Shortlist Masterplan Wind
Ship-based monitoring of seabirds and cetaceans

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Report number C099/11

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Publication date: 15 August 2011

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Contents

Summary

During April 2010 – February 2011, monthly surveys of seabirds and marine mammals were conducted aboard ships engaged in plankton surveys. After many years of little or no effort in far offshore areas of the DCS, this series of surveys provided the first recent ship-based data on seabirds, covering a large area (the entire Dutch Continental Shelf (DCS), including some Belgian and British waters) almost year-round. Due to changes in the design of the survey grid, the use of several ships, spells of bad weather conditions and seasonal differences in the number of daylight hours, the resulting coverage is not evenly spread in space and time. Still, both in terms of areas covered and detailed data gathered, this series of surveys complement the aerial surveys carried out under the same programme Shortlist Masterplan Wind. By surveying beyond the designated areas for round II offshore wind farms on the DCS, areas that might be targeted for round III, such as the shallow Dogger Bank area, got a first boost in T-zero survey effort.

From April 2010 till February 2011 11 surveys, totalling to 48 at-sea days, 4610 5-minute counts were conducted over a distance of 9021 km. At a counting strip width of mostly 300 m (200 m over a very small percentage of the counts), this amounts to a total surveyed area of 2706 km^2.

The surveys have provided rough data on seabird distribution in far offshore areas. In total, 54,593 individuals of 90 bird species were recorded, from which 15,003 individuals of 36 species were recorded within the counting strip. Marine mammals were represented by 616 individuals of seven species, of which 389 individuals of six species were seen within the counting strip. Flying heights were noted for 5044 clusters of individuals, covering 75 species. Behaviour was noted for 1790 (clusters of) individuals. Apart from birds and marine mammals, 352 balloons were counted (of which 164 were within the counting strip) and proved omnipresent in periods of offshore winds.

These surveys have identified several issues that should be taken into account in future planning of wind farms. Divers, which are the highest ranked species in terms of sensitivity to wind farms, can be encountered migrating anywhere in offshore waters and sightings of White-billed Divers at the Dogger Bank suggest the existence of a small wintering population of this near-threatened species. In relation to this, potential effects of wind farms on offshore species, such as Northern Fulmars, Atlantic Puffins, Little Auks and cetaceans, are unknown as current wind farms are located near shore where these species do not occur in large numbers.

Samenvatting

Maandelijkse tellingen van zeevogels en zeezoogdieren zijn uitgevoerd van april 2010 tot en met februari 2011 aan boord van schepen die werden ingezet voor plankton surveys. Na vele jaren waarin weinig gegevens in offshore gebieden van het NCP konden worden verzameld vanaf schepen, representeert deze serie van tochten de eerste recente set gegevens over vogelverspreiding in deze wateren. Ook zijn er gegevens verzameld in Belgisch en Britse wateren. Vanwege tussentijdse veranderingen in de gevaren route, het gebruik van verschillende schepen, wisselende weersomstandigheden en seizonale verschillen in daglichtperiode is de resulterende waarnemingsinspanning niet maandelijks gelijk over het onderzoeksgebied. Zowel wat betreft de bezochte gebieden als wat betreft de verzamelde detailgegevens, complementeert dit project echter de vliegtuigtellingen zoals uitgevoerd binnen hetzelfde programma. Door gebieden te dekken die buiten de fase II gebieden vallen, hebben gebieden die mogelijk in fase III worden geselecteerd, een eerste set t0 gegevens.

Van april 2010 tot en met februari 2011 zijn 11 tochten gevaren, resulterend in 48 zeedagen, 4610 vijf-minuten tellingen, en een totale afgelegde afstand (tijdens de tellingen) van 9021 km. Bij een telstrook van doorgaans 300 m breed (200 m tijdens een zeer klein deel van de tellingen) komt dit neer op een geïnventariseerd oppervlak van 2706 km^2.

De verzamelde gegevens geven een grofmazig beeld van de verspreiding van vogels in offshore gebieden. In totaal werden 54.593 individuen van 90 vogelsoorten geteld. Hiervan bevonden zich 15.003 individuen van 36 soorten in het transect. Van zeven soorten zeezoogdieren werden 616 individuen gezien – hiervan bevonden 389 individuen van zes soorten zich in het transect. Vlieghoogtes werden genoteerd van 5044 (groepen) vogels van 75 soorten. Gedrag werd genoteerd voor 1790 (groepen) individuen. Naast vogels en zeezoogdieren werden 352 ballonnen geteld (waarvan 164 in het transect), welke wijd verspreid in perioden met aflandige wind.

Deze zeevogeltellingen brengen enkele fenomenen aan het licht die van belang zijn bij het plannen van windmolenparken op zee. Migratie van duikers – een groep soorten met een hoge gevoeligheidsindex voor windmolenparken – vindt over grote delen van de Noordzee plaats, inclusief gebieden die ver van de kust verwijderd zijn. Waarnemingen van Geelsnavelduikers op de Doggersbank suggereren een kleine overwinterende populatie van deze bedreigde soort. Op de Doggersbank komt een soortengemeenschap voor die typisch is voor offshore gebieden. Omdat huidige windmolenparken – en daarmee het onderzoek naar de invloed daarvan – zich dicht bij de kust bevinden, zijn de mogelijke effecten in deze gebieden vooralsnog onbekend.

1. Introduction

In the light of the further development of offshore wind power on the Dutch Continental Shelf (DCS), the Dutch government intends to give out permissions for more wind farms from mid-2011 onwards. Consequently, there is an urgent need to describe an undisturbed T-zero situation for several biological parameters. In addition to this time constraint, exact locations of the future wind farms are not yet known, so data are needed for the total area under Dutch jurisdiction, i.e. the whole DCS. Several of these knowledge gaps are covered in the Shortlist Masterplan Wind program.

Data on distribution of seabirds and marine mammals on the DCS were published in two atlases in the previous century; one based on ship-based surveys (Camphuysen & Leopold, 1994), the other based on aerial surveys part of a monitoring programme that became established in 1989 (Baptist & Wolf, 1993). For the whole North Sea a distribution atlas based on ship-based surveys was published in the same period (Stone *et al.* 1995). After publication of these atlases the aerial monitoring programme continued to the present day (e.g. Arts, 2010), but the ship-based surveys on the DCS became more ad-hoc, project based. As a result data on the distribution on seabirds (and marine mammals) on the DCS is unevenly distributed in time and space, and therefore not suitable for an adequate description of T-zero. In order to fill this gap aerial surveys and ship-based surveys were conducted to obtain data on the distribution and abundance of seabirds and marine mammals. In this report the results of monthly ship-based surveys from April 2010 till March 2011 are presented. This survey was carried out along with another survey that was part of the Shortlist Masterplan Wind program: the so-called "fish eggs and fish larvae" surveys, covering the entire Dutch Continental Shelf. The result include a set of distribution maps per species over 11 months, as well as flying heights, modelled detection probabilities and additional behavioural and plumage data.

2. Materials and Methods

Seabirds and marine mammals were surveyed using standard ESAS ship-based survey techniques, which are extensively described in Tasker *et al.* (1984) and Komdeur *et al*. (1992). Seabirds were counted in five-minute bouts in a 300 m wide strip at one side of the vessel (the side that offers the best viewing conditions), by two observers working as a team. For each observed individual (or flock), species, number, distance class, details on plumage, age, sex, associations and behaviour were recorded. Environmental conditions may influence detection probabilities of birds and mammals and are therefore recorded. These include sea state (on the Beaufort scale) and visibility (in four classes). The presence of fishing activities is recorded in terms of distance to visible vessels and the presence of set nets. The observers are seated in a box, placed centrally and forward on the top-deck of the ship. The box offers protection against the wind, seating and a desk for writing down results on pre-designed field sheets. The box is further equipped with a GPS system so that observers can keep track of the position, speed and course of the ship; these parameters are logged by the bird surveyors.

The surveys were conducted during another survey under the Shortlist Masterplan Wind umbrella: the fish eggs and larvae survey. The purpose of the latter is to monitor the spatial distribution and seasonal patterns in the appearance of fish eggs and larvae on the DCS. To this end, a monthly ship-based survey has been done, during which ichthyoplankton samples were collected at sampling stations in the entire DCS and surrounding areas. The 91 sampling stations were distributed along a grid containing three stations per ICES quadrant. The sampling grid was changed during the project, especially after the May survey (*Figure 1* and *Figure 2*). At each sampling station samples were collected with a plankton torpedo towed at a ship's speed of 5 knots. Haul duration was 10 minutes at minimum. During these sampling stretches no bird counts were made, and bird surveys were therefore restricted to the transect between the plankton sampling stations. As the sampling of ichthyoplankton continued 24 hours a day, while the bird surveys could only be conducted along the transects covered during daylight, only part of the study area could be surveyed for birds.

Three different ships were assigned to the project: the Tridens II was used during June, October-December 2010 and January 2011; the Zirfaea during August-September 2010 and the Arca during April-May and July 2010 and in February 2011.

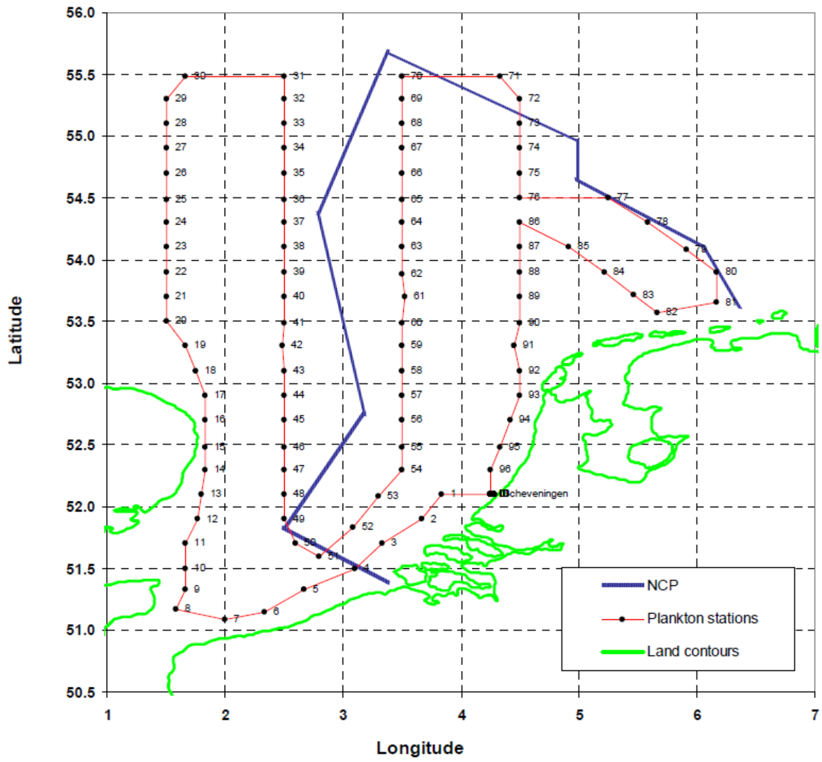

Figure 1 *Fish egg and larvae sampling stations during the surveys in April and May 2010 (van Damme et al. 2010)*

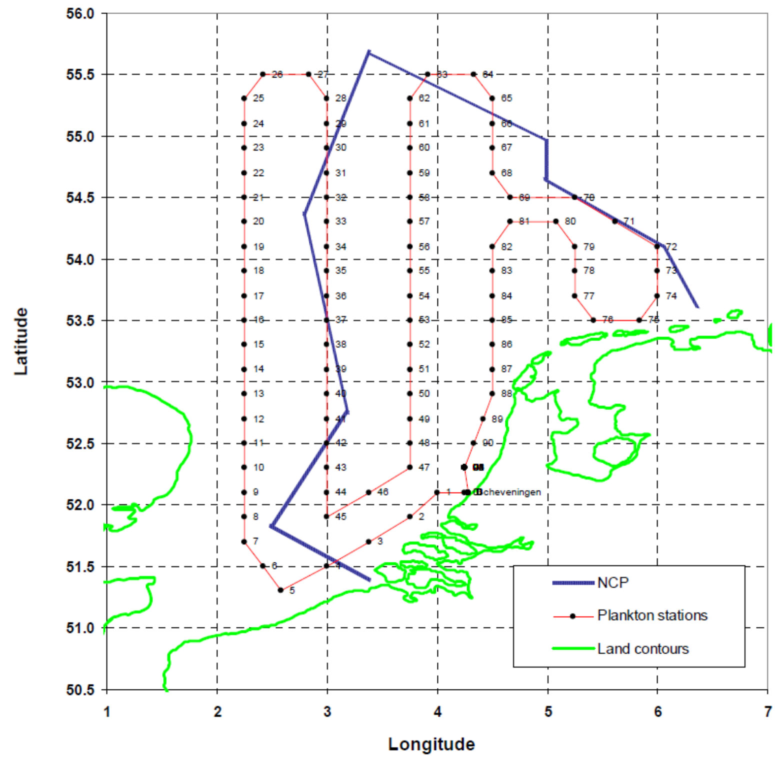

Figure 2 *Fish egg and larvae sampling stations during the surveys in June 2010 – March 2011 (van Damme et al. 2010). Note that effort was greatly reduced in September, November and December due to weather conditions*

Distance sampling for swimming birds

Objects swimming or floating on the water surface (as opposed to birds in flight) may be hard to detect. Detection probability is determined by several factors, such as colour, shape and behaviour of the bird. Especially the distance from the transect line (c.q. the observer) is a major determinant of detection probability. The technique of distance sampling (Buckland *et al.* 2001) was used to infer the relationship between detectability and distance.

All (groups of) birds on the water were assigned to a particular distance class, perpendicular to the ship's track line (*Table 1*). The counting strip consisted of four distance bands: A (0-50m), B (50-100m), C (100-200m) and D (200-300m). Distance class E contains animals or objects beyond the counting strip (>300m) and are left out of analyses of distance or detection probability. Birds seen in distance classes A-D are used to determine the relative probability of detection, in relation to distance, acknowledging that this probability decreases at increasing distances. In other words, some birds will not be detected and the probability of missing swimming birds increases as birds are situated further away from the track line. From the number of individuals counted in bands A-D, a detection function can be created using the software package Distance (v6.0) (Thomas *et al*. 2010). Additional effects included in modelling the detection function were sea state. The detection functions can be used to determine the so-called effective strip width (ESW) defined as the distance at which the expected number of detected objects would be the same as for the actual survey (Buckland *et al.* 2001). Marine mammals were assigned to the same distance bands, using the position of the first sighting. All balloons sighted on the water were also noted (per distance band) in order to build a database of sighting of seabirds-sized objects that would not show behavioural responses (attraction or avoidance) to the ship.

This software offers several model functions that are fitted to the counts per distance band. These functions are the half-normal, the hazard-rate, the uniform and the negative binomial. Additional adjustment terms to allow extra flexibility include cosinus, simple polynomial and hermite polynomial adjustments. First, all combinations of model functions and adjustments were tested. Then, the model with the lowest AIC was selected.

Note that it is implicitly assumed that all swimming birds will be detected if they swim on the track line. However, detection probability on the track line (the so-called g(0), Buckland *et al.* 2001) is unlikely to be perfect, for example due to escape diving by alcids and Harbour Porpoises. There is however no correction factor available. Observations using 'double-platforms' are needed to assess this factor.

Note that the assumption of perfect detection of swimming birds at the transect line and of flying birds within 300m (see below) from the transect line have important consequences in the calculation of absolute densities but not for distribution patterns.

Table 1 Distance classes for birds seen perpendicular to the ship's track line

Distance class	Distance range (m)
A	0-50
B	50-100
C	100-200
D	200-300
E	>300
F	Flying birds*

** Flying birds need to fulfil two criteria to be counted as "in transect" and thus to enter the seabird density calculations. First, they have to pass by the ship at the right side, within 300 m perpendicular distance. Second, they have to do so at pre-determined snap-shot moments (exactly once every whole minute) and within a distance forward from the observers which is covered by the steaming ship in one* minute (circa 300 m at 10 knots). For more details, see Tasker *et al*. 1984) and the next section of this report.

Flying birds

Due to movement of flying birds, and the fact that they usually fly much faster than the sailing speed of the ship, the density of flying birds is easily overestimated. To account for this overestimation, flying birds were counted by the so-called snap-shot method (Tasker *et al.* 1984). This method prescribes that all birds flying above the transect should be recorded as in the transect at fixed time intervals. Here, we used a 1-minute interval. The distance travelled within one time interval determines the forward distance that is regarded as in the transect. For example, at a speed of 12 kt, the distance travelled in one minute is 370 m, and consequently, all birds flying above the 370 x 300 m rectangle at whole minutes are noted as within the transect.

All birds in flight were assigned to distance class F. Birds in flight are much more easily detected than swimming birds and are assumed to be always detected within 300 m. This assumption may not be necessarily true, but unlike swimming birds, there is no way yet to correct for missed birds. This is an important issue when it comes to calculating absolute densities, but is of no consequence for relative measures of abundance. In ship-based seabirds surveys in the North Sea it is commonly assumed that all flying birds are detected within 300 m but this assumption was never tested. Barbraud & Thiebot (2009) provided the first data on this issue, during seabirds surveys in the Southern Ocean. They found that medium-sized seabirds (like gulls and Northern Fulmars in the North Sea situation) were detected with a probability of circa 0.8 within 300 m, by a single observer watching from the bridge (indoors). Finally, detection probabilities are influenced by bird behaviour: some birds avoid approaching ships by diving or by flying off (e.g. divers, auks), while others are attracted to ships (e.g. Fulmars, gulls, Gannets). The final detection probability is thus dependent from several factors, some working against each other. We tackled this problem to some extent by always using two observers working as a team (two observers detect more birds than a single observer, see Evans Mack 2002), and by always carrying out observations from the top-deck (outdoors). Given the fact that this modus operandi was used, from relatively large ships offering stable and high vantage points, that always well-trained observers were used and that most flying birds in the study area are medium-sized, with light coloration, we feel that detection probability for flying birds within 300 m approached 1.

