecula* | Robin | Roodborst | Rougegorge familier |
| 11210 | *Phoenicurus ochruros* | Black Redstart | Zwarte Roodstaart | Rougequeue noir |
| 11220 | *Phoenicurus phoenicurus* | Common Redstart | Gekraagde Roodstaart | Rougequeue à front blanc |
| 11460 | *Oenanthe oenanthe* | Northern Wheatear | Tapuit | Traquet motteux |
| 11860 | *Turdus torquatus* | Ring Ouzel | Beflijster | Merle à plastron |
| 11870 | *Turdus merula* | Blackbird | Merel | Merle noir |
| 11980 | *Turdus pilaris* | Fieldfare | Kramsvogel | Grive litorne |
| 12000 | *Turdus philomelos* | Song Trush | Zanglijster | Grive musicienne |
| 12010 | *Turdus iliacus* | Redwing | Koperwiek | Grive mauvais |
| 12770 | *Sylvia atricapilla* | Blackcap | Zwartkop | Fauvette à tête noire |
| 13110 | *Phylloscopus collybita* | Chiffchaff | Tjiftjaf | Pouillot véloce |
| 13120 | *Phylloscopus trochilus* | Willow Warbler | Fitis | Pouillot fitis |
| 13140 | *Regulus regulus* | Goldcrest | Goudhaan | Roitelet huppé |
| 13350 | *Muscicapa striata* | Spotted Flycatcher | Grauwe Vliegenvanger | Gobemouche gris |
| 13430 | *Fidecula parva* | Red-breasted Flycatcher | Kleine Vliegenvanger | Gobemouche nain |
| 14610 | *Parus ater* | Coal Tit | Zwarte Mees | Mésange noire |
| 14620 | *Parus caeruleus* | Blue Tit | Pimpelmees | Mésange bleue |
| 15490 | *Pica pica* | Magpie | Ekster | Pie bavarde |
| 15600 | *Corvus monedula* | Eurasian Jackdaw | Kauw | Choucas des tours |
| 15630 | *Corvus frugilegus* | Rook | Roek | Corbeau freux |
| 15670 | *Corvus corone* | Carrion Crow | Kraai | Corneille noire |
| 15820 | *Sturnus vulgaris* | Common Starling | Spreeuw | Etourneau sansonnet |
| 15910 | *Passer domesticus* | House Sparrow | Huismus | Moineau domestique |
| 15980 | *Passer montanus* | Tree Sparrow | Ringmus | Moineau friquet |
| 16360 | *Fringilla coelebs* | Chaffinch | Vink | Pinson des arbres |
| 16380 | *Fringilla montifringilla* | Brambling | Keep | Pinson du Nord |
| 16490 | *Carduelis chloris* | Greenfinch | Groenling | Verdier d'Europe |
| 16530 | *Carduelis carduelis* | Goldfinch | Putter | Chardonneret élégant |
| 16540 | *Carduelis spinus* | Siskin | Sijs | Tarin des aulnes |
| 16600 | *Carduelis cannabina* | Linnet | Kneu | Linotte mélodieuse |
| 18500 | *Plectrophenax nivalis* | Snow bunting | Sneeuwgors | Bruant des neiges |

| EURING | Scientific name | Family | Group (Stowe 1982) | Habitat | SAS all | SAS bcp | BBS bcp | BD | Bern | Bonn |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 | *Gavia stellata* | Gaviidae | divers | S | * | * | * | I | II | II |
| 30 | *Gavia arctica* | Gaviidae | divers | S | * | * | * | I | II | II |
| 40 | *Gavia immer* | Gaviidae | divers | S | * | | | I | II | |
| 70 | *Tachybaptus ruficollis* | Podicipedidae | grebes | S | | | * | | II | |
| 90 | *Podiceps cristatus* | Podicipedidae | grebes | S | * | * | * | | III | |
| 100 | *Podiceps grisegena* | Podicipedidae | grebes | S | * | * | * | | II | |
| 110 | *Podiceps auritus* | Podicipedidae | grebes | S | | | * | I | II | |
| 120 | *Podiceps nigricollis* | Podicipedidae | grebes | S | * | * | * | | II | |
| 220 | *Fulmarus glacialis* | Procellariidae | Fulmar | S | * | * | * | | III | |
| 400 | *Puffinus gravis* | Procellariidae | others | S | * | | | | III | |
| 430 | *Puffinus griseus* | Procellariidae | others | S | * | * | | | III | |
| 460 | *Puffinus puffinus* | Procellariidae | others | S | * | * | | | II | |
| 520 | *Hydrobates pelagicus* | Hydrobatidae | others | S | * | * | * | I | II | |
| 550 | *Oceanodroma leucorhoa* | Hydrobatidae | others | S | * | * | * | I | II | |
| 710 | *Morus bassanus* | Sulidae | Gannet | S | * | * | * | | III | |
| 720 | *Phalacrocorax carbo* | Phalacrocoracidae | Cormorant/Shag | S | * | * | * | | III | |
| 800 | *Phalacrocorax aristotelis* | Phalacrocoracidae | Cormorant/Shag | S | * | * | * | I | III | |
| 950 | *Botaurus stellaris* | Ardeidae | others | T | | | * | | | |
| 1220 | *Ardea cinerea* | Ardeidae | others | T | * | * | * | | | |
| 1520 | *Cygnus olor* | Anatidae | other wildfowl | C | * | | * | | | |
| 1570 | *Anser fabalis* | Anatidae | other wildfowl | C | | | * | | | |
| 1580 | *Anser brachyrhynchus* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1590 | *Anser albifrons* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1610 | *Anser anser* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1660 | *Branta canadensis* | Anatidae | other wildfowl | C | * | | | | | |
| 1670 | *Branta leucopsis* | Anatidae | other wildfowl | C | * | * | | | | |
| 1680 | *Branta bernicla* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1700 | *Alopochen aegyptiacus* | Anatidae | other wildfowl | C | | | * | | | |
| 1730 | *Tadorna tadorna* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1780 | *Aix galericulata* | Anatidae | other wildfowl | C | | | * | | | |
| 1790 | *Anas penelope* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1820 | *Anas strepera* | Anatidae | other wildfowl | C | * | | * | | | |
| 1840 | *Anas crecca* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1860 | *Anas platyrhynchos* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1890 | *Anas acuta* | Anatidae | other wildfowl | C | * | * | * | | | |
| 1910 | *Anas querquedula* | Anatidae | other wildfowl | C | * | * | | | | |
| 1940 | *Anas clypeata* | Anatidae | other wildfowl | C | * | * | | | | |
| 1980 | *Aythya ferina* | Anatidae | other wildfowl | C | * | * | * | | | |
| 2030 | *Aythya fuligula* | Anatidae | other wildfowl | C | * | * | * | | | |
| 2040 | *Aythya marila* | Anatidae | other seaducks | S | * | * | * | II/III | III | II |
| 2060 | *Somateria mollissima* | Anatidae | Eider | S | * | * | * | | III | II |
| 2120 | *Clangula hyemalis* | Anatidae | other seaducks | S | * | * | | | III | II |
| 2130 | *Melanitta nigra* | Anatidae | scoters | S | * | * | * | | III | II |
| 2150 | *Melanitta fusca* | Anatidae | scoters | S | * | * | * | II | III | II |
| 2180 | *Bucephala clangula* | Anatidae | other seaducks | S | | | * | | III | II |
| 2200 | *Mergus albellus* | Anatidae | other seaducks | S | | | * | | II | II |
| 2210 | *Mergus serrator* | Anatidae | other seaducks | S | * | * | * | | III | II |
| 2230 | *Mergus merganser* | Anatidae | other seaducks | S | * | | * | | III | II |
| 2600 | *Circus aeruginosus* | Accipitridae | others | T | * | * | | | | |
| 2690 | *Accipiter nisus* | Accipitridae | others | T | * | * | | | | |
| 2900 | *Buteo lagopus* | Accipitridae | others | T | * | | | | | |
| 3040 | *Falco tinnunculus* | Falconidae | others | T | * | | * | | | |
| 3100 | *Falco subbuteo* | Falconidae | others | T | * | * | | | | |
| 3200 | *Falco peregrinus* | Falconidae | others | T | * | | | | | |
| 3670 | *Perdix perdix* | Phasianidae | others | T | | | * | | | |
| 3940 | *Phasianus colchicus* | Phasianidae | others | T | | | * | | | |
| 4070 | *Rallus aquaticus* | Rallidae | others | T | | | * | | | |
| 4240 | *Gallinula chloropus* | Rallidae | others | T | | | * | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4290 | *Fulica atra* | Rallidae | Coot | T | * | * | * | | | |
| 4500 | *Haematopus ostralegus* | Haematopidae | waders | C | * | * | * | | | |
| 4560 | *Recurvirostra avosetta* | Recurvirostridae | waders | C | * | * | * | | | |
| 4690 | *Charadrius dubius* | Charadriidae | waders | C | | | * | | | |
| 4700 | *Charadrius hiaticula* | Charadriidae | waders | C | * | * | * | | | |
| 4770 | *Charadrius alexandrinus* | Charadriidae | waders | C | * | * | | | | |
| 4850 | *Pluvialis apricaria* | Charadriidae | waders | C | * | * | * | | | |
| 4860 | *Pluvialis squatarola* | Charadriidae | waders | C | * | * | * | | | |
| 4930 | *Vanellus vanellus* | Charadriidae | waders | C | * | * | * | | | |
| 4960 | *Calidris canutus* | Scolopacidae | waders | C | * | * | * | | | |
| 4970 | *Calidris alba* | Scolopacidae | waders | C | * | * | * | | | |
| 5100 | *Calidris maritima* | Scolopacidae | waders | C | * | * | * | | | |
| 5120 | *Calidris alpina* | Scolopacidae | waders | C | * | * | * | | | |
| 5170 | *Philomachus pugnax* | Scolopacidae | waders | C | | | * | | | |
| 5180 | *Lymnocryptes minimus* | Scolopacidae | waders | C | | | * | | | |
| 5190 | *Gallinago gallinago* | Scolopacidae | waders | C | * | * | * | | | |
| 5290 | *Scolopax rusticola* | Scolopacidae | waders | C | | | * | | | |
| 5320 | *Limosa limosa* | Scolopacidae | waders | C | * | * | * | | | |
| 5340 | *Limosa lapponica* | Scolopacidae | waders | C | * | * | * | | | |
| 5380 | *Numenius phaeopus* | Scolopacidae | waders | C | * | * | | | | |
| 5410 | *Numenius arquata* | Scolopacidae | waders | C | * | * | * | | | |
| 5460 | *Tringa totanus* | Scolopacidae | waders | C | * | * | * | | | |
| 5480 | *Tringa nebularia* | Scolopacidae | waders | C | * | * | | | | |
| 5610 | *Arenaria interpres* | Scolopacidae | waders | C | * | * | * | | | |
| 5640 | *Phalaropus lobatus* | Scolopacidae | waders | S | * | * | | I | III | II |
| 5650 | *Phalaropus fulicarius* | Scolopacidae | waders | S | | | * | | III | II |
| 5660 | *Stercorarius pomarinus* | Stercorariidae | skuas | S | * | * | | | III | |
| 5670 | *Stercorarius parasiticus* | Stercorariidae | skuas | S | * | * | * | | III | |
| 5680 | *Stercorarius longicaudus* | Stercorariidae | skuas | S | * | * | | | III | |
| 5690 | *Stercorarius skua* | Stercorariidae | skuas | S | * | * | * | | III | |
| 5750 | *Larus melanocephalus* | Laridae | *Larus*-gulls | S | * | * | | I | II | II |
| 5780 | *Larus minutus* | Laridae | *Larus*-gulls | S | * | * | * | | II | |
| 5790 | *Larus sabini* | Laridae | *Larus*-gulls | S | * | * | | | II | |
| 5820 | *Larus ridibundus* | Laridae | *Larus*-gulls | S | * | * | * | | III | |
| 5890 | *Larus delawarensis* | Laridae | *Larus*-gulls | S | * | | | | | |
| 5900 | *Larus canus* | Laridae | *Larus*-gulls | S | * | * | * | II | III | |
| 5910 | *Larus fuscus* | Laridae | *Larus*-gulls | S | * | * | * | II | X | |
| 5920 | *Larus argentatus* | Laridae | *Larus*-gulls | S | * | * | * | | III | |
| 5926 | *Larus cachinnans* | Laridae | *Larus*-gulls | S | * | * | * | | III | |
| 5990 | *Larus hyperboreus* | Laridae | *Larus*-gulls | S | * | | | | III | |
| 6000 | *Larus marinus* | Laridae | *Larus*-gulls | S | * | * | * | II | X | |
| 6020 | *Rissa tridactyla* | Laridae | Kittiwake | S | * | * | * | | III | |
| 6050 | *Gelochelidon nilotica* | Sternidae | terns | S | * | * | | I | II | |
| 6110 | *Sterna sandvicensis* | Sternidae | terns | S | * | * | * | I | II | II |
| 6150 | *Sterna hirundo* | Sternidae | terns | S | * | * | * | I | II | |
| 6160 | *Sterna paradisaea* | Sternidae | terns | S | * | * | | I | II | |
| 6240 | *Sterna albifrons* | Sternidae | terns | S | * | * | | I | II | II |
| 6270 | *Chlidonias niger* | Sternidae | terns | S | * | * | | I | II | II |
| 6340 | *Uria aalge* | Alcidae | auks | S | * | * | * | | III | |
| 6350 | *Uria lomvia* | Alcidae | auks | S | | | * | | III | |
| 6360 | *Alca torda* | Alcidae | auks | S | * | * | * | | III | |
| 6470 | *Alle alle* | Alcidae | auks | S | * | * | * | | III | |
| 6540 | *Fratercula arctica* | Alcidae | auks | S | * | * | * | | III | |
| 6655 | *Columba livia domestica* | Columbidae | others | T | * | * | * | | | |
| 6680 | *Columba oenas* | Columbidae | others | T | * | * | * | | | |
| 6700 | *Columba palumbus* | Columbidae | others | T | * | * | * | | | |
| 6840 | *Streptopelia decaocto* | Columbidae | others | T | | | * | | | |
| 7350 | *Tyto alba* | Strigidae | others | T | | | * | | | |
| 7610 | *Strix aluco* | Strigidae | others | T | * | * | | | | |
| 7680 | *Asio flammeus* | Strigidae | others | T | * | * | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7950 | *Apus apus* | Apodidae | others | T | * | * | |
| 9720 | *Galerida cristata* | Alaudidae | others | T | | | * |
| 9760 | *Alauda arvensis* | Alaudidae | others | T | * | * | * |
| 9810 | *Riparia riparia* | Hirundinidae | others | T | * | * | |
| 9920 | *Hirundo rustica* | Hirundinidae | others | T | * | * | |
| 10010 | *Delichon urbica* | Hirundinidae | others | T | * | * | * |
| 10090 | *Anthus trivialis* | Motacillidae | others | T | * | | |
| 10110 | *Anthus pratensis* | Motacillidae | others | T | * | * | |
| 10140 | *Anthus petrosus* | Motacillidae | others | T | * | * | |
| 10170 | *Motacilla flava* | Motacillidae | others | T | * | * | |
| 10190 | *Motacilla cinerea* | Motacillidae | others | T | * | | |
| 10200 | *Motacilla alba* | Motacillidae | others | T | * | * | |
| 10840 | *Prunella modularis* | Prunellidae | others | T | | | * |
| 10990 | *Erithacus rubecula* | Turdidae | others | T | * | * | |
| 11210 | *Phoenicurus ochruros* | Turdidae | others | T | * | * | |
| 11220 | *Phoenicurus phoenicurus* | Turdidae | others | T | * | * | |
| 11460 | *Oenanthe oenanthe* | Turdidae | others | T | * | * | |
| 11860 | *Turdus torquatus* | Turdidae | others | T | * | * | |
| 11870 | *Turdus merula* | Turdidae | others | T | * | * | * |
| 11980 | *Turdus pilaris* | Turdidae | others | T | * | * | * |
| 12000 | *Turdus philomelos* | Turdidae | others | T | * | * | * |
| 12010 | *Turdus iliacus* | Turdidae | others | T | * | * | * |
| 12770 | *Sylvia atricapilla* | Sylvidae | others | T | * | * | |
| 13110 | *Phylloscopus collybita* | Sylvidae | others | T | * | * | |
| 13120 | *Phylloscopus trochilus* | Sylvidae | others | T | * | * | |
| 13140 | *Regulus regulus* | Sylvidae | others | T | * | * | |
| 13350 | *Muscicapa striata* | Muscicapidae | others | T | * | | |
| 13430 | *Fidecula parva* | Muscicapidae | others | T | * | | |
| 14610 | *Parus ater* | Paridae | others | T | * | * | |
| 14620 | *Parus caeruleus* | Paridae | others | T | * | * | |
| 15490 | *Pica pica* | Corvidae | others | T | | | * |
| 15600 | *Corvus monedula* | Corvidae | others | T | * | * | * |
| 15630 | *Corvus frugilegus* | Corvidae | others | T | * | * | * |
| 15670 | *Corvus corone* | Corvidae | others | T | * | * | * |
| 15820 | *Sturnus vulgaris* | Sturnidae | others | T | * | * | * |
| 15910 | *Passer domesticus* | Passeridae | others | T | | | * |
| 15980 | *Passer montanus* | Passeridae | others | T | * | * | |
| 16360 | *Fringilla coelebs* | Fringillidae | others | T | * | * | * |
| 16380 | *Fringilla montifringilla* | Fringillidae | others | T | * | * | |
| 16490 | *Carduelis chloris* | Fringillidae | others | T | * | * | |
| 16530 | *Carduelis carduelis* | Fringillidae | others | T | * | * | * |
| 16540 | *Carduelis spinus* | Fringillidae | others | T | * | * | |
| 16600 | *Carduelis cannabina* | Fringillidae | others | T | * | | |
| 18500 | *Plectrophenax nivalis* | Emberizidae | others | T | * | * | * |

# *APPENDIX II*

*Review of drift experiment results worldwide. For most experiments it is indicated whether objects/species (L=Laridae, A=auks, S=seaducks, W=waterbirds, G=grebes, B=wooden blocks) were ringed (R ) or tagged (T). Information source: (1) BEER 1968, (2) JONES* et al. *1970, (3) BIBBY & BOURNE 1974, (4) LLOYD* et al. *1974, (5) BIBBY & LLOYD 1977, (6) STOWE 1982a, (7) COLOMBÉ* et al. *1996, (8) BIBBY 1981, (9) LLOYD & DIXON in CADBURY 1978, (10) STOWE 1982b, (11) JONES* et al. *1978, MONNAT 1978, (12) KEIJL & CAMPHUYSEN 1992, (13) SEYS* et al. *this study, (14) HLADY & BURGER 1993, (15) CHARDINE & PELLY 1994, (16) THRELFALL & PIATT 1983, (17) PAGE* et al. *1982, (18) PIATT* et al. *1990, (19) FLINT & FOWLER 1998, (20) FORD* et al. *1991 in BURGER 1993, (21) WOOD 1996. References with * are reproduced from CAMPHUYSEN & HEUBECK 2001.*

| Location | Date | Objects/ species | N corpses dropped | Dropped at distance (km) | Last arrival (days after) | Min-Max distance travelled (km) | N & (%) recovered | Source |
|---|---|---|---|---|---|---|---|---|
| U.K. (Bristol Channel) | 1954-68 | L (R) | ? | ? | ? | ? | ? (10) | 1 |
| U.K. (Irish Sea) | 1969 (May) | A (R) | 410 | 10 | 110 | 60-120 | 82 (20) | 2 |
| U.K. (Irish Sea) | 1973 (Feb) | L (R) | 347 | 10-50 | ? | ? | 203 (59) | 3 |
| U.K. (Irish Sea) | 1974 (Jan) | L/A | 319 | ? | ? | ? | 24 (7.5) | 4 |
| U.K. (Irish Sea) | 1974 (Jan) | L (R) | 300 | 10-50 | ? | ? | 34 (11) | 5 |
| U.K. (Irish Sea) | 1974 (May) | L (R) | 305 | 10-50 | ? | ? | 133 (44) | 5 |
| U.K. (Norfolk) | 1979 (Mar) | L | 50/50 | 0.01 | 51/156 | 0-65 | 29 (58)/20 (40) | 6 |
| U.K. (Norfolk) | 1979 (Mar) | L (T) | 20 | 0.01 | 0 | 0 | 20 (100) | 6 |
| U.K. (Irish Sea) | 1996 (Feb) | A (T) | 238 | ? | ? | ? | 12 (5) | 7 |
| N-North Sea | 1976 (Feb) | L (R) | 300 | 50-200 | ? | ? | 1 (0.3) | 8 |
| N-North Sea | 1976 (Feb) | L (T) | 300 | 50-200 | 1000 | 50-2000 | 58 (19) | 8 |
| C-North Sea | 1976 (Feb) | L | ? | ? | 614 | 450-1500 | ? (7) | 9 |
| S-North Sea | 1975 (Feb) | L (R) | 150 | 30-90 | 550 | 20-150 | 17 (11) | 10 |
| S-North Sea | 1975 (Feb) | L (T) | 98 | 30-90 | 550 | 20-150 | 40 (41) | 10 |
| France (Brittanny) | 1978 (Mar) | L (R) | 48 | 30 | ? | ?-70 | 3 (6) | 11 |
| France (Brittanny) | 1978 (Mar) | L (R) | 96 | 7.5-15 | ? | ?-70 | 29 (30) | 11 |
| The Netherlands | 1991 (Feb) | S, G (T) | 383 | 2-70 | 33 | 5-170 | 7 (2) | 12 |
| Belgium | 1996-99 | A/L/W (T) | 634 | 1-49 | 332 | 4-195 | 77 (12) | 13 |
| Canada (BC) | 1989-90 | B (T) | 600 | 1-2 | 180 | 0->700 | 258-318 (43-53) | 14 |
| Canada (BC) | 1990 (Jan) | B (T) | 300 | 35-116 | 180 | 0->700 | 30 (10) | 14 |
| Canada (NF) | ? | B | ? | ? | ? | ? | ? (7) | 15 * |
| Canada (NF) | ? | A | 115 | ? | ? | ? | 0 (0) | 16 * |
| Canada (NF) | ? | B | 400 | ? | ? | ? | 0 (0) | 16 * |
| Canada (NF) | ? | A | 129 | ? | ? | ? | 0 (0) | 16 * |
| Canada (NF) | ? | B | 600 | ? | ? | ? | 144 (24) | 16 * |
| USA (California) | ? | L | 186 | ? | ? | ? | 56 (30) | 17 * |
| USA (California) | ? | A | 63 | ? | ? | ? | 0 (0) | 17 * |
| USA (Alaska) | 1989 (May) | A (T) | 100 | 10 | 55 | 240-240 | 3 (3) | 18 |
| USA (Alaska) | 1997 (Feb-Mar) | B (T) | 150<br>152 | 6<br>6 | ? | ? | 1 (0.7)<br>93 (61) | 19 |
| USA (Washington) | ? | S (radio-T) | ? | ? | ? | ? | ? (25) | 20 |
| Australia | 1985-87 | F (T) | 375 | 9/35-45/ 50-90 | 725 | 12-198 | 37 (29.6) 35 (28) 13 (10.4) | 21 |

# *APPENDIX III*

*Summary of results of persistence experiments with sea- and coastal birds on beaches worldwide. Remarks: L=Laridae, S=seabirds, C=coastal birds, A=auks, RT=radio-tagged, *= explicitly mentioned that departure date of the corpse is midway between last location and the subsequent survey. Source: (1) STOWE 1982, (2) TANIS & MÖRZER BRUIJNS 1962, (3) CAMPHUYSEN 1989, (4) HOUWEN 1968, (5) KUIJKEN 1978, (6) VERBOVEN 1978, (7) SEYS et al. this study, (8) RAEVEL 1992, (9) PAGE et al. 1990, (10) BODKIN & JAMESON 1991, (11) BAILEY 1989 in PIATT et al. 1990, (12) JONES 1989, (13) ECI 1991, (14) VAN PELT & PIATT 1995, (15) BURGER in ECI 1991. Mean daily persistence rates or mean persistence times between brackets are figures converted from the original values mentioned in the publications.*

| Location | Date | Species | Duration of study (days) | Mean interval between counts during the first month (days) | Nr of corpses | Mean daily persistence rate | Mean persistence time (days) | Source |
|---|---|---|---|---|---|---|---|---|
| U.K. (Norfolk) | 1979 (Mar) | L | 8+13 interrupted | 1 | 50<br>37 | (0.74)<br>(0.92) | 3.8<br>12.1 | 1 |
| The Netherlands | 1958-62 | S/C | 1550 | 8 | min 1316 | (0.96) | 25.0 (*) | 2 |
| The Netherlands | ? | A | 150 | ? | 44 | 0.98 | 21 | 3 |
| Belgium | 1968 (Jan–Mar) | S/C | 40 | 8 | 427 | 0.95 | (20) | 4 |
| Belgium | ? | S | ? | ? | | 0.93 | 9.5 | 5 |
| Belgium | 1973-74 (Nov-Mar) | S | 114 | 7 | 130 | (0.94)<br>(0.83-0.92) | 17<br>5.8-12.8 (recalculation) | 6 |
| Belgium | 1997-99 (Oct-Mar) | S/C | 800 | 9.3 | 562 | 0.83-0.93 | 5.8-13.3 | 7 |
| France (Nord) | ? | S | ? | ? | 692 | (0.94) | 17.5 | 8 |
| USA (California) | ? | S | 3 | ? | 235 | 0.38-0.72 | (1.6-3.6) | 9 |
| USA (California) | 1983-84 (May–Apr) | S | 330 | 8.7 | 71 | 0.96 | 15.6 (*) | 10 |
| USA (Alaska) | 1989 (Apr–Jun) | ? | 71 | ? | ? | 0.80 | (5) | 11 |
| USA (Alaska) | 1989 (Apr–May) | S | 2 | 1 | 198 | 0.84 | (6.3) | 12 |
| USA (Alaska) | ? | S (RT) | 8 | ? | 9 | 0.80 | (5) | 13 |
| USA (Alaska) | ? | A (RT) | 7 | ? | 23 | 0.47 | (1.9) | 13 |
| USA (Alaska) | 1993 (Mar–Jun) | A | 100 | 8.0 | 398 | 0.93 | (14.2) | 14 |
| Canada (BC) | ? | S | 4 | ? | 12 | 0.54 | (2.2) | 15 |

# *APPENDIX IV*

*Mean density of the 17 most abundant bird species/taxa and of some taxonomic/functional groups for seven classes of distance to the coast, observed in Belgian marine waters during ship-based surveys in 1992-98 (during winter: Nov-March, summer: Apr-Oct). For each species/taxon the class(es) with maximal density has been shaded.*

| Distance to the coast (km) | Nov-Mar | | | | | | | Apr-Oct | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | 0-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 |
| *G.stellata/arctica* | 0.22 | 0.27 | 0.51 | 0.17 | 0.05 | 0.22 | 0.03 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| *P.cristatus* | 1.18 | 1.19 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *F.glacialis* | 0.00 | 0.01 | 0.01 | 0.02 | 0.08 | 0.24 | 0.46 | 0.01 | 0.02 | 0.04 | 0.19 | 0.43 | 0.28 | 0.59 |
| *M.bassanus* | 0.01 | 0.02 | 0.04 | 0.17 | 0.39 | 0.34 | 0.17 | 0.02 | 0.03 | 0.25 | 0.20 | 0.46 | 0.83 | 0.67 |
| *M.nigra* | 2.72 | 2.35 | 0.07 | 0.00 | 0.06 | 0.00 | 0.00 | 0.15 | 0.23 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 |
| *S.skua* | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.02 | 0.01 | 0.02 | 0.09 | 0.03 | 0.11 |
| *L.minutus* | 0.14 | 0.32 | 0.49 | 0.42 | 0.14 | 0.09 | 0.00 | 1.04 | 0.79 | 0.41 | 0.09 | 0.04 | 0.00 | 0.00 |
| *L.ridibundus* | 1.81 | 0.84 | 0.11 | 0.00 | 0.04 | 0.01 | 0.00 | 0.42 | 0.17 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| *L.canus* | 1.51 | 2.37 | 1.09 | 0.64 | 0.53 | 0.23 | 0.05 | 0.08 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| *L.fuscus* | 0.08 | 0.29 | 0.15 | 0.70 | 0.33 | 0.18 | 0.23 | 2.09 | 2.42 | 2.05 | 2.00 | 0.68 | 0.53 | 0.25 |
| *L.argentatus* | 0.80 | 1.00 | 0.81 | 0.39 | 1.06 | 0.55 | 0.48 | 2.99 | 0.69 | 0.31 | 0.13 | 0.01 | 0.01 | 0.00 |
| *L.marinus* | 0.21 | 0.70 | 0.42 | 0.30 | 2.42 | 0.35 | 0.21 | 0.41 | 0.29 | 0.21 | 0.29 | 0.06 | 0.01 | 0.20 |
| *R.tridactyla* | 0.12 | 0.26 | 0.39 | 3.00 | 1.58 | 1.21 | 0.70 | 0.03 | 0.07 | 0.13 | 0.15 | 0.37 | 0.02 | 0.09 |
| *S.sandvicensis* | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.14 | 0.08 | 0.06 | 0.08 | 0.06 | 0.02 | 0.00 |
| *S.hirundo/ paradisaea* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.25 | 0.10 | 0.08 | 0.05 | 0.00 | 0.00 |
| *U.aalge* | 0.27 | 0.39 | 2.19 | 1.99 | 2.33 | 3.04 | 2.39 | 0.00 | 0.02 | 0.06 | 0.25 | 0.36 | 0.03 | 0.10 |
| *A.torda* | 0.03 | 0.13 | 0.40 | 0.66 | 0.42 | 0.68 | 0.92 | 0.01 | 0.01 | 0.06 | 0.15 | 0.07 | 0.02 | 0.10 |
| divers | 0.22 | 0.27 | 0.51 | 0.17 | 0.05 | 0.22 | 0.03 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| grebes | 1.18 | 1.19 | 0.36 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| scoters | 2.76 | 2.39 | 0.07 | 0.00 | 0.06 | 0.00 | 0.00 | 0.15 | 0.23 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 |
| other seaduck/ *S.mollissima* | 0.18 | 0.77 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| other wildfowl | 0.76 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 |
| waders | 0.00 | 0.10 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| skuas | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.03 | 0.02 | 0.05 | 0.12 | 0.03 | 0.14 |
| *Larus*-gulls | 4.55 | 5.53 | 3.06 | 2.45 | 4.51 | 1.41 | 0.97 | 7.03 | 4.51 | 3.01 | 2.51 | 0.78 | 0.54 | 0.46 |
| terns | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.35 | 0.32 | 0.15 | 0.16 | 0.11 | 0.02 | 0.00 |
| auks | 0.31 | 0.54 | 2.62 | 2.71 | 2.80 | 3.81 | 3.31 | 0.01 | 0.03 | 0.15 | 0.39 | 0.43 | 0.08 | 0.20 |
| scavengers | 4.53 | 5.50 | 3.01 | 5.22 | 6.42 | 3.11 | 2.29 | 6.04 | 3.84 | 3.01 | 2.96 | 2.01 | 1.68 | 1.81 |
| seabirds | 9.33 | 11.00 | 7.07 | 8.54 | 9.48 | 7.25 | 5.64 | 7.63 | 5.29 | 3.83 | 3.69 | 2.77 | 1.81 | 2.17 |
| coastal birds | 0.76 | 0.10 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 |
| terrestrial birds | 0.30 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.03 | 0.03 | 0.27 | 0.00 | 0.01 | 0.00 |
| ALL birds | 10.39 | 11.10 | 7.11 | 8.54 | 9.49 | 7.25 | 5.64 | 7.64 | 5.34 | 3.86 | 3.96 | 2.86 | 1.81 | 2.17 |

# APPENDIX V

*Mean density of the 17 most abundant bird species/taxa and of some taxonomic/functional groups by depth class, observed in Belgian marine waters during ship-based surveys in 1992-98 (during winter: Nov-March, summer: Apr-Oct). For each species/taxon the depth class(es) with maximal density has been shaded.*

| Depth class (m) | Nov-Mar | | | | | Apr-Oct | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0-5 | 5-10 | 10-20 | 20-30 | 30-40 | 0-5 | 5-10 | 10-20 | 20-30 | 30-40 |
| *G.stellata/arctica* | 0.26 | 0.35 | 0.47 | 0.20 | 0.04 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 |
| *P.cristatus* | 1.00 | 1.05 | 0.41 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| *F.glacialis* | 0.00 | 0.00 | 0.02 | 0.07 | 0.17 | 0.00 | 0.02 | 0.07 | 0.22 | 0.26 |
| *M.bassanus* | 0.02 | 0.02 | 0.05 | 0.21 | 0.26 | 0.09 | 0.09 | 0.20 | 0.39 | 0.41 |
| *M.nigra* | 3.44 | 1.95 | 0.21 | 0.04 | 0.09 | 0.00 | 0.16 | 0.11 | 0.00 | 0.00 |
| *S.skua* | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.05 | 0.01 | 0.01 | 0.03 | 0.08 |
| *L.minutus* | 0.38 | 0.29 | 0.38 | 0.42 | 0.08 | 0.36 | 0.76 | 0.41 | 0.28 | 0.00 |
| *L.ridibundus* | 0.36 | 1.05 | 0.22 | 0.02 | 0.01 | 0.32 | 0.22 | 0.05 | 0.00 | 0.00 |
| *L.canus* | 1.07 | 2.13 | 1.05 | 0.49 | 0.12 | 0.03 | 0.09 | 0.04 | 0.01 | 0.00 |
| *L.fuscus* | 0.00 | 0.26 | 0.24 | 0.33 | 0.10 | 0.74 | 2.54 | 1.94 | 1.45 | 0.81 |
| *L.argentatus* | 0.37 | 1.28 | 0.46 | 0.67 | 0.55 | 0.53 | 1.85 | 0.27 | 0.09 | 0.01 |
| *L.marinus* | 0.15 | 0.58 | 0.34 | 0.85 | 0.36 | 0.16 | 0.37 | 0.20 | 0.21 | 0.02 |
| *R.tridactyla* | 2.40 | 0.23 | 0.49 | 1.89 | 0.70 | 0.04 | 0.05 | 0.10 | 0.22 | 0.06 |
| *S.sandvicensis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.05 | 0.08 | 0.00 |
| *S.hirundo/paradisaea* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.21 | 0.11 | 0.08 | 0.00 |
| *U.aalge* | 0.69 | 0.80 | 1.91 | 2.42 | 2.02 | 0.10 | 0.00 | 0.12 | 0.17 | 0.03 |
| *A.torda* | 0.27 | 0.14 | 0.35 | 0.62 | 0.58 | 0.09 | 0.01 | 0.08 | 0.09 | 0.05 |
| divers | 0.26 | 0.35 | 0.47 | 0.20 | 0.04 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 |
| grebes | 1.00 | 1.05 | 0.41 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| scoters | 3.44 | 1.98 | 0.21 | 0.04 | 0.09 | 0.00 | 0.16 | 0.11 | 0.00 | 0.00 |
| other seaduck/*S.mollissima* | 0.59 | 0.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| other wildfowl | 4.44 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 | 0.00 |
| waders | 0.00 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| skuas | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.05 | 0.02 | 0.03 | 0.05 | 0.09 |
| *Larus*-gulls | 2.33 | 5.59 | 2.69 | 2.77 | 1.21 | 2.13 | 5.82 | 2.93 | 2.04 | 0.84 |
| terns | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.32 | 0.16 | 0.16 | 0.00 |
| auks | 0.96 | 0.96 | 2.30 | 3.08 | 2.73 | 0.19 | 0.02 | 0.20 | 0.28 | 0.08 |
| scavengers | 4.37 | 5.55 | 2.87 | 4.53 | 2.26 | 1.90 | 5.22 | 2.87 | 2.59 | 1.56 |
| seabirds | 10.99 | 10.63 | 6.65 | 8.30 | 5.22 | 2.59 | 6.51 | 3.81 | 3.40 | 1.74 |
| coastal birds | 4.44 | 0.11 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 | 0.00 |
| terrestrial birds | 0.00 | 0.12 | 0.00 | 0.01 | 0.01 | 0.00 | 0.06 | 0.02 | 0.13 | 0.00 |
| ALL birds | 15.43 | 10.87 | 6.68 | 8.31 | 5.23 | 2.59 | 6.59 | 3.83 | 3.55 | 1.74 |

# *APPENDIX VI*

*Mean density of the 17 most abundant bird species/taxa and of some taxonomic/functional groups for three different stata (bank, slope, gully), observed in Belgian marine waters during ship-based surveys in 1992-98 (during winter: Nov-March, summer: Apr-Oct). For each species/taxon the class(es) with maximal density has been shaded.*

| Topography | Nov-Mar | | | Apr-Oct | | |
|---|---|---|---|---|---|---|
| | bank | slope | gully | bank | slope | gully |
| *G.stellata/arctica* | 0.50 | 0.39 | 0.19 | 0.01 | 0.01 | 0.00 |
| *P.cristatus* | 0.56 | 0.74 | 0.17 | 0.00 | 0.00 | 0.00 |
| *F.glacialis* | 0.00 | 0.01 | 0.08 | 0.05 | 0.05 | 0.19 |
| *M.bassanus* | 0.04 | 0.04 | 0.19 | 0.26 | 0.14 | 0.33 |
| *M.nigra* | 0.56 | 1.27 | 0.18 | 0.07 | 0.11 | 0.05 |
| *S.skua* | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.03 |
| *L.minutus* | 0.37 | 0.34 | 0.35 | 0.38 | 0.53 | 0.39 |
| *L.ridibundus* | 0.10 | 0.68 | 0.18 | 0.07 | 0.13 | 0.05 |
| *L.canus* | 1.20 | 1.56 | 0.69 | 0.06 | 0.05 | 0.03 |
| *L.fuscus* | 0.11 | 0.30 | 0.27 | 2.56 | 2.15 | 1.43 |
| *L.argentatus* | 0.50 | 1.00 | 0.60 | 0.71 | 1.09 | 0.15 |
| *L.marinus* | 0.41 | 0.46 | 0.73 | 0.23 | 0.30 | 0.18 |
| *R.tridactyla* | 0.67 | 0.38 | 1.52 | 0.07 | 0.07 | 0.19 |
| *S.sandvicensis* | 0.00 | 0.00 | 0.00 | 0.08 | 0.07 | 0.07 |
| *S.hirundo/paradisaea* | 0.00 | 0.00 | 0.00 | 0.03 | 0.18 | 0.08 |
| *U.aalge* | 1.77 | 1.35 | 2.10 | 0.03 | 0.08 | 0.13 |
| *A.torda* | 0.31 | 0.25 | 0.54 | 0.03 | 0.06 | 0.07 |
| divers | 0.50 | 0.39 | 0.19 | 0.01 | 0.01 | 0.00 |
| grebes | 0.56 | 0.74 | 0.17 | 0.00 | 0.00 | 0.01 |
| scoters | 0.56 | 1.29 | 0.18 | 0.07 | 0.11 | 0.05 |
| other seaduck/*S.mollissima* | 0.09 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 |
| other wildfowl | 0.67 | 0.05 | 0.00 | 0.00 | 0.01 | 0.01 |
| waders | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.01 |
| skuas | 0.00 | 0.01 | 0.01 | 0.01 | 0.03 | 0.05 |
| *Larus*-gulls | 2.68 | 4.34 | 2.82 | 4.02 | 4.25 | 2.22 |
| terns | 0.00 | 0.00 | 0.00 | 0.11 | 0.25 | 0.16 |
| auks | 2.12 | 1.64 | 2.69 | 0.08 | 0.14 | 0.21 |
| scavengers | 3.02 | 4.42 | 4.25 | 4.03 | 3.98 | 2.54 |
| seabirds | 7.23 | 9.12 | 7.84 | 4.70 | 5.05 | 3.44 |
| coastal birds | 0.67 | 0.09 | 0.00 | 0.00 | 0.01 | 0.02 |
| terrestrial birds | 0.00 | 0.08 | 0.01 | 0.14 | 0.02 | 0.09 |
| ALL birds | 7.90 | 9.29 | 7.84 | 4.83 | 5.08 | 3.55 |

# APPENDIX VII

*Mean density of the 17 most abundant bird species/taxa and of some taxonomic/functional groups for six longitude classes, observed in Belgian marine waters during ship-based surveys in 1992-98 (during winter: Nov-March, summer: Apr-Oct). For each species/taxon the class(es) with maximal density has been shaded.*

| Longitude (°E) | Nov-Mar | | | | | | Apr-Oct | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2°20-2°30 | 2°30-2°40 | 2°40-2°50 | 2°50-3°00 | 3°00-3°10 | 3°10-3°20 | 2°20-2°30 | 2°30-2°40 | 2°40-2°50 | 2°50-3°00 | 3°00-3°10 | 3°10-3°20 |
| *G.stellata/arctica* | 0.20 | 0.30 | 0.61 | 0.23 | 0.24 | 0.25 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.03 |
| *P.cristatus* | 0.04 | 0.22 | 0.63 | 0.61 | 0.81 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| *F.glacialis* | 0.09 | 0.07 | 0.02 | 0.01 | 0.01 | 0.00 | 0.20 | 0.14 | 0.04 | 0.13 | 0.00 | 0.00 |
| *M.bassanus* | 0.46 | 0.13 | 0.08 | 0.02 | 0.01 | 0.02 | 0.21 | 0.33 | 0.18 | 0.16 | 0.31 | 0.00 |
| *M.nigra* | 0.00 | 0.38 | 1.70 | 0.79 | 0.52 | 0.00 | 0.03 | 0.00 | 0.08 | 0.10 | 0.17 | 0.71 |
| *S.skua* | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.06 | 0.02 | 0.00 | 0.02 | 0.01 | 0.02 |
| *L.minutus* | 0.32 | 0.49 | 0.19 | 0.37 | 0.16 | 0.28 | 0.00 | 0.13 | 0.48 | 0.70 | 0.46 | 2.38 |
| *L.ridibundus* | 0.01 | 0.03 | 0.04 | 0.88 | 0.95 | 1.83 | 0.00 | 0.01 | 0.00 | 0.19 | 0.12 | 0.68 |
| *L.canus* | 0.80 | 0.39 | 0.82 | 1.66 | 2.02 | 6.89 | 0.01 | 0.01 | 0.02 | 0.05 | 0.13 | 0.25 |
| *L.fuscus* | 0.53 | 0.09 | 0.12 | 0.45 | 0.14 | 0.95 | 0.81 | 0.66 | 0.95 | 2.60 | 5.13 | 5.63 |
| *L.argentatus* | 0.59 | 0.54 | 0.54 | 0.88 | 0.85 | 5.55 | 0.05 | 0.09 | 0.32 | 0.43 | 1.24 | 11.91 |
| *L.marinus* | 0.47 | 0.78 | 0.42 | 0.47 | 0.30 | 1.71 | 0.10 | 0.15 | 0.15 | 0.30 | 0.30 | 1.48 |
| *R.tridactyla* | 4.91 | 0.67 | 0.55 | 0.41 | 0.50 | 0.55 | 0.31 | 0.10 | 0.12 | 0.09 | 0.06 | 0.25 |
| *S.sandvicensis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.07 | 0.11 | 0.08 | 0.04 |
| *S.hirundo/paradisaea* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.09 | 0.15 | 0.36 | 0.48 |
| *U.aalge* | 2.88 | 2.33 | 2.26 | 0.84 | 0.54 | 0.06 | 0.06 | 0.12 | 0.02 | 0.16 | 0.00 | 0.00 |
| *A.torda* | 0.88 | 0.59 | 0.30 | 0.20 | 0.05 | 0.02 | 0.04 | 0.09 | 0.03 | 0.08 | 0.00 | 0.00 |
| divers | 0.20 | 0.30 | 0.61 | 0.23 | 0.24 | 0.25 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.03 |
| grebes | 0.04 | 0.23 | 0.64 | 0.61 | 0.81 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| scoters | 0.00 | 0.38 | 1.70 | 0.81 | 0.56 | 0.00 | 0.03 | 0.00 | 0.08 | 0.10 | 0.17 | 0.71 |
| other seaduck/*S.mollissima* | 0.00 | 0.00 | 0.56 | 0.06 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| other wildfowl | 0.00 | 0.02 | 0.00 | 0.31 | 0.00 | 0.31 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.03 |
| waders | 0.00 | 0.00 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| skuas | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.06 | 0.03 | 0.01 | 0.05 | 0.03 | 0.02 |
| *Larus*-gulls | 2.71 | 2.31 | 2.13 | 4.71 | 4.43 | 17.20 | 0.97 | 1.05 | 1.93 | 4.27 | 7.38 | 22.32 |
| terns | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.08 | 0.16 | 0.26 | 0.44 | 0.55 |
| auks | 3.82 | 2.97 | 2.60 | 1.07 | 0.60 | 0.08 | 0.10 | 0.24 | 0.05 | 0.24 | 0.00 | 0.00 |
| scavengers | 7.85 | 2.70 | 2.59 | 4.77 | 4.79 | 17.49 | 1.67 | 1.48 | 1.78 | 3.94 | 7.30 | 20.20 |
| seabirds | 12.23 | 7.07 | 8.89 | 7.93 | 7.41 | 19.54 | 1.91 | 2.01 | 2.57 | 5.33 | 8.41 | 23.91 |
| coastal birds | 0.00 | 0.02 | 0.02 | 0.36 | 0.00 | 0.31 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.03 |
| terrestrial birds | 0.00 | 0.01 | 0.01 | 0.12 | 0.00 | 0.02 | 0.56 | 0.00 | 0.04 | 0.03 | 0.01 | 0.00 |
| ALL birds | 12.23 | 7.09 | 8.92 | 8.41 | 7.41 | 19.87 | 2.47 | 2.04 | 2.61 | 5.36 | 8.45 | 23.94 |

# *APPENDIX VIIIa*

*Effort, total number and oil rates of beached birds during IBBS in Belgium, 1962-'69.*

| Species | 1962 | '63 | '64 | '65 | '66 | '67 | '68 | '69 | 1960s |
|---|---|---|---|---|---|---|---|---|---|
| ***Effort (km)*** | 55 | 65.4 | 55.2 | 65.4 | 65.4 | 65.4 | 65.4 | 65.4 | 502.6 |
| ***Total number (n)*** | | | | | | | | | |
| divers | 8 | | 25 | 27 | 2 | 3 | 5 | 9 | 79 |
| grebes | 5 | 5 | 10 | 35 | 6 | 5 | 11 | 22 | 99 |
| Fulmar | 92 | 1 | 8 | 9 | | 2 | 7 | 3 | 122 |
| Northern Gannet | 4 | 2 | | 6 | 4 | 11 | 14 | 8 | 49 |
| Cormorant/Shag | 1 | | | | | | | | 1 |
| Eider | 1 | | | 1 | 1 | | 5 | 3 | 11 |
| scoters | 23 | 13 | 12 | 158 | 26 | 48 | 197 | 159 | 636 |
| other seaducks | | | | | | | 1 | 1 | |
| other wildfowl | 3 | 11 | 4 | 2 | 3 | 2 | 7 | 9 | 41 |
| Coot | 2 | 90 | 5 | | 22 | 1 | 28 | 3 | 151 |
| waders | 2 | 36 | 2 | 2 | 7 | 1 | 4 | 9 | 63 |
| skuas | 1 | | | | | | 1 | 1 | 3 |
| *Larus*-gulls | 51 | 51 | 175 | 83 | 69 | 111 | 118 | 93 | 751 |
| Kittiwake | 21 | 1 | 20 | 13 | 8 | 32 | 46 | 71 | 212 |
| auks total | 41 | 3 | 62 | 86 | 40 | 104 | 28 | 171 | 535 |
| Common Guillemot | 19 | 2 | 47 | 27 | 24 | 57 | 14 | 92 | 282 |
| Razorbill | 22 | 1 | 15 | 58 | 16 | 42 | 14 | 77 | 245 |
| others | 96 | 8 | 22 | 11 | 44 | 6 | 35 | 12 | 234 |
| ***Proportion oiled (%)*** | | | | | | | | | |
| divers | | | *96* | *96* | | | | | *97* |
| grebes | | | *90* | *83* | | | *100* | *100* | *89* |
| Fulmar | *62* | | | | | | | | *61* |
| Northern Gannet | | | | | | *100* | *93* | | *98* |
| Eider | | | | | | | | | *91* |
| scoters | *74* | *77* | *100* | *86* | *96* | *88* | *95* | *99* | *92* |
| waders | | *0* | | | | | | | *10* |
| *Larus*-gulls | *51* | *65* | *62* | *63* | *71* | *75* | *84* | *83* | *70* |
| Kittiwake | *57* | | *75* | *85* | | *69* | *87* | *85* | *79* |
| auks total | *95* | | *100* | *99* | *100* | *99* | *100* | *96* | *98* |
| Common Guillemot | *95* | | *100* | *100* | *100* | *98* | *100* | *100* | *99* |
| Razorbill | *95* | | *100* | *98* | *100* | *100* | *100* | *91* | *96* |

# APPENDIX VIIIb

*Effort, total number and oil rates of beached birds during IBBS in Belgium, 1970-'79.*

| Species | 1970 | '71 | '72 | '73 | '74 | '75 | '76 | '77 | '78 | '79 | 1970s |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Effort (km)*** | 65.4 | 65.4 | 65.4 | 65.4 | 65.4 | 65.4 | 55.4 | 65.4 | 65.4 | 65.4 | 644 |
| ***Total number (n)*** | | | | | | | | | | | |
| divers | 7 | | 2 | 4 | | | 1 | 2 | 3 | 10 | 29 |
| grebes | 51 | 1 | 4 | 7 | | 1 | 5 | 1 | 10 | 64 | 144 |
| Fulmar | 2 | | 2 | | 3 | | 3 | 2 | 4 | 2 | 18 |
| Northern Gannet | 1 | 1 | 3 | 4 | | 1 | 2 | 3 | | | 15 |
| Cormorant/Shag | | | | | | | | | | | 0 |
| Eider | | | 1 | | | | 1 | | | | 2 |
| scoters | 65 | 3 | 2 | 19 | 7 | 13 | 3 | 3 | 2 | 60 | 177 |
| other seaducks | | 1 | | | | | | 1 | | | 2 |
| other wildfowl | 4 | 3 | 4 | 1 | | | 3 | 1 | 2 | 52 | 70 |
| Coot | 3 | 2 | 1 | 2 | | | 1 | | | 181 | 190 |
| waders | 3 | 3 | 4 | 2 | | | 26 | 2 | 3 | 60 | 103 |
| skuas | | | | 1 | | | | | | | 1 |
| *Larus*-gulls | 43 | 22 | 24 | 35 | 23 | 30 | 17 | 26 | 34 | 221 | 475 |
| Kittiwake | 20 | 7 | 9 | 7 | 2 | 1 | 4 | 12 | 2 | 11 | 75 |
| auks total | 92 | 11 | 4 | 37 | 10 | 7 | 5 | 6 | 11 | 22 | 205 |
| Common Guillemot | 20 | 3 | 2 | 12 | 4 | 4 | 1 | 5 | 7 | 11 | 69 |
| Razorbill | 72 | 8 | 2 | 25 | 6 | 3 | 3 | 1 | 4 | 11 | 135 |
| others | 10 | 2 | 5 | 5 | 5 | | 10 | 3 | 17 | 82 | 141 |
| ***Proportion oiled (%)*** | | | | | | | | | | | |
| divers | | | | | | | | | | | *86* |
| grebes | *71* | | | | | | | | | | *55* |
| Fulmar | | | | | | | | | | | *65* |
| Northern Gannet | | | | | | | | | | | *87* |
| Eider | | | | | | | | | | | |
| scoters | *97* | | | *100* | | *100* | | | | *16* | *76* |
| waders | | | | | | | *4* | | | *0* | *6* |
| *Larus*-gulls | *67* | *64* | *25* | *71* | *37* | *67* | *29* | *0* | *26* | *23* | *36* |
| Kittiwake | *90* | | | | | | | *42* | | *30* | *63* |
| auks total | *97* | *100* | | *100* | *70* | | | | *82* | *67* | *93* |
| Common Guillemot | *100* | | | *100* | | | | | | | *90* |
| Razorbill | *96* | | | *100* | | | | | | | *94* |

# *APPENDIX VIIIc*

*Effort, total number and oil rates of beached birds during IBBS in Belgium, 1980-'89.*

| Species | 1980 | '81 | '82 | '83 | '84 | '85 | '86 | '87 | '88 | '89 | 1980s |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Effort (km)*** | 0 | 7.1 | 29.2 | 43.7 | 19 | 12.4 | 50.5 | 17.6 | 47.8 | 25.2 | 252.5 |
| ***Total number (n)*** | | | | | | | | | | | |
| divers | | | | 1 | 1 | 1 | 4 | | 1 | | 8 |
| grebes | | | 1 | | 5 | 3 | 9 | 13 | 1 | 2 | 34 |
| Fulmar | | 1 | 5 | | 3 | | 1 | 2 | 6 | 1 | 19 |
| Northern Gannet | | | | | | | 1 | 1 | 1 | | 3 |
| Cormorant/Shag | | | | | 1 | | | | | | 1 |
| Eider | | | | | | 1 | | 1 | | 1 | 3 |
| scoters | | 2 | 2 | 1 | 4 | 4 | 10 | 5 | 2 | 9 | 39 |
| other seaducks | | | | | | | | 1 | | | 1 |
| other wildfowl | | | 1 | | 1 | | 1 | | 1 | 1 | 5 |
| Coot | | | 1 | | | | | 2 | 1 | | 4 |
| waders | | | 7 | 2 | 1 | 2 | 6 | 6 | | | 24 |
| skuas | | | | | | | | | 1 | | 1 |
| *Larus*-gulls | | 8 | 17 | 10 | 6 | 3 | 13 | 3 | 14 | 9 | 83 |
| Kittiwake | | 2 | 1 | 3 | 46 | | 7 | 10 | 9 | 13 | 91 |
| auks total | | 13 | 6 | 20 | 79 | 8 | 37 | 13 | 20 | 13 | 209 |
| Common Guillemot | | 10 | 5 | 11 | 47 | 8 | 32 | 12 | 12 | 10 | 147 |
| Razorbill | | 2 | 1 | 9 | 32 | | 5 | 1 | 7 | 3 | 60 |
| others | | 1 | 6 | | 4 | 1 | 7 | 2 | 7 | 1 | 29 |
| ***Proportion oiled (%)*** | | | | | | | | | | | |
| divers | | | | | | | | | | | |
| grebes | | | | | | | | *85* | | | *79* |
| Fulmar | | | | | | | | | | | *53* |
| Northern Gannet | | | | | | | | | | | |
| Eider | | | | | | | | | | | |
| scoters | | | | | | | *30* | | | | *74* |
| waders | | | | | | | | | | | *0* |
| *Larus*-gulls | | | *20* | *30* | | | *23* | | | | *22* |
| Kittiwake | | | | | | | | *100* | | *100* | *86* |
| auks total | | *92* | | *59* | | *100* | *78* | *100* | | *100* | *83* |
| Common Guillemot | | *100* | | *45* | | | *75* | *100* | | *100* | |
| Razorbill | | | | | | | | | | | |

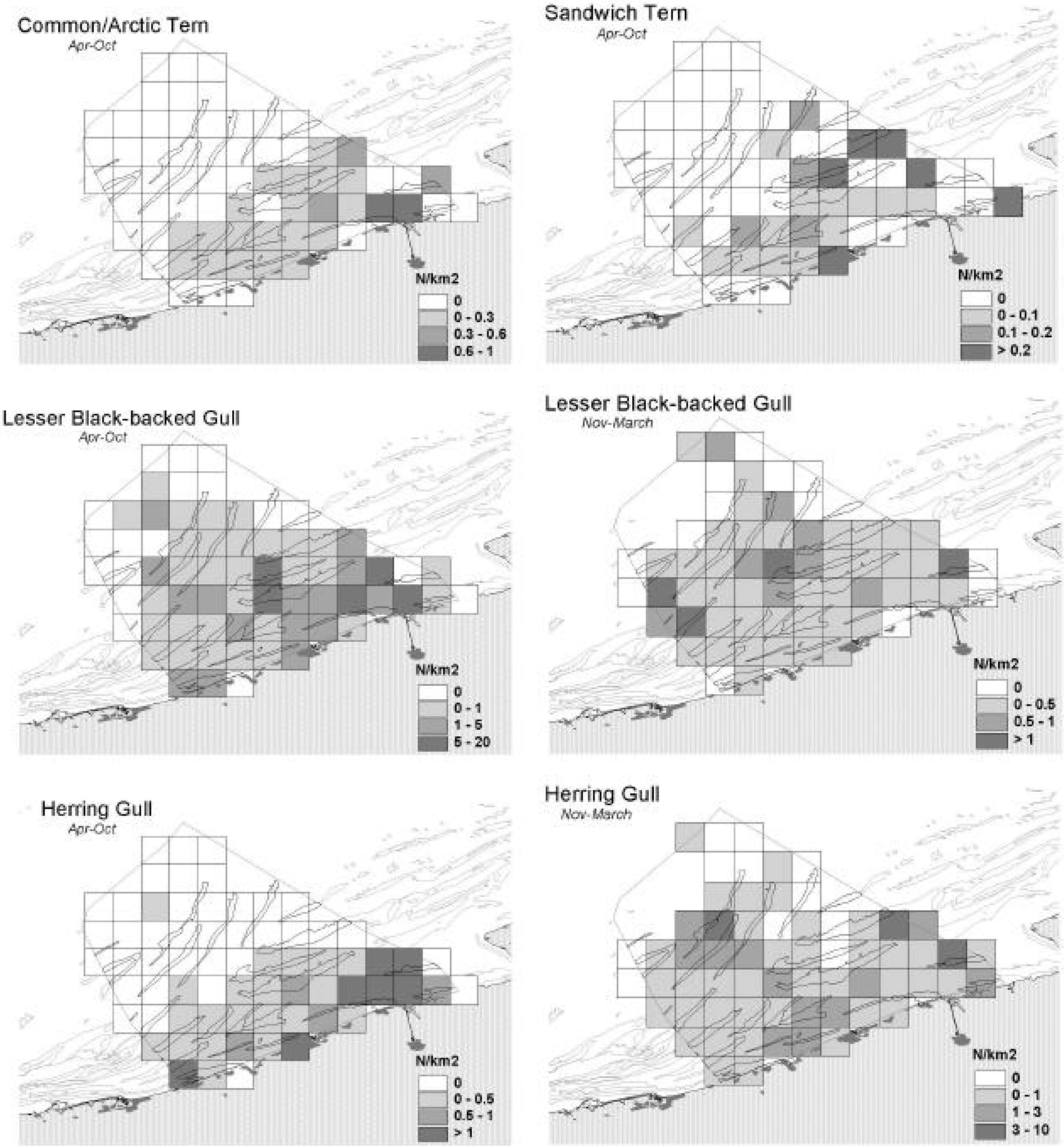
# *APPENDIX VIIId*

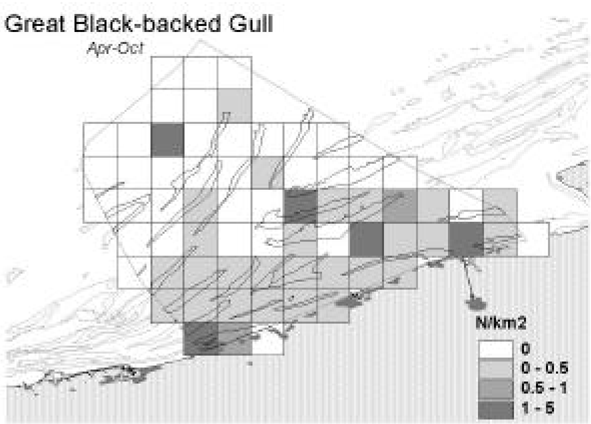
*Effort, total number and oil rates of beached birds during IBBS in Belgium, 1990-'99 and overall 1962-99.*

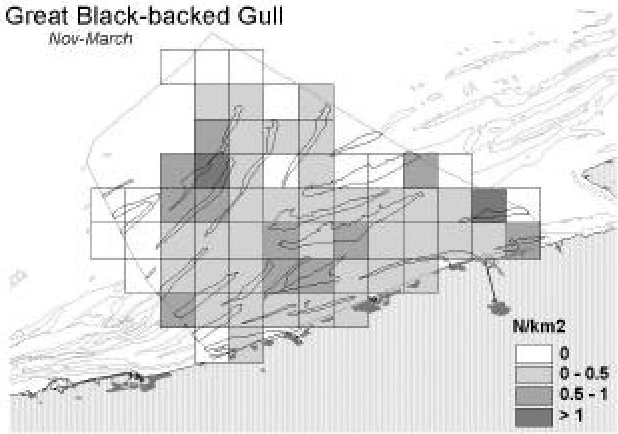
| Species | 1990 | '91 | '92 | '93 | '94 | '95 | '96 | '97 | '98 | '99 | 1990s | 1962-99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Effort (km)*** | 65.4 | 30.3 | 62.1 | 59.5 | 62.1 | 51.1 | 65.4 | 61.1 | 54 | 65.4 | 576.4 | 1975.5 |
| ***Total number (n)*** | | | | | | | | | | | | |
| divers | 2 | 1 | 1 | | | 1 | | 1 | | 2 | 8 | 124 |
| grebes | 7 | 4 | 4 | 2 | 1 | 2 | 18 | 3 | 1 | 11 | 53 | 330 |
| Fulmar | 5 | 3 | | | 1 | 6 | 1 | 2 | 3 | 88 | 109 | 268 |
| Northern Gannet | | | | | 1 | | 1 | | | 2 | 4 | 71 |
| Cormorant/Shag | | | | | | | | | | | 0 | 2 |
| Eider | | 2 | | 1 | | | | 1 | | 3 | 7 | 23 |
| scoters | 3 | 6 | 6 | | 1 | 1 | 5 | 3 | 1 | 9 | 35 | 887 |
| other seaducks | | 2 | | | | | 2 | | | | 5 | 9 |
| other wildfowl | 1 | 3 | 4 | | | 1 | 11 | 3 | | | 23 | 139 |
| Coot | | 1 | | | | | 1 | 1 | | | 3 | 348 |
| waders | | 20 | 2 | 3 | 3 | | 217 | 16 | 1 | 2 | 264 | 454 |
| skuas | | | | | | | | | | | 0 | 5 |
| *Larus*-gulls | 18 | 16 | 11 | 6 | 4 | 8 | 61 | 13 | 3 | 16 | 156 | 1465 |
| Kittiwake | 16 | 10 | | 6 | 1 | 3 | 2 | 5 | 3 | 26 | 72 | 450 |
| auks total | 191 | 25 | 9 | 44 | 54 | 21 | 55 | 44 | 25 | 224 | 692 | 1641 |
| Common Guillemot | 149 | 22 | 9 | 34 | 52 | 20 | 41 | 37 | 22 | 202 | 588 | 1086 |
| Razorbill | 41 | 3 | | 10 | 2 | 1 | 10 | 6 | 3 | 20 | 96 | 536 |
| others | 5 | 9 | 3 | 2 | 1 | 6 | 4 | 2 | 3 | 88 | 123 | 527 |
| ***Proportion oiled (%)*** | | | | | | | | | | | | |
| divers | | | | | | | | | | | | *94* |
| grebes | | | | | | | *13* | | | *70* | *39* | *67* |
| Fulmar | | | | | | | | | | *26* | *28* | *48* |
| Northern Gannet | | | | | | | | | | | | *91* |
| Eider | | | | | | | | | | | | *76* |
| scoters | | | | | | | | | | | *66* | *88* |
| waders | | | | | | | *1* | *0* | | | *2* | *4* |
| *Larus*-gulls | *50* | | | | | | *2* | | | *40* | *12* | *53* |
| Kittiwake | | | | | | | | | | *71* | *60* | *74* |
| auks total | *87* | *53* | | *28* | *52* | *55* | *53* | *95* | *56* | *63* | *66* | *84* |
| Common Guillemot | *89* | *50* | | *19* | *52* | *53* | *68* | *97* | *50* | *60* | *66* | *79* |
| Razorbill | | | | | | | | | | *85* | *72* | *92* |

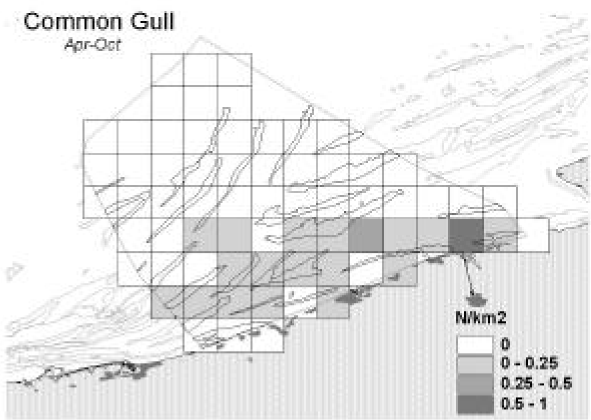
# APPENDIX IX

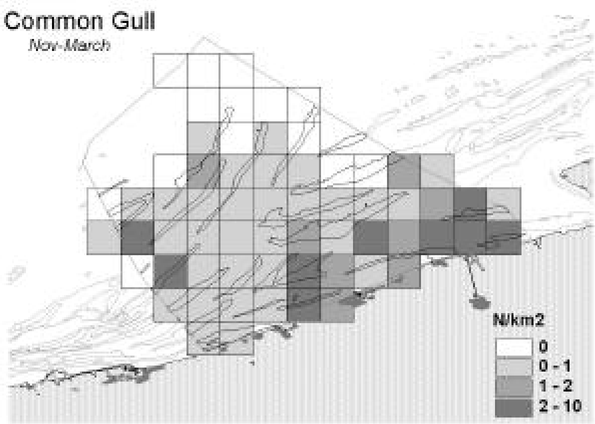
*Density of seabirds (N km$^{-2}$) in Belgian marine waters during 1992-98, in 5x5' grid-units. 'Summer'= April-Oct; 'Winter'= Nov-March.*