Behaviour

In addition to recording bird densities, data were collected on bird behaviour (following Camphuysen & Garthe 2004) and on flying altitudes of birds seen in flight, following methods used for standardized counts of birds migrating over land (LWVT 1985; Lensink 2002; Leopold *et al.* 2004) and using altitude classes as given in *Table 2*. These additional data were collected for all birds seen and incorporated in the standard (ESAS) protocol.

Table 2 Altitude classes used to describe the flying height (in meters above sea level) for birds seen in flight

Altitude Class	Altitude range (m asl)
1	0-2
2	2-10
3	10-25
4	25-50
5	50-100
6	100-200
7	> 200

3. Results

Effort, sea states and fishing activities

From April 2010 till February 2011 11 surveys, totalling to 48 at-sea days, 4610 5-minute counts were conducted over a distance of 9021 km. At a counting strip width of mostly 300 m (200 m over a very small percentage of the counts), this amounts to a total surveyed area of 2706 km^2 (see Table 3 and *Figure 3*). The species specific effective strip width (ESW), however, is smaller than 300 m (see species accounts). Due to changes in day length and weather conditions, the amount of effort spent differs between surveys (see Table 3 and Figure 4). During all surveys only part of the transects on the DCS could be covered. The lowest effort was realised in September and between November and January; the highest effort between April and August. The effort was mostly determined by sea state. The resulting spatial coverage is uneven (
Figure *3*).

No data were collected during March 2011, although there was a plankton survey. This was due to changed last-minute planning and the unavailability of professional observers at such short notice.

Observations were conducted only at sea states ranging from 0 to 6 – observations were stopped at sea states exceeding 6 Bft. The highest sea states were encountered in autumn (see Figure 5).

Table 3 Observer effort per survey

Year	**Month**	**Ship**	**Observers[1]**	**Days**	**5-min counts**	**Area (km^2)**	**Distance (km)**
2010	April	ms Arca	ML & HV	5	562	335.2	1115.8
	May	ms Arca	ML & RvB	7	690	403.6	1343.6
	June	Tridens II	HV & SG	4	551	347.2	1157.7
	July	ms Arca	RvB & GK	5	640	373.7	1245.6
	August	ms Zirfaea	SG & GK	5	590	291.3	971.1
	September	ms Zirfaea	ML & RW	3	277	139.7	465.5
	October	Tridens II	HV & SG	5	412	261.1	870.2
	November	Tridens II	ML & HV	3	148	97.5	325.0
	December	Tridens II	SG & RW	2	130	84.2	280.6
2011	January	Tridens II	RW & LW	4	207	141.1	470.5
	February	ms Arca	RvB & SG	5	398	230.9	772.4
Total				**48**	**4605**	**2705.5**	**9018.1**

[1] **RvB** Rob van Bemmelen; **SG** Steve Geelhoed; **GK** Guido Keijl; **ML** Mardik Leopold; **HV** Hans Verdaat; **LW** Louis Witte; **RW** Richard Witte

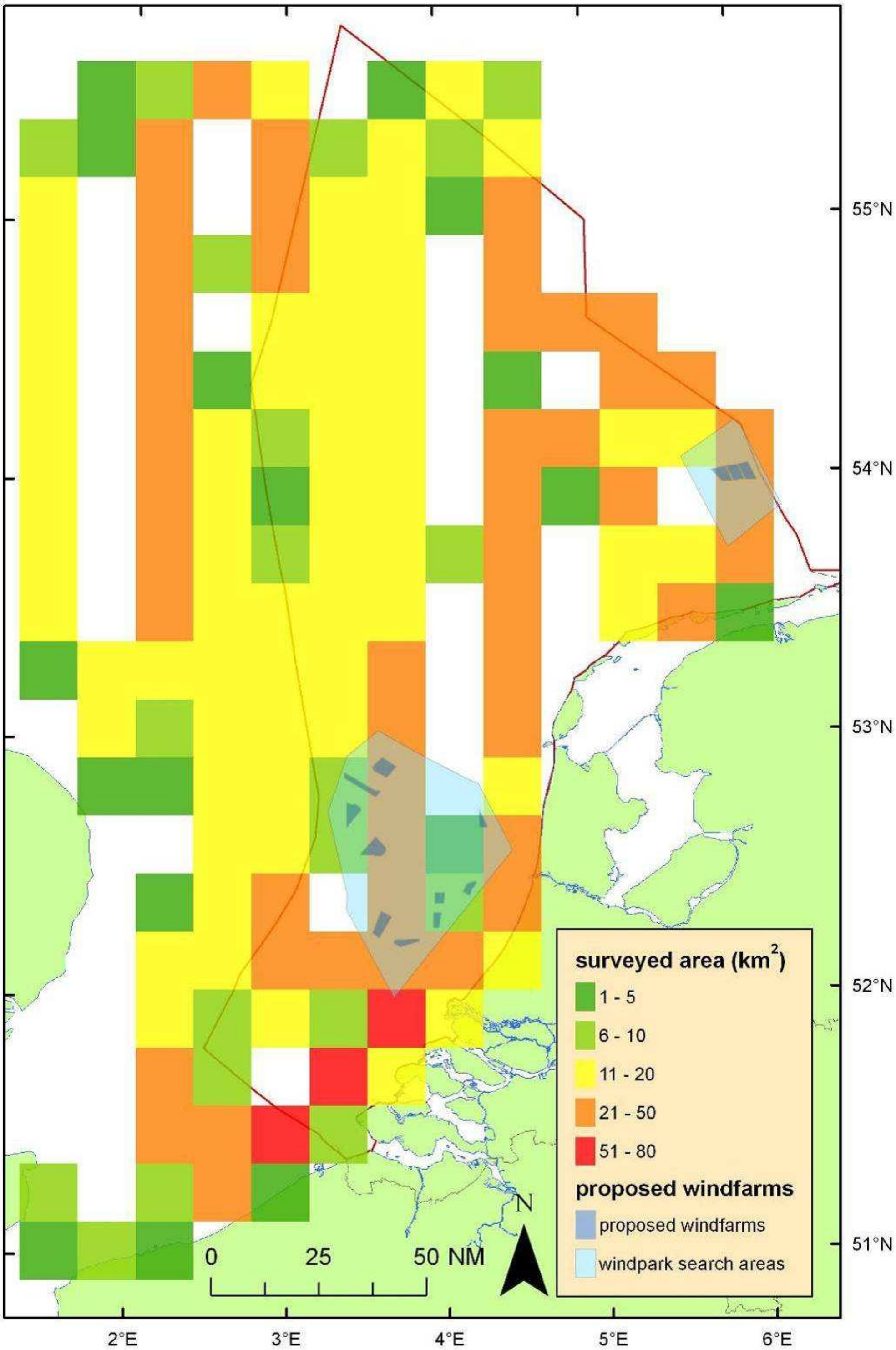

Figure 3 *Total surveyed area (km^2) per 25x25km block. This is the summation of the area surveyed during each 5-minute count (which is the distance travelled multiplied by the counting strip width) of which the midpoints fall within the boundaries of a 25x25 block. Therefore, this may include segments covered in more than one visit*

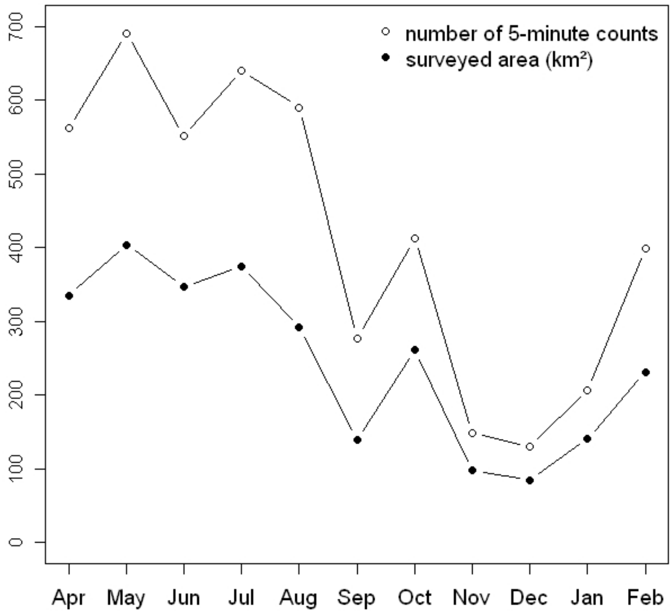

Figure 4 *Effort per month, expressed as the number of 5-minute counts and the surveyed area (km^2)*

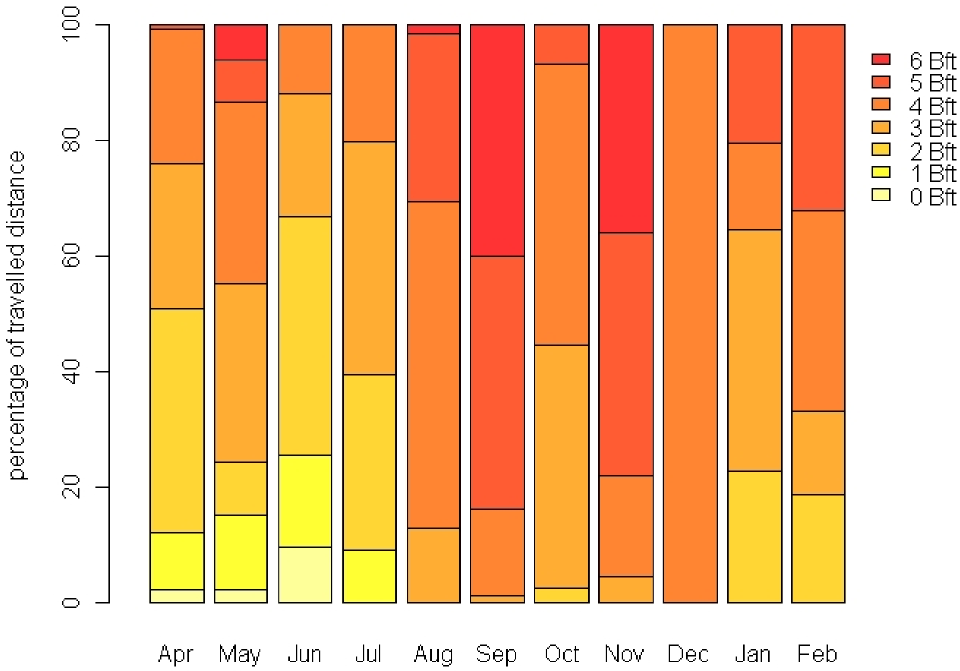

Figure 5 *Distribution of sea states over travelled distance per survey*

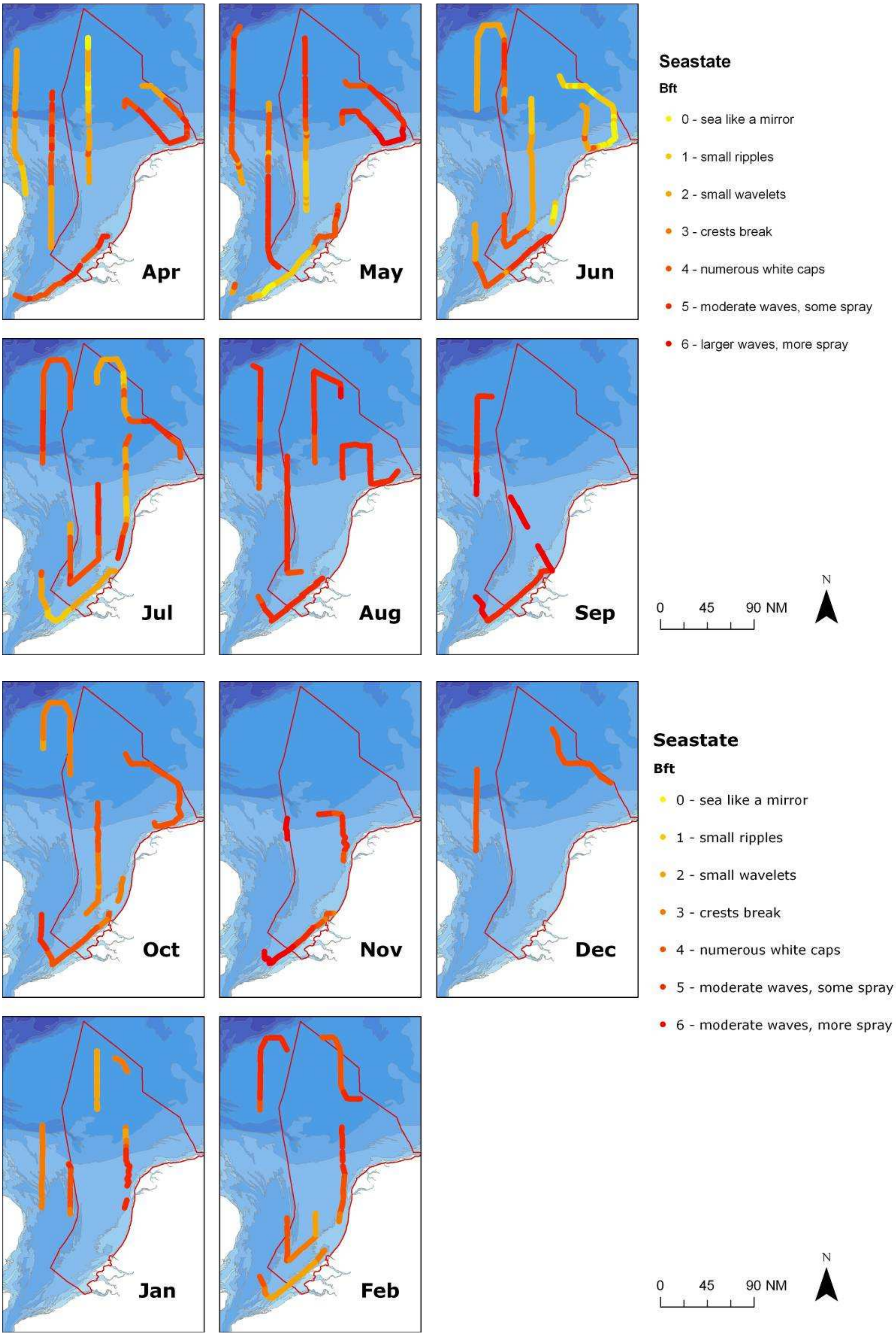

Figure 6 Sea states (Bft) during the surveys in April 2010 - February 2011

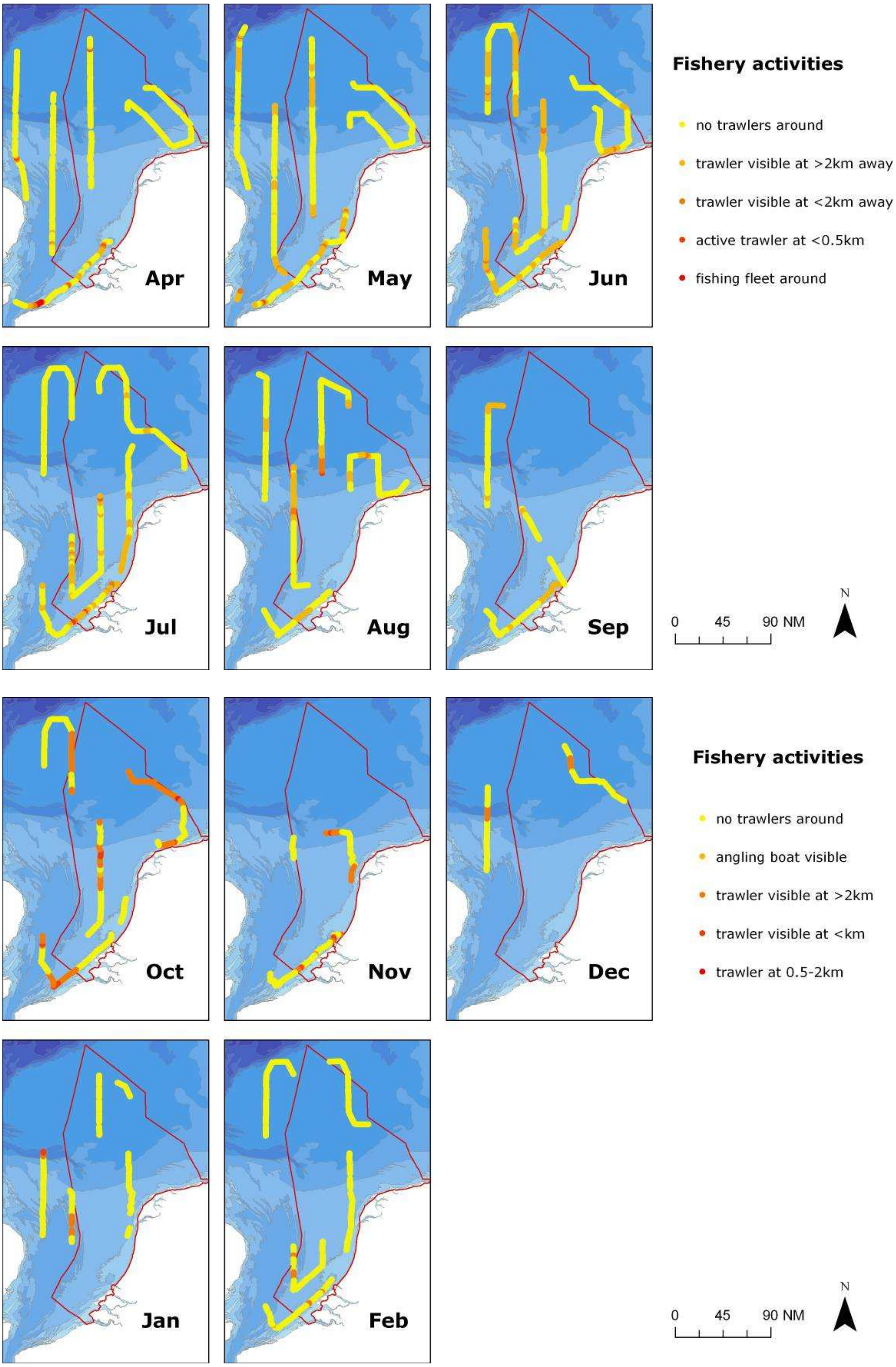

Figure 7 Fishery activities as observed during surveys in April 2010 - February 2011

Fishing activities

Active fishery vessels were observed on all surveys, scattered over the entire study area (*Figure 7*). Set nets were mainly recorded off the Belgian coast.