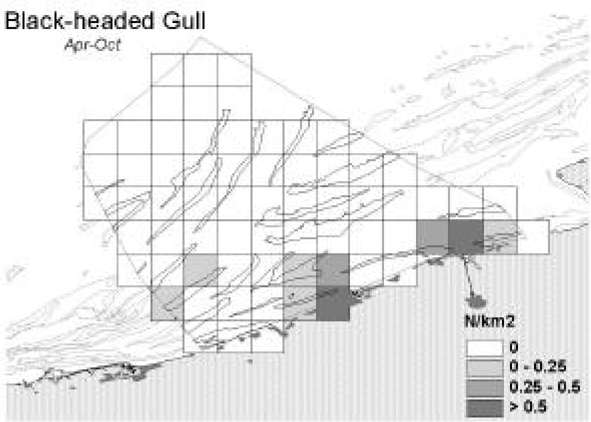


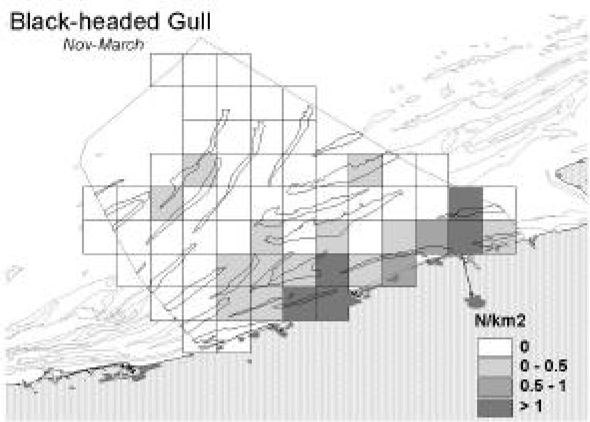

Great Black-backed Gull
Apr-Oct
N/km2
0
0 - 0.5
0.5 - 1
1 - 5

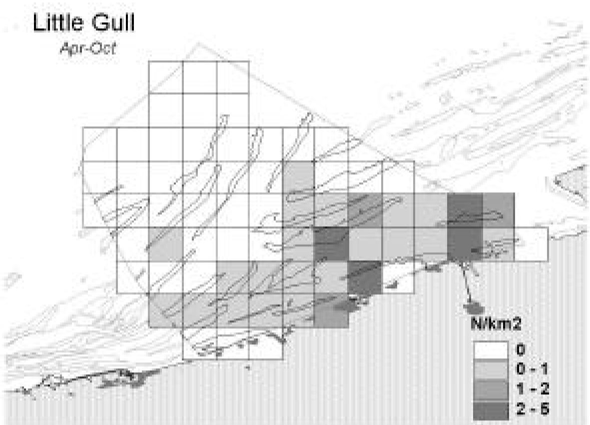

Great Black-backed Gull
Nov-March
N/km2
0
0 - 0.5
0.5 - 1
> 1

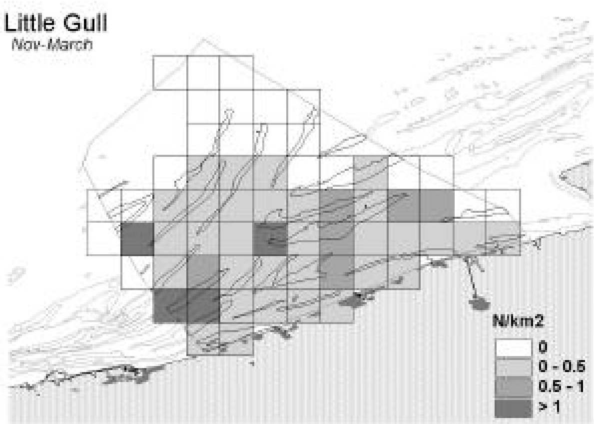

Common Gull
Apr-Oct
N/km2
0
0 - 0.25
0.25 - 0.5
0.5 - 1

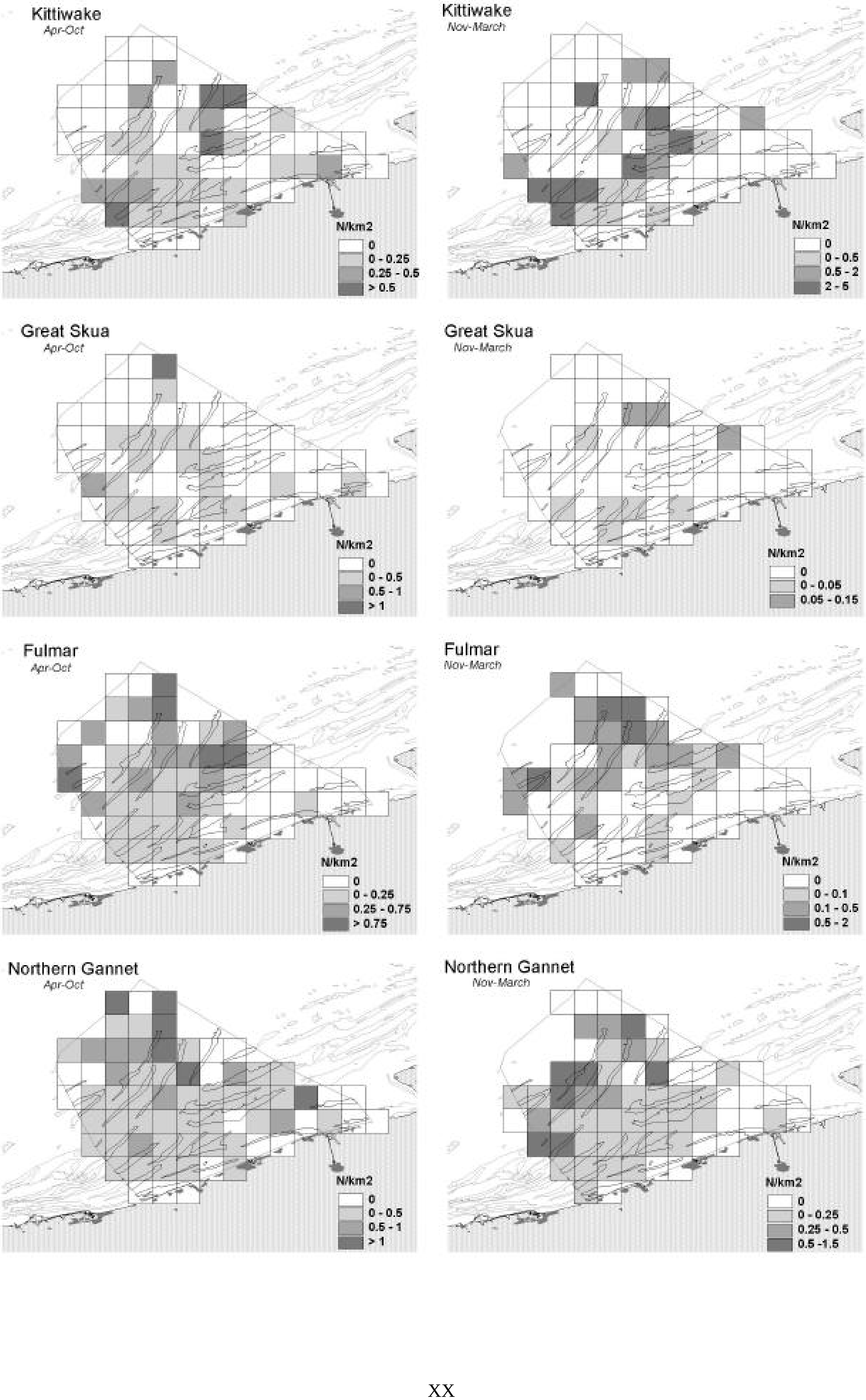

Common Gull
Nov-March
N/km2
0
0 - 1
1 - 2
2 - 10

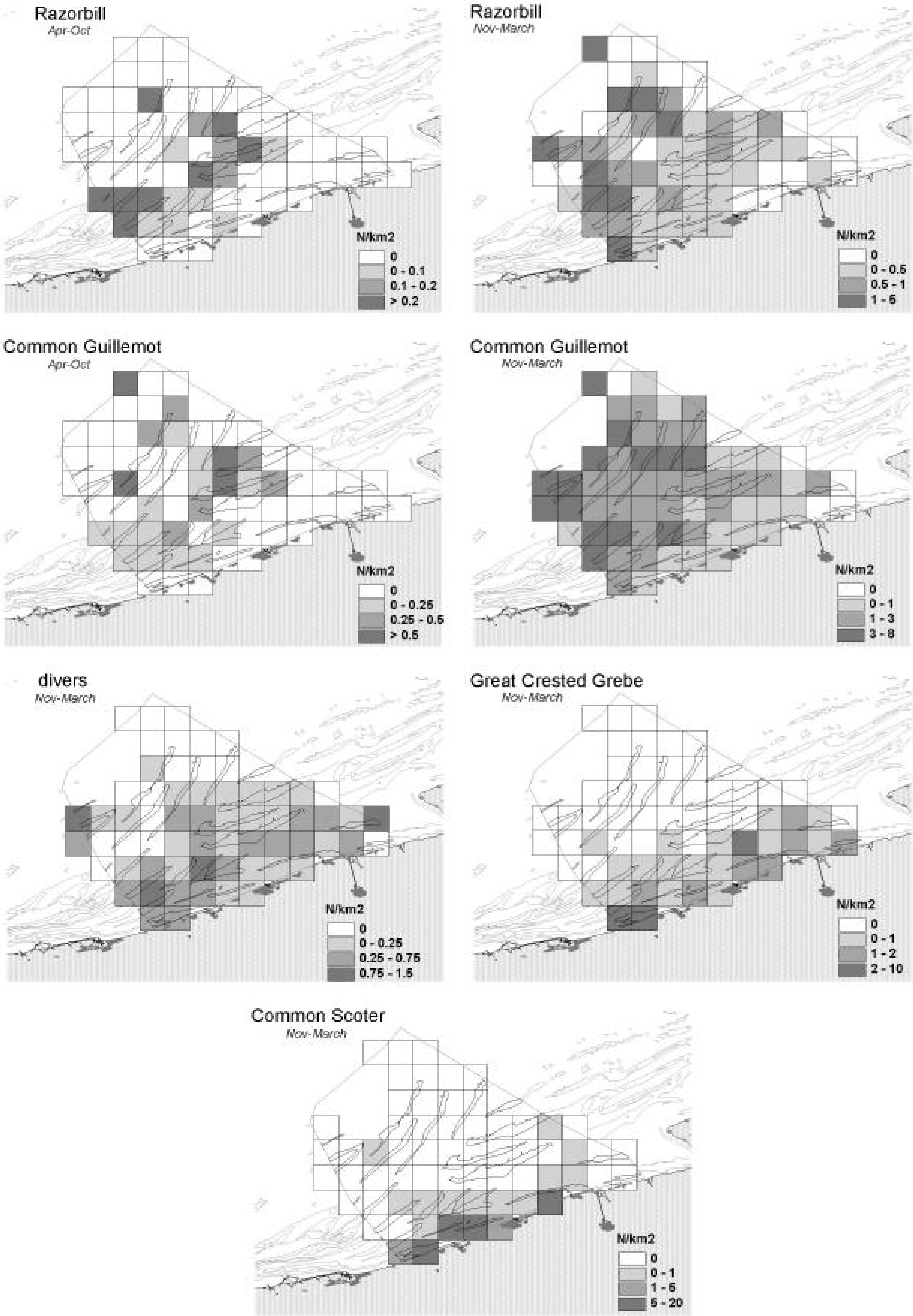

Black-headed Gull
Apr-Oct
N/km2
0
0 - 0.25
0.25 - 0.5
> 0.5


Black-headed Gull
Nov-March
N/km2
0
0 - 0.5
0.5 - 1
> 1


Little Gull
Apr-Oct
N/km2
0
0 - 1
1 - 2
2 - 5


Little Gull
Nov-March
N/km2
0
0 - 0.5
0.5 - 1
> 1


Kittiwake
Apr-Oct
N/km2
0
0 - 0.25
0.25 - 0.5
> 0.5
Kittiwake
Nov-March
N/km2
0
0 - 0.5
0.5 - 2
2 - 5
Great Skua
Apr-Oct
N/km2
0
0 - 0.5
0.5 - 1
> 1
Great Skua
Nov-March
N/km2
0
0 - 0.05
0.05 - 0.15
Fulmar
Apr-Oct
N/km2
0
0 - 0.25
0.25 - 0.75
> 0.75
Fulmar
Nov-March
N/km2
0
0 - 0.1
0.1 - 0.5
0.5 - 2
Northern Gannet
Apr-Oct
N/km2
0
0 - 0.5
0.5 - 1
> 1
Northern Gannet
Nov-March
N/km2
0
0 - 0.25
0.25 - 0.5
0.5 -1.5


Razorbill
Apr-Oct
N/km2
0
0 - 0.1
0.1 - 0.2
> 0.2
Razorbill
Nov-March
N/km2
0
0 - 0.5
0.5 - 1
1 - 5
Common Guillemot
Apr-Oct
N/km2
0
0 - 0.25
0.25 - 0.5
> 0.5
Common Guillemot
Nov-March
N/km2
0
0 - 1
1 - 3
3 - 8
divers
Nov-March
N/km2
0
0 - 0.25
0.25 - 0.75
0.75 - 1.5
Great Crested Grebe
Nov-March
N/km2
0
0 - 1
1 - 2
2 - 10
Common Scoter
Nov-March
N/km2
0
0 - 1
1 - 5
5 - 20

# APPENDIX X

## BEACHED BIRD SURVEYS IN BELGIUM DURING 1962-1999: A PRESENTATION OF THE DATA

Jan Seys[1,*], Henk Offringa[2], Jeroen van Waeyenberge[1], Patrick Meire[3] & Eckhart Kuijken[1]

[1] *Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium*
[2] *Ministry of Transport, Public Works and Water Management, Directorate General of Public Works and Water Management, North Sea Directorate, P.O.Box 5807, 2280 HV Rijswijk, The Netherlands*
[3] *University Antwerpen, Department Biology, Universiteitsplein 1, B-2610 Wilrijk, Belgium*
* *present adress: Flanders Marine Institute (VLIZ), Victorialaan 3, B-8400 Oostende, Belgium*

*published as a report of the Institute of Nature Conservation*

## ABSTRACT

This first detailed overview of almost four decades of beached bird surveying in Belgium, is primarily based on a dataset including some 15,000 bird corpses collected on an overall distance of 8000 km of beaches during 1962-1999. Additionally we included data collected through one of the major coastal rehabilitation centres (Marine Ecological Centre at Oostende: period 1988-1999), dealing with more than 2000 moribund and injured sea- and coastal birds and some 800 ringing recoveries of birds ringed abroad and recovered at the Belgian coast (period 1970-1999). For each of the dominant sea- and coastal bird taxa a detailed description is presented of species composition, frequency-distribution of densities, long-term trends in density and oil-rate, seasonal patterns in beaching, differences in state of decay and condition, age-composition, various plumages and subspecies, mortality causes, biometry and ringing data.

The majority of beached corpses are somehow emaciated. Winter-sensitive taxa such as waders and waterbirds are most affected. Species vulnerable to oil and ‘wreck-conditions’ (auks, Kittiwake) are found in a more or less emaciated condition. Comparatively the Fulmar and Northern Gannet appear rather fat when stranded. Other taxa and species are intermediate in their performance. An inverse relationship between the emaciation of a corpse and the oil-contamination exist, with unoiled birds predominantly strongly emaciated and oiled specimens usually rather fat. Taxa such as grebes and scoters become leaner in the course of the winter, beached Kittiwake and Fulmar show a similar pattern but with the leanest specimens in December/January. Waders are always strongly emaciated but more so during December/March than in early winter. On the other hand, *Larus*-gulls and auks are less affected on average later in winter: fat specimens are more common as the winter goes on.

Over the entire study period 1962-1999 a grand total of 15,368 bird corpses (105 species) and 3 marine mammals (2 species) have been collected on Belgian beaches that were recorded in the database of the Institute of Nature Conservation (IN). With almost 8000 km of beach travelled during these surveys, an overall mean winter density of 1.9 bird corpses $km^{-1}$ can be calculated. The very high mean densities in the 1960s (5.1 ind $km^{-1}$) dropped drastically during the 1990s (2.2 ind $km^{-1}$), and reached – after a slight increase in the 1980s (2.5 ind $km^{-1}$) – their lowest values in the last decade (1.4 ind $km^{-1}$). Although the past ten years the effort in beached bird surveying was significantly enhanced (65% of all distance travelled), only 45.5% of all bird carcasses were collected in this period.

On the beach the most frequently encountered sea- and coastal bird species were the Common Guillemot ($N$=3703: 24.1%), large *Larus*-gulls ($N$=1831: 11.9%), small *Larus*-gulls ($N$=1537: 10%), Kittiwake ($N$=1413: 9.2%), Common Scoter ($N$=1260: 8.2%), Razorbill ($N$=1019: 6.6%), Fulmar ($N$=735: 4.8%), grebes ($N$=607: 3.9%), divers ($N$=197: 1.3%) and Northern Gannet ($N$=182: 1.2%). Other important taxa include waders ($N$=680: 4.4%), passerines ($N$=304: 2.0%) and rails ($N$=395: 2.6%). This ranking of most important oil victims corresponds well with the situation on Dutch, French, German and Danish beaches.

Nowadays ‘terrestrial’ or coastal bird taxa such as rails, waders and passerines run only a small risk to get oil-contaminated. For all gull species the rather high oil-rates of the early days have turned into small values. Offshore taxa such as Fulmar and (Great)skuas have a probability of 20-25% to be found as an oil-contaminated corpse on the beach. A group consisting of grebes (inshore) and three mid/offshore species (Kittiwake, Northern Gannet and Common Guillemot) is still seriously affected by oil, as shown by oil-rates amounting to 40-60%. Most vulnerable are Razorbill (mid/offshore), divers (midshore) and scoters (inshore)(70-80% contaminated). The gradient in oil-sensitivity in species is a direct consequence of their behaviour and distribution and hence of the probability of exposure to oil. Marine oriented species that tend to flock and swim rather than fly at sea (divers, seaducks, auks) are highly vulnerable, whereas terrestrial and coast-oriented birds (passerines, waders, *Larus*-gulls) and species that spend much of their time on the wing (Fulmar) will show lower oil-rates.

Compared to other North Sea areas, oil-rates are significantly higher for most species than in the Shetlands and Norway, and more or less consistent with oil-rates at other European continental coasts. The small differences for most species indicate that oil-rate values are comparable with Danish data, higher than in Germany and slightly lower than in The Netherlands in the same period.

Of the unoiled birds found dead on the beach or at rehabilitation centresl, the majority shows severe signs of exhaustion and will be categorised as 'cold -' or 'wreck victims'. Very few bird corpses on the beach show external injuries (1-3% for most species). However, in the MEC-rehabilitation centre 60-70% of all gulls arriving without oil-fouling are injured, with wings being the most affected parts of the body. Grebes treated at the MEC-rehabilitation centre often have external injuries (31% of all records) particularly at the legs (about 50%). Hunting victims are rarely recognized as such, but probably underestimated. Shot wounds were found in Herring Gull, Red-throated Diver and Common Scoter. Fishhooks were detected in a Fulmar's wing, a Common Gull's tongue and a Herring Gull's bill. At least one Herring Gull, one Lesser Black-backed Gull and one Kittiwake apparently suffocated by eating a big fish. Entanglement in fishing rope or nets is often observed in Northern Gannet (8 out of 69 individuals found on the beach: 11.6%; 1 out of 21 birds at the rehabilitation centre MEC: 4.8%) and less frequently in divers, grebes, gulls and auks (0.1-2.0%).

Northern Gannet, *Larus*-gulls, Kittiwake and auks were systematically aged during the winters 1992-99. Compared to age-ratios at sea, young birds are overrepresented at beached bird surveys demonstrating their higher mortality and vulnerability during winter. Age-composition in beached birds can change drastically in the course of the winter period. In species that have a high share of young birds in our regions during winter, proportions of immatures found dead on the beach seem to increase as winter goes by (Greater Black-backed Gull, Kittiwake, Common Guillemot). There is an increase in mortality of young birds of these species during severe winter weather. Immatures of other species (Northern Gannet, Common Gull, Lesser Black-backed Gull) do not stay in our waters in important numbers during winter and hence will be more common as beached birds in migration periods (autumn, early winter). In Herring Gull characteristics of both types are combined: high proportions of immatures in October-November (68-74%) are followed by much smaller percentages (49%), slightly increasing towards the end of the winter (64%).

From mid-October to end March 0.4-2.4 bird corpses $km^{-1}$ were found on Belgian beaches in the 1990s. Numbers steadily increase during winter with a peak mid-February followed by a decline with more than 50% in March. This pattern is primarily determined by the occurrence of beaching auks, in particular the Common Guillemot. Severe winters disrupt the seasonal pattern slightly by adding important numbers of waders on our beaches during cold spells. A smaller peak end November is caused by substantial numbers of dead *Larus*-gulls linked to important migratory movements in the area.

## INTRODUCTION

Beached bird surveying has proved to be a useful tool in the monitoring of oil-pollution at sea. The proportion of oiled birds to the total number of birds collected, generally referred to as the oil-rate, and the density of beached birds are of great use when quantifying the impact of oil-pollution on birds. The oil-rate has been shown to follow consistent patterns in different countries bordering the North Sea and to reflect important changes in policy in individual countries (CAMPHUYSEN 1995b). The density of beached birds (N $km^{-1}$) gives an insight in fluctuations on a temporal and spatial scale, and is necessary as background information for the interpretation of the oil-rate figures.

Additionally beached bird surveys (BBS) can give information on ecotoxicological and pathological variables, biometrical data, etc. enhancing the understanding of the way seabirds live and die at sea. In Belgium, beached bird censuses have been carried out since the late 1950s with standardized surveys from 1962 onwards. An analysis of the long-term evolutions in densities and oil-rates, based on international beached bird surveys (IBBS) in February 1962-1999 at the Belgian coast, revealed a general trend of decreasing oil-rates over the years (SEYS *et al*. submitted a). A comparison of various methods, using detailed information available for the winters 1993-99, demonstrated the value of each of the methods applied and indicated the impact of differences in survey frequency and distance on the final results (SEYS *et al*. accepted). Thirdly, the route a bird corpse describes between the moment it dies and is being found by a surveyor on the beach is assessed by interpreting drift experiments and corpse persistence experiments at the Belgian coast in SEYS *et al*. (submitted b). The report below is an extended description at a species level of the basic characteristics of the dominant sea- and coastal bird species as found during almost forty years of beached bird monitoring at the Belgian coast. For each of the dominant species and taxa, it gives an overview of the data collected at beached bird surveys and at the major coastal rehabilitation centre. It includes data on species composition within taxa, frequency-distribution of densities, long-term trends in density and oil-rate, seasonal patterns, differences in state of decay and condition, age-composition, various plumages and subspecies, mortality causes, biometry and ringing recoveries. As such, this contribution is the first detailed and most complete approach published so far on beached bird surveying results and seabird rehabilitation centre databases in Belgium.

# MATERIAL & METHODS

STUDY AREA

The shoreline in Belgium consists of 62.1 km of sandy beaches and another 3.3 km of industrial area in between the harbour piers of Zeebrugge (Fig. 1). Beaches are easily accessible and for more than 50% bordered by dykes. Breakwaters are omnipresent (on average every 200-400 m), except at the westcoast and small stretches elsewhere. Four major beach sections were distinguished for further analysis (from west to east): French border-Nieuwpoort FRNP (14.3 km), Nieuwpoort-Oostende NPOO (16.7 km), Oostende-Zeebrugge OOZB (20.9 km) and Zeebrugge-Dutch border ZBNL (10.2 km). For more details on the study area we refer to SEYS *et al.* (accepted).

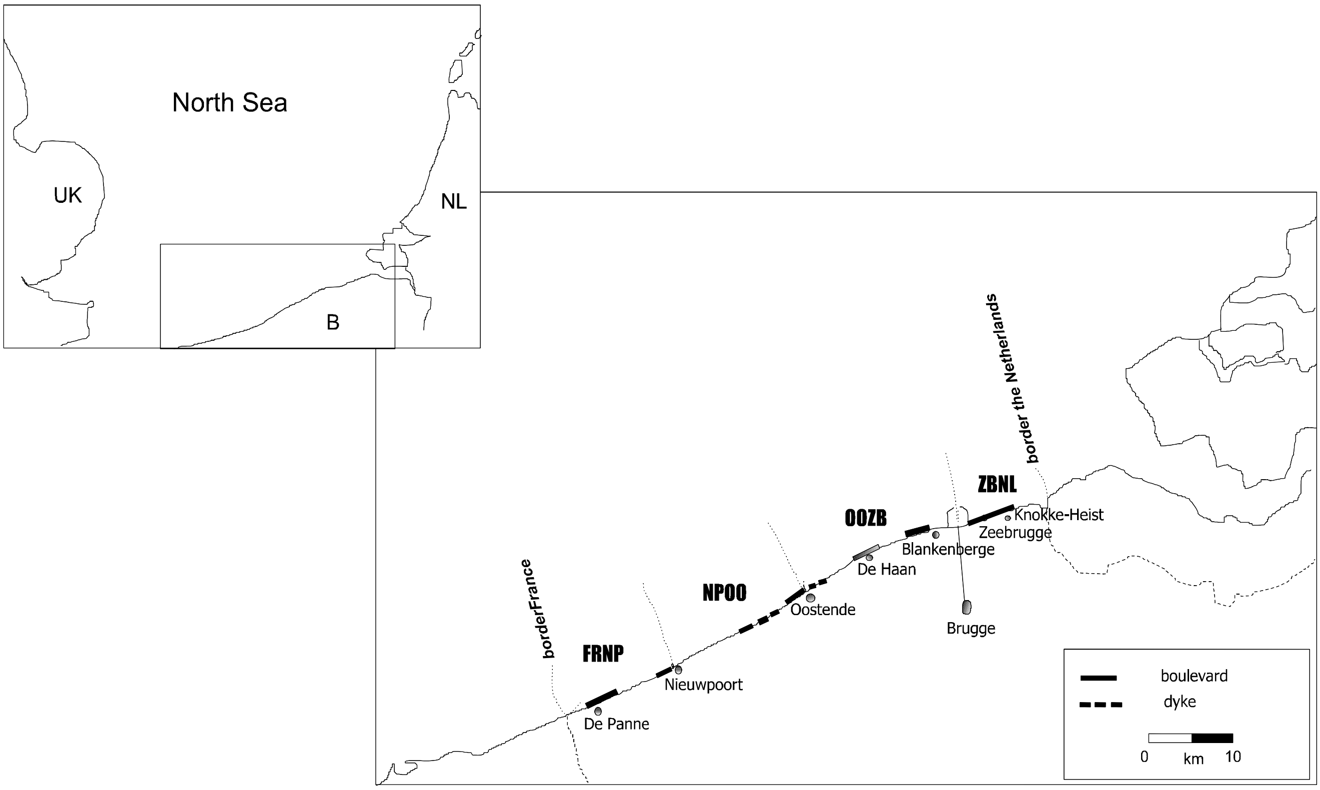



*Fig. 1. Study area covered with the Belgian beached-bird surveys.*

WEATHER CONDITIONS

The IJnsen factor V= v2/363 + 2/3 y + 10/9 z (with v=number of frost days, minimum t° < 0°C, y=number of ice days, maximum t° < 0°C, z=number of very cold days, minimum t°< -10°C: IJNSEN 1991) was used as a measure for the severity of the winter, after a conversion towards local meteorological data from Oostende-Middelkerke (source: KMI). Since the classification of IJnsen is based on data from De Bilt (inland and more to the north than our study-area) new categories were created, fitting the winter character figures of the Belgian coast into a theoretical frequency distribution (see IJNSEN, 1991: Table II). In such a way, it can be avoided e.g. that the winter 1963 (one of the three most severe winters since 1707 according to IJnsen) is treated as being no more than a 'severe winter', that 1979 is nothing more than a 'normal winter' (although the beach water started to freeze!) and that more than 50% of all Belgian coastal winters during the past 40 years get the label 'extremely mild' or 'very mild'. Using this new classification, winters were relatively cold in the early 1960s with 1963 catalogued as 'very severe'. The late 1960s, 1970s and early 1980s were rather mild, with only one severe winter (1978-1979). Although the 1980s and 1990s had several normal/mild winters, both include three winters entitled as severe according to the IJnsen classification (Table 1).

The frequency of occurrence of strong (>30 km $h^{-1}$) onshore (WSW-NNE) winds has been quantified for the winters 1985-1999 (period October 1st – March 31st)(Table 1).

*Table 1. Characterisation of the winters 1962-63 to 1998-99 at the Belgian coast (data from KMI: stations Oostende/Middelkerke) in terms of severity (IJnsen factor) and frequency of occurrence of strong (>30 km $h^{-1}$) onshore (WSW-NNE) winds.*

| Winter | Winter severity | | Strong onshore winds (days) |
|---|---|---|---|
| | IJnsen factor (Belgian coast) | Category (classification Belgian coast) | |
| 1962 | 13.9 | cold | |
| 1963 | 48.8 | very severe | |
| 1964 | 11.3 | cold | |
| 1965 | 5.9 | normal (cold) | |
| 1966 | 11.4 | cold | |
| 1967 | 1.9 | moderately mild | |
| 1968 | 4.2 | normal (cold) | |
| 1969 | 2.5 | moderately mild | |
| 1970 | 9.8 | cold | |
| 1971 | 8.6 | cold | |
| 1972 | 2.5 | moderately mild | |
| 1973 | 0.6 | mild | |
| 1974 | 0.4 | very mild | |
| 1975 | 0.2 | extremely mild | |
| 1976 | 6.6 | normal (cold) | |
| 1977 | 2.8 | normal (mild) | |
| 1978 | 1.7 | moderately mild | |
| 1979 | 19.2 | severe | |
| 1980 | 2.7 | normal (mild) | |
| 1981 | 3.2 | normal (mild) | |
| 1982 | 11.5 | cold | |
| 1983 | 2.0 | moderately mild | |
| 1984 | 5.4 | normal (cold) | |
| 1985 | 20.4 | severe | 11 |
| 1986 | 21.9 | severe | 42 |
| 1987 | 22.0 | severe | 29 |
| 1988 | 1.0 | mild | 34 |
| 1989 | 1.2 | moderately mild | 23 |
| 1990 | 3.6 | normal (mild) | 34 |
| 1991 | 16.3 | severe | 21 |
| 1992 | 8.0 | cold | 41 |
| 1993 | 7.4 | cold | 31 |
| 1994 | 4.0 | normal (cold) | 39 |
| 1995 | 2.7 | normal (mild) | 39 |
| 1996 | 15.3 | Severe | 11 |
| 1997 | 17.7 | Severe | 12 |
| 1998 | 4.2 | normal (cold) | 18 |
| 1999 | 5.7 | normal (cold) | 23 |

## DATA

*Beached bird surveys*

Data from Belgian beached bird surveys (BBS) were entered in a database. It consists of I(nternational), M(onthly), W(eekly) and O(ccasional) surveys covering the period February 1962 – April 1999. International Beached Bird Surveys (IBBS) are organised once a winter – generally in February - in most countries bordering the North Sea and cover ideally the entire Belgian coastline. Monthly surveys aim to take place six times a winter (October-March) along the full 65 km of Belgian beaches, with the February survey taken as the IBBS of that winter. Occasional counts are partial surveys organised during events with mass stranding of birds (oil, wrecks, severe winter weather). Weekly surveys were started in the winter 1991-92 and carried out on the beach section Nieuwpoort-Oostende (16.7 km, i.e. 25% of the entire Belgian coast). They give the most detailed and consistent picture of beaching intensity, oil-rates and other invaluable parameters (SEYS *et al*. accepted).

The database at the Institute of Nature Conservation comprises an effort of roughly 8000 km travelled, yielding 15,000 bird corpses (Table 3). It does not include another 2000 km of partial surveys (not covering the entire coast) in the period 1958-1979 (VERBOVEN 1979) and is incomplete where it concerns partial counts in the 1980s.

*Rehabilitation centre*

Data from the rehabilitation centre of Oostende (Marine Ecological Centre – MEC) were analysed for the winters 1988-1999 (October 1$^{st}$ – March 31$^{st}$)(Table 4). The majority of the birds hosted here were found on beaches between Westende and De Haan (c. 20 km), but smaller numbers might have had their origin in the polders or on other beach sections.

*Ringing recoveries*

Data on birds ringed abroad and recovered at the Belgian coast or in the polders (up to 12-25 km inland) are derived from the filing-card system at the Belgian ringing centre (KBIN) and go back as far as 1970 (Table 2). The majority of the recoveries refer to *Larus*-gulls (82%) and 78% was ringed as pullus.

*Table 2. Ringing recoveries of sea- and coastal birds at the Belgian coast and polders. Only data of birds ringed abroad, recovered after 1970 and reported to the Belgian ringing centre (KBIN) are included.*

| Species | Ringed as full-grown | Pullus | total |
|---|---|---|---|
| *Gavia stellata* | 0 | 1 | 1 |
| *Gavia arctica* | 0 | 0 | 0 |
| *Podiceps cristatus* | 0 | 0 | 0 |
| *Fulmarus glacialis* | 0 | 1 | 1 |
| *Morus bassanus* | 0 | 14 | 14 |
| *Phalacrocorax carbo* | 0 | 3 | 3 |
| *Melanitta nigra* | 0 | 0 | 0 |
| *Melanitta fusca* | 0 | 0 | 0 |
| *Somateria mollissima* | 0 | 0 | 0 |
| *Stercorarius parasiticus* | 0 | 0 | 0 |
| *Stercorarius pomarinus* | 0 | 0 | 0 |
| *Stercorarius skua* | 0 | 6 | 6 |
| *Larus minutus* | 0 | 0 | 0 |
| *Larus ridibundus* | 132 | 284 | 416 |
| *Larus canus* | 16 | 50 | 66 |
| *Larus fuscus* | 0 | 22 | 22 |
| *Larus argentatus* | 7 | 143 | 150 |
| *Larus marinus* | 0 | 20 | 20 |
| *Rissa tridactyla* | 0 | 4 | 4 |
| *Sterna sandvicensis* | 2 | 11 | 13 |
| *Sterna hirundo* | 5 | 45 | 50 |
| *Sterna albifrons* | 10 | 5 | 15 |
| *Uria aalge* | 3 | 24 | 27 |
| *Alca torda* | 3 | 6 | 9 |
| *Alle alle* | 0 | 0 | 0 |
| *Fratercula arctica* | 0 | 0 | 0 |

## DATA PRESENTATION AND ANALYSIS

Data analysis is restricted to the most common seabird species/taxa: divers, grebes, Fulmar, Northern Gannet, scoters, skuas, *Larus*-gulls, Kittiwake and auks. Data are grouped in ten days periods (1-10, 11-20, 21-31). For each species/taxon the data of the Belgian beached bird surveys and of the MEC rehabilitation centre are analysed and the following aspects described:

*Species composition*

Within the taxa divers, grebes, scoters, skuas, *Larus*-gulls and auks the share of the individual species was calculated for all available data.

*Frequency distribution of densities in four major transects*

In order to get an idea what numbers of bird corpses one is likely to encounter when walking along Belgian beaches in winter time, frequency distributions are made of densities (N km$^{-1}$) per ten days periods, expressed per beach section. Surveys of ? 5 km or with ? 3 corpses collected were not taken into account.

*Mean density and oil-rate by decade*

All available surveys of > 5 km and rendering ? 3 bird corpses were classified by decade. Mean densities were calculated by dividing the total number of bird corpses collected by the total effort (km) for the periods: 1962-1969, 1970-1979, 1981-1989, and 1990-99. The oil-rate by decade is the proportion of the sum of oiled birds on the total number of bird corpses scored for oil-contamination (with a required minimum of 4 specimens).

*Trends in density and oil-rate (IBB surveys only)*

For plots of densities and oil-rates during the winters 1962-99, only IBB survey data have been used. Oil-rates were calculated on a minimum of four complete bird corpses.

*Spatial differences in beaching intensity*

We compared the four beach sections at the Belgian coast (Fig. 1) in terms of beaching intensity throughout the study period. Only the 59 monthly and international beached bird surveys covering the entire Belgian coast were used for this analysis. The total number of bird corpses that has been collected by decade was divided by the total effort (km) for each of the sections.

*Seasonal patterns in beaching*

BBS and MEC data of the winters 1993-99 were classified in ten days periods in order to get a picture of the seasonal pattern of beaching. A correlation test between the temporal pattern in numbers of bird corpses on the beach and at the MEC rehabilitation centre was carried out for species/taxa of which at least 40 specimens had been registered at the MEC.

*Mortality causes (oil, injuries, deformations, entanglement,...)*

The identification of the probable cause of death is based on an external visual examination only. As such, only very prominent injuries, impacts or defections could be detected, such as (external) oil-contamination, entanglement in fishing ropes or nets, deformations or injuries/fractures of limbs, body or head. In living birds (at the MEC) an additional group of apparently 'exhausted' specimens was distinguished. Descriptions of behaviour by the centre wardens, such as 'groggy', 'paralysed', 'poisoned', 'infested with parasites', 'diarrhoea', ... all refer to debilitated, unoiled birds. Although the mortality categories were not mutually exclusive, birds were placed into a single category according to the following ranking: 1) oil 2) wing injuries 3) leg injuries 4) eye and bill injuries 5) non-defined injuries 6) no external injuries ('groggy', 'exhausted', 'paralysed', 'poisoned', 'parasites', 'diarrhoea',...).

*State of decay*

The state of decay of a bird corpse is an indication of how long ago the bird has died. During the 1990s many bird corpses were assigned a score of 0 to 3, based on a superficial inspection and with state of decay 0 = very fresh (bright eyes, intact plumage), 1 = fresh (dull eyes, intact plumage), 2 = rotten (smelling and/or pecked upon), 3 = carcass with only wings and legs. A 'state of decay-index' is calculated as the average of values of individual birds and should not be used in other ways then as to give a first, indicative picture.

*Condition*

In a similar way, the 'condition-index' is the mean of condition values of specimens. Information on the might be of interest for the interpretation of BBS data. A mass stranding of severely emaciated, slightly oiled or unoiled juveniles of Common Guillemots is quite different from a stranding of heavily oiled, fat corpses following oil discharge further offshore (CAMPHUYSEN & VAN FRANEKER 1992). During the 1990s the condition of many bird corpses was scored by estimating the atrophy of the pectoral muscle (by 'touching' the pectoral muscle), assigning condition 0 to fat birds (normal pectoral muscle), 1 to slightly or moderately emaciated corpses (slight or moderate pectoral muscle atrophy) and 2 to severely emaciated specimens (severe pectoral muscle atrophy). These condition indices are not more than rough indicators of the health of a bird before it died.

*Age-composition*

An assessment of age-composition in beached birds was possible for *Larus*-gulls, Kittiwake, Northern Gannet and Razorbill. First-winter Common Guillemots were distinguished from older birds during the 1990s by checking the presence of white tips to the greater underwing coverts and the contrast between primary and inner secondary upperwing coverts (CAMPHUYSEN 1995). Classification of Razorbills was based on bill grooves only (CAMPHUYSEN 1995), separating three age groups: first-winter birds, immatures and adults.

*Plumage characteristics*

First-winter and female scoters were distinguished from immature and adult males (*N*=462). Only six dark-phase Fulmars could be found in the database, two during the 1980s and four in the next decade. Breeding and non-breeding plumage was systematically scored in auks during the 1990s (*N*=1086) and only sporadically during the 1980s (*N*=77). Dark-plumaged northern Common Guillemots (*Uria aalge aalge/hyperborea*) were not systematically distinguished from the southern and browner '*albionis'*-subspecies. Only very distinct specimens were registered, making any interpretation based on plumage impossible.

*Biometry*

Species of which variations in length of bill, wings and/or legs through their distribution area has been documented (such as Common Guillemot, Razorbill and Fulmar) were systematically measured during the 1990s in order to get an insight in the origin of the birds found on Belgian beaches. Numbers of measured Fulmars appeared to be too small (*N*=71) for any separation into groups. Differences in biometry of Common Guillemot and Razorbill could only be related to the age of the birds. With a One-Way ANOVA we analysed the difference between first-winter, immatures and adult birds.

*Ringing recoveries at the Belgian coast*

For the sea- and coastal bird species that were considered in this report, all ringing recoveries at the Belgian coast were retrieved from the KBIN ringing scheme.

# RESULTS

GENERAL INFORMATION

*Total effort and yield of bird corpses at beached bird surveys*

Almost 8000 km has been surveyed on Belgian beaches during 1962-1999 (Table 3). International BBS account for 25% of the effort, monthly surveys for 39%, weekly surveys 20% and occasional surveys for 15%. A grand total of 15,398 bird corpses has been collected over these 38 years, resulting in a mean density of 1.93 bird corpse $km^{-1}$.

*Table 3. Major characteristics of the Belgian beached bird monitoring database, with I=International, M=monthly, W=weekly and O=occasional surveys. Presented are total effort (N km travelled), total number of birds recorded and type of information available, with: D/O= density and oil-rate; PL= plumage characteristics; B=biometry; D/C= state of decay and condition. Quality of data: ++=data collected in a systematical way, i.e. > 100 birds scored; +=data sporadically gathered, i.e. < 100 birds scored.*

| Winter | I | | M | | W | | O | | All | | Type of information available | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Km* | Ntot | *Km* | Ntot | *Km* | Ntot | *Km* | Ntot | *Kmtot* | Ntot | D/O | PL | B | D/C |
| 1962 | *55.0* | 259 | | | | | | | *55.0* | 259 | ++ | | | |
| 1963 | *65.4* | 220 | | | | | | | *65.4* | 220 | ++ | | | |
| 1964 | *55.2* | 337 | | | | | | | *55.2* | 337 | ++ | | | |
| 1965 | *65.4* | 424 | | | | | | | *65.4* | 424 | ++ | | | |
| 1966 | *65.4* | 232 | | | | | | | *65.4* | 232 | ++ | | | |
| 1967 | *65.4* | 324 | | | | | | | *65.4* | 324 | ++ | + | | |
| 1968 | *65.4* | 499 | | | | | | | *65.4* | 499 | ++ | | | |
| 1969 | *65.4* | 571 | | | | | | | *65.4* | 571 | ++ | | | |
| 1970 | *65.4* | 299 | *62.1* | 252 | | | | | *127.5* | 551 | ++ | + | | |
| 1971 | *65.4* | 56 | *62.1* | 166 | | | | | *127.5* | 222 | ++ | + | | |
| 1972 | *65.4* | 63 | *62.1* | 93 | | | *30.0* | 24 | *157.5* | 180 | ++ | + | + | + |
| 1973 | *65.4* | 124 | *62.1* | 183 | | | | | *127.5* | 307 | ++ | + | | + |
| 1974 | *65.4* | 47 | | | | | *10.2* | 5 | *75.6* | 52 | ++ | + | | + |
| 1975 | *65.4* | 54 | *59.5* | 58 | | | | | *124.9* | 112 | ++ | + | + | + |
| 1976 | *55.4* | 78 | *21.2* | 128 | | | | | *76.6* | 206 | ++ | + | + | + |
| 1977 | *65.4* | 62 | | | | | | | *65.4* | 62 | ++ | + | + | + |
| 1978 | *65.4* | 84 | | | | | | | *65.4* | 84 | ++ | + | | |
| 1979 | *65.4* | 485 | | | | | | | *65.4* | 485 | ++ | | | |
| 1980 | *0.0* | | | | | | | | *0.0* | 0 | | | | |
| 1981 | *7.1* | 26 | *47.8* | 196 | | | *19.3* | 58 | *74.2* | 280 | ++ | + | | |
| 1982 | *29.2* | 30 | | | | | *27.9* | 42 | *57.1* | 72 | ++ | + | + | + |
| 1983 | *43.7* | 37 | | | | | *51.1* | 111 | *94.8* | 148 | ++ | + | | + |
| 1984 | *19.0* | 148 | | | | | *96.6* | 257 | *115.6* | 405 | ++ | + | | |
| 1985 | *12.4* | 23 | | | | | *31.1* | 74 | *43.5* | 97 | ++ | + | | + |
| 1986 | *50.5* | 95 | *114.3* | 291 | | | *28.2* | 79 | *193.0* | 465 | ++ | ++ | | |
| 1987 | *17.6* | 57 | *85.4* | 251 | | | | | *103.0* | 308 | ++ | ++ | | |
| 1988 | *47.8* | 58 | *125.7* | 357 | | | *112.1* | 347 | *285.6* | 762 | ++ | ++ | + | |
| 1989 | *25.2* | 49 | *236.7* | 499 | | | *59.8* | 186 | *321.7* | 734 | ++ | ++ | + | |
| 1990 | *65.4* | 244 | *159.4* | 165 | | | *122.4* | 259 | *347.2* | 668 | ++ | + | | + |
| 1991 | *30.3* | 99 | *84.8* | 195 | | | *55.8* | 215 | *170.9* | 509 | ++ | ++ | | + |
| 1992 | *62.1* | 39 | *103.9* | 167 | *209.4* | 127 | *19.7* | 51 | *395.1* | 384 | ++ | ++ | ++ | ++ |
| 1993 | *59.5* | 64 | *263.0* | 170 | *311.0* | 316 | *178.2* | 164 | *811.7* | 714 | ++ | ++ | ++ | ++ |
| 1994 | *62.1* | 66 | *243.7* | 132 | *215.0* | 136 | *72.5* | 52 | *593.3* | 386 | ++ | ++ | ++ | ++ |
| 1995 | *51.1* | 44 | *228.9* | 214 | *149.5* | 156 | *91.4* | 174 | *520.9* | 588 | ++ | ++ | ++ | ++ |
| 1996 | *65.4* | 377 | *281.4* | 447 | *150.3* | 221 | *104.6* | 311 | *601.7* | 1356 | ++ | ++ | + | ++ |
| 1997 | *61.1* | 92 | *271.8* | 487 | *182.6* | 154 | *51.2* | 184 | *566.7* | 917 | ++ | ++ | ++ | ++ |
| 1998 | *54.0* | 39 | *276.2* | 233 | *210.8* | 101 | *11.5* | 18 | *552.5* | 391 | ++ | ++ | ++ | ++ |
| 1999 | *65.4* | 383 | *297.0* | 253 | *200.4* | 240 | *55.4* | 211 | *618.2* | 1087 | ++ | ++ | ++ | ++ |
| All | *1976* | 6188 | *3149* | 4937 | *1629* | 1451 | *1230* | 2822 | *7983* | 15398 | | | | |

*Number of birds received at the MEC rehabilitation centre*

During the period 1988-99 the MEC hosted some 180 sea- and coastal birds by winter, i.e. an average of one bird received by day (Table 4).

*Table 4. Number of sea- and coastal birds received at the MEC rehabilitation centre Oostende in the winters 1988-1999 (period October 1st – March 31st).*

| Taxon | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| auks | 120 | 84 | 215 | 151 | 108 | 61 | 119 | 90 | 31 | 53 | 76 | 182 |
| Cormorant/Shag | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| divers | 3 | 2 | 0 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 1 | 7 |
| Eider | 0 | 3 | 2 | 7 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| Fulmar | 1 | 1 | 0 | 5 | 2 | 1 | 1 | 1 | 0 | 0 | 4 | 7 |
| Northern Gannet | 2 | 0 | 2 | 0 | 5 | 1 | 2 | 1 | 0 | 0 | 1 | 4 |
| grebes | 8 | 1 | 7 | 30 | 12 | 3 | 5 | 4 | 13 | 9 | 5 | 10 |
| Kittiwake | 4 | 0 | 2 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 4 | 0 |
| *Larus*-gulls | 37 | 38 | 34 | 57 | 47 | 46 | 26 | 29 | 59 | 42 | 34 | 25 |
| other seaducks | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| other waterbirds | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 1 | 1 |
| others | 1 | 1 | 0 | 5 | 2 | 1 | 1 | 1 | 0 | 0 | 4 | 7 |
| scoters | 19 | 9 | 1 | 20 | 4 | 1 | 8 | 3 | 2 | 2 | 0 | 4 |
| skuas | 2 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| waders | 7 | 6 | 2 | 14 | 9 | 3 | 5 | 7 | 21 | 21 | 5 | 11 |
| Sea-and coastal birds total | 204 | 145 | 265 | 292 | 195 | 123 | 171 | 139 | 132 | 131 | 132 | 251 |

*Numbers per species collected during BBS*

The total number of birds collected during Belgian beached bird surveys from 1962 to 1999 is summarized in Table 5. Numbers have not been corrected for travelled distance (effort: see Table 3). The 10 most encountered species are: Common Guillemot (*N*=3703), Kittiwake (*N*=1413), Common Scoter (*N*=1260), Razorbill (*N*=1019), Herring Gull (*N*=920), Black-headed Gull (*N*=843), Oystercatcher (N=814), Fulmar (*N*=735), Common Gull (*N*=551) and Great-crested Grebe (*N*=533). Two White-beaked Dolphins *Lagenorhynchus albirostris* and one Common Seal *Phocoena phocoena* were the only marine mammals found by beached bird surveyors during their monitoring work.

*Table 5. Total number of birds/sea mammals collected on Belgian beaches during beached birds surveys in the period 1962-1999.*

| Winter | *62* | *63* | *64* | *65* | *66* | *67* | *68* | *69* | *70* | *71* | *72* | *73* | *74* | *75* | *76* | *77* | *78* | *79* | *81* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Gavia stellata* | 4 | 0 | 21 | 20 | 2 | 3 | 4 | 8 | 11 | 0 | 2 | 7 | 0 | 0 | 2 | 2 | 3 | 0 | 0 |
| *Gavia arctica* | 4 | 0 | 4 | 7 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gavia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Tachybaptus ruficollis* | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 0 |
| *Podiceps cristatus* | 5 | 0 | 9 | 34 | 2 | 4 | 9 | 20 | 51 | 3 | 28 | 19 | 0 | 3 | 3 | 1 | 8 | 0 | 0 |
| *Podiceps grisegena* | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Podiceps auritus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Podiceps nigricollis* | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Podiceps* sp. | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 |
| *Fulmarus glacialis* | 92 | 1 | 8 | 9 | 0 | 2 | 7 | 3 | 3 | 1 | 2 | 2 | 4 | 0 | 5 | 2 | 4 | 1 | 23 |
| *Hydrobates pelagicus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Oceanodroma leucorhoa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Morus bassanus* | 4 | 2 | 0 | 6 | 4 | 11 | 14 | 8 | 2 | 3 | 3 | 5 | 0 | 1 | 3 | 3 | 0 | 0 | 3 |
| *Phalacrocorax carbo* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phalacrocorax aristotelis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botaurus stellaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ardea cinerea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cygnus olor* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cygnus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anser fabalis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anser brachyrhynchus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anser albifrons* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anser anser* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anser* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Winter | *62* | *63* | *64* | *65* | *66* | *67* | *68* | *69* | *70* | *71* | *72* | *73* | *74* | *75* | *76* | *77* | *78* | *79* | *81* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Branta bernicla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alopochen aeygyptiacus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tadorna tadorna* | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 3 | 5 | 4 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 |
| *Aix galericulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anas penelope* | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anas strepera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anas crecca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Anas platyrhynchos* | 1 | 0 | 2 | 1 | 0 | 0 | 3 | 3 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Anas acuta* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aythya ferina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aythya fuligula* | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aythya marila* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Somateria mollissima* | 1 | 0 | 0 | 1 | 1 | 0 | 5 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Anatidae *sp.* | 0 | 11 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 |
| *Melanitta nigra* | 20 | 13 | 11 | 156 | 25 | 46 | 194 | 156 | 82 | 3 | 24 | 57 | 7 | 32 | 5 | 0 | 2 | 30 | 4 |
| *Melanitta* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| *Melanitta fusca* | 3 | 0 | 1 | 2 | 1 | 2 | 3 | 3 | 6 | 0 | 1 | 5 | 0 | 2 | 1 | 1 | 0 | 0 | 0 |
| *Bucephala clangula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Mergus albellus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mergus serrator* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mergus merganser* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mergus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falco tinnunculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Perdix perdix* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phasianus colchicus* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rallus aquaticus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gallinula chloropus* | 0 | 1 | 2 | 0 | 2 | 0 | 1 | 2 | 2 | 3 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 14 | 0 |
| *Fulica atra* | 2 | 90 | 5 | 0 | 22 | 1 | 28 | 3 | 13 | 13 | 7 | 4 | 0 | 0 | 2 | 0 | 0 | 120 | 2 |
| *Haematopus ostralegus* | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 5 | 4 | 2 | 2 | 0 | 0 | 20 | 0 | 1 | 0 | 0 |
| *Recurvirostra avosetta* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Charadrius dubius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Charadrius hiaticula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| *Pluvialis apricaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Pluvialis squatarola* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Vanellus vanellus* | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Calidris canutus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Calidris alba* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Calidris maritima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calidris alpina* | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 8 | 1 | 0 | 0 | 0 | 81 | 0 | 0 | 0 | 0 |
| *Philomachus pugnax* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Lymnocryptes minimus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gallinago gallinago* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scolopax rusticola* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Limosa limosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Limosa lapponica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Numenius arquata* | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| *Tringa totanus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 |
| *T.totanus robusta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arenaria interpres* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phalaropus fulicarius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Limicolae *sp.* | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 |
| *Stercorarius parasiticus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stercorarius skua* | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Larus minutus* | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Larus ridibundus* | 7 | 0 | 35 | 14 | 21 | 22 | 32 | 29 | 51 | 72 | 23 | 22 | 14 | 19 | 15 | 3 | 8 | 0 | 11 |
| *Larus canus* | 24 | 0 | 88 | 31 | 18 | 17 | 10 | 33 | 37 | 31 | 14 | 20 | 3 | 1 | 7 | 2 | 7 | 0 | 6 |
| small *Larus* sp. | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 114 | 0 |
| *Larus fuscus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 2 |
| *L.fuscus* or *L.argentatus* | 0 | 0 | 0 | 0 | 0 | 27 | 33 | 14 | 0 | 0 | 0 | 29 | 2 | 1 | 0 | 1 | 12 | 0 | 1 |
| *Larus argentatus* | 0 | 0 | 0 | 24 | 15 | 0 | 0 | 0 | 6 | 3 | 4 | 2 | 1 | 4 | 3 | 7 | 0 | 0 | 13 |

| Winter | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 81 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *L.argentatus heuglini* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Larus cachinnans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Larus marinus* | 13 | 0 | 35 | 13 | 15 | 24 | 37 | 17 | 6 | 3 | 3 | 10 | 1 | 5 | 6 | 9 | 5 | 0 | 10 |
| *Larus* sp. | 7 | 22 | 16 | 0 | 0 | 21 | 6 | 0 | 33 | 12 | 12 | 0 | 4 | 21 | 2 | 4 | 2 | 52 | 16 |
| *Rissa tridactyla* | 21 | 1 | 20 | 13 | 8 | 32 | 46 | 71 | 41 | 14 | 16 | 27 | 2 | 3 | 6 | 12 | 2 | 10 | 66 |
| *Sterna sandvicensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sterna hirundo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Uria aalge* | 19 | 2 | 47 | 27 | 24 | 57 | 14 | 92 | 48 | 5 | 6 | 28 | 4 | 12 | 2 | 5 | 7 | 6 | 101 |
| *U.aalge* or *A.torda* | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| *Uria lomvia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alca torda* | 22 | 1 | 15 | 58 | 16 | 42 | 14 | 77 | 92 | 11 | 4 | 51 | 6 | 3 | 4 | 1 | 4 | 9 | 14 |
| *Alle alle* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Fratercula arctica* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Columba livia domestica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Columba oenas* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Columba palumbus* | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Streptopelia decaocto* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Tyto alba* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Galerida cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alauda arvensis* | 0 | 0 | 0 | 0 | 35 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alauda sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anthus pratensis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anthus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Prunella modularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Turdus merula* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 2 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Turdus pilaris* | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| *Turdus philomelos* | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Turdus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Turdus iliacus* | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 6 | 1 | 0 | 1 | 0 | 0 | 6 | 1 | 6 | 0 | 0 |
| *Pica pica* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corvus monedula* | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corvus frugilegus* | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corvus corone* | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *C.corone cornix* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sturnus vulgaris* | 1 | 0 | 3 | 2 | 3 | 2 | 6 | 2 | 6 | 1 | 3 | 3 | 0 | 0 | 2 | 2 | 2 | 0 | 1 |
| *Passer domesticus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Fringilla coelebs* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Fringilla* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Carduelis carduelis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Plectrophenax nivalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aves *sp.* | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 |
| **BIRDS TOTAL NR** | 259 | 220 | 337 | 424 | 232 | 324 | 499 | 571 | 551 | 222 | 179 | 307 | 52 | 111 | 206 | 62 | 84 | 485 | 280 |
| *Lagenorhynchus albirostris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phocoena phocoena* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Winter | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Gavia stellata* | 0 | 1 | 0 | 1 | 5 | 0 | 8 | 3 | 4 | 6 | 6 | 2 | 3 | 14 | 5 | 3 | 4 | 8 | 162 |
| *Gavia arctica* | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 26 |
| *Gavia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 9 |
| *Tachybaptus ruficollis* | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 0 | 22 |
| *Podiceps cristatus* | 1 | 1 | 8 | 3 | 20 | 20 | 16 | 30 | 30 | 16 | 26 | 13 | 14 | 11 | 54 | 25 | 10 | 36 | 533 |
| *Podiceps grisegena* | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 19 |
| *Podiceps auritus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| *Podiceps nigricollis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 4 |
| *Podiceps* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| *Fulmarus glacialis* | 5 | 1 | 9 | 2 | 32 | 20 | 143 | 46 | 13 | 19 | 16 | 11 | 6 | 27 | 15 | 11 | 37 | 153 | 735 |
| *Hydrobates pelagicus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Oceanodroma leucorhoa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Morus bassanus* | 0 | 1 | 2 | 0 | 4 | 3 | 7 | 4 | 15 | 3 | 2 | 14 | 5 | 11 | 11 | 6 | 6 | 16 | 182 |

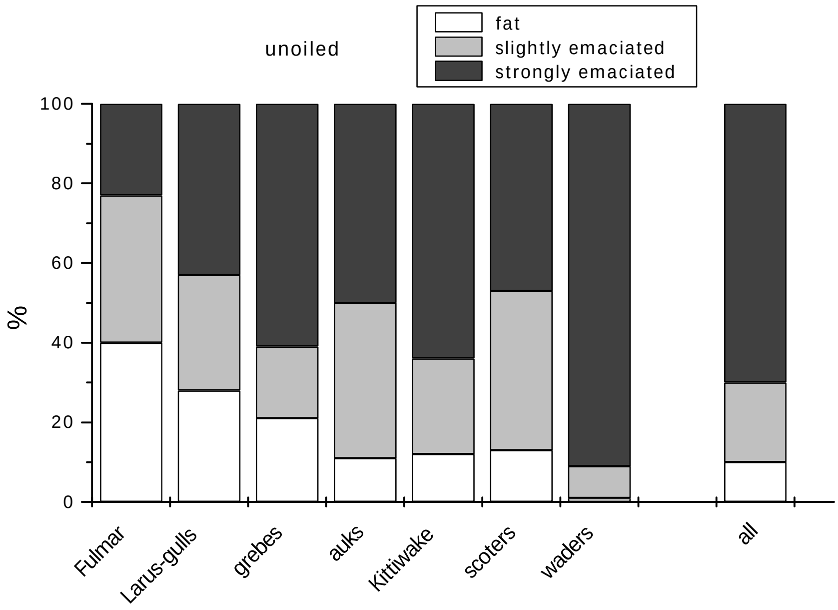
| Winter | *82* | *83* | *84* | *85* | *86* | *87* | *88* | *89* | *90* | *91* | *92* | *93* | *94* | *95* | *96* | *97* | *98* | *99* | *All* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phalacrocorax carbo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 2 | 1 | 0 | 9 |
| *Phalacrocorax aristotelis* | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Botaurus stellaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ardea cinerea* | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 11 |
| *Cygnus olor* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Cygnus* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Anser fabalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Anser brachyrhynchus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anser albifrons* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 11 |
| *Anser anser* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anser* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| *Branta bernicla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 3 | 0 | 3 | 0 | 0 | 11 |
| *Alopochen aeygyptiacus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| *Tadorna tadorna* | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 1 | 2 | 3 | 3 | 0 | 1 | 12 | 7 | 1 | 0 | 59 |
| *Aix galericulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anas penelope* | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 0 | 0 | 1 | 6 | 0 | 1 | 2 | 4 | 3 | 1 | 0 | 29 |
| *Anas strepera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anas crecca* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 8 |
| *Anas platyrhynchos* | 0 | 0 | 1 | 0 | 8 | 2 | 1 | 3 | 1 | 3 | 6 | 4 | 1 | 2 | 8 | 4 | 2 | 1 | 64 |
| *Anas acuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Aythya ferina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 6 |
| *Aythya fuligula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 6 |
| *Aythya marila* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 | 2 | 0 | 0 | 10 |
| *Somateria mollissima* | 0 | 0 | 2 | 6 | 6 | 7 | 5 | 11 | 3 | 7 | 6 | 4 | 0 | 1 | 2 | 4 | 2 | 7 | 87 |
| Anatidae *sp.* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 42 |
| *Melanitta nigra* | 3 | 1 | 10 | 23 | 21 | 28 | 50 | 65 | 4 | 33 | 33 | 10 | 12 | 19 | 29 | 15 | 9 | 28 | 1260 |
| *Melanitta* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Melanitta fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 34 |
| *Bucephala clangula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| *Mergus albellus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Mergus serrator* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 9 |
| *Mergus merganser* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 4 |
| *Mergus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| *Falco tinnunculus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| *Perdix perdix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Phasianus colchicus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Rallus aquaticus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 3 |
| *Gallinula chloropus* | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 0 | 2 | 42 |
| *Fulica atra* | 1 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 1 | 1 | 0 | 8 | 18 | 0 | 2 | 350 |
| *Haematopus ostralegus* | 4 | 0 | 1 | 3 | 9 | 3 | 1 | 2 | 3 | 15 | 20 | 38 | 6 | 5 | 407 | 240 | 6 | 8 | 814 |
| *Recurvirostra avosetta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Charadrius dubius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Charadrius hiaticula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 |
| *Pluvialis apricaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 4 |
| *Pluvialis squatarola* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 2 | 1 | 0 | 1 | 26 | 0 | 0 | 38 |
| *Vanellus vanellus* | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 4 | 2 | 1 | 0 | 0 | 24 |
| *Calidris canutus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 13 | 16 | 1 | 0 | 33 |
| *Calidris alba* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 11 |
| *Calidris maritima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Calidris alpina* | 0 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 | 19 | 19 | 6 | 0 | 2 | 15 | 102 | 0 | 0 | 265 |
| *Philomachus pugnax* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Lymnocryptes minimus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Gallinago gallinago* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 |
| *Scolopax rusticola* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 1 | 1 | 0 | 6 | 4 | 5 | 0 | 2 | 27 |
| *Limosa limosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Limosa lapponica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| *Numenius arquata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 12 | 7 | 0 | 0 | 37 |
| *Tringa totanus* | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 31 | 60 | 0 | 0 | 115 |
| *Tringa totanus robusta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| *Arenaria interpres* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 10 | 1 | 7 | 1 | 26 |

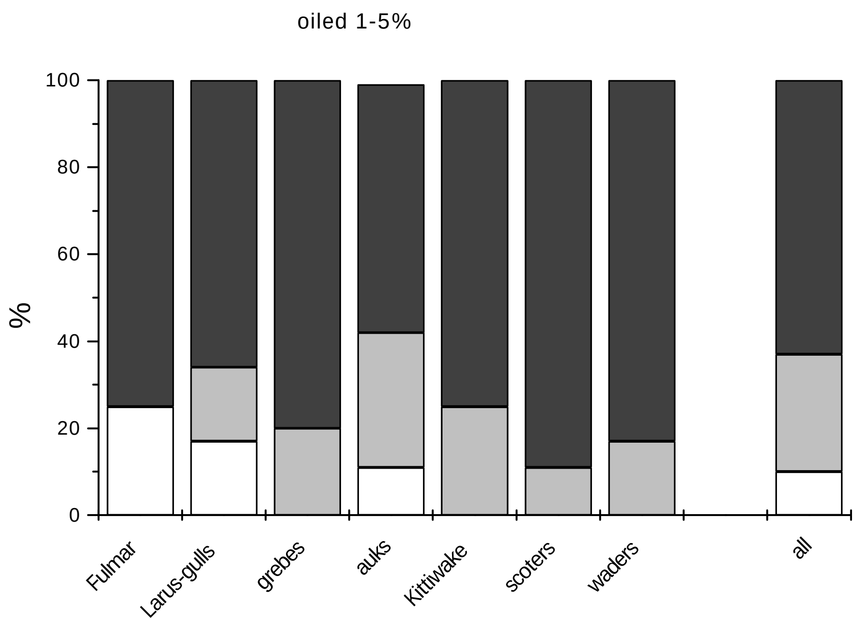
| Winter | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phalaropus fulicarius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Limicolae *sp.* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 77 |
| *Stercorarius parasiticus* | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 |
| *Stercorarius skua* | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 1 | 1 | 0 | 3 | 16 |
| *Larus minutus* | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 5 | 2 | 0 | 1 | 1 | 0 | 4 | 0 | 1 | 0 | 1 | 25 |
| *Larus ridibundus* | 7 | 6 | 8 | 6 | 22 | 10 | 43 | 37 | 15 | 23 | 36 | 31 | 27 | 14 | 57 | 60 | 21 | 22 | 843 |
| *Larus canus* | 5 | 1 | 5 | 5 | 9 | 3 | 13 | 9 | 11 | 14 | 15 | 7 | 5 | 14 | 47 | 24 | 4 | 11 | 551 |
| small *Larus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 143 |
| *Larus fuscus* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 2 | 4 | 3 | 8 | 0 | 11 | 40 | 2 | 11 | 16 | 111 |
| *L.fuscus* or *L.argentatus* | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 128 |
| *Larus argentatus* | 2 | 5 | 8 | 0 | 20 | 21 | 33 | 67 | 22 | 49 | 32 | 70 | 43 | 72 | 214 | 72 | 46 | 62 | 920 |
| *L.argentatus heuglini* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Larus cachinnans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Larus marinus* | 2 | 2 | 4 | 2 | 10 | 0 | 15 | 12 | 4 | 6 | 1 | 12 | 4 | 18 | 30 | 8 | 15 | 13 | 370 |
| *Larus* sp. | 5 | 0 | 3 | 0 | 17 | 0 | 1 | 8 | 15 | 12 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 2 | 300 |
| *Rissa tridactyla* | 3 | 12 | 122 | 3 | 69 | 105 | 185 | 101 | 45 | 72 | 18 | 67 | 9 | 45 | 23 | 25 | 44 | 54 | 1413 |
| *Sterna sandvicensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Sterna hirundo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 3 |
| *Uria aalge* | 8 | 69 | 141 | 31 | 155 | 68 | 140 | 283 | 368 | 146 | 89 | 320 | 203 | 252 | 130 | 96 | 127 | 571 | 3703 |
| *U.aalge* or *A.torda* | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 18 |
| *Uria lomvia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Alca torda* | 3 | 41 | 67 | 2 | 15 | 7 | 75 | 17 | 91 | 16 | 10 | 38 | 20 | 24 | 62 | 22 | 16 | 49 | 1019 |
| *Alle alle* | 0 | 0 | 1 | 0 | 6 | 0 | 3 | 5 | 6 | 6 | 1 | 0 | 0 | 0 | 36 | 8 | 3 | 2 | 80 |
| *Fratercula arctica* | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 13 |
| *Columba livia domestica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 10 | 4 | 0 | 0 | 2 | 0 | 0 | 25 |
| *Columba oenas* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 3 |
| *Columba palumbus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 |
| *Streptopelia decaocto* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Tyto alba* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Galerida cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Alauda arvensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 39 |
| *Alauda* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| *Anthus pratensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anthus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Prunella modularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Turdus merula* | 2 | 0 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 1 | 1 | 0 | 2 | 5 | 1 | 2 | 1 | 35 |
| *Turdus pilaris* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 1 | 2 | 0 | 20 |
| *Turdus philomelos* | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 0 | 0 | 14 |
| *Turdus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| *Turdus iliacus* | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 2 | 0 | 0 | 12 | 3 | 0 | 2 | 51 |
| *Pica pica* | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Corvus monedula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 |
| *Corvus frugilegus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| *Corvus corone* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 15 |
| *C.corone cornix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Sturnus vulgaris* | 11 | 0 | 3 | 0 | 5 | 0 | 1 | 8 | 0 | 4 | 5 | 5 | 1 | 0 | 2 | 1 | 0 | 3 | 88 |
| *Passer domesticus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Fringilla coelebs* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Fringilla* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Carduelis carduelis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Plectrophenax nivalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Aves *sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 46 |
| **BIRDS TOTAL NR** | 72 | 148 | 405 | 97 | 465 | 308 | 762 | 734 | 666 | 509 | 383 | 709 | 377 | 584 | 1356 | 914 | 387 | 1087 | 15368 |
| *Lagenorhynchus albirostris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Phocoena phocoena* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |

*Condition*

The majority of beached corpses are somehow emaciated. Winter-sensitive taxa such as waders and waterbirds are most affected: the majority died of starvation (sternum protruding clearly, pectoral muscles atrophied). Species vulnerable to oil and ‘wreck-conditions’ (auks, Kittiwake) are found in a more or less emaciated condition.