Collected data

In total, 54593 individuals of 90 bird species were recorded. Of these, 15003 individuals of 36 species were recorded within the counting strip. Marine mammals were represented by 616 individuals of seven species, of which 389 individuals of six species were seen within the counting strip. Flying heights were noted for 5044 clusters of individuals, covering 75 species. Behaviour and/or associations were noted for 1790 (clusters of) individuals. Apart from birds and marine mammals ‘anthropogenic’ objects were counted. In total 352 balloons were counted, of which 164 were within the counting strip (see Table 5 and Table 6 for details). Furthermore, 48 set net (flags) were noted, of which 15 within the counting strip.

Detection probabilities

Detection probability curves have been determined for swimming Northern Fulmars, Northern Gannets, Lesser Black-backed Gulls, Black-legged Kittiwakes, large alcids (Common Guillemot and Razorbill), small alcids (Atlantic Puffin and Little Auk), Harbour Porpoises and balloons. Alcids are rather hard to detect on the water as they often occur singly and are dark-backed, which makes them hard to see in less sunny conditions and at greater distances. Harbour Porpoises are even harder to detect, as they stay mostly under water. The latter only surface to breathe, as opposed to auks that only dive to feed: “surfacers” versus “divers”. Porpoises near the track line are often disturbed by the approaching vessel and might flee away suddenly, with a conspicuous splash, known as “rooster tail”. Animals at greater perpendicular distances are less prone to disturbance and are more often missed. Balloons on the other hand, are often brightly coloured and do not respond to ships. We would therefore expect a flat detection curve for balloons and steep detection curves for Harbour Porpoise and the smaller alcids (Atlantic Puffin and Little Auk), with larger alcids (Razorbill and Guillemot) showing intermediate detection curves. The results are included in the species accounts.

Estimated effective strip widths per sea state per species are presented in *Table 4*, together with their associated correction factors used to correct observed numbers for missed individuals.

Table 4 Estimated Effective Strip Width, corresponding correction factors and the associated sample size per sea state for swimming seabirds, Harbour Porpoises and balloons. Note that esw and cf have been modelled by using all available data, allowing estimates for all cells, even when samples sizes were zero

		Sea state (Bft)						
Species		**0**	**1**	**2**	**3**	**4**	**5**	**6**
Lesser Black-backed Gull	**ss**	48	44	86	77	60	12	7
	esw	263	257	250	243	234	224	214
	cf	1.14	1.17	1.20	1.24	1.28	1.34	1.40
Black-legged Kittiwake	**ss**	0	2	76	87	135	56	11
	esw	267	253	235	212	185	157	130
	cf	1.12	1.18	1.28	1.42	1.62	1.91	2.30
Northern Fulmar	**ss**	3	21	83	117	167	70	3
	esw	285	273	252	220	179	135	99
	cf	1.05	1.10	1.19	1.36	1.68	2.22	3.04
Northern Gannet	**ss**	0	4	50	84	86	45	8
	esw	298	295	287	265	216	144	85
	cf	1.01	1.02	1.05	1.13	1.39	2.08	3.52
large alcids	**ss**	13	156	412	557	570	390	71
(Common Guillemot & Razorbill)	**esw**	238	225	210	193	176	158	141
	cf	1.26	1.34	1.43	1.55	1.71	1.90	2.13
small alcids	**ss**	10	5	13	16	15	35	0
(Atlantic Puffin & Little Auk)	**esw**	195	183	170	157	145	133	122
	cf	1.54	1.64	1.77	1.91	2.07	2.26	2.47
Harbour Porpoise	**ss**	12	37	62	55	27	10	9
	esw	161	160	158	157	156	155	154
	cf	1.86	1.88	1.90	1.91	1.93	1.94	1.95
balloon	**ss**	1	7	35	36	31	9	3
	esw	159	159	159	159	159	160	160
	cf	1.88	1.88	1.88	1.88	1.88	1.88	1.88

ss = sample size; esw = effective strip width; cf = correction factor

Table 5 Species list with total number of recorded individuals and the total number within the transect strip. Note that the total refers to the number of individuals recorded (as opposed to the number of detections or clusters)

Species		**total**	**in transect**
Birds			
Red-throated Diver	*Gavia stellata*	86	17
Black-throated Diver	*Gavia arctica*	15	5
unidentified small diver	*Gavia stellata / G arctica*	25	3
White-billed Diver	*Gavia adamsii*	2	1
unidentified great diver	*Gavia adamsii / G immer*	2	
Red-necked Grebe	*Podiceps grisegena*	2	2
Northern Fulmar	*Fulmarus glacialis*	3457	1583
Sooty Shearwater	*Puffinus griseus*	9	4
Manx Shearwater	*Puffinus puffinus*	6	1
Balearic Shearwater	*Puffinus mauretanicus*	1	
European Storm-petrel	*Hydrobates pelagicus*	4	2
Northern Gannet	*Morus bassanus*	2669	624
Great Cormorant	*Phalacrocorax carbo*	608	315
Greylag Goose	*Anser anser*	5	
Brent Goose	*Branta bernicla*	15	
Common Shelduck	*Tadorna tadorna*	42	
Eurasian Wigeon	*Anas penelope*	7	
Gadwall	*Anas strepera*	2	
EurasianTeal	*Anas crecca*	1	
Tufted Duck	*Aythya fuligula*	5	2
Black Scoter	*Melanitta nigra*	454	12
Red-breasted Merganser	*Mergus serrator*	5	
Osprey	*Pandion haliaetus*	1	
Eurasian Oystercatcher	*Haematopus ostralegus*	3	
Ringed Plover	*Charadrius hiaticula*	1	
Grey Plover	*Pluvialis squatarola*	1	
Northern Lapwing	*Vanellus vanellus*	17	
Red Knot	*Calidris canutus*	4	
Purple Sandpiper	*Calidris maritima*	2	
Dunlin	*Calidris alpina*	1	
Ruff	*Philomachus pugnax*	1	1
Snipe	*Gallinago gallinago*	19	
Eurasian Woodcock	*Scolopax rusticola*	1	
Bar-tailed Godwit	*Limosa lapponica*	1	
Eurasian Curlew	*Numenius arquata*	3	
Common Redshank	*Tringa totanus*	2	1
Common Sandpiper	*Actitis hypoleucos*	1	
Ruddy Turnstone	*Arenaria interpres*	2	
Pomarine Skua	*Stercorarius pomarinus*	16	5
Arctic Skua	*Stercorarius parasiticus*	37	13
Great Skua	*Stercorarius skua*	72	23
Little Gull	*Larus minutus*	301	124
Black-headed Gull	*Larus ridibundus*	393	259
Common Gull	*Larus canus*	835	349
Lesser Black-backed Gull	*Larus fuscus*	18845	3231
Herring / Lesser Black-backed gull	*L. fuscus / L. argentatus*	4100	
Herring Gull	*Larus argentatus*	1652	438
Great Black-backed Gull	*Larus marinus*	2220	591
large gull	*Larus spec.*	226	
Black-legged Kittiwake	*Rissa tridactyla*	8137	1714
Sandwich Tern	*Sterna sandvicensis*	555	141
Common Tern	*Sterna hirundo*	214	104
Arctic Tern	*Sterna paradisaea*	208	109
Common / Arctic tern	*S. hirundo / S. paradisaea*	150	8
Little Tern	*Sterna albifrons*	2	2
Black Tern	*Chlidonias niger*	6	4
Common Guillemot	*Uria aalge*	6810	4575
Common Guillemot / Razorbill	*Alca torda / Uria aalge*	56	27
Razorbill	*Alca torda*	768	542
Little Auk	*Alle alle*	23	9
Atlantic Puffin	*Fratercula arctica*	153	120
domestic pigeon	*Columba livia*	7	

Eurasian Collared Dove	*Streptopelia decaocto*	4	
Common Swift	*Apus apus*	7	
Sky Lark	*Alauda arvensis*	4	
unidentified lark	*unidentified lark*	40	
Barn Swallow	*Hirundo rustica*	7	3
Meadow Pipit	*Anthus pratensis*	6	
Yellow Wagtail	*Motacilla flava*	1	
Grey Wagtail	*Motacilla cinerea*	1	
Pied Wagtail	*Motacilla alba*	2	
European Robin	*Erithacus rubecula*	2	
Common Redstart	*Phoenicurus phoenicurus*	1	
Northern Wheatear	*Oenanthe oenanthe*	4	
Ring Ouzel	*Turdus torquatus*	1	
Common Blackbird	*Turdus merula*	24	
Fieldfare	*Turdus pilaris*	3	
Song Thrush	*Turdus philomelos*	4	
Redwing	*Turdus iliacus*	14	
Mistle Thrush	*Turdus viscivorus*	1	
Sedge Warbler	*Acrocephalus schoenobaenus*	1	
Marsh Warbler	*Acrocephalus palustris*	1	
Lesser Whitethroat	*Sylvia curruca*	1	
Common Whitethroat	*Sylvia communis*	1	
Blackcap	*Sylvia atricapilla*	2	
Common Chiffchaff	*Phylloscopus collybita*	5	
Willow Warbler	*Phylloscopus trochilus*	1	
Goldcrest	*Regulus regulus*	3	
Great Tit	*Parus major*	6	
Rook	*Corvus frugilegus*	4	
Common Starling	*Sturnus vulgaris*	1138	38
Chaffinch	*Fringilla coelebs*	3	
Brambling	*Fringilla montifringilla*	1	
Common Linnet	*Carduelis cannabina*	1	
Snow Bunting	*Plectrophenax nivalis*	1	1
Individuals		**54563**	**15003**
Species		**90**	**36**
Marine mammals			
Minke Whale	*Balaenoptera acutorostrata*	3	1
unidentified dolphin	*Dolphin*	3	
Bottlenose Dolphin	*Tursiops truncatus*	3	3
Common Dolphin	*Delphinus delphis*	2	
White-beaked Dolphin	*Lagenorhynchus albirostris*	15	10
Harbour Porpoise	*Phocoena phocoena*	552	348
unidentified seal	*unidentified pinniped*	5	3
Grey Seal	*Halichoerus grypus*	15	8
Common Seal	*Phoca vitulina*	18	16
Individuals		**616**	**389**
Species		**7**	**6**
set net (flag)		48	15
Classic balloon		281	131
Foil balloon		71	33
Total		**352**	**164**

Table 6 *List of species and the absolute numbers counted within the transect per survey. Note that these numbers are lower than those given in the cruise reports, as those included individuals seen outside the counting strip. Only non-passerines and individuals inside the counting strips are included in the analyses*

	2010									2011		
Species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**total**
Birds												
Red-throated Diver	3						1	8			5	17
Black-throated Diver	5											5
White-billed Diver											1	1
unidentified diver	3											3
Red-necked Grebe											2	2
Northern Fulmar	41	1143	260	29	72	8	7	1	1	16	5	1583
Sooty Shearwater					3	1						4
Manx Shearwater						1						1
European Storm-petrel		1				1						2
Northern Gannet	40	20	75	24	60	27	161	30	9	13	165	624
Great Cormorant	5	4	290	11	2	3						315
Tufted Duck	2											2
Black Scoter							8	4				12
Pomarine Skua						1	1	2	1			5
Arctic Skua	6		1		1	5						13
Great Skua	3		5	2	5	3	1	3			1	23
Little Gull	52						45	15	2		10	124
Black-headed Gull		2		2		1	250	4				259
Common Gull	2	2		3	1	1	51	2		4	283	349
Lesser Black-backed Gull	500	696	357	1183	447	23	4	1			20	3231
Herring Gull	10	198	7	165		15	13	11	1	7	11	438
Great Black-backed Gull	50	5	12	10	22	19	355	42	14	13	49	591
Black-legged Kittiwake	81	287	561	48	163	27	53	56	20	64	354	1714
Sandwich Tern	98	20	14	2	5	2						141
Common Tern	3	17	14	1	67	2						104
Arctic Tern	80	14		3	12							109
Common / Arctic tern	7	1										8
Little Tern			2									2
Black Tern	2			2								4
Common Guillemot	337	138	835	505	385	88	665	126	344	305	846	4574
Common Guillemot / Razorbill										17	10	27
Razorbill	83	24	29		2	9	18	50	36	30	261	542
Little Auk									1	1	7	9
Atlantic Puffin	51	17	2	1		1	4			2	42	120
Total (individuals)	**1464**	**2589**	**2464**	**1991**	**1248**	**239**	**1637**	**355**	**429**	**472**	**2072**	**14960**
Total (species)	**21**	**16**	**15**	**16**	**16**	**21**	**16**	**15**	**10**	**10**	**16**	**33**

Table 6 *(continued)*

	2010									2011		
Species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**total**
Marine mammals												
Minke Whale			1									1
Bottlenose Dolphin							3					3
White-beaked Dolphin		10										10
Harbour Porpoise	61	70	83	50	4	20	11	5	2	3	39	348
unidentified seal			1	2								3
Grey Seal	1	1		2		1		1		1	1	8
Common Seal	1	2	8	1				2	1		1	16
Total (individuals)	**63**	**83**	**93**	**55**	**4**	**21**	**14**	**8**	**3**	**4**	**41**	**389**
Total (species)	**3**	**4**	**3**	**3**	**1**	**2**	**2**	**3**	**2**	**2**	**3**	**6**
Objects												
Set net (flag)	4	3	4	2	1						1	15
Classic balloon	48	3		45	11	9	2			2	11	131
Foil balloon	11	8		14								33
Total balloons	**59**	**11**	**0**	**59**	**11**	**9**	**2**	**0**	**0**	**2**	**11**	**164**
5-min counts												
Count with no birds/mammals	123	162	151	172	215	102	92	9	14	40	51	1131
Count with birds/mammals	439	528	400	468	375	175	320	139	116	167	347	3474
Percentage counts with no birds/mammals	22	23	27	27	36	37	22	6	11	19	13	25
Total number of counts	**562**	**690**	**551**	**640**	**590**	**277**	**412**	**148**	**130**	**207**	**398**	**4605**

Species accounts

Species accounts are presented per species group and contain at least the following information: spatial distribution, seasonal occurrence and behaviour (including flying heights). If relevant, data on moult and age-composition is presented and discussed. Detection curves are presented for Northern Gannet, Northern Fulmar, Black-legged Kittiwake, Lesser Black-backed Gull, large alcids (Common Guillemot and Razorbill), small alcids (Atlantic Puffin and Little Auk), Harbour Porpoises and balloons. These are the species for which the sample size (the number of clusters of birds sitting on the water) was large enough to allow reasonable model output.

For abundant species spatial distribution is illustrated with maps, showing monthly distribution patterns of birds seen within the transect. For scarcer species, observations are plotted in one map. In case of divers, rare tubenoses, cetaceans and seals, sightings outside the transect are also plotted.

In addition, the vulnerability to wind farms (see below),and the species conservation status are shown in the species headings. These are meant to help the reader assess the importance of the particular species to planning of wind farms.

Wind farm sensitivity index
To quantify the vulnerability of seabirds to wind farms, Garthe & Hüppop (2004) developed a windfarm sensitivity index for seabirds in German waters. This index is based on nine species-specific factors grouped in flight behaviour (flight manoeuvrability; flight altitude; percentage of time flying; nocturnal flight activity), general behaviour (sensitivity towards disturbance by ship and helicopter traffic; flexibility in habitat use) and status (biogeographical population size; adult survival rate; and European threat and conservation status). Each factor was scored on a 5-point scale from 1 (low vulnerability) to 5 (high vulnerability). For all three groups, an average score was calculated, which were multiplied by each other to give a species specific index (SSI). Since several species were not assigned an index by Garthe & Hüppop (2004), their work has been extrapolated to Dutch waters by Leopold & Dijkman (2010) for an assessment of future offshore wind farms in relation to birds on the Dutch Continental Shelf. Apart from an extension of considered species, the SSIs were adjusted for a number of species by the sensitivity to ship disturbance (*cf.* Garthe & Hüppop 2004). The indices are presented in Appendix A.