Comparatively the Fulmar and Northern Gannet appear rather fat when stranded. Other taxa and species are intermediate in their performance. An inverse relationship between the emaciation of a corpse and the oil-contamination exist, with unoiled birds predominantly strongly emaciated and oiled specimens usually rather fat (Fig. 2). That corpses with only 1-5% oil behave as unoiled corpses may have two possible explanations: either they were oil-contaminated post-mortem, or a very small amount of oil in their plumage does not kill them instantly but very slowly, with severe emaciation as a direct consequence.



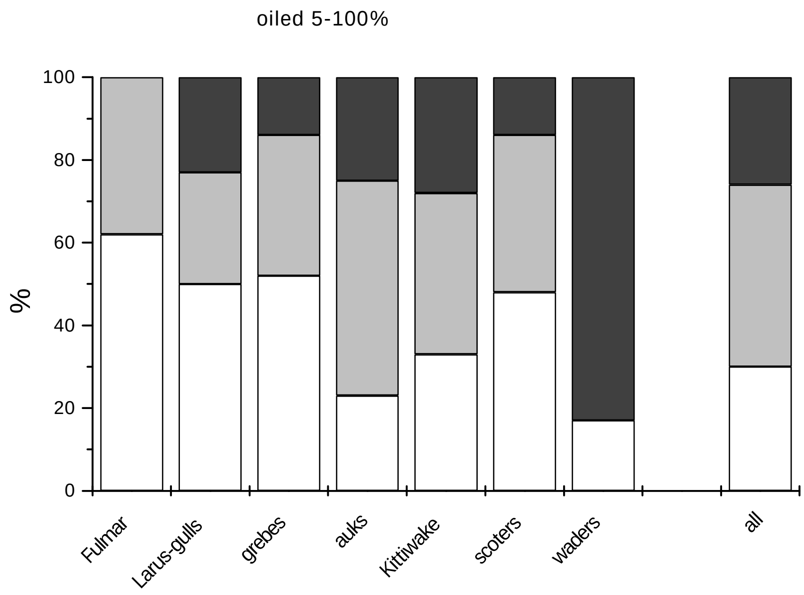



*Fig. 2. Condition of unoiled, slightly oiled and oiled seabird taxa/species at the Belgian coast as found during beached bird surveys in the period 1993-1999 (*N*=2136). The condition is presented as the proportions of the corpses in three classes of emaciation (0=fat, 1=slightly emaciated; 2=strongly emaciated).*

Taxa such as grebes and scoters become leaner in the course of the winter (Table 6), beached Kittiwake and Fulmar show a similar pattern but with the leanest specimens in December/January. Waders are always strongly emaciated but more so during December/March than in early winter. On the other hand, *Larus*-gulls and auks are less affected on average later in winter: fat specimens are more common as the winter goes on. For gulls an explanation can be found in the presence of larger numbers of young birds in early winter (more sensitive to food-shortage), for auks the situation is less clear.

*Table 6. Seasonal pattern in condition of beached birds at the Belgian coast in the period 1993-1999 (*N*=2136). Classes of condition are: 0= fat; 1= lightly emaciated; 2= strongly emaciated. The condition is presented as the frequency distribution (%) of the three emaciation classes.*

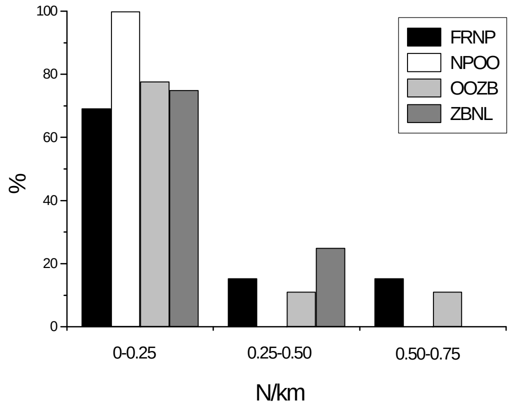
| % | Oct/Nov | | | Dec/Jan | | | Feb/March | | |
|---|---|---|---|---|---|---|---|---|---|
| class | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 |
| grebes | 100 | 0 | 0 | 31 | 31 | 38 | 29 | 21 | 50 |
| Fulmar | 63 | 25 | 12 | 40 | 13 | 47 | 41 | 48 | 11 |
| scoters | 78 | 22 | 0 | 27 | 40 | 33 | 17 | 35 | 48 |
| waders | 23 | 8 | 69 | 0 | 10 | 90 | 2 | 6 | 92 |
| *Larus*-gulls | 17 | 20 | 63 | 24 | 34 | 42 | 37 | 18 | 45 |
| Kittiwake | 56 | 33 | 11 | 11 | 25 | 64 | 20 | 32 | 48 |
| auks | 12 | 34 | 54 | 13 | 39 | 48 | 18 | 47 | 35 |
| ALL BIRDS | 25 | 21 | 54 | 11 | 24 | 65 | 16 | 28 | 56 |

SPECIES ACCOUNT

**DIVERS** *Gavia* sp.

The majority (86%) of the divers found dead on Belgian beaches are Red-throated Divers (*G. stellata*). Only 14% has been identified as Black-throated Divers (*G.arctica*). This figure is comparable with the 12% recorded in The Netherlands by experienced observers on a sample of 108 divers (CAMPHUYSEN 1995d). No other diver species have been recorded on Belgian beaches so far.

Usually numbers of beached divers are small (Fig. 3), with densities higher than 0.50 specimens km$^{-1}$ only recorded in the 1960s.



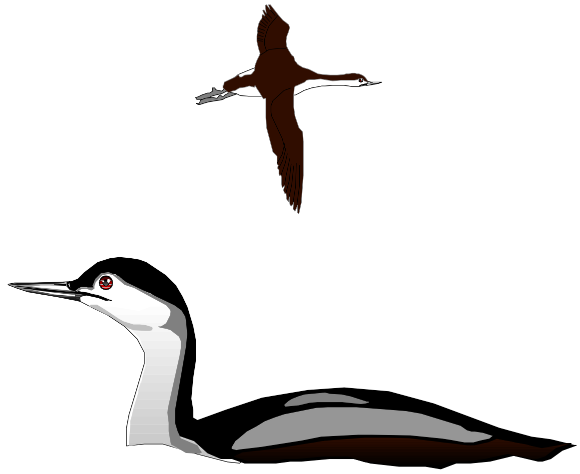



*Fig. 3. Frequency distribution of densities of beached divers* Gavia sp*. on Belgian beaches during 1962-1999 at four beach sections.*

Highest densities of divers were recorded in the first half of the 1960s. Divers have a high probability to get oil-fouled. Oil-rates and densities decreased clearly over the last four decades (Table 7, Fig. 4) although only densities show a significant trend (Spearman Rank *R*: -0.444, *N*=37, *P*<0.01). Accordingly oil-rates of divers in The Netherlands decreased from 93% (1947-65) to 80% (1986-95) and densities from 0.16 to 0.03 $km^{-1}$. (CAMPHUYSEN 1995b; PLATTEEUW 1987). This is in contrast with increasing numbers of divers at sea in the period 1975-95, and suggests that the risk of getting contaminated with oil has decreased substantially (CAMPHUYSEN 1995b). Oil-rates of divers at the continental North Sea coasts are still very high compared to other regions (Shetland islands - HEUBECK 1995: 23% during 1979-92).

*Table 7. Mean densities and oil-rates of divers* Gavia sp*. by decade on Belgian beaches*.

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.16 | 98 |
| 1970s | 0.03 | 87 |
| 1980s | 0.02 | 85 |
| 1990s | 0.01 | 80 |

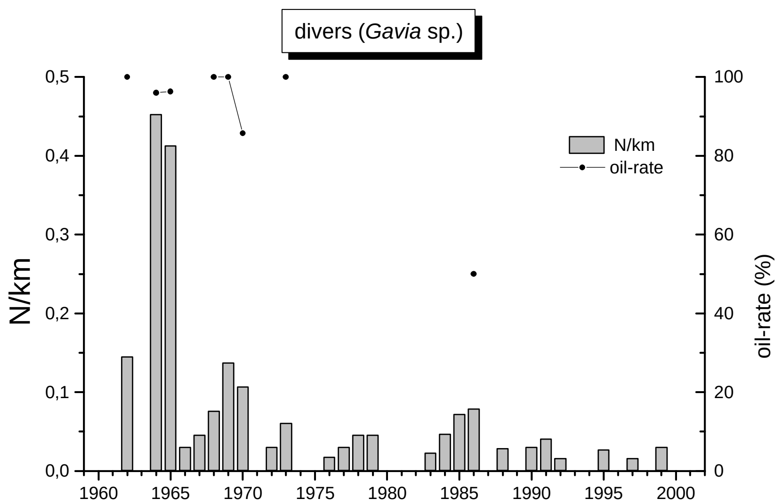



*Fig.4. Density and oil-rate of beached divers* Gavia sp. *during IBB surveys at the Belgian coast 1962-1999.*

The MEC rehabilitation centre received 26 divers in the winters 1988-1999. No distinct peaks in occurrence can be observed.

Divers show a rather uniform pattern of beaching from December to April, with only marginal numbers in November (Tab. 8). A similar pattern is observed on Dutch beaches (PLATTEEUW 1987).

*Table 8. Seasonal pattern in density of beached divers* Gavia sp. *at Nieuwpoort-Oostende 1993-99.*

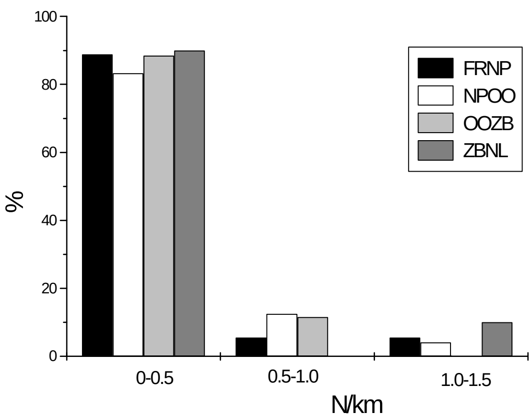
| Month | N $km^{-1}$ |
|---|---|
| October | 0.000 |
| November | 0.001 |
| December | 0.012 |
| January | 0.017 |
| February | 0.016 |
| March | 0.012 |

Out of 26 divers hosted at the MEC rehabilitation centre in 1988-1999 one has apparently been shot, and one showed a leg injury. From 47 divers found dead on the beach in 1993-1999, ten missed head, legs and/or wings (collectors) and one was entangled.

There is only one ringing record. A Red-throated diver ringed at Lempäälä (Finland) as a pullus on 09.07.1989 was found dead at Beveren a/d Yzer (at approximately 20 km inland) on 30.01.1994.

**GREBES** *Podiceps* sp.
Great-crested Grebes (*P.cristatus*) constitute 92% of the grebes found on Belgian beaches. Little Grebe (*Tachybaptus ruficollis*) and Red-necked Grebe (*P.grisegena*) make up 4 and 3% respectively, Black-necked (*P.nigricollis*) and Slavonian Grebes (*P.auritus*) are rarely found (< 1%). These ratios seem to be slightly biased due to the data collected during the 1990s, when Great-crested Grebes became more and more dominant (CAMPHUYSEN & DERKS 1989). On Dutch beaches during 1965-91, CAMPHUYSEN (1993) found 85% Great-crested Grebe, 9% Red-necked Grebe and smaller numbers of Black-necked, Slavonian and Little Grebes.

Grebes are rarely found in densities higher than 0.5 specimens $km^{-1}$ (Fig. 5). High oil-rates due to chronic oil pollution alternate with low oil-rates induced by severe winter weather.



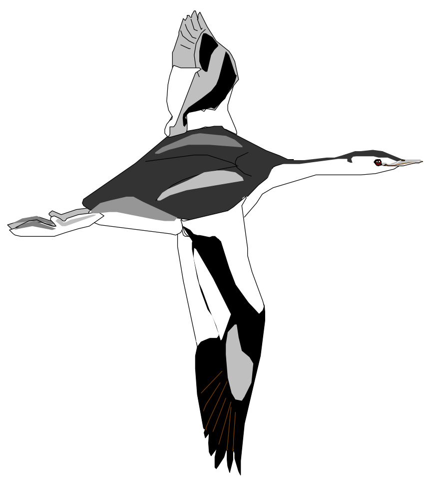



*Fig. 5. Frequency distribution of densities of beached grebes on Belgian beaches during 1962-1999 at four beach sections.*

Oil-rates show a significant decreasing trend (Spearman Rank *R*: -0.577, *N*=20, *P*<0.01) over the last four decades (Tab. 9, Fig. 6). Although mean values of densities by decade decrease, a non-significant, very irregular pattern emerge rather than a consistent decline (Spearman Rank *R*: -0.147, *N*=37, *P*< 0.05). As in divers, the increase in numbers at sea, particularly since 1978 (CAMPHUYSEN & DERKS 1989), is not followed by higher numbers of beaching grebes. In combination with lower oil-rates, this seems to point at a lowered risk for several inshore species to get oil-fouled.

*Table 9. Mean densities and oil-rates of grebes by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.20 | 89 |
| 1970s | 0.15 | 66 |
| 1980s | 0.08 | 75 |
| 1990s | 0.05 | 42 |

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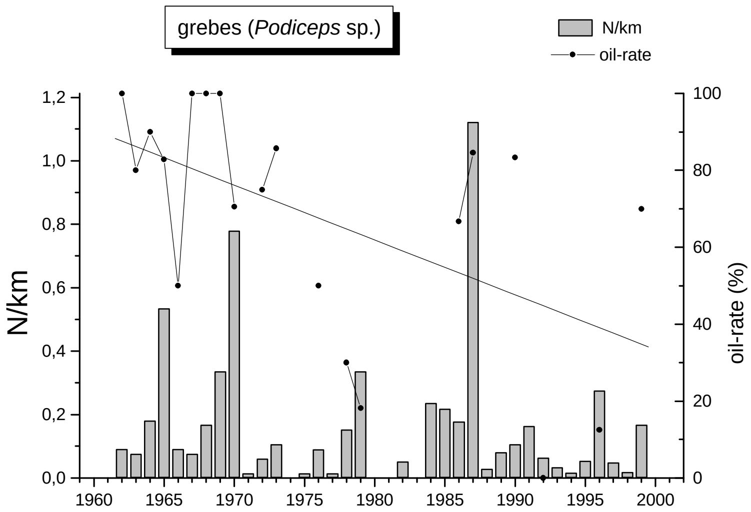



*Fig. 6. Density and oil-rate of beached grebes during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

A grand total of 94 Great-crested Grebes has been registered at the MEC rehabilitation centre during 1988-1999. No distinct peaks can be observed, except for February 1991 when 18 grebes were received in one month time (with 10 specimens in the second ten days period). Numbers increase in the course of the winter with peaks in February. The total number of grebes received every winter at the MEC correlates positively with the IJnsen factor (Kendall *Tau*: 0.4733, $P<0.05$). CAMPHUYSEN & DERKS (1989) demonstrated that important mortality amongst grebes occur in severe winters following one or more mild ones.

The chance to find grebes dead on the beach increases as the winter goes on (Tab. 10). The second ten days period of February show the highest score, with an average density of 0.10 specimens $km^{-1}$. Hence, IBB surveys in February can provide a good picture of killed numbers per winter. In The Netherlands the peak in grebe corpses takes place one month later (CAMPHUYSEN & DERKS 1989, PLATTEEUW 1987).

*Table 10. Seasonal pattern in density of beached grebes at Nieuwpoort-Oostende 1993-99.*

| Month | N $km^{-1}$ |
|---|---|
| October | 0.006 |
| November | 0.009 |
| December | 0.028 |
| January | 0.050 |
| February | 0.073 |
| March | 0.060 |

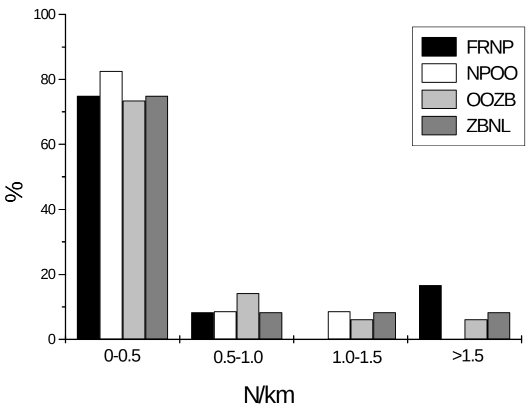
Leg injuries (15 birds) were the most frequent type of injuries observed in grebes arriving at the MEC rehabilitation centre. At least in three cases the injury was caused by a dog bite. Another 24 specimens died of starvation. Wing injuries ($N$=3), head injuries ($N$=5) and undefined injuries ($N$=6) were the other causes of death. From 175 grebes found on the beach in 1993-1999 two specimens were entangled, three had broken legs and two showed head injuries. Considering 107 Great-crested grebes recovered under known circumstances all over Europe (i.e. not restricted to coastal areas), ADRIAENSEN *et al*. (1993) found 34% being shot or hunted, 37% as casualties of all kinds of fishery activities, and smaller numbers as victims of pollution (4%), predation (4%) and bad weather (8%).

At the KBIN no recoveries could be traced of grebes ringed abroad and found at the Belgian coast during 1970-1999. Grebes demonstrate a high fidelity to their breeding area, concentrate in moulting grounds during summer and move in south-eastern (SE-Europe, central European lakes) or south-western direction (North Sea coasts and Channel) from

November to March (Adriaensen *et al*. 1993). Probably an important part of the grebes wintering in our coastal waters have a Dutch (or German) origin, and only limited numbers come from further north. Movements in south-western direction after the migratory season (October-November) are strongly temperature dependent (Camphuysen & Derks 1989).

**FULMAR** *Fulmarus glacialis*

Fulmars were very common victims during the wrecks of 1962 and 1999, with densities at major transects of more than 2 specimens $km^{-1}$. The wreck of 1962 was also recorded in Britain, The Netherlands and Sweden (Pashby & Cudworth 1969), the one of 1999 at least along all continental coasts of the North Sea (pers. comm. Camphuysen). These and other important wrecks observed in Belgium happened to coincide either with low or high oil-rates. 'Normal' numbers of beached Fulmars used to be much smaller (Fig. 7).



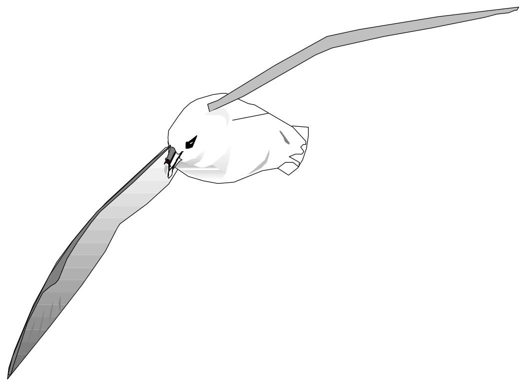



*Fig. 7. Frequency distribution of densities of beached Fulmar* Fulmarus glacialis *on Belgian beaches during 1962-1999 on four beach sections.*

The chance to find dead Fulmars on the beach was highest in the 1960s and 1980s and 4-10 times smaller in the 1970s and 1990s (Tab. 11). A much higher sampling effort in the 1990s, compared to the 1960s, results in a different impact of the wrecks of 1962 and 1999 on mean densities per decade. Oil-rates decreased substantially, but not significantly (Spearman Rank $R$: 0.012; $N$=37, $P$<0.05) after the 1970s (Tab. 11, Fig. 8) and used to be lower on Belgian beaches than in The Netherlands (1947-65: 72%, Platteeuw 1987; 1965-78: 87%, Camphuysen 1991; 1978-91: 68%; Camphuysen & van Franeker 1992; 1986-95: 56%, Camphuysen 1995b).

*Table 11. Mean densities and oil-rates of Fulmar* Fulmarus glacialis *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.24 | 62 |
| 1970s | 0.02 | 71 |
| 1980s | 0.22 | 43 |
| 1990s | 0.06 | 23 |

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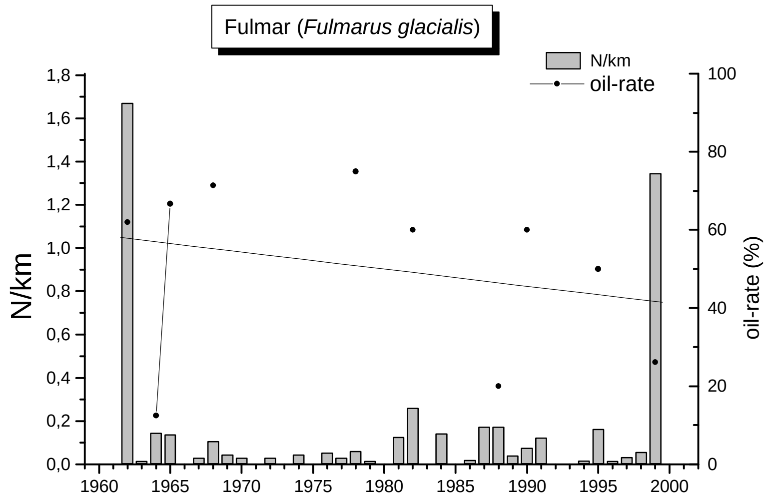



*Fig. 8. Density and oil-rate of beached Fulmar* Fulmarus glacialis *during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

Only 23 Fulmars were recorded at the MEC rehabilitation centre in the winters 1988-1999, with a maximum of 7 specimens per winter in 1999. Another 13 birds were received during August-September or April-May.

Findings of Fulmar on the beach are well distributed throughout the winter (Tab. 12), with a remarkable peak in February (cf. important wrecks). Fulmars collected outside the winter season are not described here, although they are known to be widespread (on average: 0.021 $km^{-1}$ in April, e.g.: 11 Fulmars/25 km on 15.04.1989).

*Table 12. Seasonal pattern in density of beached Fulmar* Fulmarus glacialis *at Nieuwpoort-Oostende 1993-99*.

| Month | N $km^{-1}$ |
|---|---|
| October | 0.060 |
| November | 0.025 |
| December | 0.023 |
| January | 0.030 |
| February | 0.167 |
| March | 0.035 |

Over the entire study period Fulmars showed the highest densities at OOZB (0.124 $km^{-1}$), compared to ZBNL (0.096 $km^{-1}$), FRNP (0.091 $km^{-1}$) and NPOO (0.054 $km^{-1}$)(Tab. 13). Differences between beach sections were not consistent during the various decades: strandings at ZBNL became more important in the 1980s and 1990s, possibly because of changes in current patterns following the construction of the outer harbour of Zeebrugge.

*Table 13. Differences in density of beached Fulmar* Fulmarus glacialis *on four beach sections of the Belgian coast, by decade.*

| Decade | transect | Density (N $km^{-1}$) |
|---|---|---|
| 1960s | FRNP | 0.408 |
| | NPOO | 0.194 |
| | OOZB | 0.441 |
| | ZBNL | 0.074 |
| 1970s | FRNP | 0.016 |
| | NPOO | 0.013 |
| | OOZB | 0.036 |
| | ZBNL | 0.019 |
| 1980s | FRNP | 0.047 |
| | NPOO | 0.072 |
| | OOZB | 0.210 |
| | ZBNL | 0.412 |
| 1990s | FRNP | 0.069 |
| | NPOO | 0.043 |
| | OOZB | 0.090 |
| | ZBNL | 0.090 |

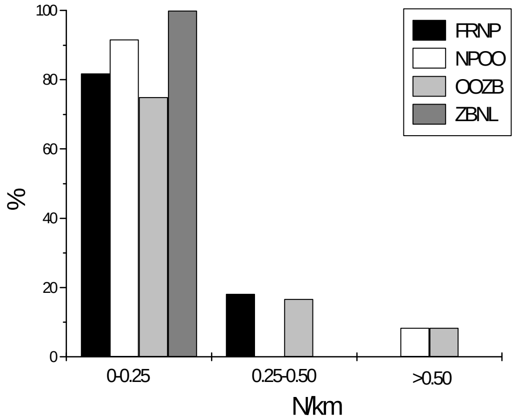
In Belgium, the occurrence of dark-phase specimens (D, versus light-coloured LL) has only been registered conscientiously from the 1990s onwards. Hence historical trends in proportions of coloured Fulmars as described by VAN FRANEKER (1979) cannot be demonstrated for the Belgian coast. Here, coloured Fulmars amounted to 2.1% during the 1990s (4 D/185 LL-coloured), with the majority being found during the wreck of 1999 (see: 24.02.1999 with 3 D/31 LL, i.e. 8.8%).

Fulmars are on average rather fresh (state of decay index: 1.14) and only slightly emaciated (condition index: 0.79) when found on the beach. Corpses seem to be markedly fresher when found at the eastcoast (s.d.i.: 0.33 at ZBNL compared to 1.54 at NPOO). This seems to correlate well with the comparatively high numbers beaching here, suggesting a possible ‘channelling’ effect for offshore species in this zone. Fulmars received at the rehabilitation centre were very often exhausted and parasite-infested. Two birds arrived with injuries, one with a sticky substance in its plumage (20.12.1990). Dead Fulmars are a favourite target for head-hunters. One bird was found with a fishhook in the wing.

A Fulmar ringed as a pullus at Inchkeith (Scotland) on 12.08.1981 was recovered totally exhausted one month later (15.09.1981) at the Belgian coast.

### NORTHERN GANNET *Morus bassanus*

Northern Gannets are usually found in very small numbers (Fig. 9), which makes the stranding of 9 birds on 7.1 km in the second ten days period of October 1989 quite remarkable.



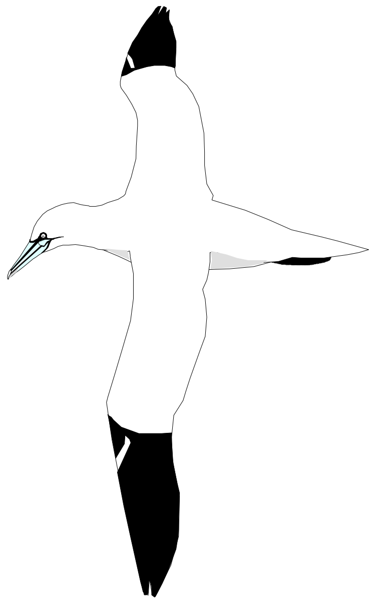



*Fig. 9. Frequency distribution of densities of beached Northern Gannets* Morus bassanus *on Belgian beaches during 1962-1999 at four beach sections.*

Relatively large numbers of Northern Gannets beached in the 1960s, numbers decreased and stabilised afterwards (Tab. 14, Fig. 10). Oil-rates declined continuously over the four decades (Spearman Rank *R*: -0.536; *N*=37; *P*<0.001). Oil-rates on Belgian beaches compare well to those in The Netherlands (1969-85: 87%, 1986-95: 79%, CAMPHUYSEN 1995b), where in recent years, just over half of all Northern Gannets found were somehow oiled or contaminated with other lipophilic substances (CAMPHUYSEN 2001).

*Table 14. Mean densities and oil-rates of Northern Gannet* Morus bassanus *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.10 | 98 |
| 1970s | 0.02 | 90 |
| 1980s | 0.02 | 70 |
| 1990s | 0.02 | 55 |

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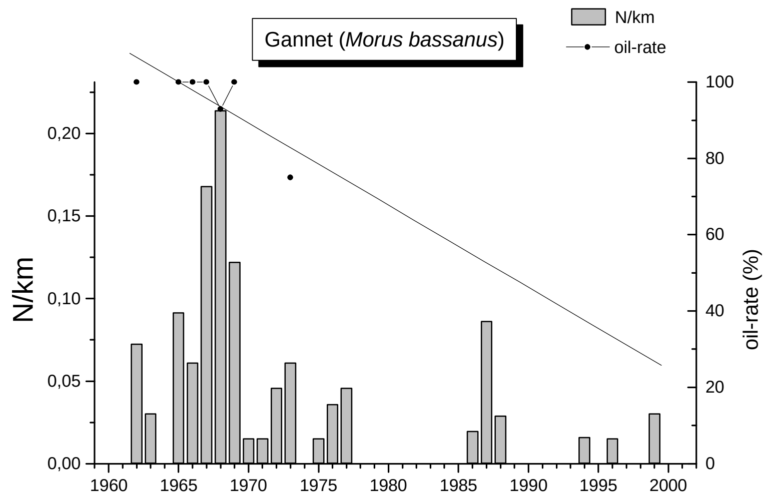



*Fig. 10. Density and oil-rate of beached Northern Gannets* Morus bassanus *during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

During 11 winters at the MEC-rehabilitation centre only 18 Northern Gannets were treated, 50% of them being oil-fouled. The number of Northern Gannets received at the MEC by winter correlates positively with the number of days with strong (>30 km $h^{-1}$) onshore winds (Kendall *Tau*: 0.583, $P<0.01$). Stronger winds mean more turbid waters, assumed to deter Northern Gannets even from areas rich in target fish species (LEOPOLD & PLATTEEUW 1987). Another 20 birds arrived at the centre in the summer period (June-September) with comparatively low oil-rates (18%). Numbers of beached Northern Gannets are low throughout the winter (Tab. 15) and only markedly higher in November (0.034 $km^{-1}$), following a maximum of recoveries at the MEC-rehabilitation centre in October (the 18 Northern Gannets received here during the winter are well-distributed over the different months with a maximum in October: 7 specimens). The peak in November is consistent with a period of maximal migration and presence on the Channel doormat in this month (OFFRINGA *et al*. 1996).

*Table 15. Seasonal pattern in density of beached Northern Gannet* Morus bassanus *at Nieuwpoort-Oostende 1993-99.*

| Month | N $km^{-1}$ beach | N at MEC |
|---|---|---|
| October | 0.012 | 7 |
| November | 0.034 | 3 |
| December | 0.011 | 1 |
| January | 0.018 | 2 |
| February | 0.014 | 2 |
| March | 0.020 | 3 |

Considering beached birds during the winter season, adults outnumber immature/first-year birds in a proportion of 77% versus 11 and 13% respectively (Tab. 16). Young birds are rare in Belgian beached bird surveys in January-March.

*Table 16. Age-composition of beached Northern Gannet* Morus bassanus *by month at the Belgian coast.*

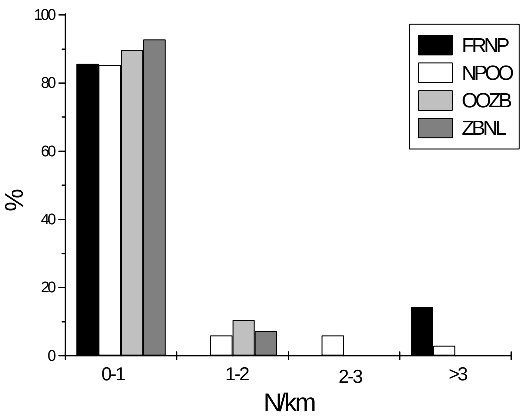
| Month | N scored | First-year (%) | Immature (%) | Adult (%) |
|---|---|---|---|---|
| October | 6 | 33 | 33 | 33 |
| November | 13 | 23 | 23 | 54 |
| December | 4 | 25 | 0 | 75 |
| January | 13 | 0 | 0 | 100 |
| February | 11 | 0 | 9 | 91 |
| March | 9 | 11 | 0 | 89 |
| October-March | 56 | 13 | 11 | 77 |

Northern Gannet's corpses tend to be rather poorly emaciated (c.i.: 0.84) and are often in an advanced stage of decay (s.d.i.: 1.53). The former is in conflict with the conclusion as should exhaustion be the main reason for Northern Gannets to arrive in a rehabilitation centre (81%, $N$=21). An exhausted second-year Northern Gannet received at MEC on 26.09.1988 appeared to have a stomach full of plastics! Only one bird had a broken leg, one was entangled in a net, and one had a sticky brown resinous substance in its plumage (16.10.1989). Whether the latter bird became victim of the documented spillage of lubricating oil and dodecylphenol near the Frisian islands in early winter 1990 (ZOUN & BOSHUIZEN 1992) is unclear. Entanglement in nets and ropes is an important cause of mortality in this species (12% of 69 beached Northern Gannets). This figure is twice as high as the rate reported by CAMPHUYSEN (2001) for The Netherlands, who states that the overall proportion of evidently entangled individuals is higher than in any other species found in beached bird surveys in The Netherlands and is increasing. Since most trapped Northern Gannets will be pulled out of the net by fishermen and be thrown into the sea, without obvious indications of the cause of death visible on the corpse, these high entanglement rates recorded on the beach might even be highly underestimated.

Fifteen Northern Gannets recovered at the Belgian coast could be traced: one bird ringed in the UK (BTO SW71236216) that arrived sick in the MEC rehabilitation centre on 22.09.1989 was not found in the Belgian filing-card system (KBIN), the other 14 specimens were all ringed as pulli in the U.K. (6x Bass Rock, 2x Hermaness), on Jersey (4x Les Etacs, 1x Ortac) or in Norway (1x Skarvklakken).

**SCOTERS** *Melanitta sp.*

Velvet Scoters (*M.fusca*) are rare at the Belgian coast and hence make out a marginal proportion of all beached scoters (2.6%). In The Netherlands Velvet Scoters are slightly more abundant with 4.8% (1965-78), 7.7% (1979-91) and 2.5% (1986-95) respectively (CAMPHUYSEN 1993, 1995b). At the Belgian coast scoters were particularly common in the 1960s with sometimes extraordinary high densities at the westcoast, e.g. 94 oil-fouled birds on 14.3 km in the third ten days period of February 1968. Usually numbers are much smaller and rarely exceed 1 bird $km^{-1}$ (Fig. 11).



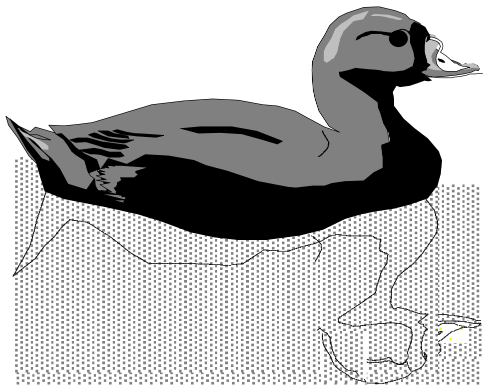



*Fig. 11. Frequency distribution of densities of beached scoters* Melanitta sp. *on Belgian beaches during 1962-1999 at four beach sections.*

Numbers of scoters declined strongly in the course of the four decades (Spearman Rank $R$:-0.575; $N$=37; $P$<0.001). Oil-rates show a non-significant decrease (Spearman Rank $R$:-0.118; $N$=21; $P$<0.05) (Tab. 17, Fig. 12).

*Table 17. Mean densities and oil-rates of scoters* Melanitta sp. *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 1.27 | 92 |
| 1970s | 0.26 | 79 |
| 1980s | 0.16 | 80 |
| 1990s | 0.04 | 71 |

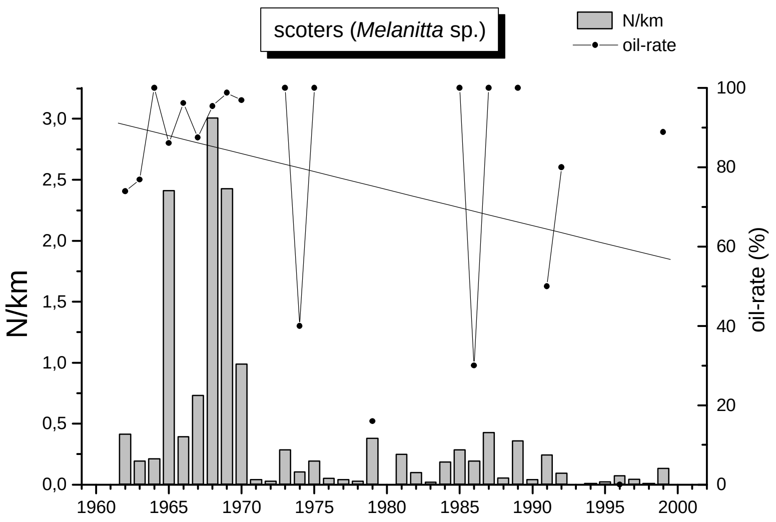



*Fig. 12. Density and oil-rate of beached scoters* Melanitta sp. *during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

The majority of scoters arrive at the MEC rehabilitation centre during winter, with only marginal numbers in April. During 1988-99 high numbers of scoters were brought to the centre in the winters 1991 (*N*=20), 1988 (*N*=19), 1989 (*N*=9) and 1994 (*N*=8). Oil-rates of these birds (71%) are comparable with those observed on beached corpses in the 1990s.

The chance to find beached scoters increases throughout winter (Tab. 18) and drops from March onwards. In the MEC rehabilitation centre maximal numbers are recorded earlier, i.e. in the second half of February. This pattern shows a time lag of 1-1.5 month with the peak in abundance of scoters at sea (January) as demonstrated by aerial surveys conducted in this area (OFFRINGA *et al*., 1996).

*Table 18. Seasonal pattern in density of beached scoters* Melanitta sp. *at Nieuwpoort-Oostende 1993-99.*

| Month | N $km^{-1}$ beach | N at MEC |
|---|---|---|
| October | 0.006 | 0 |
| November | 0.018 | 11 |
| December | 0.021 | 7 |
| January | 0.030 | 14 |
| February | 0.045 | 26 |
| March | 0.048 | 15 |
| April | 0.031 | 3 |

In the 1960s and 1970s the number of beached scoters increased gradually from the east to the westcoast. However in the 1990s the situation has changed with densities at OOZB 3-5 times higher than elsewhere. This is remarkable since no important concentrations of scoters have ever been observed at the eastcoast in the 1990s.
Birds in the brown female/immature plumage constitute 60% of the total number. On average corpses are fresh when they beach (s.d.i.: 1.12) and moderately emaciated (c.i.: 1.07). These values are comparable to those of another inshore bird group, the grebes. Scoters become more and more emaciated as the winter progresses (Tab. 19):

*Table 19. Changes in condition-index in beached scoters* Melanitta sp. *during winter.*

| Month | Condition-index |
|---|---|
| October | 0.00 |
| November | 0.29 |
| December | 0.60 |
| January | 1.30 |
| February | 1.12 |
| March | 1.67 |

Scoters without oil received at the MEC rehabilitation centre are very often exhausted; only few show visible injuries (shot, bitten by dog, leg missing, neck broken, wing broken). Corpses on the beach appear mostly intact, only one record could be found of a Common Scoter with its right wing damaged and a blood-stained face.

**SKUAS** *Stercorarius* sp.
Skuas are rarely encountered as beached birds at the Belgian coast. For the entire study-period not more than 8 Arctic Skuas (*S.parasiticus*) and 16 Great Skuas (*S.skua*) could be traced, 44% of them oiled.

Arctic Skuas were most abundant as beached birds in the 1980s, Great Skuas reached their highest numbers in the 1960s. Oil-rates declined drastically over time (Tab. 20), but not enough data were available to demonstrate this decline statistically.

*Table 20. Density and oil-rate of beached skuas* Stercorarius sp. *at the Belgian coast by decade.*

| Decade | *S.skua* N $km^{-1}$ | *S.parasiticus* N $km^{-1}$ | all skuas Oil-rate (%) |
|---|---|---|---|
| 1960s | 0.0060 | 0.0000 | 100 |
| 1970s | 0.0000 | 0.0010 | |
| 1980s | 0.0016 | 0.0047 | 33 |
| 1990s | 0.0021 | 0.0002 | 25 |

The MEC rehabilitation centre received 6 Great Skuas, 2 Arctic Skuas and 1 Long-tailed Skua (*S. longicaudus*) in 1988-99. Only two of them were oil-fouled (22%), the others were reported as ‘exhausted’. Six skuas arrived in September/ October, one Arctic Skua in December, and one Great Skua in January and February. The number of skuas received at the MEC by winter correlates positively with the number of days with strong onshore winds (Kendall *Tau*: 0.546, $P<0.05$). On the beach, dead skuas were most abundant in November (0.010 $km^{-1}$) and January (0.005 $km^{-1}$).

Corpses are usually in an advanced stage of decay (s.d.i.: 1.64) and severely emaciated (c.i.: 1.60).

Five ringed Great Skuas found dead on Belgian beaches were ringed as pulli in Shetland (4x Foula, 1x Noss). Another Great Skua captured in bad condition on the Lemanbank appeared to be banded as a pullus at Hermaness (Shetland). All birds were recovered at an age of less than five months, except for one Foula-born specimen found dead on the beach of Westende when 7.5 years old.

**LARUS -GULLS** *Larus sp.*
Seven *Larus* species have been found during the beached bird surveys treated in this report. First-winter *L.argentatus/fuscus* were not identified in the 1960s and 1970s and not consistently in the 1980s. The table shows that – although densities of corpses declined during the entire study period – the group of Herring Gull, Lesser Black-backed Gull and Yellow-legged Gull became proportionally more important at the expense of Black-headed Gull, Common Gull and Great Black-backed Gull. Compared to The Netherlands, more corpses of Black-headed Gull and fewer Herring Gulls are found on Belgian beaches (Tab. 21).

*Table 21. Species-composition of beached* Larus-*gulls at the Belgian coast by decade, compared to data from The Netherlands in the period 1969-85 (*Camphuysen *1989).*

*Belgium*

| Decade | *L.minutus* | *L.ridibundus* | *L.canus* | *L.fuscus* | *L.fuscus /argentatus* | *L.argentatus* | *L.cachinnans* | *L.marinus* |
|---|---|---|---|---|---|---|---|---|
| 1960s | 0.3% | 24.6% | 34.0% | - | 11.4% | 6.0% | 0.0% | 23.7% |
| 1970s | 0.0% | 47.3% | 25.4% | 1.7% | 9.4% | 6.3% | 0.0% | 10.0% |
| 1980s | 2.9% | 32.9% | 12.3% | 1.3% | 1.1% | 37.1% | 0.0% | 12.5% |
| 1990s | 0.7% | 22.5% | 11.2% | 7.1% | 0.3% | 50.0% | 0.1% | 8.1% |
| Overall | 0.8% | 28.6% | 18.7% | 3.8% | 4.3% | 31.2% | 0.03% | 12.5% |

*The Netherlands*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1969-85 | 0.2% | 2.8% | 16.9% | 2.8% | - | 52.5% | - | 9.4% |

The MEC rehabilitation centre receives comparatively more Black-headed Gull, and less Herring/Lesser Black-backed and Great Black-backed Gulls (Tab. 22). This shift towards more 'land-oriented' gulls can be explained by the input of substantial numbers of gulls from inland polders.

*Table 22. Species-composition of beached* Larus-*gulls at the Belgian coast in the 1990s, compared to the situation at the MEC-rehabilitation centre in 1988-99.*

| Species | Beach 1990s (%) | MEC 1988-99 (%) |
|---|---|---|
| *L.minutus* | 0.7 | 0.0 |
| *L.ridibundus* | 22.5 | 43.6 |
| *L.canus* | 11.2 | 10.3 |
| *L.argentatus/fuscus/cachinnans* | 57.5 | 39.7 |
| *L.marinus* | 8.1 | 6.5 |

*Larus*-gulls can be found in any state of decay from very fresh to a carcass with wings and legs only. On average they have the highest state of decay index of all groups treated (s.d.i.: 1.75) indicating that a majority of the gulls is found in an advanced stage of decay (very fresh: 16%, fresh: 21%, rotten: 35%, wings and legs only: 28%). Half of the birds are strongly emaciated (Tab. 23), 25% moderately emaciated and 25% not emaciated (c.i.: 1.26). The gulls found dead in early winter are leaner than those collected from December onwards:

*Table 23. Changes in condition-index in beached* Larus-*gulls during winter.*

| Month | Condition index |
|---|---|
| October | 1.44 |
| November | 1.47 |
| December | 1.03 |
| January | 1.25 |
| February | 1.11 |
| March | 1.03 |

**LITTLE GULL** *Larus minutus*

Merely 25 Little Gulls were found in the BBS-database of the Belgian coast, of which 22% was oiled (Tab. 24).

*Table 24. Mean densities and oil-rates of Little Gull* Larus minutus *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.004 | |
| 1970s | 0.000 | |
| 1980s | 0.010 | 27 |
| 1990s | 0.002 | 0 |
| Overall | 0.003 | 22 |

The number of Little Gulls beached by winter (period 1988-99) correlates negatively with the IJnsen factor (Kendall *Tau*: -0.477; $P<0.05$). No Little Gulls reached the MEC rehabilitation centre in the winters 1988-99; one unoiled bird arrived on 7.04.1999. The 25 beached Little Gulls were collected throughout winter (Nov: 5, Dec: 1, Jan: 6, Feb: 5, March: 5, Apr: 3), a pattern apparently not in line with migration peaks in autumn or spring (GARTHE 1993; KEIJL & LEOPOLD 1997; OFFRINGA *et al*. 1996). Half of the birds were in adult plumage (47%). Records are evenly spread over the east- and central coast.

**BLACK-HEADED GULL** *Larus ridibundus*

Although Black-headed Gulls are common on the beach, numbers of corpses are rarely higher than 1 bird $km^{-1}$ (Fig. 13).

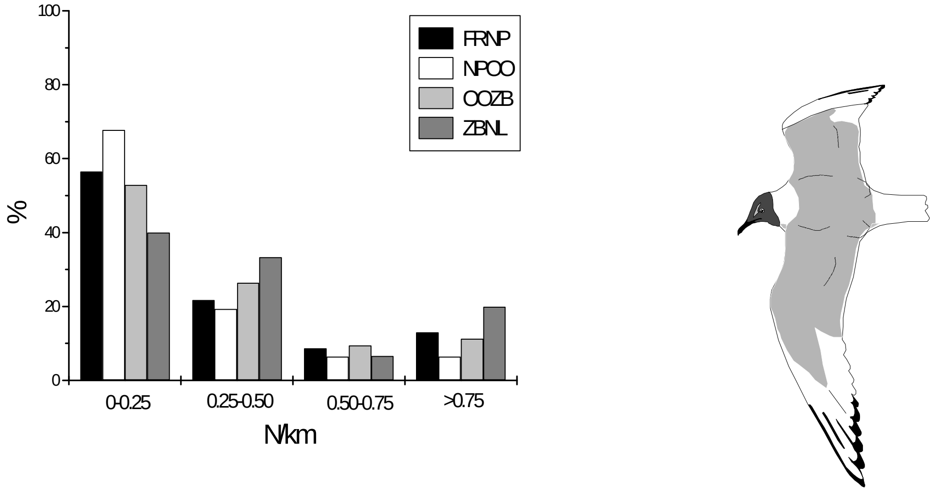



*Fig. 13. Frequency distribution of densities of beached Black-headed Gull* Larus ridibundus *on Belgian beaches during 1962-1999 at four beach sections.*

Densities and oil-rates of beached Black-headed Gull show a steady decline over the period 1962-1999 (Tab. 25, Fig. 14). This pattern results from a decrease in oil-pollution (particularly inshore and on beaches) and declining numbers of Black-headed Gulls at the Belgian coast as breeding bird (SEYS *et al.* 1998) and during wintertime (SPANOGHE 1999). Spanoghe demonstrated that numbers of wintering Black-headed Gulls at the Belgian coast in the winter 1998-99 (2000-4000) were merely 20-40% of the 9500 Black-headed Gulls that were counted here in December 1989 (DEVOS & DEBRUYNE 1990). The oil-rate observed in the 1990s (9%) is one of the lowest values observed and only slightly higher than in waders (3%) and other groups that use beaches/terrestrial habitats.

*Table 25. Mean densities and oil-rates of Black-headed Gull* Larus ridibundus *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.32 | 72 |
| 1970s | 0.22 | 41 |
| 1980s | 0.12 | 14 |
| 1990s | 0.06 | 9 |

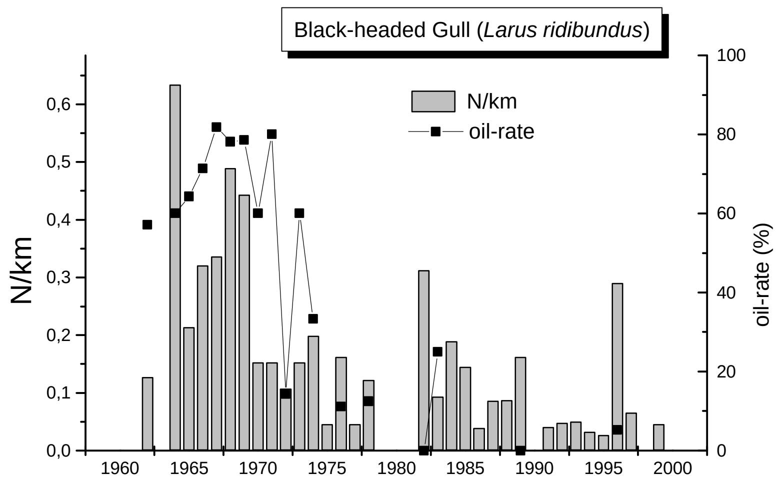



*Fig. 14. Density and oil-rate of beached Black-headed Gull* Larus ridibundus *during IBB surveys at the Belgian coast 1962-1999.*

The Black-headed Gull is the second most registered species in the winters 1988-1999 at the MEC rehabilitation centre (Common Guillemot: *N*=1170, Black-headed Gull: *N*=208, Herring Gull: *N*=161, Razorbill: *N*=97, Great-crested Grebe: *N*=91). Although during 1988-1999 highest densities of Black-headed Gulls on the beach and total numbers received at the MEC coincide with severe winters (1991, 1996, 1997: Fig. 15) no significant correlation with the IJnsen factor could be detected.

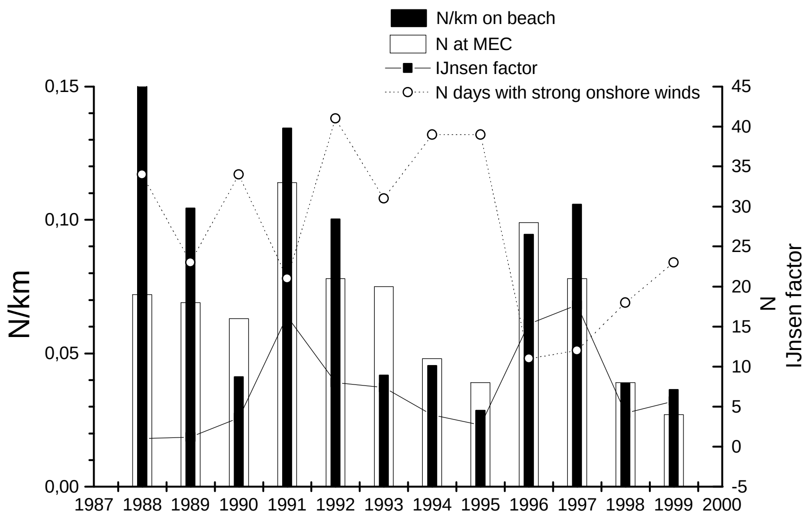



*Fig. 15. Density of beached Black-headed Gull* Larus ridibundus *and number of specimens hosted at the MEC-rehabilitation centre during 1988-99, compared to the winter severity (IJnsen factor) and frequency of strong onshore winds.*

Oil-rates of Black-headed Gulls at the MEC rehabilitation centre are extremely low (2%, vs. 9% on the beach in the 1990s). Unoiled birds arriving at the centre are often injured (61%), with wings most frequently affected. Gulls with no visible external injuries are mostly described as 'exhausted', 'cold victim' or 'poisoned'. On the beach, very few Black-headed Gull corpses were registered as 'injured' (3%). The large majority seems to be victim of cold weather, exhaustion, sickness and (possible) poisoning.

Corpses of Black-headed Gull are found on the beach throughout the study-period with a peak in December-January (Tab. 26). Numbers at the MEC rehabilitation centre peak on average one month later.

*Table 26. Seasonal pattern of beached Black-headed Gulls* Larus ridibundus *at the Belgian coast: number of birds received by month at the MEC rehabilitation centre and density of dead specimens during beached bird surveys at the beach section Nieuwpoort-Oostende 1993-99.*

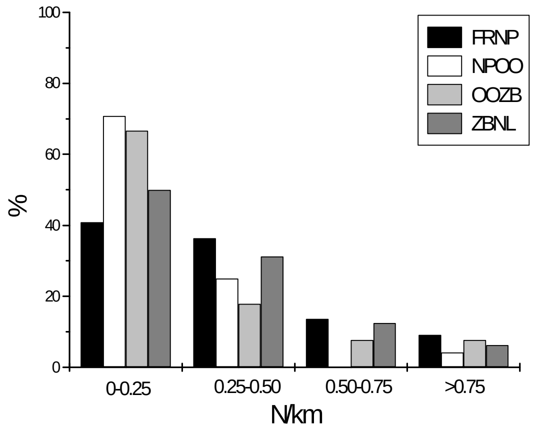
| Month | N at MEC | N km$^{-1}$ on beach |
|---|---|---|
| October | 24 | 0.027 |
| November | 32 | 0.032 |
| December | 39 | 0.079 |
| January | 46 | 0.085 |
| February | 43 | 0.062 |
| March | 24 | 0.035 |

The ratio of first-winter birds to older ones is significantly higher in beached bird surveys (29%) than what is observed during counts of living birds on beaches and dykes during October-March (2%)(SPANOGHE 1999), indicating a much higher mortality rate in young birds.

Out of 416 records of Black-headed Gulls ringed abroad and recovered/controlled at the Belgian coast, 68% were ringed as pulli. Almost half of these birds (46%) were born in Estonia, Latvia, Lithuania or Poland, another 26% in Scandinavia, The Netherlands or Germany. Black-headed Gulls ringed or controlled as full-grown birds originated from France (27%), The Netherlands/Germany (29%) or Estonia, Latvia, Lithuania, Poland and Tchechia (27%). Only small numbers of British Black-headed Gulls could be recovered at the Belgian coast (10% of those ringed or controlled as full-grown birds).

**COMMON GULL** *Larus canus*

Densities of beached Common Gull are usually smaller than 0.50 birds $km^{-1}$ (Fig. 16). All densities higher than 0.50 $km^{-1}$ were recorded in the 1960s and 1970s. Numbers as well as oil-rates show a marked decrease in time (Tab. 27, Fig. 17).



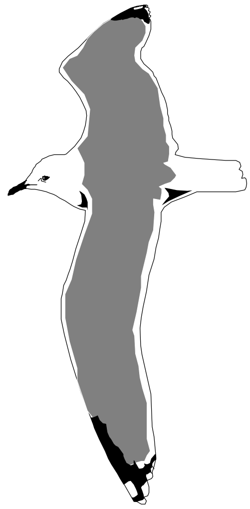



*Fig. 16. Frequency distribution of densities of beached Common Gull* Larus canus *on Belgian beaches during 1962-1999 at four beach sections.*

*Table 27. Mean densities and oil-rates of Common Gull* Larus canus *by decade on Belgian beaches*.

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.44 | 62 |
| 1970s | 0.12 | 43 |
| 1980s | 0.04 | 29 |
| 1990s | 0.03 | 11 |

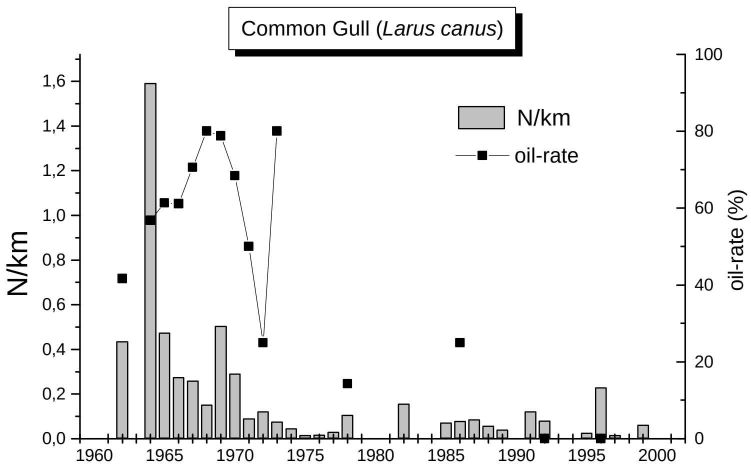



*Fig. 17. Density and oil-rate of beached Common Gull* Larus canus *during IBB surveys at the Belgian coast 1962-1999.*

Compared to Black-headed Gull, only small numbers of Common Gulls arrive at the MEC rehabilitation centre. Differences in numbers between winters are small, ranging from 1 to 10. As in Black-headed Gull, highest densities of Common Gulls on the beach during 1988-1999 coincided with severe winters (1991, 1996, 1997)(Fig. 18), although no significant correlation with the IJnsen factor was found.

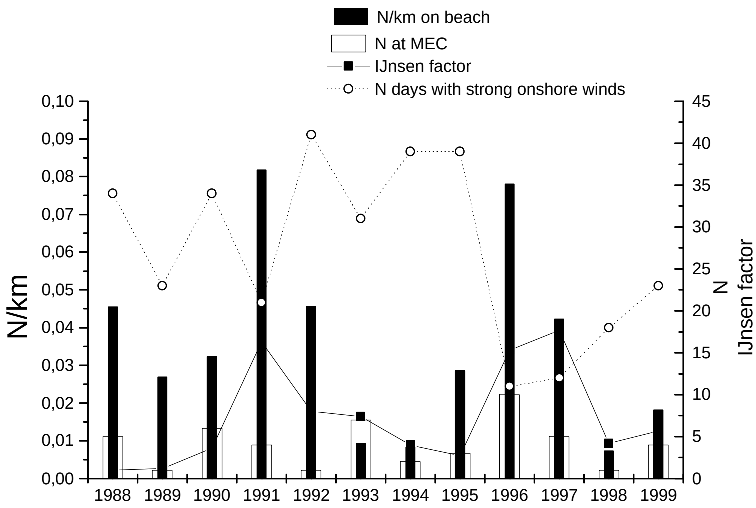



*Fig. 18. Density of beached Common Gull* Larus canus *and number of specimens hosted at the MEC-rehabilitation centre during 1988-99, compared to the winter severity (IJnsen factor) and frequency of strong onshore winds.*

Of the 49 specimens treated at the MEC rehabilitation centre during twelve successive winters (1988-99), 9% was oiled, a value only slightly below the oil-rate on the beach. The other specimens showed injuries (69%) or were exhausted, possibly poisoned, cold victims or had diarrhoea. Wing injuries were the most common type of injury. On the beach the situation is quite different, with few external injuries observed. One Common Gull had a fishhook in its tongue. On January 6th, 1993 a partially albinistic first-winter Common Gull was found on the beach of Lombardsijde (more details see SEYS 1993b).

The seasonal pattern in beaching of Common Gull corpses is consistent with the one of injured or exhausted Common Gulls received at the MEC rehabilitation centre. Both build up to a peak in February and decline sharply afterwards (Tab. 28).

*Table 28. Seasonal pattern of beached Common Gulls* Larus canus *at the Belgian coast: number of received birds by month at the MEC rehabilitation centre and density of dead specimens during beached bird surveys at Nieuwpoort-Oostende 1993-99.*

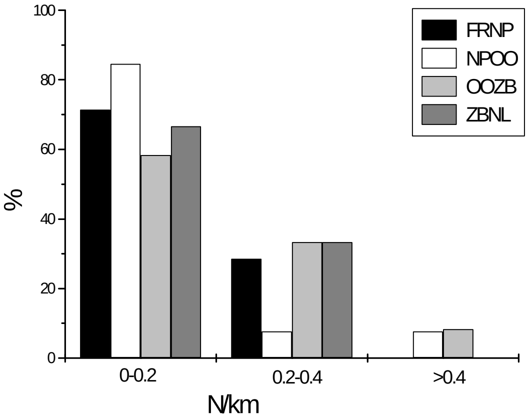
| Month | N at MEC | N $km^{-1}$ on beach |
|---|---|---|
| October | 5 | 0.011 |
| November | 5 | 0.020 |
| December | 10 | 0.022 |
| January | 12 | 0.036 |
| February | 13 | 0.044 |
| March | 4 | 0.015 |

Mortality is much higher in first-winter birds than in second-winters or adults. Hence the ratio of first-winter Common Gulls to older ones is much higher in beached bird surveys (39%) than in flocks of living gulls on the beach during the same winter period (5%: SPANOGHE 1999). Young birds are more common at beached bird surveys in October-November (56%) than in mid-winter December-March (33%). First- and second winter birds are present in comparable numbers (each 15-20% of total number).

The KBIN Belgian ringing scheme database contains 66 recoveries of Common Gulls at the Belgian coast ringed abroad, of which 76% was ringed as pullus. Birds with a Scandinavian origin were most frequently recovered (60%: Finland: 12; Sweden: 8; Norway: 5; Denmark: 5). Others had their origin in Germany/The Netherlands (18%) or Estonia/ Poland/ Russia (22%). Of the Common Gulls ringed as full-grown, a substantial part was banded in The Netherlands (7 out of 16).

**LESSER BLACK-BACKED GULL** *Larus fuscus*

Lesser Black-backed Gulls winter in small numbers at the Belgian coast (OFFRINGA *et al*. 1996; SPANOGHE 1999). The majority leaves the North Sea in autumn and early winter, a period when most of the beached Lesser Black-backed Gulls are found (Table 29). That peak densities are recorded in the 1990s is due to the steady population increase during the last 40 years, the lack of early winter surveys in the 1960s and 1970s, and the grouping of Herring and Lesser Black-backed Gulls in these early days of beached bird surveying. Densities are seldom higher than 0.4 birds $km^{-1}$ (Fig. 19).



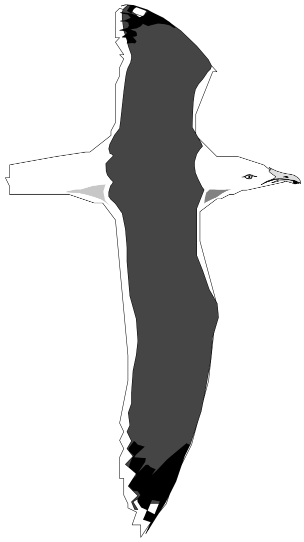



*Fig. 19. Frequency distribution of densities of beached Lesser Black-backed Gull* Larus fuscus *on Belgian beaches during 1962-1999 at four beach sections.*

Oil-rates declined dramatically in the last decade (Tab. 29).

*Table 29. Mean densities and oil-rates of Lesser Black-backed Gull* Larus fuscus *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.000 | |
| 1970s | 0.008 | 86 |
| 1980s | 0.005 | 50 |
| 1990s | 0.019 | 10 |

The MEC rehabilitation centre received 28 Lesser Black-backed Gulls during the winters 1988-1999. None had oil, the majority was injured at wings (*N*=13), legs (*N*=4) or undefined (*N*=4). Only 4 specimens revealed no external injuries and were catalogued as 'exhausted' or 'poisoned'. Of 88 Lesser Black-backs collected on the beach during the winters 1993-1999, one was entangled, one injured at the legs and one found with a little Whiting in its bill. All the others apparently died from starvation. Adult birds slightly dominate throughout winter (58%). First-winter birds are most common (94%) amongst young Lesser Black-backed gull victims.

The temporal pattern in numbers of corpses of Lesser Black-backs on the beach is very similar to the one observed at the MEC rehabilitation centre (Tab. 30). There is a time lag of one month between the peak in numbers on the beach and at the MEC.

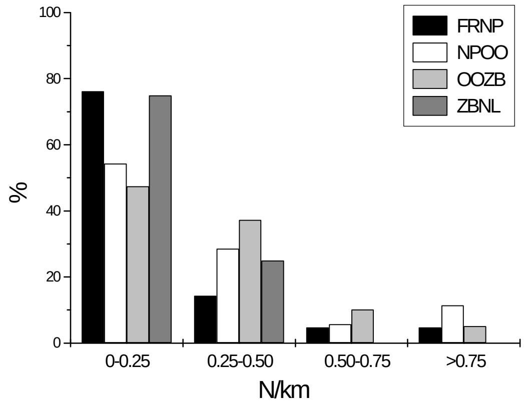
*Table 30. Seasonal pattern of beached Lesser Black-backed Gulls* Larus fuscus *at the Belgian coast: number of received birds by month at the MEC rehabilitation centre and density of dead specimens during beached bird surveys at Nieuwpoort-Oostende 1993-99.*

| Month | N at MEC | N $km^{-1}$ on beach |
|---|---|---|
| October | 13 | 0.041 |
| November | 8 | 0.065 |
| December | 1 | 0.023 |
| January | 2 | 0.008 |
| February | 4 | 0.003 |
| March | 0 | 0.022 |

Twenty-two birds ringed abroad and recovered at the Belgian coast could be traced at the KBIN Belgian ringing coordination unit: 11 of them were banded as pulli in South-Norway, 3 in Denmark, 1 in England and 7 in The Netherlands. More than 70% was recovered in their first or second calendar year.