These indices should be used with caution – low values do not necessarily mean that there is no or little effect on small scales. Another criticism on these indices is that they do not consider the sensitivity to wind farms by birds at the sea surface. The physical presence of the turbines or produced (underwater) sound can cause animals to partly or completely avoid the area. Alternatively, the presence of the turbines can result in the creation of an artificial reef, in which the foundations of the wind mills act as a substrate on which animals and plants can grow, thereby attracting fish. Such changes to the fish fauna and productivity are likely to be neutral or even positive to opportunistic feeders like Cormorants or Harbour porpoises.

Conservation status
The conservation status is reflected by the status assessment of the International Union for Conservation of Nature (IUCN) and the listing of the species in appendices of the Bonn Convention and the Bern Convention. The IUCN is the world's main authority on the conservation status of species. The aim of the IUCN Red List of threatened species is to assess the risk of extinction. From low to high conservation status, the following categories are used: Least Concern (LC), Near-threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX).

The Bonn Convention, also known as the Convention on the Conservation of Migratory Species (CMS), aims to conserve migratory species. Membership parties strive to protect these species and their habitats. In Appendix I of the convention, migratory species threatened with extinction are listed. Appendix II lists species that need or would significantly benefit from international co-operation.

The Bern Convention, in full the Bern Convention on the Conservation of European Wildlife and Natural Habitats, is aimed at conserving wild flora and fauna and their natural habitats. Strictly protected fauna species are listed in Appendix II; protected fauna species are listed in Appendix III

Photo 1 Two Northern Gannets. (Guido Keijl)

Divers

White-billed Diver Gavia adamsii

SSI = 68.3; Conservation status: IUCN (2009): Near Threatened; Appendix II Bonn Convention

Red-throated Diver Gavia stellata

SSI =45.0; Conservation status: Annex I Birds Directive; Appendix II Bonn Convention; Appendix II Bern Convention; IUCN (2009): Least Concern

Black-throated Diver Gavia arctica

SSI = 49.5; Conservation status: IUCN (2009): Least Concern; Appendix II Bonn Convention

Divers are ranked as the most sensitive species with regards to offshore windfarms (Garthe & Hüppop 2004; Leopold & Dijkman 2010). Red-throated and Black-throated Divers are notoriously difficult to survey from ships, since they flee at great distance for approaching vessels. Furthermore divers in winter plumage are difficult to recognize, when seen under less optimal observation conditions. During the surveys 79,2% of the divers (n = 130) could be identified to species level. The ratio between the two smaller species Black-throated and Red-throated Diver was 1:5.7 within the transects. Divers were seen between October and April.

Red-throated Diver was the most abundant species, with a distribution that was mainly restricted to the coastal zone (*Figure 9*). Some Red-throated Divers were seen in areas further offshore, especially in April, probably reflecting offshore migration routes. Highest numbers were found in November and February. It should be noted, however, that the effort in the intervening period was relatively low.

Black-throated Divers showed a complementary distribution pattern to that of Red-throated Divers, with most observations further offshore and virtually no records in the coastal zone. In April offshore migration of Black-throated Divers was noted. Sightings from this survey dominate the offshore areas in the distribution map *Figure 9*. This phenomenon has been described by Stegeman & Den Ouden (1995), but the exact migration routes are not clear. The migration routes and the migration intensity probably depend on wind direction and wind speed, as observed during sea watches along the Dutch mainland coast (Van der Ham, 1987).

The sightings of White-billed Divers in April 2010 and February 2011 at the Dogger Bank are interesting. The species breeds in Arctic Alaska, Canada and Russia and the main part of the small European wintering population (ca. 500 individuals) can be found along the Norwegian coast. Numbers seen in the Baltic have probably increased over the last decades (Bellebaum *et al*. 2010). In the breeding area, numbers show a moderately rapid decline, apparently due to harvesting by indigenous people (IUCN 2010). Therefore, the IUCN changed its status on the Red List of endangered species to "Near Threatened". The fact that both records made during the surveys resulted from only a relatively minor amount of effort spent in the Dogger Bank area contrasts heavily with the status as a vagrant in the Netherlands. Despite a huge observer effort by birdwatchers, only 36 records were accepted in the period 1800 – 2009 by the CDNA, the Dutch Rarity Committee (van der Vliet *et al.* 2007; Ovaa *et al.* 2009). This suggests that the Dogger Bank may be a wintering location for White-billed Divers. This calls for dedicated surveys to assess the size of this population and the extent to which this population uses the Dutch part of the Dogger Bank.

A small proportion of the divers (26,7%, n = 101) was seen at the sea surface; of which one Red-throated Diver was apparently diving for food. The majority was seen flying, presumably partly disturbed by the approaching vessel. Of the Red-throated divers 73,5% were seen flying (n = 86), the percentage of flying Black-throated Divers was 60% (n = 15). The data on flight altitudes were pooled (*Figure 8*), and show that flying divers were predominantly seen in the lower height classes (< 25 m), with a median height of 2-10 m. A small proportion was flying at higher altitudes between 25-50 m. Group size apparently did not influence the flying height. These findings are in accordance with coastal observations of migrating divers in the North Sea, which may fly well below 25 meters but predominantly directly above the sea surface (pers obs). Systematic observations on Wangerooge in autumn 1999 (Krüger & Garthe, 2001) quantify these findings for Red-throated Divers, showing that migrating individuals mostly fly at altitudes below 25 m. Flying height is lower with headwinds than with tailwinds. In headwinds the proportion of low (< 1.5 m) flying birds increased from 60% in light winds to 100% at wind speeds above 10.8 m/sec. During tail winds the greatest percentage of Red-throated Divers remained low-flyers, but the proportion of birds flying at medium heights (1.5-12 m) increased with higher wind speed.

Twenty per cent of the 'small divers' (Red-throated or Black-throated Divers) remained unidentified (n=126). Of the proportion identified, 86% was identified as Red-throated and the remainder as Black-throated Diver (n=101). For comparison: during land-based migration counts, only 16% of the 'small divers is identified (Camphuysen 2009b). Also during aerial surveys, only a very small proportion of the birds can be identified to species level with confidence (e.g. Baptist & Wolf 1993; Arts 2010).

Given their vulnerability to offshore wind farms (Garthe & Hüppop 2004, Leopold & Dijkman 2010), the offshore spring migration and the likely existence of a wintering population of White-billed Divers call for special attention during planning of wind farms.

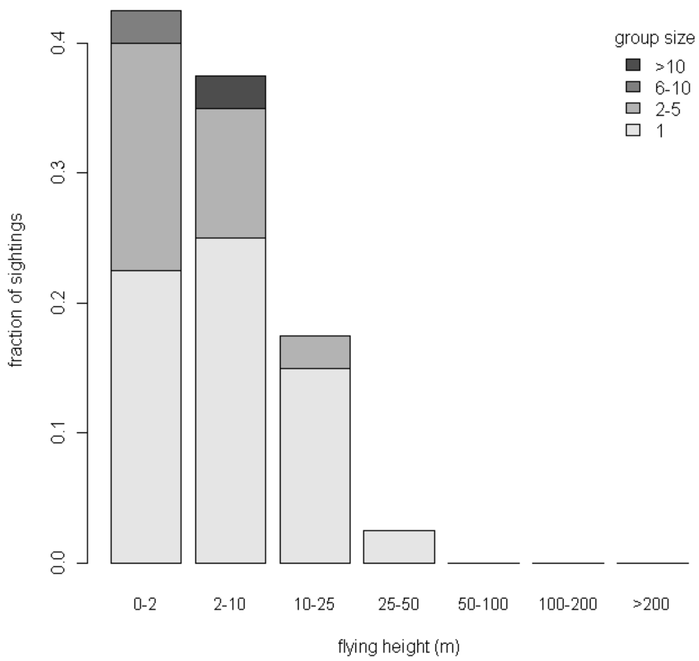

Figure 8 Flying heights of Red-throated and Black-throated Divers (n=40)

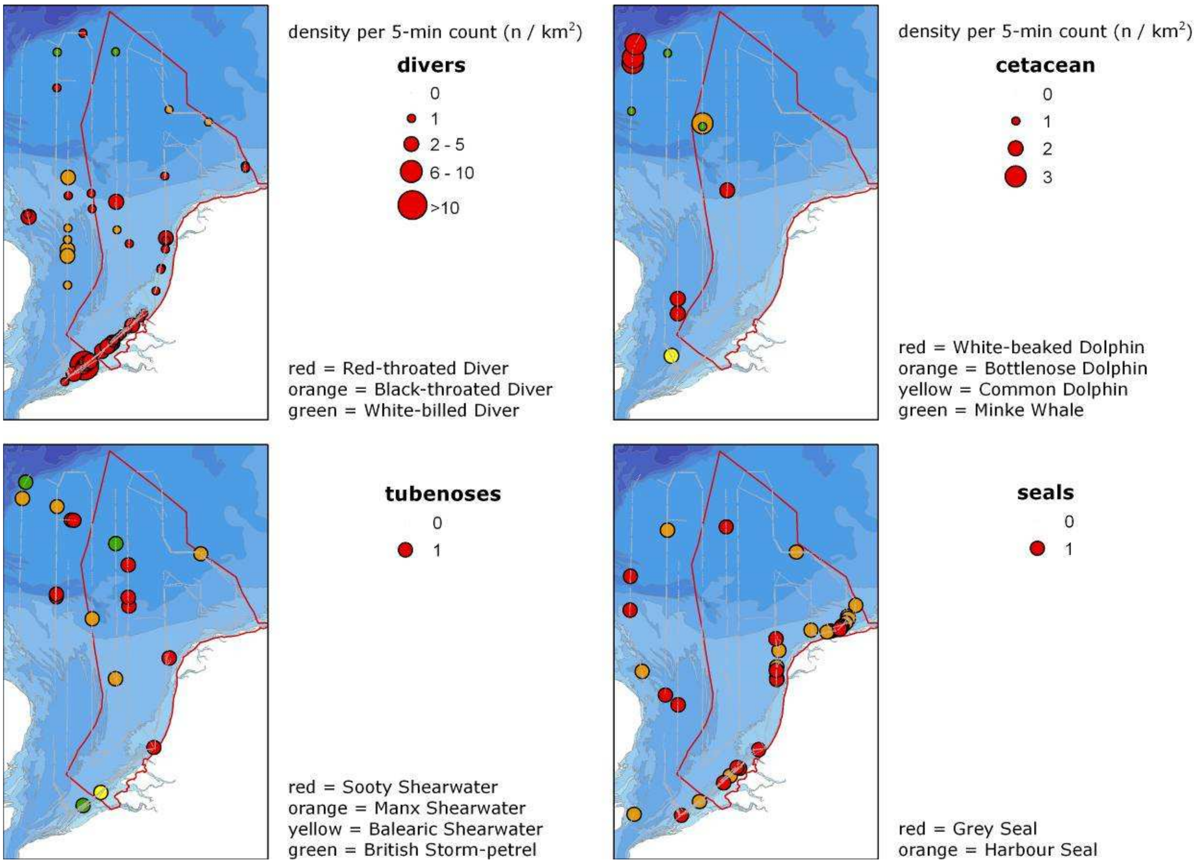

Figure 9 Maps showing sightings of four groups of rarer species for all surveys combined: divers (Red-throated, Black-throated and White-billed Diver); tubenoses (Sooty, Manx and Balearic Shearwater and British Storm-petrel); cetaceans other than Harbour Porpoise (White-beaked, Bottlenose and Common Dolphin and Minke Whale); and seals (Grey and Harbour Seal). Unidentified divers, cetaceans and seals are not shown

Tubenoses

Northern Fulmar Fulmarus glacialis

SSI = 5.8; Conservation status: IUCN (2009): Least Concern

From the tubenoses, Northern Fulmar ranks among the species with the lowest wind farm sensitivity index values.

During the surveys Northern Fulmar was by far the most numerous tubenose. Its distribution was limited to offshore areas, without any observations in the coastal zone. Areas with high densities include the Dogger Bank, the Cleaver Bank, English Channel and the Frisian Front (*Figure 10*). Northern Fulmars showed a clear seasonal pattern with highest densities during May-August and lowest densities during autumn and winter. Virtually all birds belonged to the light morph (van Franeker & Wattel 1982), that constitutes the majority of the breeders in southern latitudes. Observations of individuals belonging to the dark morph, breeding at higher latitudes, were scarce (n = 14) and showed no clear pattern.

The majority of the Fulmars of which the behaviour was recorded, was seen resting or asleep at the sea surface, 5% was scavenging around fishing vessels, 13% of the animals was actively feeding (either dipping or surface pecking).

About a third of the Fulmars was seen flying (35.1%, n =1927). Flying Fulmars were predominantly seen in the lower height classes (< 10 m), with a median height below 2 m. A small proportion of the birds was flying above 10 m (*Figure 12*). Group size apparently did not influence the flying height. These findings are in accordance with observations of migrating individuals along the North Sea coast, which perform a characteristic flap and glide flight with stiff wings, trailing the sea surface with a wing tip.

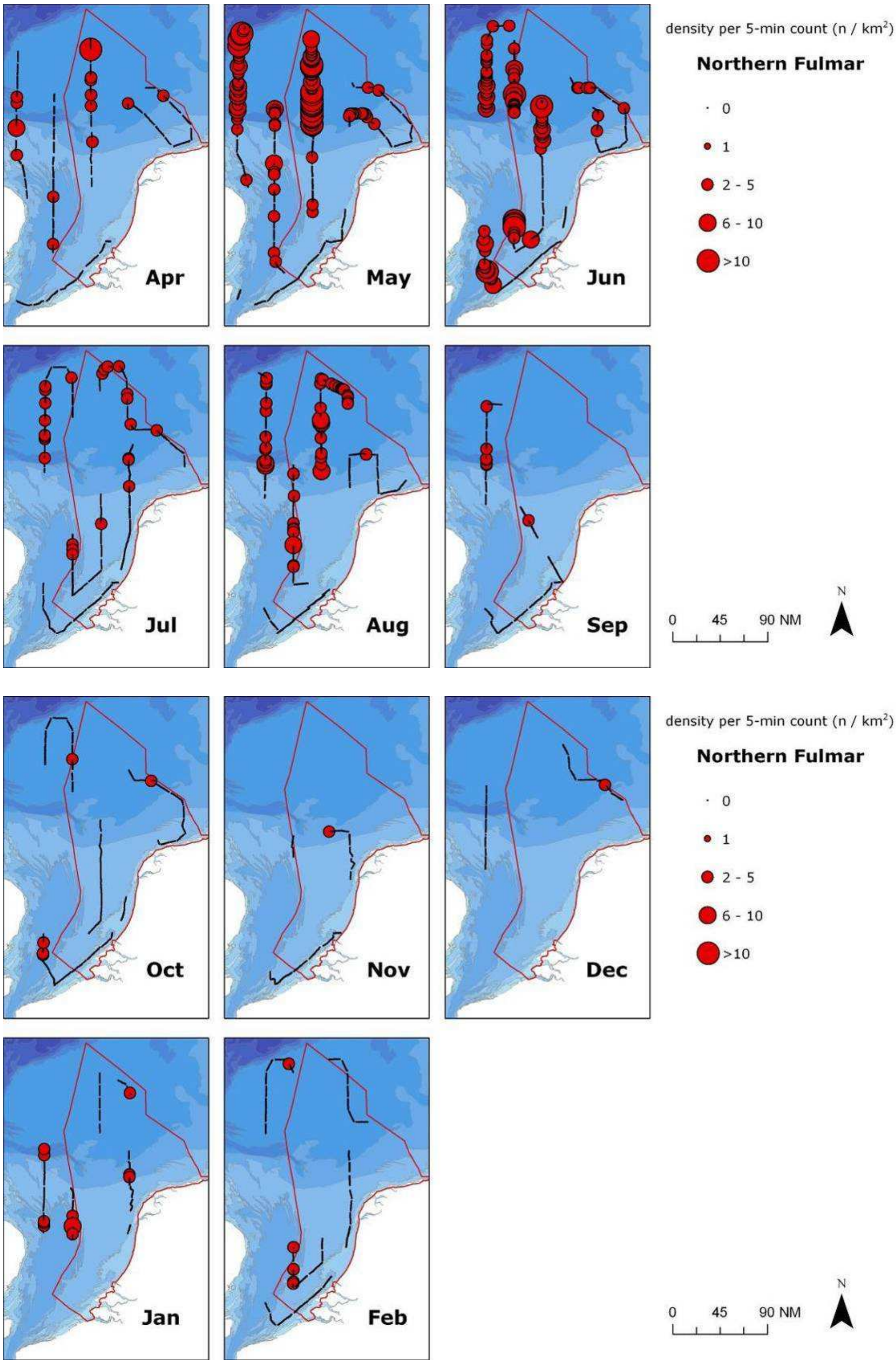

Figure 10 Distribution of Northern Fulmars during surveys in April 2010 – February 2011