**HERRING GULL** *Larus argentatus*

The same remark as for the previous species (concerning the grouping of Herring and Lesser Black-backed Gulls in many surveys of the 1960s and 1970s) holds for the Herring Gull. Peak densities of grouped large *Larus*-gulls, i.e. Herring, Lesser Black-backed, Great Black-backed, Yellow-legged and undetermined large gulls were prevalent in the 1960s and mid-1990s. High densities of more than 1 bird $km^{-1}$ of Herring Gull happen to occur (Fig. 20).



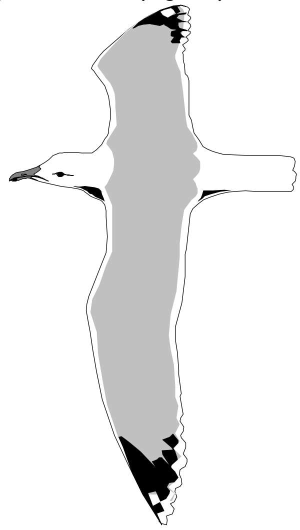



*Fig. 20. Frequency distribution of densities of beached Herring Gull* Larus argentatus *on Belgian beaches during 1962-1999 at four beach sections.*

The large *Larus*-gulls were more than twice as common as beached birds in the 1960s than in the following decades (Tab. 31, Fig. 21). Oil-rates show a spectacular decline from 76 to 12% during these 37 years.

*Table 31. Mean densities and oil-rates of Herring Gull* Larus argentatus *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.68 | 76 |
| 1970s | 0.27 | 48 |
| 1980s | 0.22 | 31 |
| 1990s | 0.18 | 12 |

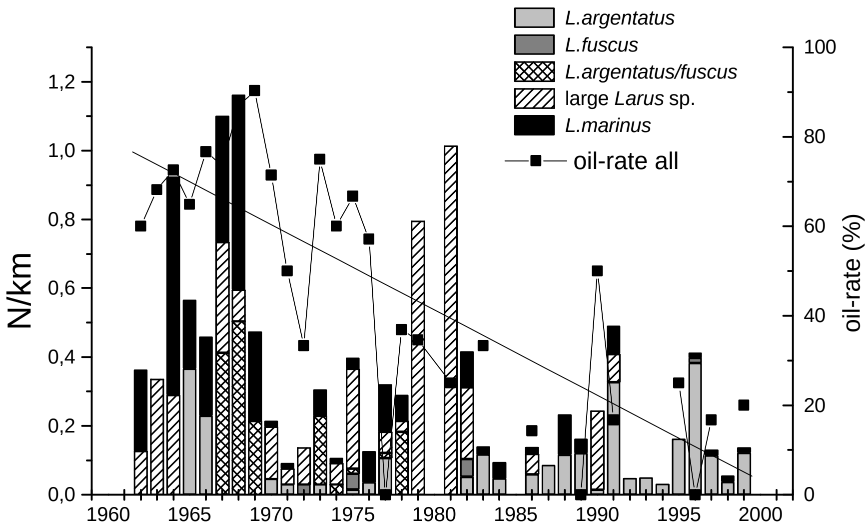



*Fig. 21. Density and oil-rate of beached large* Larus*-gulls during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

In 12 winters (1988-99) a total number of 161 Herring Gulls were received at the MEC rehabilitation centre (6-20 per winter). Highest numbers correlate neither with winter severity nor frequency of strong onshore winds (Fig. 22). The overall oil-rate during 1988-99 at the MEC (3%) is much lower than what is observed in beached corpses in the 1990s

(9%). Two thirds of the gulls had external injuries; wings were most affected (85%). Few Herring Gulls were entangled (*N*=2 or 1.4%).

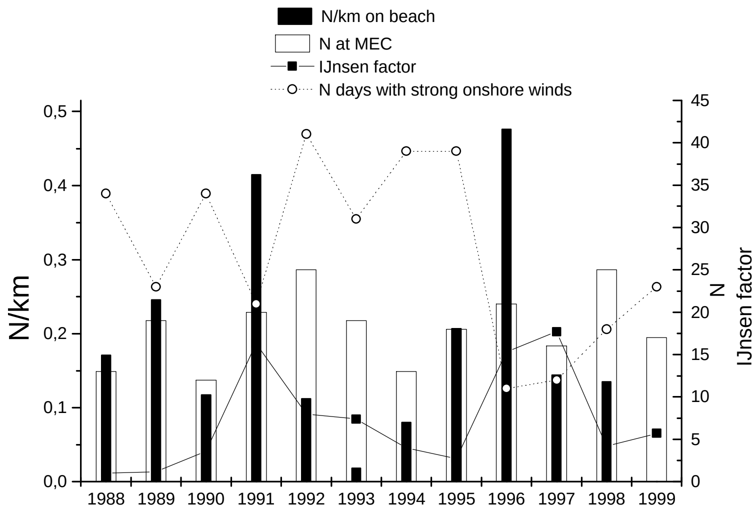



*Fig. 22. Density of beached Herring Gull* Larus argentatus *and number of specimens hosted at the MEC-rehabilitation centre during 1988-99, compared to the winter severity (IJnsen factor) and frequency of strong onshore winds.*

Very few of the corpses collected on the beach show signs of external injuries (3.6%). The figures for entanglement are similar to those of the MEC (1.2%). One Herring Gull had a fishhook in its tongue, one was apparently shot and one suffocated in a Whiting of about 20 cm.

Most Herring Gulls were collected in November, with a steady decline throughout the winter (Tab. 32).

*Table 32. Seasonal pattern of beached Herring Gulls* Larus argentatus *at the Belgian coast: number of received birds by month at the MEC rehabilitation centre and density of dead specimens during beached bird surveys at Nieuwpoort-Oostende 1993-99.*

| Month | N at MEC | N $km^{-1}$ on beach |
|---|---|---|
| October | 37 | 0.17 |
| November | 40 | 0.27 |
| December | 31 | 0.12 |
| January | 25 | 0.12 |
| February | 18 | 0.09 |
| March | 10 | 0.08 |

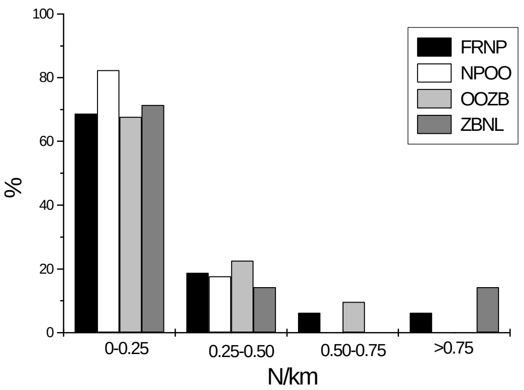
Young Herring Gulls have higher mortality rates than adults and are therefore better represented in beached bird surveys (59%) than what could be expected from counts of Herring Gulls at the beach (40%: SPANOGHE 1999).
The ratio of immatures vs. adults first decreases sharply from October-November (70-74%) to December-January (49-51%) and increases again from February onwards (February: 55%, March: 64%)(Tab. 33). In general the younger the immature the more specimens are found at beached bird surveys.

*Table 33. Age-composition of beached Herring Gull* Larus argentatus *at the Belgian coast.*

| Age | % |
|---|---|
| I1 | 44.3 |
| I2 | 9.0 |
| I3 | 4.2 |
| I4 | 1.4 |
| adult | 41.1 |

In the database of the KBIN Belgian ringing scheme we found 150 Herring Gulls recovered at the Belgian coast and ringed abroad, of which 95% ringed as pullus. Most birds were born in The Netherlands (89%) and only 1-3 specimens in each of the following countries: BRD (Helgoland), Denmark, Estonia, Finland (south), Sardinia, Norway (north), Russia (Kola peninsula), Scotland and Wales. Seven birds were ringed as full-grown birds: 2 in England, 2 in France (north) and 3 in The Netherlands. Half of the Dutch birds ringed as pullus were born in the Delta area (50%), 27% along the North- or South Holland coast and 23% on the Wadden islands.

**GREAT BLACK-BACKED GULL** *Larus marinus*
Great Black-backed Gulls are not that common as beached birds: densities are seldom larger than 0.5 specimens km$^{-1}$ (Fig. 23).



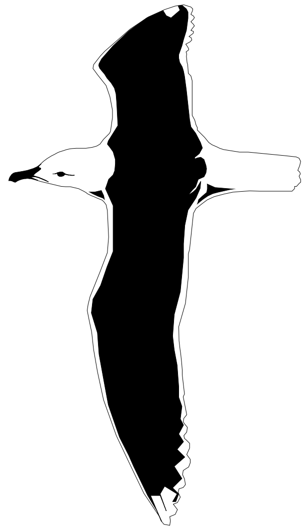



*Fig. 23. Frequency distribution of densities of beached Great Black-backed Gull* Larus marinus *on Belgian beaches during 1962-1999 at four beach sections.*

This species happened to be much more common at beached bird surveys in the 1960s (Tab. 34). The major change appears to have taken place at the end of the 1960s when densities and oil-rates dropped sharply (Tab. 35). Nowadays oil-rates are the highest of all *Larus*-gulls (*L.minutus*: 0%; *L.ridibundus*: 8.5%; *L.canus*: 11.0%; *L.fuscus*: 9.8%; *L.argentatus*: 11.8%) probably as a result of its mid/offshore distribution and preference for harbours as roosting sites (OFFRINGA *et al*. 1996; SPANOGHE 1999).

*Table 34. Mean densities and oil-rates of Great Black-backed Gull* Larus marinus *by decade on Belgian beaches.*

| Decade | N km$^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.306 | 81 |
| 1970s | 0.047 | 44 |
| 1980s | 0.044 | 46 |
| 1990s | 0.021 | 20 |

At the MEC rehabilitation centre Great Black-backed Gulls (*N*=31) were as ‘common’ as Lesser Black-backed Gulls (*N*=28) during the winters 1988-1999. As for corpses collected on the beach, this species appears to be more oil-sensitive (7% with oil) than other *Larus*-species. The birds without oil showed external injuries in 64% of the specimens, with wing injuries most frequently encountered (61% of injuries). In contrast with the situation at the rehabilitation centre, only very few of the Great Black-backed Gull corpses collected on the beach showed external injuries (3%).

Adults constitute 43% of all birds collected on the beach (1993-1999), I1: 28%, I2: 25%, I3: 2%, I4: 1%.
The seasonal pattern (Tab. 35) is identical to the one described for the Herring Gull: after the peak in November they become less and less abundant. Adults constitute half of the victims in October-November, and only 33% in December-March.

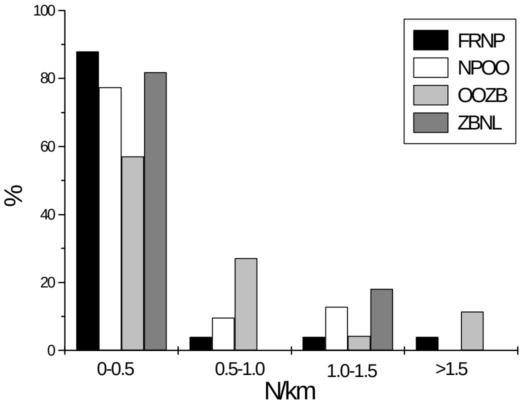
*Table 35. Seasonal pattern of beached Great Black-backed Gulls* Larus marinus *at the Belgian coast: number of birds received by month at the MEC rehabilitation centre and density of dead specimens during beached bird surveys at Nieuwpoort-Oostende 1993-99.*

| Month | N at MEC | N km$^{-1}$ on beach |
|---|---|---|
| October | 8 | 0.027 |
| November | 10 | 0.046 |
| December | 4 | 0.031 |
| January | 5 | 0.025 |
| February | 4 | 0.014 |
| March | 0 | 0.007 |

Twenty Great Black-backed Gulls ringed abroad were recovered at the Belgian coast according to the KBIN Belgian ringing scheme database. All birds - except one from Fair Isle (Scotland) - were born in SW-Norway (see also VANDENBULCKE 1989).

**KITTIWAKE** *Rissa tridactyla*

Major mass strandings ('wrecks') of Kittiwake were observed during the 1980s and early 1990s, when densities of more than 1.5 Kittiwakes km$^{-1}$ were not uncommon (Fig. 24). Massive wrecks of starved Kittiwakes in this period in the North Sea could only be explained as being the result of a shortage of food (CAMPHUYSEN 1995c). In all but a few occasions 60-100% of those birds were (heavily) oiled. Lower oil-rates were observed in March 1988 (23%) and December 1990 (40%).



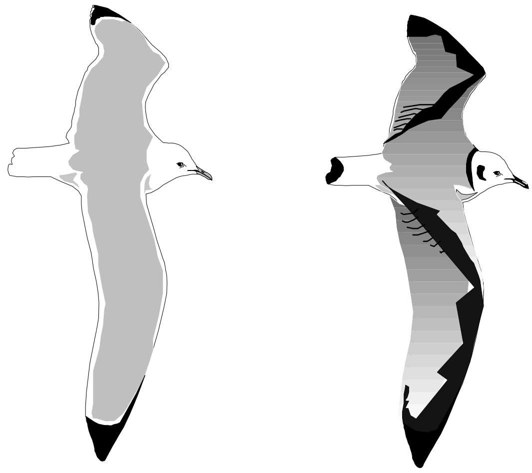



*Fig. 24. Frequency distribution of densities of beached Kittiwakes* Rissa tridactyla *on Belgian beaches during 1962-1999 at four beach sections.*

Oil-rates show a marked decrease in the last decade (Tab. 36), an overall trend cannot be demonstrated for the IBB surveys (Fig. 25).

*Table 36. Mean densities and oil-rates of Kittiwake* Rissa tridactyla *by decade on Belgian beaches.*

| Decade | N km$^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.42 | 79 |
| 1970s | 0.13 | 68 |
| 1980s | 0.52 | 69 |
| 1990s | 0.08 | 48 |

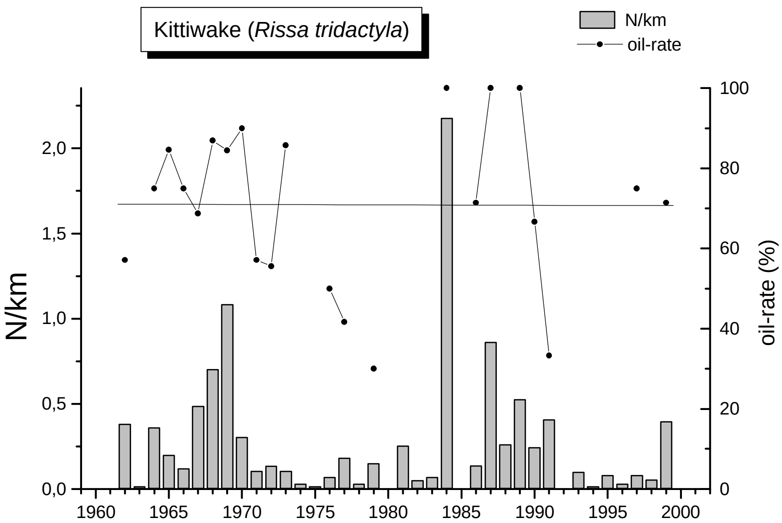



*Fig. 25. Density and oil-rate of beached Kittiwake* Rissa tridactyla *during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

There is no correlation between the numbers of Kittiwake beached by winter and the IJnsen factor or frequency of strong onshore winds (Fig. 26).

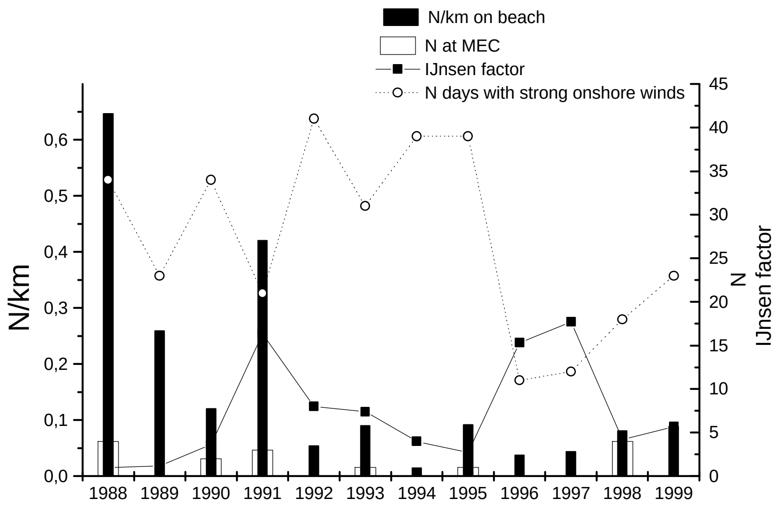



*Fig. 26. Density of beached Kittiwake* Rissa tridactyla *and number of specimens hosted at the MEC-rehabilitation centre during 1988-99, compared to the winter severity (IJnsen factor) and frequency of strong onshore winds.*

Only 15 Kittiwakes were registered at the MEC rehabilitation centre during the winters 1988-1999, ten of them in 1988-1993. Relatively few birds were oiled (38%). Birds without oil were mainly 'wreck-victims' (no external injuries, and often very weak). Three specimens (or 38% of unoiled birds) had broken wings (*N*=2) or eye-injuries (*N*=1). Entanglement of Kittiwakes in fishing rope was observed in 1.1% of all corpses. One bird apparently suffocated in a fish (not specified) of 22cm.

Kittiwakes are most abundant as beached birds in January-February (Tab. 37). This pattern could not be confirmed from data of the MEC (low numbers).

*Table 37. Seasonal pattern in density of beached Kittiwake* Rissa tridactyla *at Nieuwpoort-Oostende 1993-99.*

| Month | N $km^{-1}$ |
|---|---|
| October | 0.009 |
| November | 0.043 |
| December | 0.048 |
| January | 0.095 |
| February | 0.095 |
| March | 0.048 |

The state of decay-index averages 1.58 as a result of comparable numbers in class 0,1,2 and 3. With a condition index of 1.31 - the highest value of all treated taxa – it classifies as 'rather strongly emaciated' following other typical 'wreck species' as Common Guillemot and Razorbill.

Over the entire study-period 1962-99, adults were slightly dominant (54%). During 1992-99 age-composition was as follows: adults: 57%, I1: 37%, I2: 6%. Young birds become progressively commoner in the course of the winter: October-November: 33%, December-January: 41%, February-March: 51%.

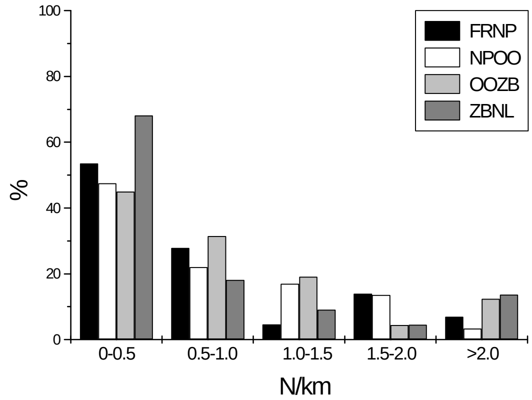
Only 4 recoveries from birds ringed abroad and found at the Belgian coast were available: two were born at the Farne Islands (NE-England), one in Bretagne (France) and one on the Lofoten (N-Norway). One of the British birds that were recovered dead on the beach of Oostende had an age of almost 18.5 years.

**COMMON GUILLEMOT** *Uria aalge*
Less than 0.5% of all auks collected on the beach has not been identified to species. Numbers of Common Guillemot and Razorbill were roughly comparable in the 1960s and 1970s (though absolute numbers sharply decreased in the 1970s)(Tab. 38). The 1980s showed decreasing numbers of Razorbill (although some important strandings might have been missed due to a rather poor coverage at the Belgian coast in that period, see CAMPHUYSEN 1998, VAN GOMPEL 1981, 1984, VERBOVEN 1985) at a time Common Guillemots became more and more abundant. In the 1990s about 13% of all auks were identified as Razorbill, a figure in line with their relative abundance at sea: 9-20% (OFFRINGA & MEIRE 1996).

*Table 38. Species-composition of beached auks at the Belgian coast by decade.*

| Decade/species | *Uria aalge* | *Uria lomvia* | *Alca torda* | *Fratercula arctica* | *Alle alle* |
|---|---|---|---|---|---|
| 1960s | 53.2% | 0.0% | 46.2% | 0.4% | 0.2% |
| 1970s | 39.5% | 0.0% | 59.5% | 0.6% | 0.3% |
| 1980s | 79.2% | 0.0% | 19.2% | 0.4% | 1.3% |
| 1990s | 84.8% | 0.04% | 12.8% | 0.1% | 2.3% |
| Overall | 76.9% | 0.02% | 21.2% | 0.3% | 1.7% |

During auk wrecks or oil-incidents densities of beached Common Guillemot can easily exceed 2 birds $km^{-1}$ (Fig. 27), with peak values of 4-6 specimens $km^{-1}$ locally.



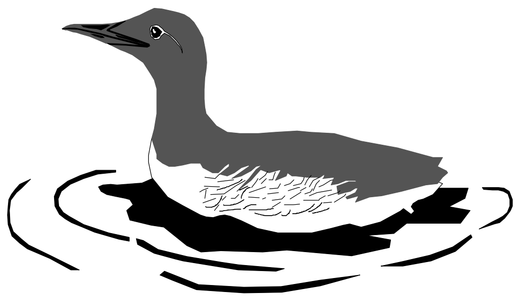



*Fig. 27. Frequency distribution of densities of beached Common Guillemots* Uria aalge *on Belgian beaches during 1962-1999 at four beach sections.*

All peak densities of Common Guillemots of more than 3 birds $km^{-1}$ were noticed in the last decade. Mean oil-rates declined strongly during the study-period 1962-1999. The majority was oiled in the 1960s and 1970s, in the 1990s 'only' 57% of the Common Guillemots showed external signs of oil-contamination. A Spearman Rank correlation shows a highly significant decrease in oil-rate ($R$:-0.604; $N$=33; $P$<0.001). Mean densities were highest in the 1980s (Tab. 39) as a result of increased numbers and food-shortage in the southern North Sea from 1981 onwards (HEUBECK *et al*. 1992). Wrecks of starved Common Guillemots (and other species) became an almost annual event at the North Sea coasts in the first half of the 1980s and again during the winters of 1989 and 1990 (CAMPHUYSEN 1990 1998; HEUBECK *et al*. 1992; UNDERWOOD & STOWE 1984; VAN GOMPEL 1981, 1984; VERBOVEN 1985). In the 1990s wrecks of auks were still a widespread phenomenon, with e.g. very large numbers of Common Guillemots (and Fulmar) beaching in February-March 1999 (CAMPHUYSEN pers.comm; SEYS *et al*. 1999)(Fig. 28). As a result, densities of Common Guillemot show an overall significant increase during the study period (Spearman Rank $R$: 0.346; $N$=37; $P$<0.05). During these wrecks, Common Guillemots can be observed at large distances from the coast. This was e.g. demonstrated during the winter 1992-93 when tens of Common Guillemots were observed along the Schelde river (SEYS 1993a).

*Table 39. Mean densities and oil-rates of Common Guillemot* Uria aalge *by decade on Belgian beaches.*

| Decade | N $km^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.56 | 99 |
| 1970s | 0.21 | 93 |
| 1980s | 0.77 | 70 |
| 1990s | 0.45 | 57 |

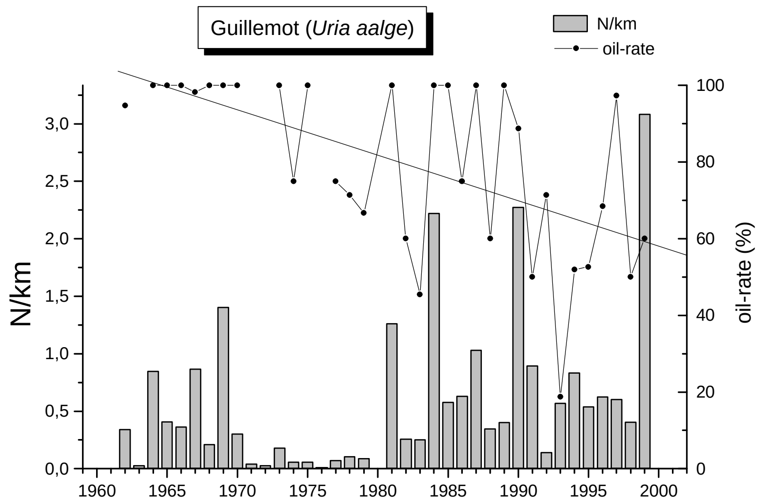



*Fig. 28. Density and oil-rate of beached Common Guillemot* Uria aalge *during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

At the MEC rehabilitation centre the Common Guillemot happened to be the most common species, with 1170 birds recorded over 12 winters. Oil-rates of Common Guillemots received here during 1988-99 were markedly higher (89%, with a range of 74-98% by winter) than oil-rates observed on beached corpses (57% during the 1990s)(see also RAEVEL 1992a; SEYS *et al*. accepted). Only Razorbill (95%) and divers (100%) showed higher proportions of oiled birds. Peak-periods at the MEC rehabilitation centre largely coincide with large numbers of corpses on the beach (Fig. 29). No correlation could be demonstrated nor with the IJnsen factor (winter severity) neither with the number of days with strong onshore winds.

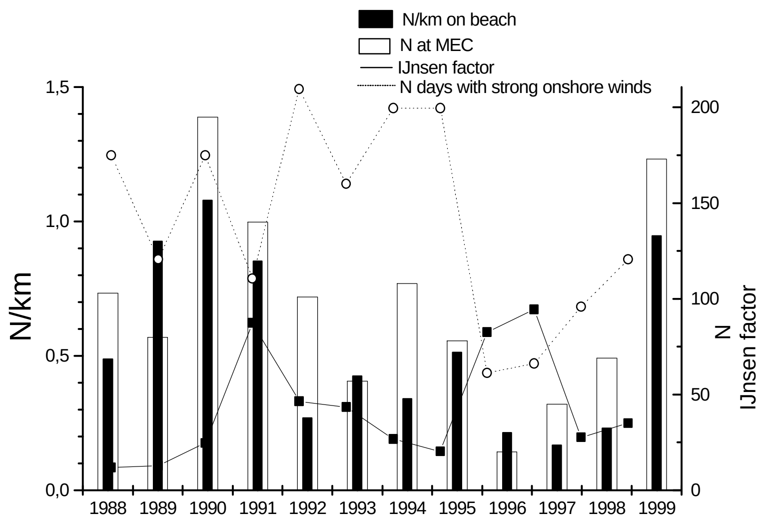



*Fig. 29. Density of beached Common Guillemot* Uria aalge *and number of specimens hosted at the MEC-rehabilitation centre during 1988-99, compared to winter severity (IJnsen factor) and frequency of strong onshore winds.*

Common Guillemots become more and more abundant in the course of the winter, with peak numbers in (the second ten days period of) February (Fig. 30). An early peak in December is much more prominent in the MEC rehabilitation centre than it is on the beach, possibly due to the Christmas holidays and a subsequent increase in visitors on the beach.

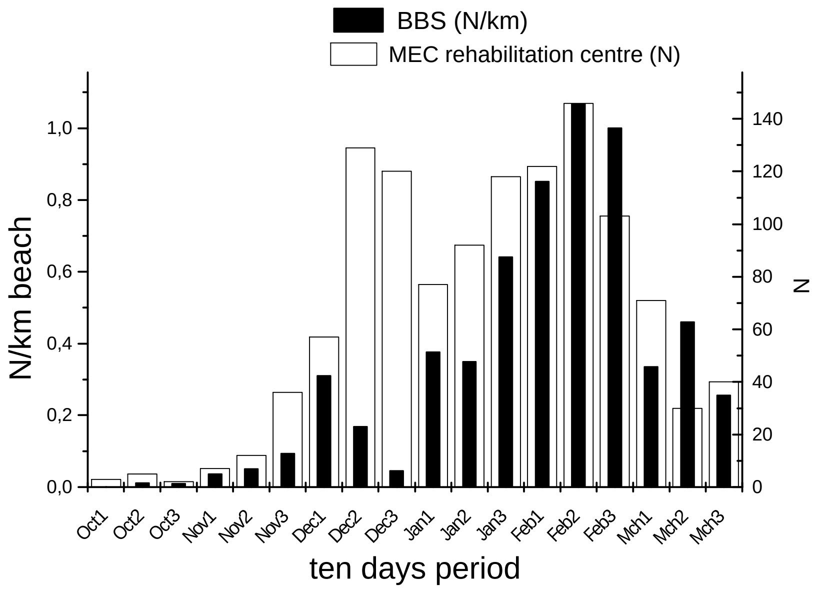



*Fig. 30. Comparison between the seasonal pattern in beaching intensity of Common Guillemot* Uria aalge *corpses at the Belgian coast and numbers hosted at the MEC rehabilitation centre.*

With 1.27 as state of decay-index the Common Guillemot classifies with divers and auks, all occurring in the mid-shore area of the Belgian coast and beaching in a rather fresh state. As the winter goes by, corpses of Common Guillemot found on the beach become more and more rotten (Tab. 40):

*Table 40. Changes in state of decay-index in beached Common Guillemot* Uria aalge *during winter.*

| Month | State of decay index |
|---|---|
| October | 0.50 |
| November | 1.03 |
| December | 1.17 |
| January | 1.15 |
| February | 1.28 |
| March | 1.58 |
| April | 1.63 |

Regarding condition, the Common Guillemot (c.i.: 1.23) compares well with the Razorbill (c.i.: 1.29) and the Kittiwake (c.i.: 1.31), both species known as ‘wreck-sensitive’.

Auks were aged according to CAMPHUYSEN (1995a), classifying Common Guillemots in two (separating juveniles from older birds) and Razorbills in three classes (separating juveniles, immatures, adults). During 1995-99 Common Guillemots were systematically aged: 46% were adult or immature, 54% first-winter birds (Tab.41). Less first-winter birds occur in early winter: October-December: 41%, January: 54%, February: 55%, March: 61%. Age-composition differed markedly between winters with first-winter birds present in numbers more than average in the winters 1995 and 1996.

*Table 41. Age-composition of beached Common Guillemots* Uria aalge *during 1995-99 at the Belgian coast.*

| Winter | N | A/I>1 (%) | I1 (%) |
|---|---|---|---|
| 1995 | 76 | 29 | 71 |
| 1996 | 22 | 32 | 68 |
| 1997 | 27 | 81 | 19 |
| 1998 | 41 | 59 | 41 |
| 1999 | 300 | 46 | 54 |

Beached Common Guillemots collected at the Belgian coast are virtually all in winter plumage in October-December, transition and breeding plumages becoming more and more abundant from January onwards (Tab. 42):

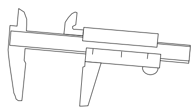
*Table 42. Seasonal pattern in plumage in beached Common Guillemot* Uria aalge *at the Belgian coast.*

| Month | N obs. | Winter (%) | Transition (%) | Breeding (%) |
|---|---|---|---|---|
| October | 3 | 100 | 0 | 0 |
| November | 31 | 97 | 3 | 0 |
| December | 53 | 94 | 4 | 2 |
| January | 270 | 76 | 7 | 17 |
| February | 522 | 70 | 11 | 19 |
| March | 102 | 55 | 15 | 30 |

The occurrence of dark-plumaged 'northern' Common Guillemots has not been recorded systematically. Hence the very low numbers that were registered (*N*=14 in the 1980s, *N*=27 in the 1990s) might be a glaring underestimate of real numbers. Spectacled Common Guillemots are rare at the Belgian coast. They can be found in small numbers here every winter: only 4 out of 1699 (0.2%) of the beached corpses in 1993-99 were spectacled, and 29 out of 1170 Common Guillemots (2.5%) at the MEC rehabilitation centre (1988-99).

Size frequency distribution of first-winter vs. adult/immature Common Guillemots collected on Belgian beaches (Tab. 43) demonstrate highly significant (*P*<0.001) differences in wing-length, bill-length and bill-height and a significant difference (*P*<0.05) in tarsus-length between first-winter Common Guillemots and older birds. Due to a slightly different way of measuring wing-length ('loosely stretched' instead of 'maximum flattened chord' see JONES 1988) mean wing-lengths of adult/immature Common Guillemots beached at the Belgian coast are significantly lower than wing-lengths determined for various subpopulations in NW-Europe (CAMPHUYSEN & VAN FRANEKER 1992; JONES 1988) and as such of little value in assessing which population or race our Common Guillemots are derived from. From their measurements, CAMPHUYSEN & VAN FRANEKER (1992) concluded that North Sea Common Guillemots in the 1980s originate from the same 'pool' of mainly Scottish birds. A view that is supported by recoveries of ringed birds in The Netherlands in the 1980s. They consider arctic Common Guillemots on the European continental coasts as rarities. OFFRINGA *et al*. (1995) and OFFRINGA & MEIRE (1995) came to the same conclusion for the strandings of Common Guillemots on Belgian beaches in the early 1990s, based on biometrical analysis. In contrast, VAN GOMPEL (1989) estimated that 24-80% of all Common Guillemots beaching during 1981-1988 belonged to the northern subspecies '*aalge*', a conclusion that was drawn primarily on subtle colour gradation of the dorsal plumage.

*Table 43. Biometrical data on beached first-winter and adult/immature Common Guillemots* Uria aalge *collected on Belgian beaches during the winter 1993-99.*

|  | | bill-length<br>0.1 mm | bill-height gonys<br>0.1 mm | tarsus-length<br>0.1 mm | wing-length 'loosely stretched'<br>mm |
|---|---|---|---|---|---|
| Adults/immatures | | | | | |
| | mean | 47.3 | 13.1 | 38.9 | 199 |
| | s.d. | 3.0 | 1.3 | 1.8 | 5 |
| | min | 40.0 | 9.0 | 34.5 | 184 |
| | max | 54.5 | 18.4 | 44.0 | 210 |
| | N | 161 | 161 | 158 | 171 |
| First-winters | | | | | |
| | mean | 45.2 | 12.2 | 38.4 | 195 |
| | s.d. | 2.9 | 0.9 | 2.0 | 5 |
| | min | 34.8 | 10.0 | 32.2 | 183 |
| | max | 54.0 | 18.0 | 46.2 | 208 |
| | N | 172 | 170 | 175 | 203 |

Oil-pollution is a major cause of mortality in auks. Common Guillemots not oiled are usually largely emaciated and exhausted. Only very small numbers show external injuries at legs, head or wings (0.7% on beach; 1.5% at the MEC rehabilitation centre). Two birds collected on the beach had severe bill deformations (curved bill). At our coasts, marginal numbers seem to fall victim to entanglement in fishing nets or ropes (2 out of 1601: 0.12%). However it cannot be excluded that an unknown number of auks drown in gill-nets and are not recognized as such with the current methods of beached bird surveying.

The database of the KBIN Belgian ringing scheme holds 27 records of Common Guillemots ringed abroad and recovered at the Belgian coast. Three refer to full-grown birds (1 SE-England, 2 The Netherlands). Common Guillemots ringed as pullus generally have a Scottish origin (17 birds all but two from the E-NE coast). Two birds were ringed at Helgoland, 3 in SE-Ireland, 1 at Skomer (Wales) and 1 in SE-Sweden. Five more records of Common Guillemots refer to ringed specimens that could not be found in the KBIN-database: 4 had a UK-ring, 1 was ringed in The Netherlands.

**RAZORBILL** *Alca torda*

During the study-period densities of Razorbill higher than 0.5 birds km$^{-1}$ were not uncommon (Fig. 31).

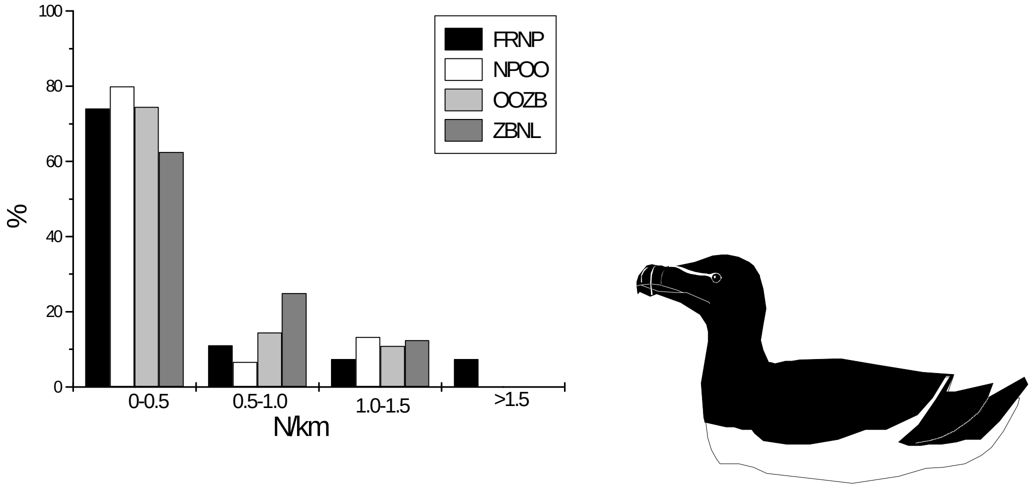



*Fig. 31. Frequency distribution of densities of beached Razorbill* Alca torda *on Belgian beaches during 1962-1999 at four beach sections.*

Razorbills were more abundant as beached birds in the 1960s than in the following decades (see remark above about poor coverage and hence missed strandings of Razorbill in the 1980s)(Tab. 44, Fig. 32), though the trend is not significant (Spearman Rank *R*: -0.305; *N*=37; *P*<0.05). Oil-rates of Razorbill decreased in a similar way as those of Common Guillemot during the study period, except that Razorbill showed higher oil-rates during the last decade (69% vs. 57% in Common Guillemot). The high frequency of 'wrecks' with often large numbers of unoiled Common Guillemots in this period, might explain this difference. Oil-rates show a significant decrease during the study period (Spearman Rank *R*: -0.540; *N*=19; *P*<0.05).

*Table 44. Mean densities and oil-rates of Razorbill* Alca torda *by decade on Belgian beaches.*

| Decade | N km$^{-1}$ | Oil-rate (%) |
|---|---|---|
| 1960s | 0.49 | 96 |
| 1970s | 0.18 | 92 |
| 1980s | 0.19 | 76 |
| 1990s | 0.07 | 69 |

High densities of Razorbills during the winters 1981 and 1983 as found in The Netherlands (CAMPHUYSEN 1998), cannot be demonstrated from the Belgian IBB surveys 1962-1999 (Fig. 32).

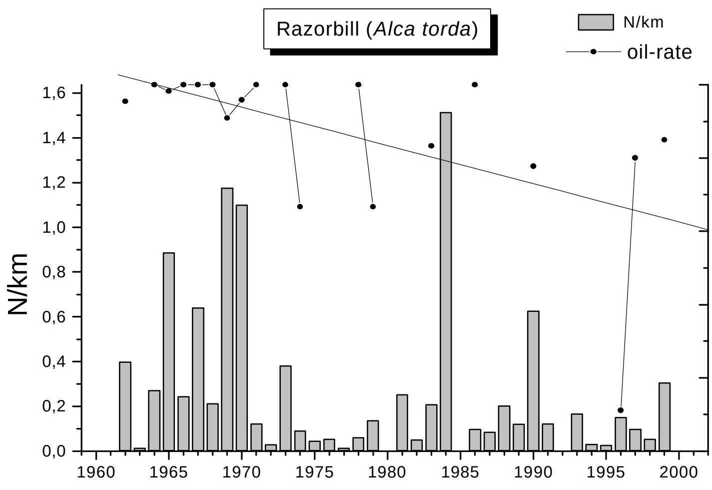



*Fig. 32. Density and oil-rate of beached Razorbill* Alca torda *during IBB surveys at the Belgian coast 1962-1999 (line fitted by eye).*

During 1988-99 the MEC rehabilitation centre at Oostende received merely 97 Razorbill (compared to 1170 Common Guillemots, i.e. 7.5% of all auks), 95% of them being oiled. The two most prominent peak numbers at the MEC (1988 and 1990) are in line with the highest densities on the beaches (Fig. 33).

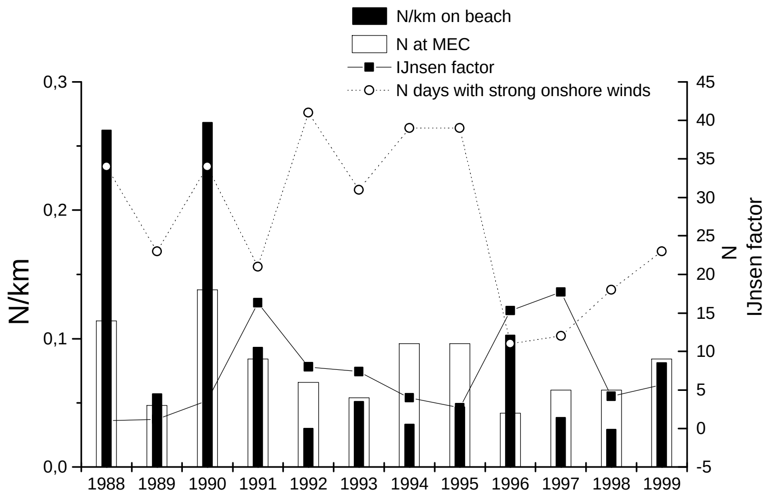



*Fig. 33. Density of beached Razorbill* Alca torda *and number of specimens hosted at the MEC-rehabilitation centre during 1988-99, compared to the winter severity (IJnsen factor) and frequency of strong onshore winds.*

The seasonal pattern in beaching of Razorbill corpses and debilitated specimens is very similar to the pattern observed in the Common Guillemot. Numbers increase during winter to reach peak values in the second half of February (Fig. 34).

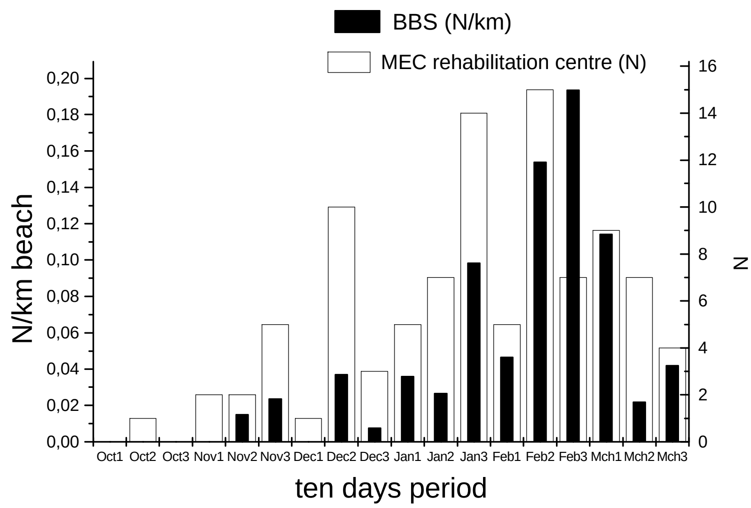



*Fig. 34. Comparison between seasonal patterns in beaching intensity of Razorbill* Alca torda *corpses at the Belgian coast and numbers hosted at the MEC rehabilitation centre.*

Although generally spoken the spatial pattern of beaching follows the overall picture demonstrated for most species/taxa (highest at FRNP and OOZB), the west coast holds relatively more Razorbills than Common Guillemots (Tab. 45).

*Table 45. Spatial variation in beached Razorbill* Alca torda *and Common Guillemot* Uria aalge *density at the Belgian coast.*

| Transect | Razorbill | | Common Guillemot | | Common Guillemot/Razorbill | |
|---|---|---|---|---|---|---|
| | N $km^{-1}$ | N $km^{-1}$ | N $km^{-1}$ | N $km^{-1}$ | | |
| | *1962-99* | *1990-99* | *1962-99* | *1990-99* | *1962-99* | *1990-99* |
| FRNP | 0.21 | 0.09 | 0.50 | 0.50 | 2.34 | 5.46 |
| NPOO | 0.15 | 0.08 | 0.32 | 0.34 | 2.10 | 4.46 |
| OOZB | 0.19 | 0.08 | 0.54 | 0.64 | 2.85 | 7.87 |
| ZBNL | 0.05 | 0.02 | 0.25 | 0.25 | 5.23 | 10.86 |

The state of decay-index is a little higher than in Common Guillemot (1.46), indicating Razorbills are on average more rotten when they strand. Corpses get more and more rotten as winter goes by (Tab. 46):

*Table 46. Changes in state of decay-index in beached Razorbill* Alca torda *during winter.*

| Month | State of decay index |
|---|---|
| October | - |
| November | 1.13 |
| December | 1.00 |
| January | 1.40 |
| February | 1.41 |
| March | 1.90 |

As a typical 'wreck-species' the average Razorbill is rather strongly emaciated (c.i.: 1.29) when found on the beach. Razorbills were classified in three age classes (CAMPHUYSEN 1995a), separating juveniles, immatures and adults (based on wing-coverts contrast and bill development). During 1993-99 Razorbills were systematically aged: 61% was adult, 11% immature and 28% less than one year old (Tab. 47). Age-composition appeared more constant compared to Common Guillemot.

*Table 47. Age-composition of beached Razorbill* Alca torda *during 1993-99 at the Belgian coast.*

| Winter | N | A (%) | imm (%) | I1 (%) |
|---|---|---|---|---|
| 1993 | 49 | 74 | 11 | 15 |
| 1994 | 0 | - | - | - |
| 1995 | 8 | 50 | 25 | 25 |
| 1996 | 33 | 61 | 12 | 27 |
| 1997 | 8 | 63 | 0 | 37 |
| 1998 | 14 | 58 | 21 | 21 |
| 1999 | 29 | 59 | 3 | 38 |

As for Common Guillemot, the Razorbills found dead on Belgian beaches are mainly in winter plumage during November-December and turn gradually to breeding plumage from January onwards (Tab. 48). However it should be noticed that the small numbers checked for plumage can only give a rough idea.

*Table 48. Seasonal pattern in plumage in beached Razorbill* Alca torda *at the Belgian coast.*

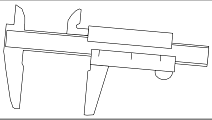
| Month | N obs. | Winter (%) | Transition (%) | Breeding (%) |
|---|---|---|---|---|
| November | 2 | 100 | 0 | 0 |
| December | 2 | 100 | 0 | 0 |
| January | 23 | 91 | 4 | 4 |
| February | 32 | 62 | 16 | 22 |
| March | 18 | 66 | 17 | 17 |

There is no significant age-related difference in tarsus-length (Tab. 49). Bill and wing are significantly longer in adults compared to first-winter birds. The bill becomes increasingly higher with age.

Most Razorbills that were found on the beach without signs of oil-contamination showed no external injuries but were apparently exhausted and had a very poor condition. Two birds got entangled, one in white plastic, one in a fishing net (together: 0.9%). At the MEC rehabilitation centre 97 Razorbills were registered during the winters 1988-99. One had a fracture, one missed a leg and another bird was fouled with some kind of varnish. The great majority had been affected by oil.

Only 9 recoveries of Razorbill ringed abroad and found at the Belgian coast could be traced in the database of the KBIN Belgian ringing scheme and one additional record in a local ornithological journal (DE PUTTER *et al*. 1996). All birds were ringed in the U.K., 3 as full-grown in Scotland, 7 as pulli distributed evenly over various parts of the U.K. (2 Isle of Man, 1 SW-Ireland, 2 mainland Scotland, 2 Wales).

*Table 49. Biometrical data on beached first-winter, immature and adult Razorbill* Alca torda *collected on Belgian beaches.*

|  | bill-length 0.1 mm | bill-height gonys 0.1 mm | tarsus-length 0.1 mm | wing-length 'loosely stretched' mm |
|---|---|---|---|---|
| Adults | | | | |
| mean | 32.9 | 20.0 | 32.1 | 193 |
| s.d. | 2.4 | 1.3 | 1.7 | 5 |
| min | 27.5 | 16.1 | 28.0 | 182 |
| max | 38.9 | 23.0 | 38.0 | 204 |
| N | 52 | 53 | 53 | 55 |
| Immatures | | | | |
| mean | 31.6 | 19.1 | 32.2 | 190 |
| s.d. | 1.4 | 1.2 | 2.4 | 6 |
| min | 30.0 | 17.5 | 27.4 | 182 |
| max | 33.5 | 21.0 | 35.0 | 198 |
| N | 8 | 8 | 8 | 8 |
| First-winters | | | | |
| mean | 31.0 | 15.7 | 32.4 | 185 |
| s.d. | 1.4 | 0.9 | 1.7 | 5 |
| min | 28.6 | 13.8 | 29.0 | 179 |
| max | 33.6 | 17.0 | 37.2 | 197 |
| N | 24 | 24 | 24 | 24 |

One-way ANOVA

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| F | 7.24 | | 110.43 | | 0.36 | 20.35 | |
| P | ** | | *** | | ns | *** | |
| Post-hoc Tukey HSD | ad | imm | ad | imm | | ad | imm |
| adults | - | ns | - | ns | | - | ns |
| immatures | ns | - | ns | - | | ns | - |
| first-winters | ** | ns | *** | *** | | *** | * |

# DISCUSSION

The beached bird survey database at the Institute of Nature Conservation gives the most complete picture of what has been collected on Belgian beaches during the period 1962-1999. It contains a grand total of 15,368 bird corpses (105 species) and 3 sea mammals (2 species), collected on a total surveyed distance of almost 8000 km. That means that on average a winter density of 1.9 bird corpse km$^{-1}$ has been found. The very high mean densities in the 1960s (5.1 km$^{-1}$) dropped drastically during the next decade (2.2 km$^{-1}$), and reached – after a slight increase in the 1980s (2.5 km$^{-1}$) – their lowest values in the last decade (1.4 km$^{-1}$). Although the effort in beached bird surveying was significantly enhanced during the past decade (65% of all distance travelled), only 45.5% of all bird carcasses were collected in this period.

Sea- and coastal bird species most frequently collected are Common Guillemot (*N*=3703: 24.1%), large *Larus*-gulls (*N*=1831: 11.9%), small *Larus*-gulls (*N*=1537: 10%), Kittiwake (*N*=1413: 9.2%), Common Scoter (*N*=1260: 8.2%), Razorbill (*N*=1019: 6.6%), Fulmar (*N*=735: 4.8%), grebes (*N*=607: 3.9%), divers (*N*=197: 1.3%) and Northern Gannet (*N*=182: 1.2%). Other important taxa include waders (*N*=680: 4.4%), passerines (*N*=304: 2.0%) and rails (*N*=395: 2.6%). This ranking corresponds well with the most affected species collected on Dutch, French, German and Danish beaches (Tab. 50). Only the Eider, that breeds in the Wadden Sea in important numbers and forms large wintering flocks along the northern Dutch coasts, shows a much higher ranking in The Netherlands compared to Belgian beaches and is one of the most common bird victims in Germany and Denmark. The Atlantic coasts of Portugal are quite different in species composition (GRANADEIRO & SILVA 1992). Here, Razorbill, Northern Gannet and Puffin are some of the most affected species. Although results of (northern) France are quite consistent with data of other North Sea countries, the very high numbers of passerines found dead on beaches here are remarkable and should be explained by the impact of the cold spell of late February 1991 on species such as Redwing (*Turdus iliacus*), Fieldfare (*T.pilaris*) and to a lesser extent Sky Lark (*Alauda arvensis*) and Meadow Pipit (*Anthus pratensis*).

*Table 50. Comparison of the top-10 most common beached bird species in different European countries. For each species/taxon its relative abundance is expressed as: (1) >15% of all bird specimens; (2) 10-15%; (3) 5-10%; (4) >5%.*

| | Portugal | N-France | Belgium | The Netherlands | Germany | Denmark |
|---|---|---|---|---|---|---|
| | *N*=250 | *N*=26,385 | *N*=15,368 | *N*=95,986 | *N*=13,368 | *N*=13,825 |
| | GRANADEIRO & SILVA 1992 | RAEVEL 1992b | SEYS *et al.* this study | CAMPHUYSEN 1989 | VAUK *et al.* 1987 | SKOV *et al.* 1996 |
| Rank | 1990-91 | 1967-91 | 1962-99 | 1969-85 | 1983-86 | 1984-95 |
| 1 | **Razorbill 1** | **passerines 1** | Common Guillemot 1 | Common Guillemot 1 | **Eider 1** | Common Guillemot 1 |
| 2 | large *Larus*-gulls 1 | Common Guillemot 1 | large *Larus*-gulls 2 | Common Scoter 2 | Common Guillemot 1 | **Eider 1** |
| 3 | **Northern Gannet 1** | large *Larus*-gulls 2 | small *Larus*-gulls 2 | large *Larus*-gulls 2 | Common Scoter 2 | large *Larus*-gulls 2 |
| 4 | **Puffin 3** | small *Larus*-gulls 3 | Kittiwake 3 | waders 3 | Kittiwake 3 | small *Larus*-gulls 3 |
| 5 | Common Guillemot 4 | Kittiwake 3 | Common Scoter 3 | Kittiwake 3 | small *Larus*-gulls 3 | Common Scoter 3 |
| 6 | small *Larus*-gulls 4 | Razorbill 3 | Razorbill 3 | **Eider 3** | large *Larus*-gulls 3 | swans 3 |
| 7 | Kittiwake 4 | waders 3 | Fulmar 4 | small *Larus*-gulls 3 | Mallard 4 | Kittiwake 3 |
| 8 | terns 4 | grebes 4 | waders 4 | passerines 4 | Razorbill 4 | Razorbill 3 |
| 9 | Common Scoter 4 | Anatidae 4 | grebes 4 | Razorbill 4 | Shelduck 4 | Shelduck 4 |
| 10 | Shag 4 | rails 4 | rails 4 | rails 4 | Fulmar 4 | Mallard 4 |

Sea- and coastal birds show differences in vulnerability to oil pollution, as demonstrated by the oil-rates of the most abundant species/taxa found on Belgian beaches (Tab. 51):

*Table 51. Oil-rates of various taxa/species by decade during beached bird surveys at the Belgian coast, ranked according to their oil-rates in the 1990s.*

| Species/taxon | 1960s | 1970s | 1980s | 1990s |
|---|---|---|---|---|
| rails | 45 | 9 | 0 | 3 |
| waders | 10 | 7 | 10 | 3 |
| passerines | 5 | 7 | 3 | 5 |
| small *Larus*-gulls | 66 | 42 | 19 | 9 |
| large *Larus*-gulls | 76 | 48 | 31 | 12 |
| Fulmar | 62 | 71 | 43 | 23 |
| skuas | 100 | - | 33 | 25 |
| grebes | 89 | 66 | 75 | 42 |
| Kittiwake | 79 | 68 | 69 | 48 |
| Northern Gannet | 98 | 90 | 70 | 55 |
| Common Guillemot | 99 | 93 | 70 | 57 |
| Razorbill | 96 | 92 | 76 | 69 |
| scoters | 92 | 79 | 80 | 71 |
| divers | 98 | 87 | 85 | 80 |

Non-marine bird taxa such as rails, waders and passerines run only a small risk to get oil-contaminated. For all gull species the rather high oil-rates of the early days have turned into small values. Offshore taxa that spend much of their time on the wing (Fulmar, skuas, ...) have a chance of 20-25% to get oil-contaminated. A group consisting of grebes (inshore) and three mid/offshore species (Kittiwake, Northern Gannet and Common Guillemot) are still seriously affected by oil, as shown by the oil-rates amounting to 40-60%. Most vulnerable are Razorbill (mid/offshore), divers (midshore) and scoters (inshore)(70-80% contaminated). The gradient in oil-sensitivity is a direct consequence of different behaviour and exposure to oil. Marine oriented species that tend to flock and swim, rather than fly at sea (divers, seaducks, auks) are highly vulnerable, whereas terrestrial and coast-oriented birds (passerines, waders, *Larus*-gulls) and species that spend much of their time on the wing (Fulmar) will show lower oil-rates.

In a comparison with other North Sea areas, oil-rates of most Belgian beached bird species are significantly higher than in northern areas such as the Shetlands and Norway, and more or less in line with oil-rates at other European continental coasts (Tab. 52). Oil-rates during the 1980s appear to compare best with Danish data, to be on average a bit higher than in Germany and slightly lower than in The Netherlands.

*Table 52. Comparison of oil-rates in dominant taxa/species in various regions bordering the North Sea (after* CAMPHUYSEN *&* VAN FRANEKER *1992; Belgian data: this report).*

| Species/ taxon | Shetland | Norway | Denmark | Germany | Belgium | | The Netherlands | |
|---|---|---|---|---|---|---|---|---|
| | 1980-92 | 1987-92 | 1987-89 | 1984-90 | 1981-89 | 1990-99 | 1969-85 | 1978-91 |
| divers | 26 | - | 70 | 80 | 85 | 80 | 92 | 89 |
| grebes | - | - | 78 | 79 | 75 | 42 | 60 | 64 |
| Fulmar | 7 | 12 | 65 | 25 | 43 | 23 | 68 | 68 |
| Northern Gannet | 15 | - | 65 | 46 | 70 | 55 | 87 | 77 |
| scoters | - | - | 72 | 51 | 80 | 71 | 95 | 70 |
| waders | 0 | - | - | 6 | 10 | 3 | 12 | 9 |
| skuas | 0 | - | - | 14 | 33 | 25 | 56 | - |
| *Larus*-gulls | 5 | 13 | 32 | 14 | 26 | 11 | 43 | 43 |
| Kittiwake | 12 | 37 | 52 | 15 | 69 | 48 | 84 | 77 |
| Common Guillemot | 11 | 34 | 82 | 70 | 70 | 57 | 89 | 88 |
| Razorbill | 12 | - | 93 | 70 | 76 | 69 | 89 | 90 |

Oil-contamination is still a major cause of mortality in many coastal and seabird species, as demonstrated by the oil-rates tabled above. Of unoiled birds found on the beach or received at rehabilitation centres, the majority shows severe signs of exhaustion and is categorised as 'cold -' or 'wreck victims'. Very few birds found dead on the beach show external injuries (1-3% for most species). This is in firm contrast to the results obtained for gulls and grebes through the MEC-rehabilitation centre: 60-70% of all the gulls that arrive here and that are not oil-fouled show external injuries (mostly broken wings). Grebes treated at the MEC-rehabilitation centre have external injuries in 31% of all records, with legs most often injured (about 50%). Hunting victims are rarely recognized as such, but are probably underestimated. Shot wounds were found in Herring Gull, Red-throated Diver and Common Scoter. Fishhooks were detected in a Fulmar's wing, a Common Gull's tongue and a Herring Gull's bill. At least one Herring Gull, Lesser Black-backed Gull and one Kittiwake apparently suffocated, eating a big fish. Entanglement in fishing rope or nets is often observed in Northern Gannet (8/69 on beach: 11.6%; 1/21 at MEC: 4.8%) and less frequently in divers, grebes, gulls and auks (0.1-2.0%). Two Northern Gannets entangled together in one net were collected on 18.11.1992 on the beach of Westende. On Dutch beaches, CAMPHUYSEN (1990) found 0.2% of all birds on the beach entangled, with only Northern Gannet (5.4%), Cormorant (2.6%) and Great Black-backed Gulls (1.3%) relatively numerous as entangled bird species. Also SCHREY & VAUK (1987) recognized the issue of Northern Gannets killed by entanglement. CAMPHUYSEN (1990) found that the number of entanglements reported per km surveyed increased significantly between 1979 and 1989, mainly because of an increase in entanglements in nylon thread. For Northern Gannet, the proportion entangled in fishing nets declined from 3.2% to 1.5% during 1977-2000, whereas that of Northern Gannets in nylon lines increased from only 0.3% to 3.8% (CAMPHUYSEN 2001).

The state of decay in which bird corpses are found on the beach seems to rely on three factors:
1) the distance to the coast of their major distribution area (the further away, the more decayed the beaching corpse will be), 2) whether the injured or oil-fouled bird actively search for the coast or not (some species will at least to some extent seek for the coast before dying, and as such react different in terms of state of decay to what can be expected based on their main wintering area), 3) their attractiveness for carrion eaters after stranding (for medium-sized and large birds, the number of specimens in class 3, i.e. a carcass with wings and legs, might indicate their attractiveness for beach scavengers such as crows, magpies and gulls). Oystercatchers and other winter-sensitive species (waders, waterbirds) are fresh when found on the beach, and have a relatively high chance of being removed from the beaches by carrion-feeders before the decaying process can really take off. Grebes and scoters are common in inshore waters and hence will be found frequently in a very fresh or fresh state. Divers occurring in the midshore area reflect a transient stage in decay to mid- and offshore species such as Razorbill, Common Guillemot, large *Larus*-gulls, Northern Gannet and skuas. This latter group is most often found in a rather rotten stage, with the auks showing important numbers of fresh and very fresh specimens as well, pointing to an active search for the beach when exhausted or dying.

Kittiwake and Common Gull are evenly distributed over the four classes. Both species occur offshore and inshore (for Kittiwake particularly when exhausted, oiled or injured) and are eaten frequently by carrion eaters (resulting in important class three numbers). The Fulmar shows a similar pattern except for the lack of class three birds, a consequence of the avoidance of Fulmar corpses by scavengers. Finally, the Black-headed Gull seems to reflect a pattern of an inshore species that is not preferred by carrion eaters: all categories are well presented, with a peak in class two.

Northern Gannets, *Larus*-gulls, Kittiwakes and auks were systematically aged during the winters 1992-99. Compared to age-ratios at sea, young birds are overrepresented at beached bird surveys (Tab. 53) demonstrating their higher mortality and vulnerability during winter. Age-composition in beached birds can change drastically in the course of the winter period. In species that hold substantial numbers of wintering young birds in our regions, proportions of immatures corpses on the beach apparently increase in the course of the winter (Greater Black-backed Gull, Kittiwake, Common Guillemot). The higher toll in young birds becomes more prominent with increasing winter severity. Immatures of other species (Northern Gannet, Common Gull, Lesser Black-backed Gull) do not stay in our waters in important numbers during winter and hence will be more common as beached birds in migration periods (autumn, early winter). In the Herring Gull characteristics of both types are combined: high proportions of immatures in October-November (68-74%) are followed by much smaller percentages (49%), slightly increasing towards the end of the winter (64%).

*Table 53. Age-composition of divers* Gavia sp.*, Northern Gannet* Morus bassanus*,* Larus*-gulls, Kittiwake* Rissa tridactyla *and auks as found during beached bird surveys at the Belgian coast (winters 1992-99) compared to ratios observed at sea or during coastal surveys in wintertime. * indicates adults/immatures are separated from 1st-winter birds (instead of adults versus all immatures).*

| | Beached bird surveys | | Seabirds at sea (OFFRINGA *et al*. 1996) | | Coastal surveys *Larus*-gulls (SPANOGHE 1999) | |
|---|---|---|---|---|---|---|
| *Species/age* | Adult (%) | Immature (%) | Adult (%) | Immature (%) | Adult (%) | Immature (%) |
| divers | 59 | 41 | 67 | 33 | | |
| Northern Gannet | 68 | 32 | 88 | 12 | | |
| Black-headed Gull | 80 * | 20 | 91 * | 9 | 99 * | 1 |
| Common Gull | 79 * | 21 | 93 * | 7 | 95 * | 5 |
| Lesser Black-backed Gull | 60 | 40 | 84 | 16 | 96 | 4 |
| Herring Gull | 38 | 62 | 58 | 42 | 57 | 43 |
| Greater Black-backed Gull | 40 | 60 | 43 | 57 | 88 | 12 |
| Kittiwake | 63 * | 37 | 84 | 16 | | |
| Common Guillemot | 46 * | 54 | | | | |
| Razorbill | 72 * | 28 | | | | |

In the 1990s from mid-October till end March, an average of 0.4-2.4 bird corpses $km^{-1}$ was found on Belgian beaches (Tab. 54). Numbers steadily increase during winter with a peak mid-February followed by a decline with more than 50% in March. This pattern is primarily determined by the occurrence of beaching auks, in particular the Common Guillemot. Severe winters disrupt the seasonal pattern slightly by adding important numbers of waders on our beaches during cold spells. A smaller peak end November is caused by substantial numbers of dead *Larus*-gulls linked to important migratory movements in the area.

*Table 54. Seasonal pattern of beached birds at the Belgian coast (winters 1992-99), illustrated by the total number of bird victims per km travelled by ten days period, the total number of seabirds per km by ten days period, and densities of auks,* Larus*-gulls and waders.*

| Month | | Oct | | | Nov | | | Dec | |
|---|---|---|---|---|---|---|---|---|---|
| Ten days period | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| auks | 0.00 | 0.01 | 0.01 | 0.06 | 0.08 | 0.25 | 0.31 | 0.21 | 0.06 |
| *Larus*-gulls | 0.22 | 0.24 | 0.31 | 0.38 | 0.33 | 0.64 | 0.28 | 0.23 | 0.39 |
| waders | 0.10 | 0.01 | 0.01 | 0.01 | 0.03 | 0.06 | 0.02 | 0.02 | 0.05 |
| all birds | 0.38 | 0.43 | 0.47 | 0.56 | 0.65 | 1.26 | 0.71 | 0.67 | 0.73 |
| all seabirds | 0.22 | 0.42 | 0.41 | 0.48 | 0.56 | 1.08 | 0.67 | 0.62 | 0.63 |

| Month | | Jan | | | Feb | | | March | |
|---|---|---|---|---|---|---|---|---|---|
| Ten days period | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| auks | 0.42 | 0.39 | 0.75 | 0.42 | 0.39 | 0.75 | 0.42 | 0.39 | 0.75 |
| *Larus*-gulls | 0.30 | 0.31 | 0.21 | 0.30 | 0.31 | 0.21 | 0.30 | 0.31 | 0.21 |
| waders | 1.01 | 0.40 | 0.61 | 1.01 | 0.40 | 0.61 | 1.01 | 0.40 | 0.61 |
| all birds | 2.03 | 1.42 | 1.91 | 2.03 | 1.42 | 1.91 | 2.03 | 1.42 | 1.91 |
| all seabirds | 0.96 | 0.94 | 1.26 | 0.96 | 0.94 | 1.26 | 0.96 | 0.94 | 1.26 |

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