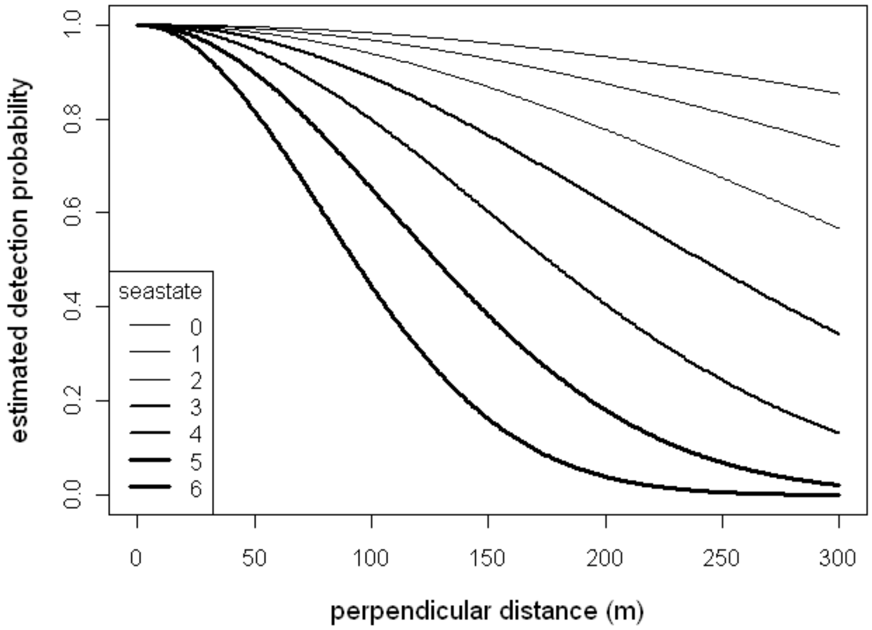

Figure 11 Modelled detection functions of (groups of) swimming Northern Fulmars per sea state (Bft) (n=464). The percentage missed increases with sea state

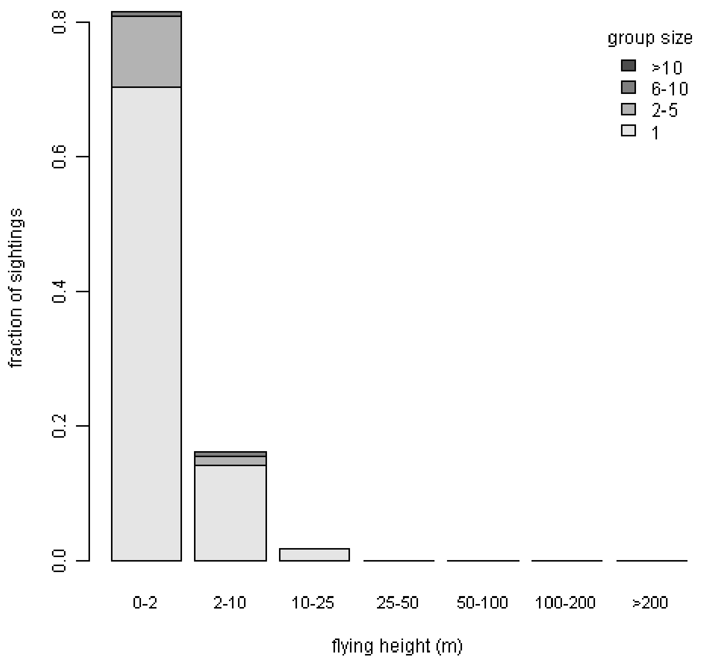

Figure 12 Flying heights of Northern Fulmars (n=557)

Sooty Shearwater Puffinus griseus

SSI = -; Conservation status: IUCN (2009): Near Threatened

Manx Shearwater Puffinus puffinus

SSI = -; Conservation status: IUCN (2009): Least Concern

Balearic Shearwater Puffinus mauretanicus

SSI = -; Conservation status: Appendix I Bonn Convention; IUCN (2009): Critically Endangered

European Storm-petrel Hydrobates pelagicus -

SSI = -; Conservation status: IUCN (2009): Least Concern

Apart from Northern Fulmars, observed tubenose species were European Storm-petrel, Sooty, Manx and Balearic Shearwater. These species were too scarce in German and Dutch waters to warrant a sensitivity index. These species show similarities in flight behaviour and general behaviour, but show marked differences in status. Their behavioural sensitivity to wind farms may therefore be roughly similar to Northern Fulmar, but their vulnerability to habitat loss and/or increased mortality may be different given their conservation status (see above). Like in Northern Fulmar, no studies on the effect of offshore wind farms have yet been conducted in areas where densities of these species are high.

The number of sightings is low, totalling 20 for all species together. These species were mainly seen in offshore areas (*Figure 9*), the only exception was a Balearic Shearwater off Walcheren, Zeeland, in July 2010. Occurrence in near-shore waters seems typical for this species. Also, in July, two Manx Shearwaters were seen; other observations of this species were done in May (1), and August-September (3). Sooty Shearwaters (9) were seen in August-November, with the majority in September. Four observations of European Storm-petrel were made: three in the north western part of the survey area (Apr-May, Sep), one in October off the Belgian coast.

Most shearwaters were seen resting on the sea surface or flying at low altitude. One Sooty Shearwater joined a group of scavenging gulls behind a fishing vessel on 20 August, south(east) of Dogger Bank. Tubenoses typically fly close to the water surface, but in strong winds, especially Sooty Shearwaters can make high arches. All the Sooty Shearwaters recorded flew below 25 m, most flew below 10 m (*Figure 13*).

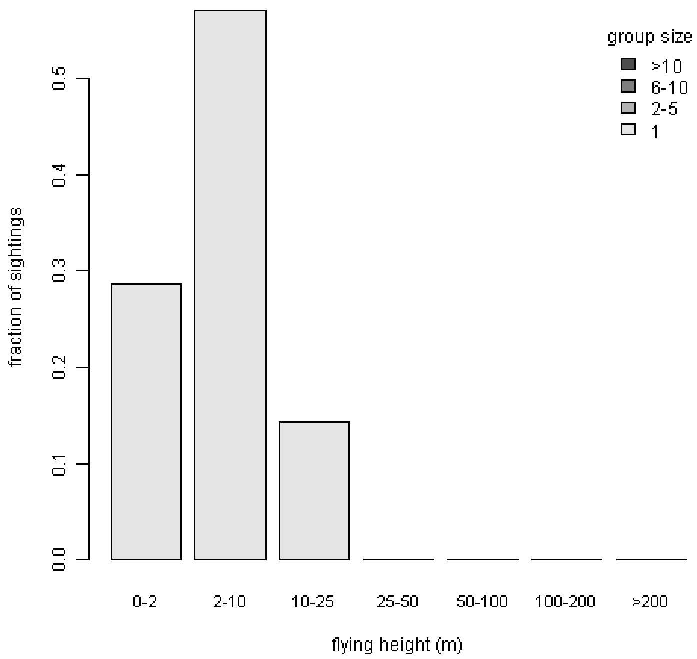

Figure 13 Flying heights of Sooty Shearwaters (n=7)

Gannets

Northern Gannet Morus bassanus

SSI = 11.0; Conservation status: IUCN (2009): Least Concern

The Northern Gannet was assigned a SSI of 11.0, meaning that the species is not particularly sensitive to wind farms.

Gannets were widespread, with a patchy distribution and temporary areas with high densities (*Figure 14*). Adults in spring in the north eastern part of the study area, especially during April-July, may originate from Helgoland. Adults in western areas are likely to originate from colonies of the Bempton cliffs or Bass Rock, Scotland. Satellite-tagged chick-rearing breeders from Bass Rock made regular foraging trips well extending to the Outer Silver Pit and the Dutch part of the Dogger Bank or even further east (Hamer *et al.* 2000; 2007). Two areas regularly held high concentrations of Gannets. First, the Dogger Bank and nearby Silver Pit, especially during June, August and October. Second, the Belgian continental shelf, mainly in April, June, October and February (*Figure 14*).

Gannets acquire their adult plumage after four or five years. During the surveys the plumage of observed individuals has been scored according to the classification of Tasker *et al.* (1986). Immatures (I2-I5) dominated in April-September. The first juveniles (J1) were seen in August. With progressing autumn (migration) the proportion of adults increased. This pattern reflects the migration of North Atlantic Gannets. After the breeding season they migrate to their wintering areas in West-Africa or in the Mediterranean. Adults stay longer at northern latitudes than juvenile and immature birds, and return early to the breeding colonies where most stay in the vicinity of the colonies during the breeding season. Immature birds stay in the wintering grounds or migrate later towards the breeding grounds than adults (Nelson, 1978). This pattern is reflected in the age composition of the Northern Gannets recorded during these surveys (*Figure 15*).

A large part of the Northern Gannets were seen in directional flight (28%), many were resting on the water surface (21%). Gannets seen actively searching for prey comprised 16% of the individuals, some of which were associated with cetaceans; 8% were actually seen diving. Gannets associated with anthropogenic activities, especially with fishing vessels (12%), with the observers' ship and other ships (5%) and with offshore platforms (4%).

Flying Gannets were predominantly seen flying at relatively low altitudes (<25 m), with a median height between 2-10 m. A small proportion of birds was seen flying above 25 m, up to the height class of 100-200 m (*Figure 17*).

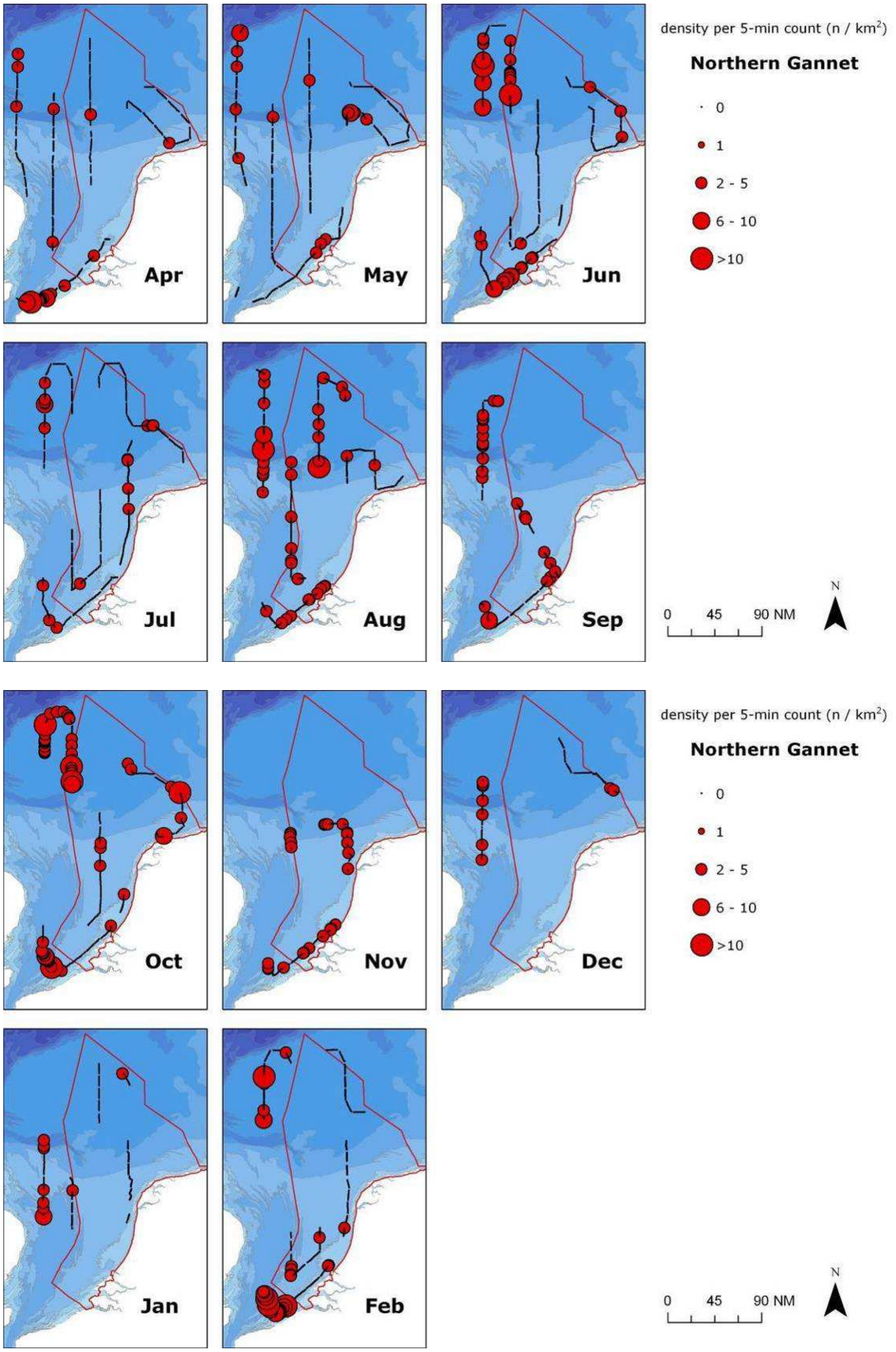

Figure 14 *Distribution of Northern Gannets during surveys in April 2010 – February 2011*

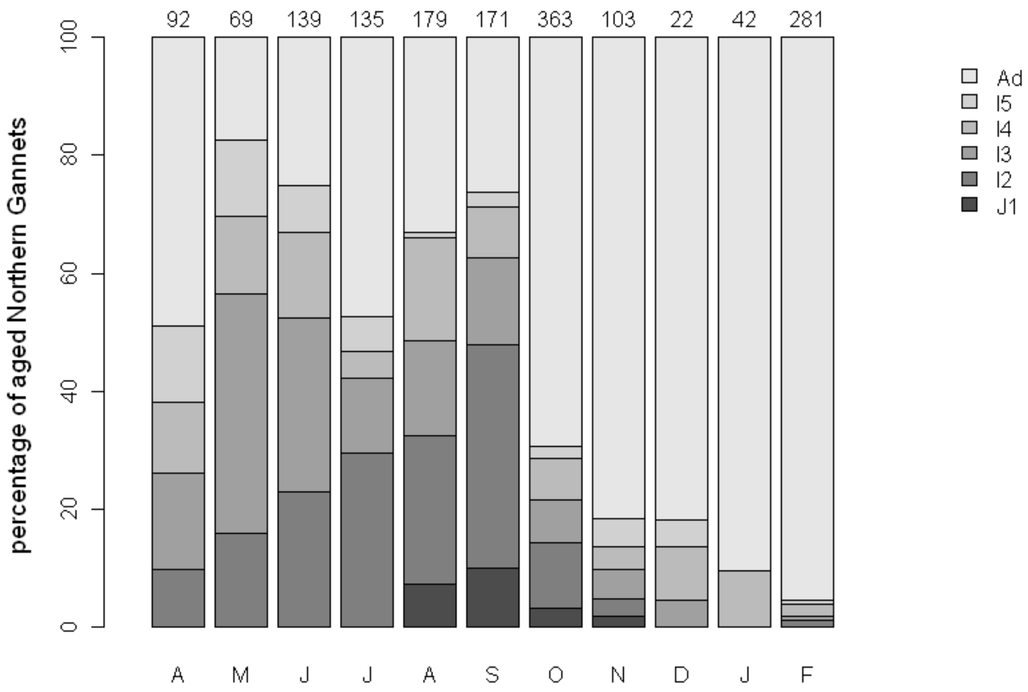

Figure 15 *Plumage composition of Northern Gannets, following the age/plumage classification of Tasker et al. (1986). (n=1596)*

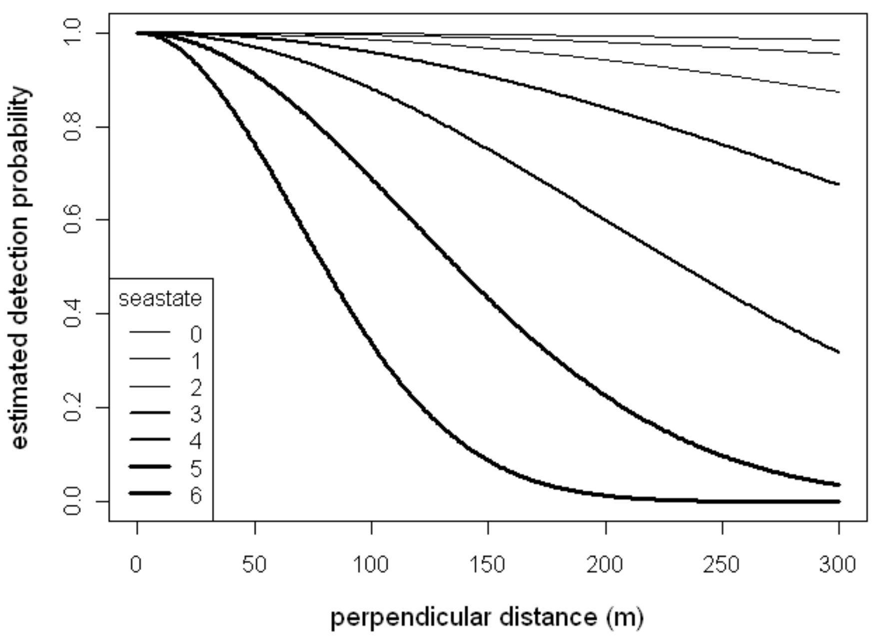

Figure 16 *Modelled detection functions of (groups of) swimming Northern Gannets per sea state (Bft) (n=277). The percentage missed increases dramatically with sea state, but this is probably a result of low sample sizes at high sea states (cf Table 4) and possibly a behavioural effect, in which birds were more prone to alight close to the ship with heavy winds*

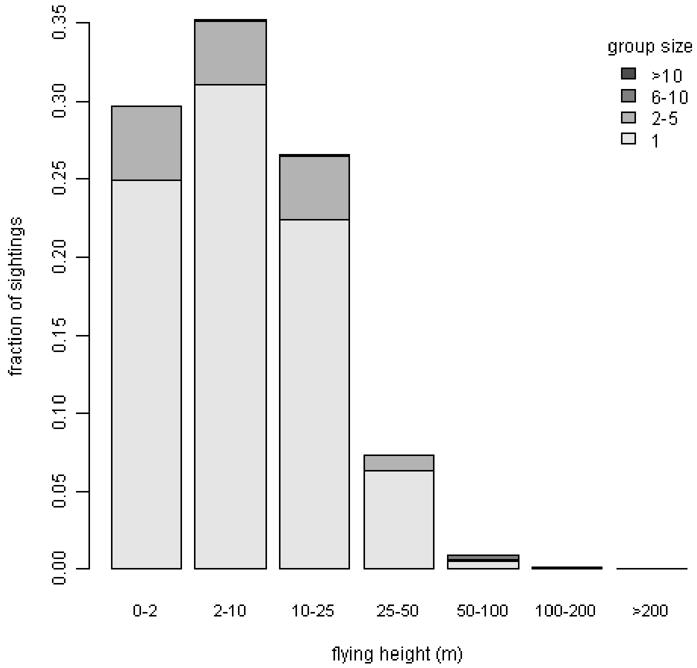

Figure 17 Flying heights of Northern Gannets (n=777)

Skuas

Arctic Skua Stercorarius parasiticus

SSI = 13.3; Conservation status: IUCN (2009): Least Concern

Pomarine Skua Stercorarius pomarinus

SSI = 15.0; Conservation status: IUCN (2009): Least Concern

Great Skua Stercorarius skua

SSI = 16.5; Conservation status: IUCN (2009): Least Concern

Sensitivity index values of skuas range from 13.3 for Arctic to 16.5 for Great Skua, ranking them among species with medium sensitivity to wind farms.

Great Skua was the most numerous skua with observations in almost every month, except May. Most Arctic Skuas were seen in April and September. In April the distribution was restricted to the Belgian coastal zone, despite poor coverage the records in September were distributed over the largest area. Other records were made in June and August. Pomarine Skuas were seen in September-December.

Most skuas were seen flying: ranging from 59.1% for Great Skua, 88.9% for Arctic Skua to 92.8% for Pomarine Skua. Apart from two resting Great Skuas the behaviour of all skuas was recorded as kleptoparasitising. Flying skuas were predominantly seen at lower altitudes (<50 m), with a median height between 2-10 m. A small proportion of birds was seen flying between 50 and 100 m (*Figure 18*).

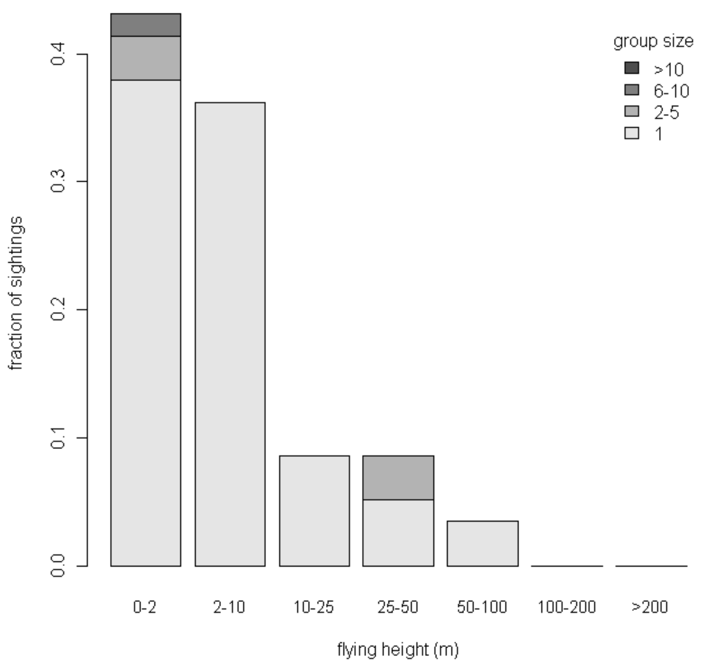

Figure 18 Flying heights of Great, Pomarine and Arctic Skua (n=58)

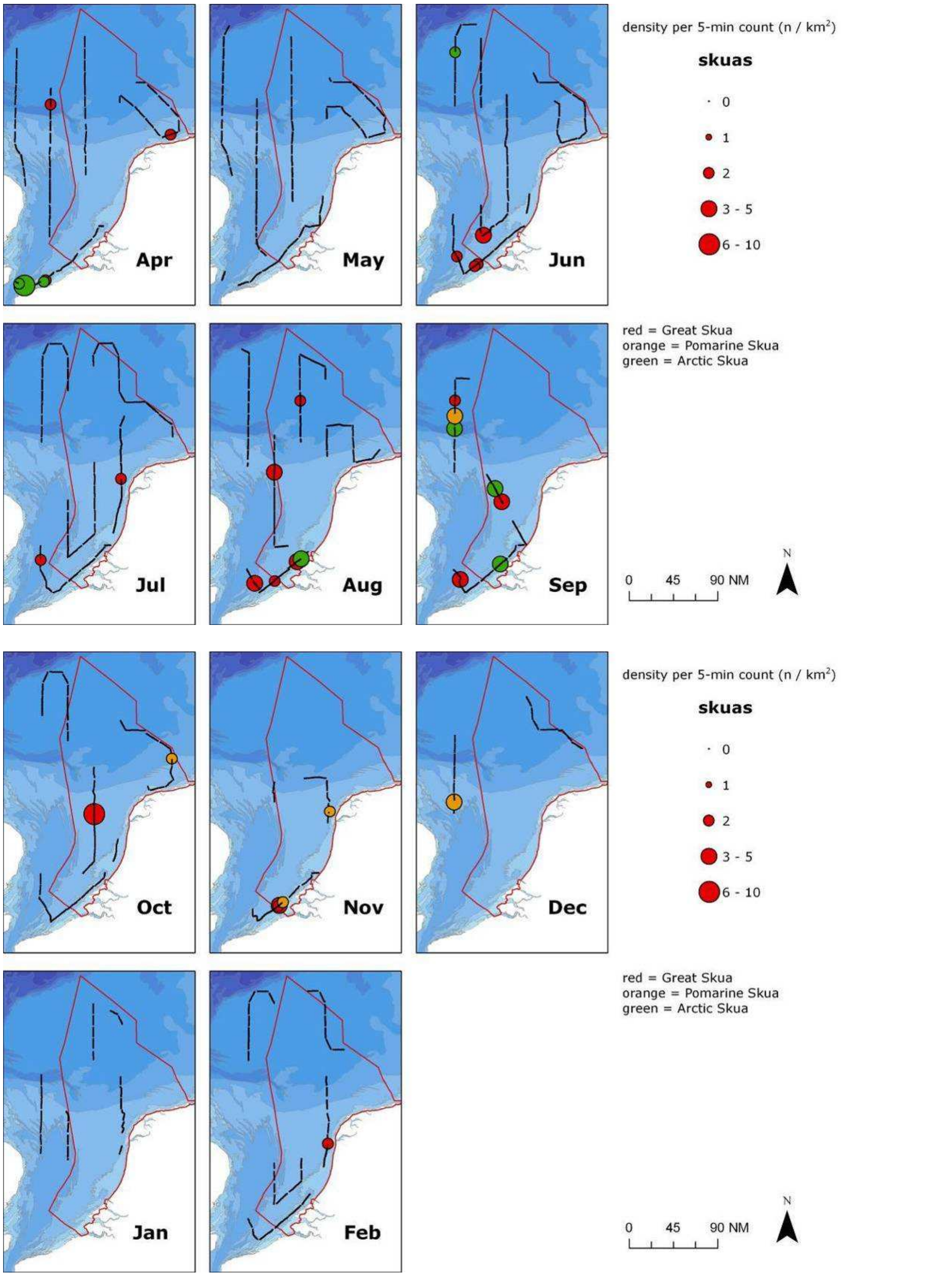

Figure 19 Distribution of skuas during surveys in April 2010 - February 2011

Gulls

Little Gull Hydrocoloeus minutus

SSI = 16.0; Conservation status: Annex I Birds Directive; Appendix II Bern Convention; IUCN (2009): Least Concern

The Little Gull was assigned a vulnerability index for wind farms of 16.0, reflecting a medium sensitivity to wind farms.

This gull was mainly seen in the coastal zone, with offshore sightings in April and October (*Figure 21*). These months coincide with the two distinct seasonal peaks in spring and autumn (Camphuysen, 2009b). Little Gulls were absent in late spring-summer. In winter observations were restricted to November and February (*Figure 21*).

Flying Little Gulls were predominantly seen at lower altitudes (<25 m), with a median height between 2 and 10 m. A small proportion of birds was seen flying between 25 and 100 m (*Figure 20*). Some Little Gulls were seen in association with Common Guillemots (n=5) or Razorbills (n=5).

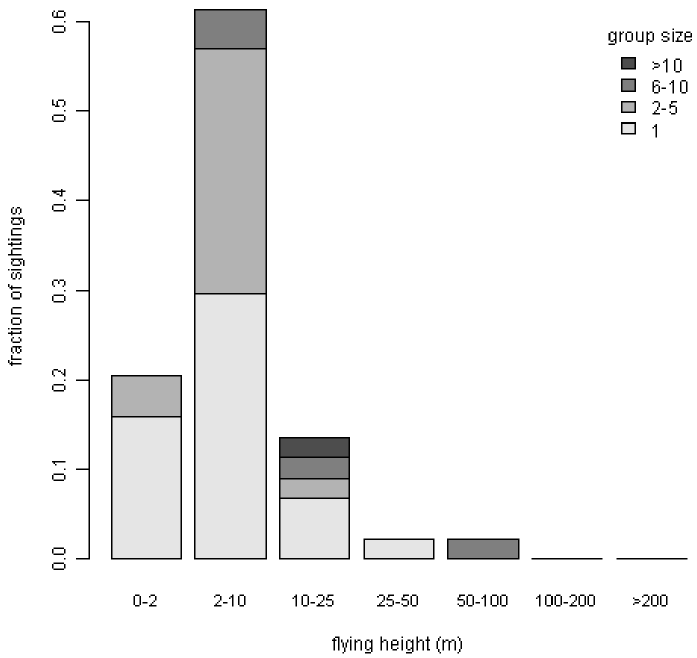

Figure 20 Flying heights of Little Gulls (n=44)

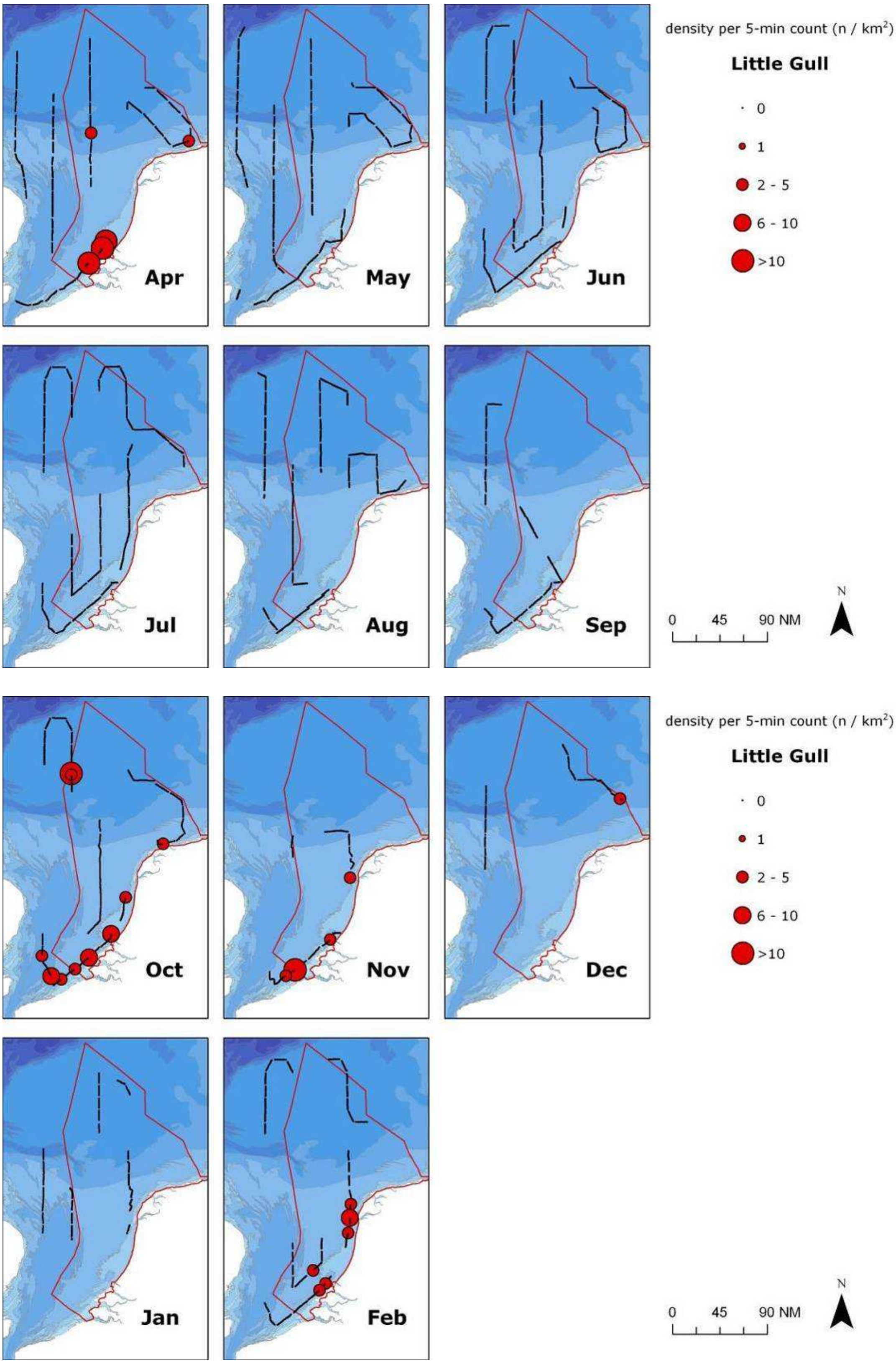

Figure 21 Distribution of Little Gulls during surveys in April 2010 - February 2011

Black-legged Kittiwake Rissa tridactyla

SSI = 5.6; Conservation status: IUCN (2009): Least Concern

The Black-legged Kittiwake was assigned a wind farm sensitivity index of 5.6, being the lowest of all considered species.

Kittiwakes were the second most numerous gull during the surveys. Birds were seen during all surveys. Highest densities were recorded offshore in the (north)western part of the study area, especially in April-August. These months the Dutch coastal zone was devoid of Kittiwakes. From October onwards densities in coastal waters increased (*Figure 22*).

On 25 May, in UK waters a group of prospecting birds was seen flocking around an offshore platform Barque PB (ca. 53°35’52” NB; 001°30’09” EL), just north of the English Banks. One bird was seen carrying nest material towards this platform. Subsequent surveys did not visit the vicinity of this platform, thus rendering it impossible to confirm the first offshore breeding colony in UK waters.

On 23 June 2010 a new breeding colony of Black-legged Kittiwake was discovered on the platform K15-FC-1 (53°15’59” NB; 003°45’44” EL), ca. 75 km west of Vlieland. During the July survey successful breeding could be confirmed as 28 not yet fledged juveniles could be photographed (*Figure 23*). The location of the colony is remarkable, since all other breeding sites known to date are situated in the clear waters north of the Frisian Front (Camphuysen & Leopold 2007). This colony is the first south of it, in more turbid waters.

Many birds associated with the observer ship (69%). Others foraged behind fishing vessels (17%) or around offshore platforms (12%). Black-legged Kittiwakes were regularly seen associating with Common Guillemots (n=85 groups; 390 individual guillemots) and Razorbills (n=73 groups; 253 individual razorbills).

Kittiwakes were seen flying predominantly at lower heights (< 25m), with a median height between 2-10 m. A small proportion of birds was seen flying above 25 m, with some animals flying high (> 100m, *Figure 25*).

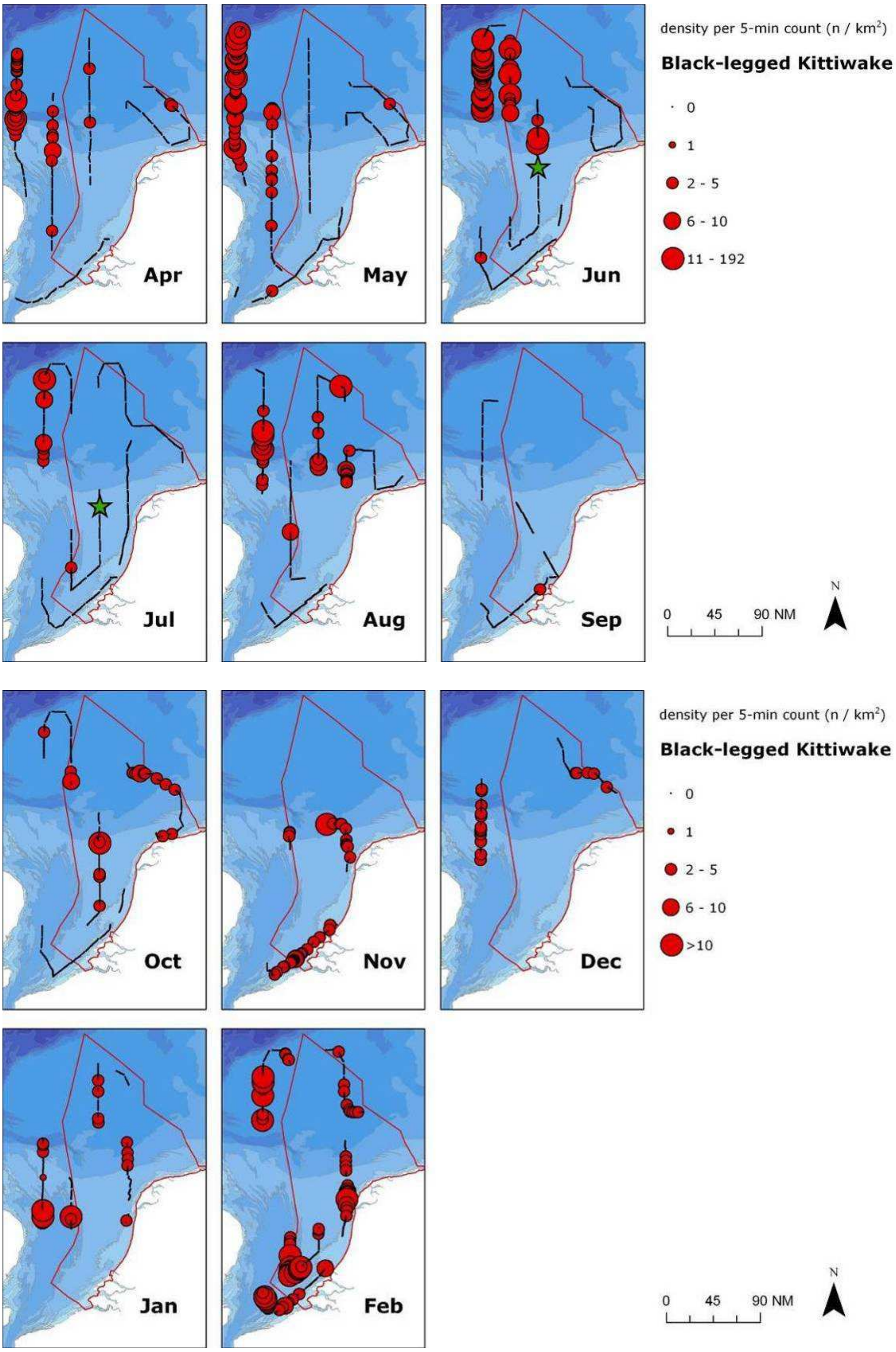

Figure 22 Distribution of Black-legged Kittiwakes during surveys in April 2010 - February 2011. The green stars represent the newly found breeding colony (see text)

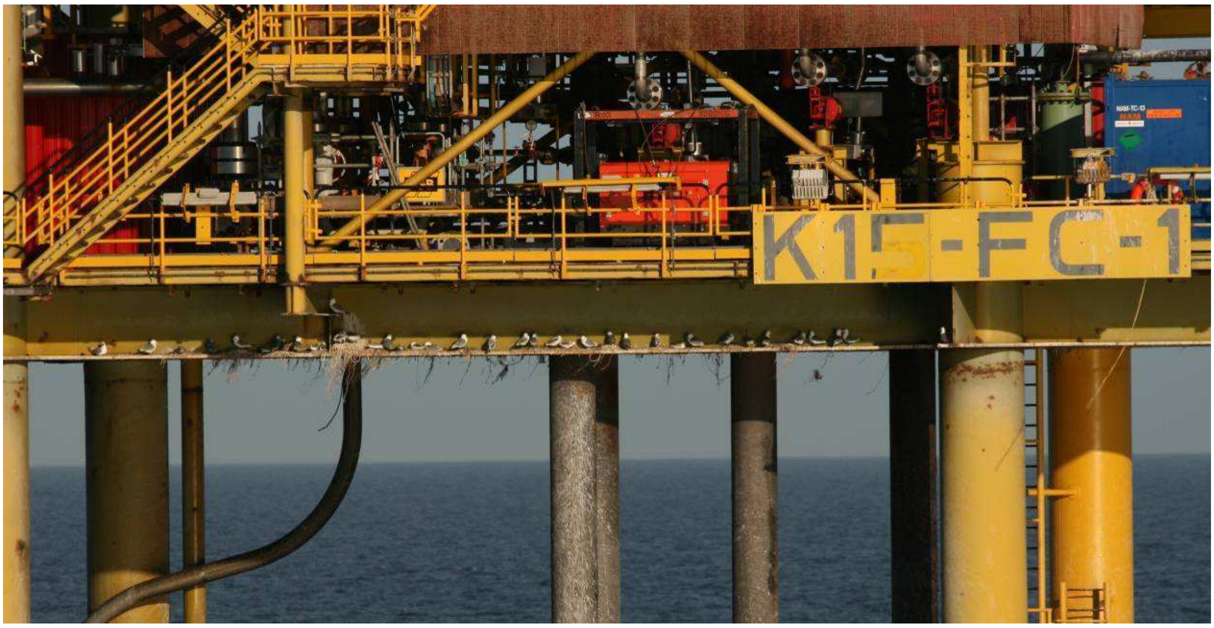

Figure 23 *Part of the newly discovered breeding colony of Black-legged Kittiwakes (July 2010), showing nests, juveniles and adults (Guido Keijl). The location is marked by a green star on the June and July maps overleaf*

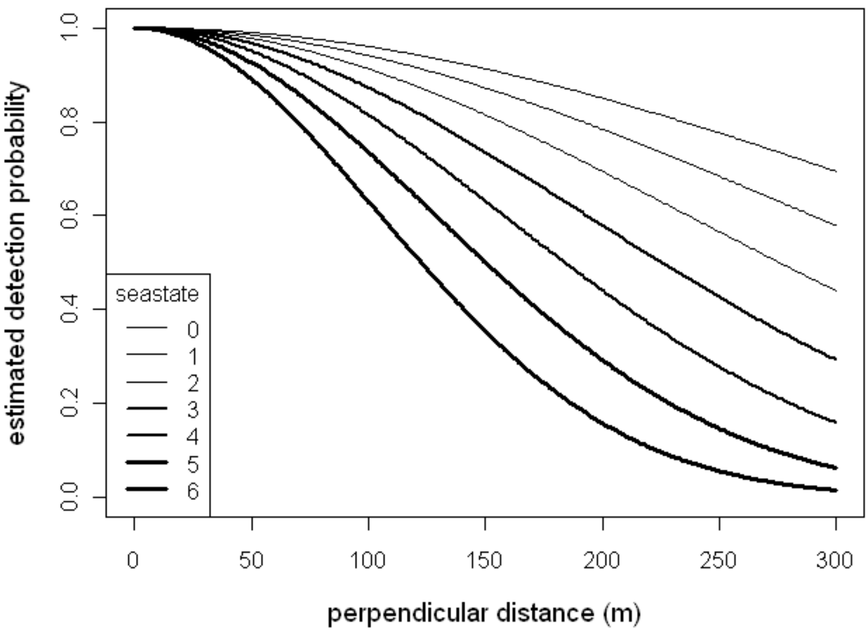

Figure 24 *Modelled detection functions of (groups of) swimming Black-legged Kittiwakes per sea state (Bft) (n=367). The percentage missed increases with sea state*

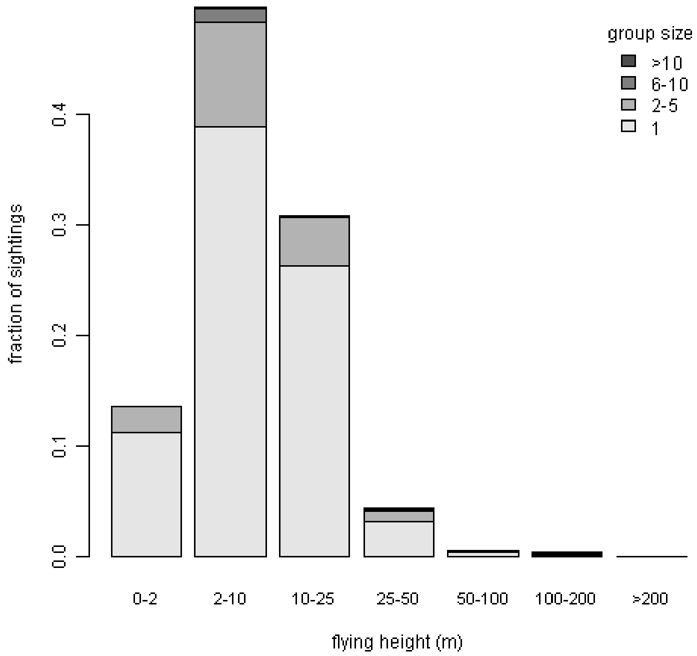

Figure 25 Flying heights of Black-legged Kittiwakes (n=942)

Common Gull Larus canus

SSI = 9.0; Conservation status: IUCN (2009): Least Concern

The Common Gull was ranked amongst the less sensitive species in regard to wind farms.

Densities of Common Gulls were usually low in offshore waters. Somewhat higher densities were encountered in October, January and February. In February, groups of up to 250 birds were seen in near shore waters just before sunset; these birds seemed to use the area for overnight roosting (*Figure 27*).

Common Gulls were seen flying predominantly at lower heights (< 50m), with a median height between 10-25 m. A small proportion of birds was seen flying above 50 m (*Figure 26*).

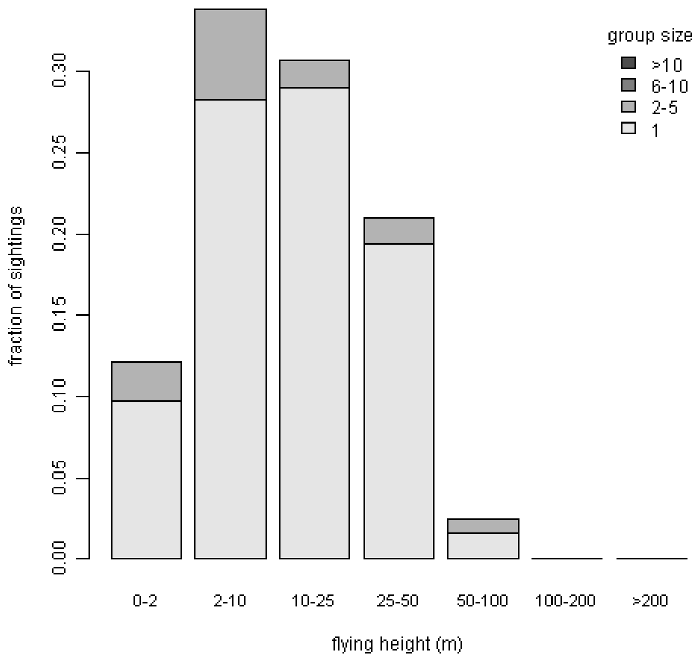

Figure 26 Flying heights of Common Gulls (n=124)

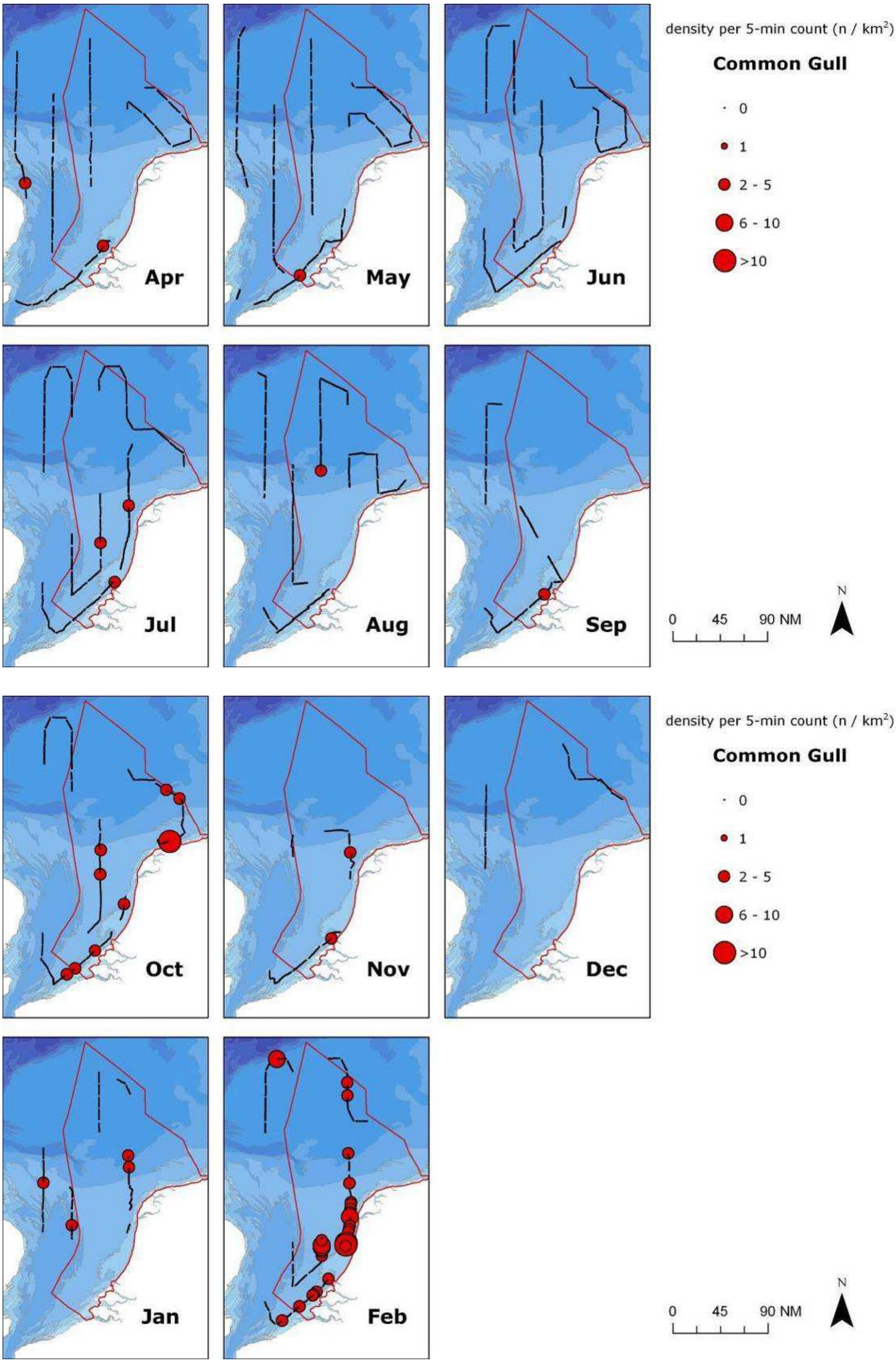

Figure 27 Distribution of Common Gulls during surveys in April 2010 – February 2011

Herring Gull Larus argentatus

SSI = 7.3; Conservation status: IUCN (2009): Least Concern

The Herring Gull was ranked among the five least vulnerable species in regard to wind farms.

This gull species showed a coastal distribution along the mainland of The Netherlands and Belgium in April-October; peak densities were recorded in May. North of the Wadden Isles observations were scarce. From November onwards numbers dropped and the distribution became more offshore, with observations as far as the Dogger Bank (*Figure 29*). Although this was not quantified, these offshore sightings concerned mainly individuals from the Northern subspecies *Larus argentatus argentatus*. This subspecies does not breed in The Netherlands, but is a common winter visitor.

Flying Herring Gulls were predominantly seen at lower altitudes (<50 m), with a median height between 10-25 m. A small proportion of birds was seen flying between 50 and 100 m (*Figure 28*).

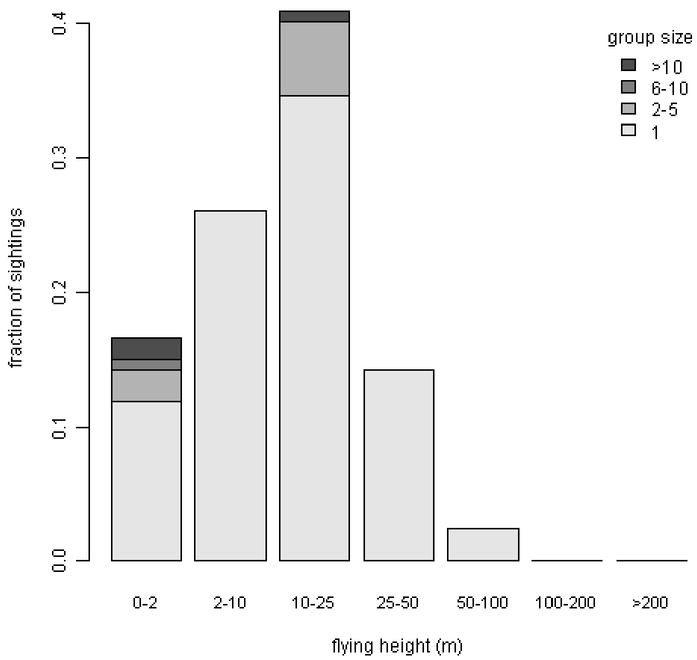

Figure 28 Flying heights of Herring Gulls (n=127)

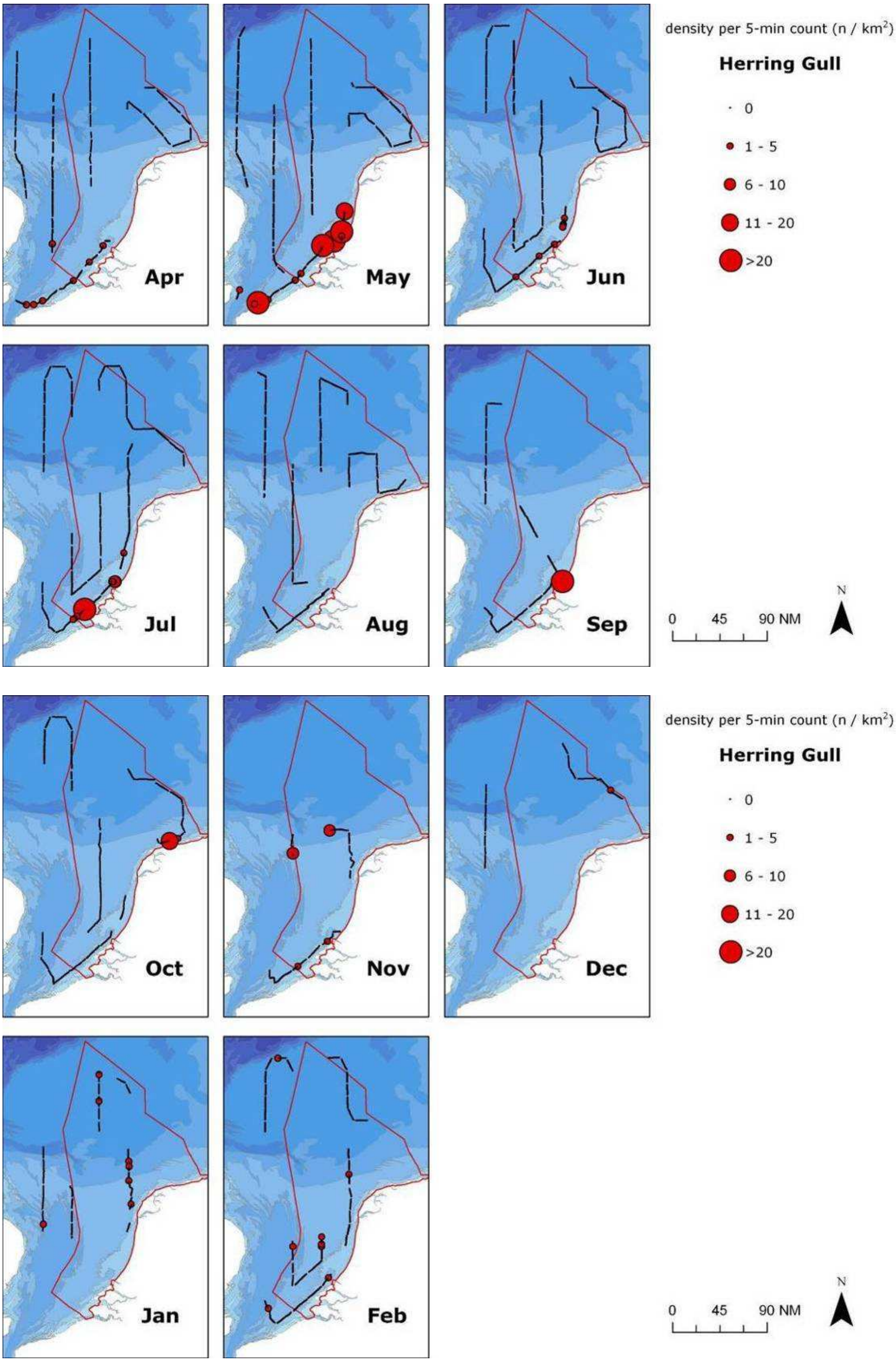

Figure 29 Distribution of Herring Gulls during surveys in April 2010 - February 2011

Lesser Black-backed Gull Larus fuscus

SSI = 9.2; Conservation status: IUCN (2009): Least Concern

Lesser Black-backed Gull was assigned a wind farm vulnerability index of 9.2, qualifying this species among the species with medium to low values.

During the surveys Lesser Black-backed Gulls were the most abundant gull species. From April until August this species was recorded throughout the entire survey area. Densities were highest in the coastal zone, reflecting the location of large Dutch breeding colonies (e.g. Texel, IJmuiden, Maasvlakte; *Figure 30*). In July a steady flow of Lesser Black-backed Gulls was –presumably- flying to and fro the breeding colonies of Texel and IJmuiden – these were predominantly adult birds (*Figure 31*). Recently fledged juveniles appeared at sea in August, and as total numbers dropped in September and from October, the percentage of juvenile and immature birds increased (*Figure 31*). From September till January the DCS was virtually devoid of Lesser Black-backed Gulls. In February birds returning from their wintering grounds started entering the southern North Sea again (*Figure 30*).

From all Lesser Black-backed Gulls noted (n=15.738), 15% (n=2.428) did not show any obvious association with e.g. vessels, platforms or cetaceans. Of the birds of which associations and behaviour was recorded, 16% (n=2.462) was actively searching or feeding. This number is dominated by huge feeding flocks off the coast of Noord-Holland in July. These birds (real figures must have numbered in the thousands) were feeding on small pelagic fish. The majority of birds, however, was seen in association with fishing activities (63%, n=9.852. Associations with the observers' ship occurred regularly but always concerned low numbers (2%; n=288). Platforms were used by 2% of the birds (n=441).

Flying Lesser Black-backed Gulls were predominantly seen at lower altitudes (<50 m), with a median height between 10-25 m. A small proportion of birds was seen flying between 50 and 200 m (*Figure 33*).

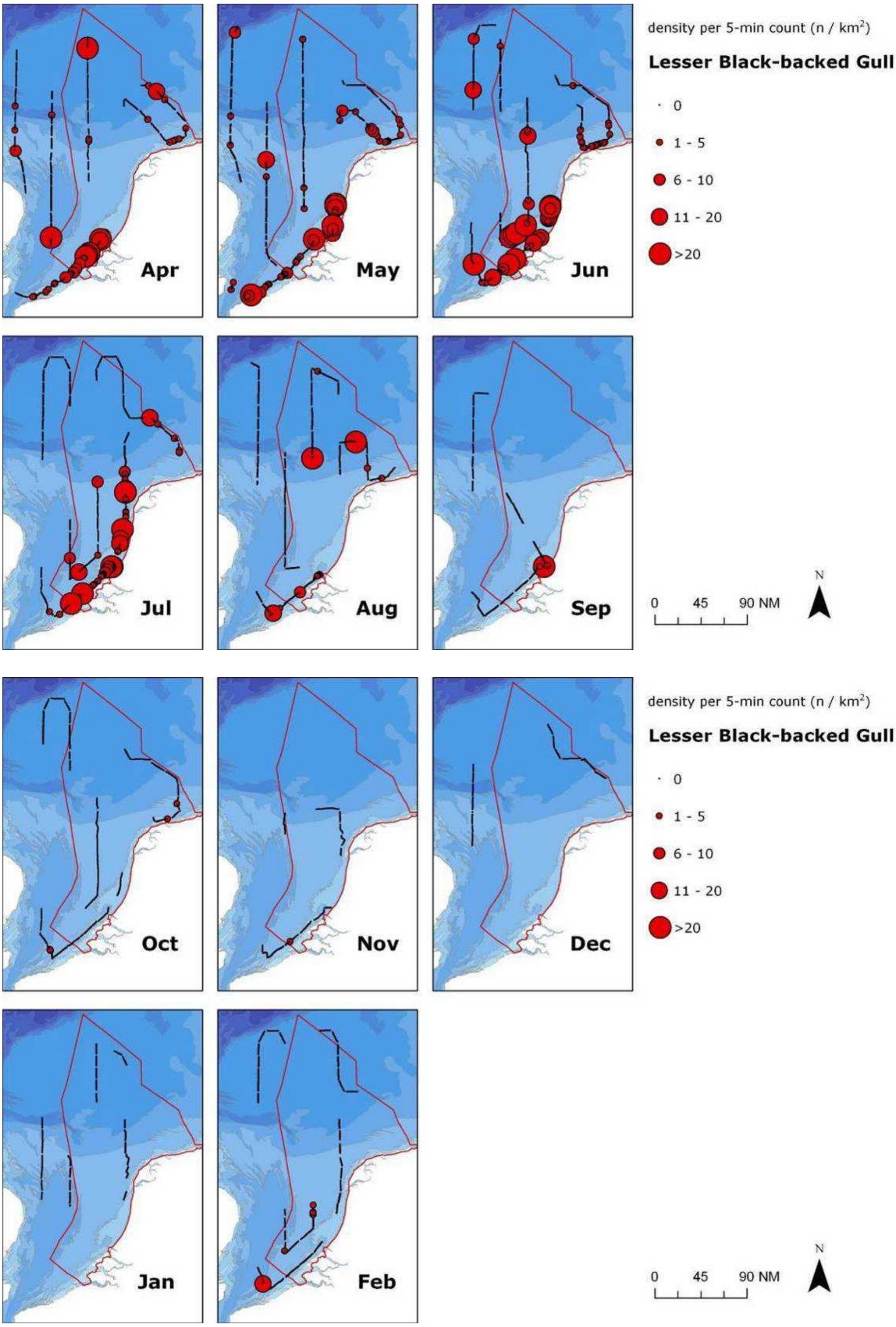

Figure 30 Distribution of Lesser Black-backed Gulls during surveys in April 2010 - February 2011

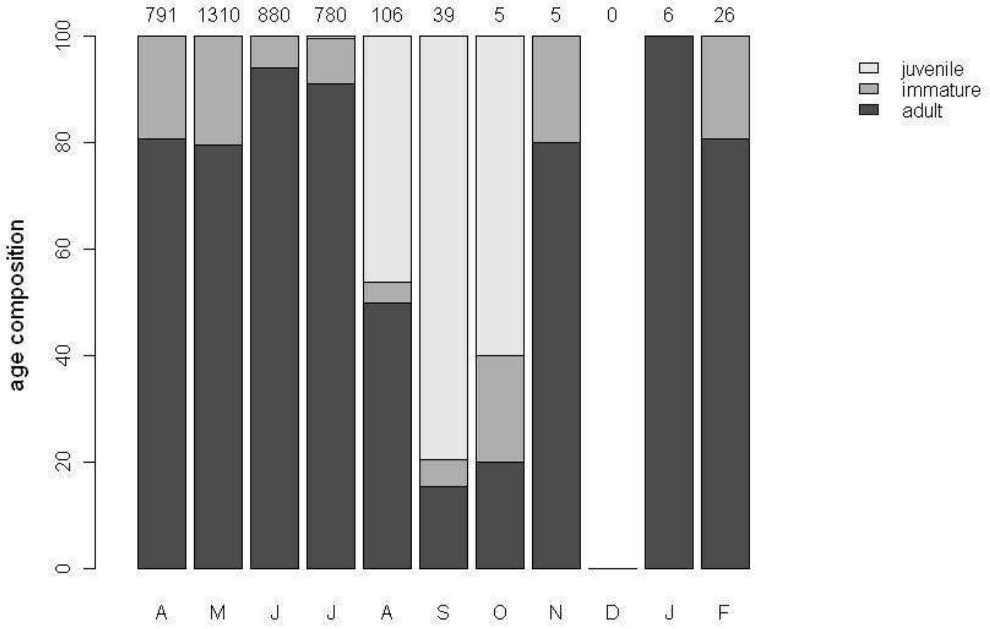

Figure 31 Age composition of Lesser Black-backed Gulls

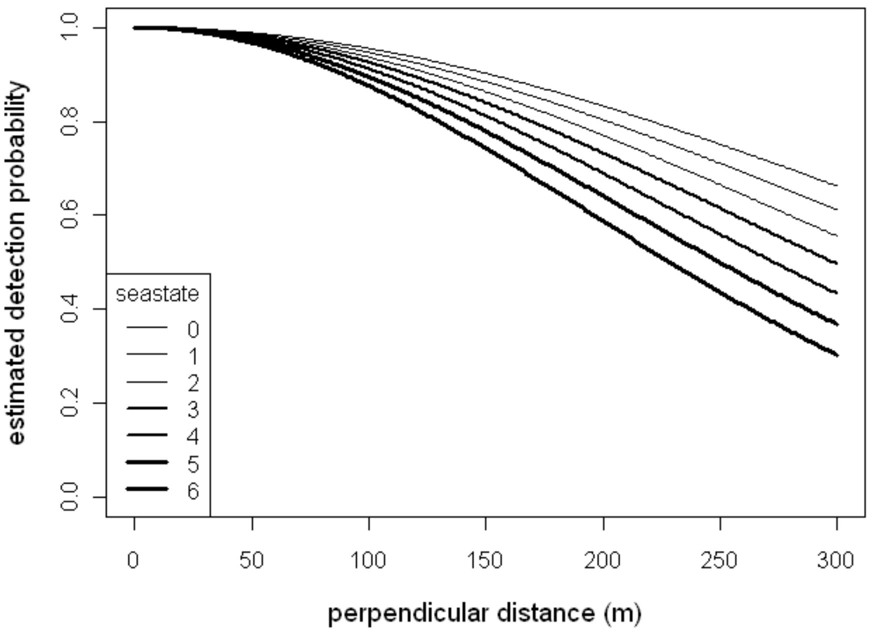

Figure 32 Modelled detection functions of (groups of) swimming Lesser Black-backed Gulls per sea state (Bft) (n=334). The percentage missed increases with sea state

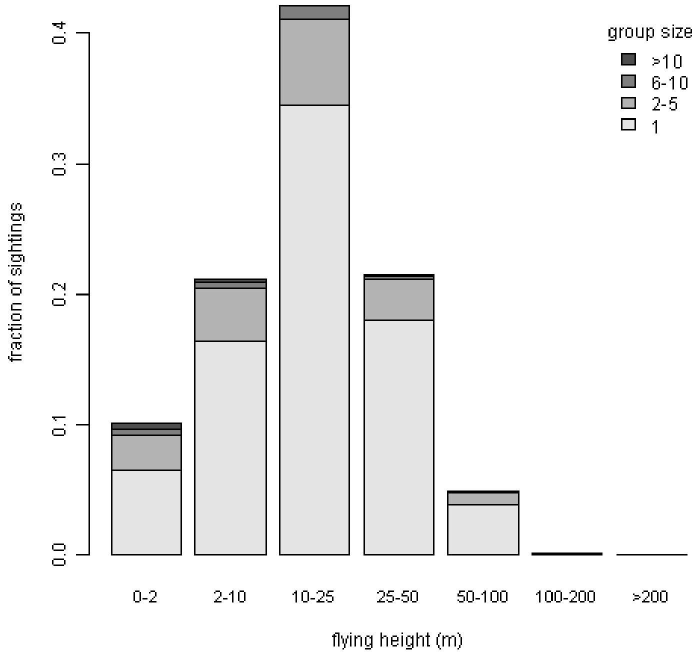

Figure 33 Flying heights of Lesser Black-backed Gulls (n=920)

Great Black-backed Gull Larus marinus

SSI = 13.8; Conservation status: IUCN (2009): Least Concern

With a SSI of 13.8, the Great Black-backed Gull ranked amongst the species with medium SSI values.

This species was the third most abundant gull species during the surveys. It showed a distinct seasonal pattern with low densities and a more or less coastal distribution in May-July (*Figure 35*). During April-September, the majority of the recorded individuals was immature (68-100%). Numbers built up from August onwards, when (adult) birds had reached the Frisian Front. During October-February, adults predominated with 45-75% of the individuals. The highest densities on the DCS seemed to be present in October, with an emphasis on the coastal zone (*Figure 35*).

Of the birds of which the behaviour was recorded 74.8% (n =835) was feeding, either scavenging (57.7%) or actively feeding (17.2%). Actively searching (9.6%) and resting and preening (14.8%) were the most common other behaviours. Flying Great Black-backed Gulls were predominantly seen at lower altitudes (<50 m), with a median height between 10-25 m. A small proportion of birds was seen flying between 50 and 200 m (*Figure 34*).

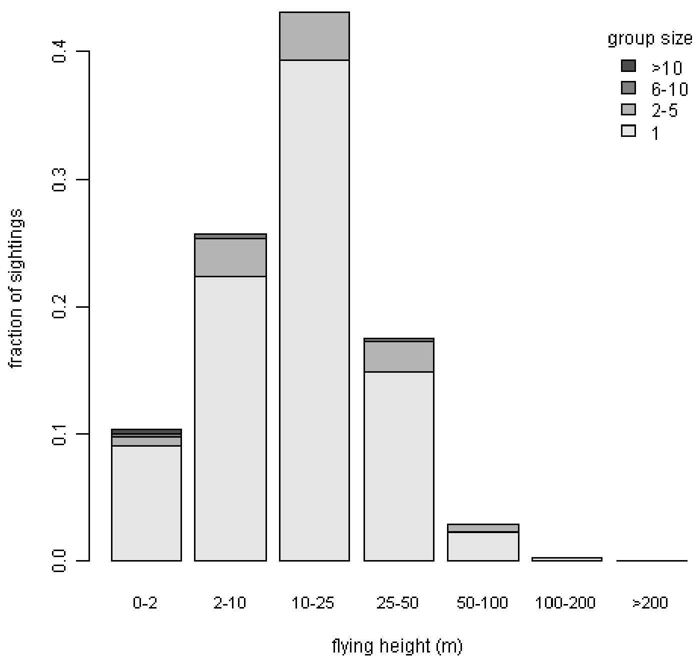

Figure 34 Flying heights of Great Black-backed Gulls

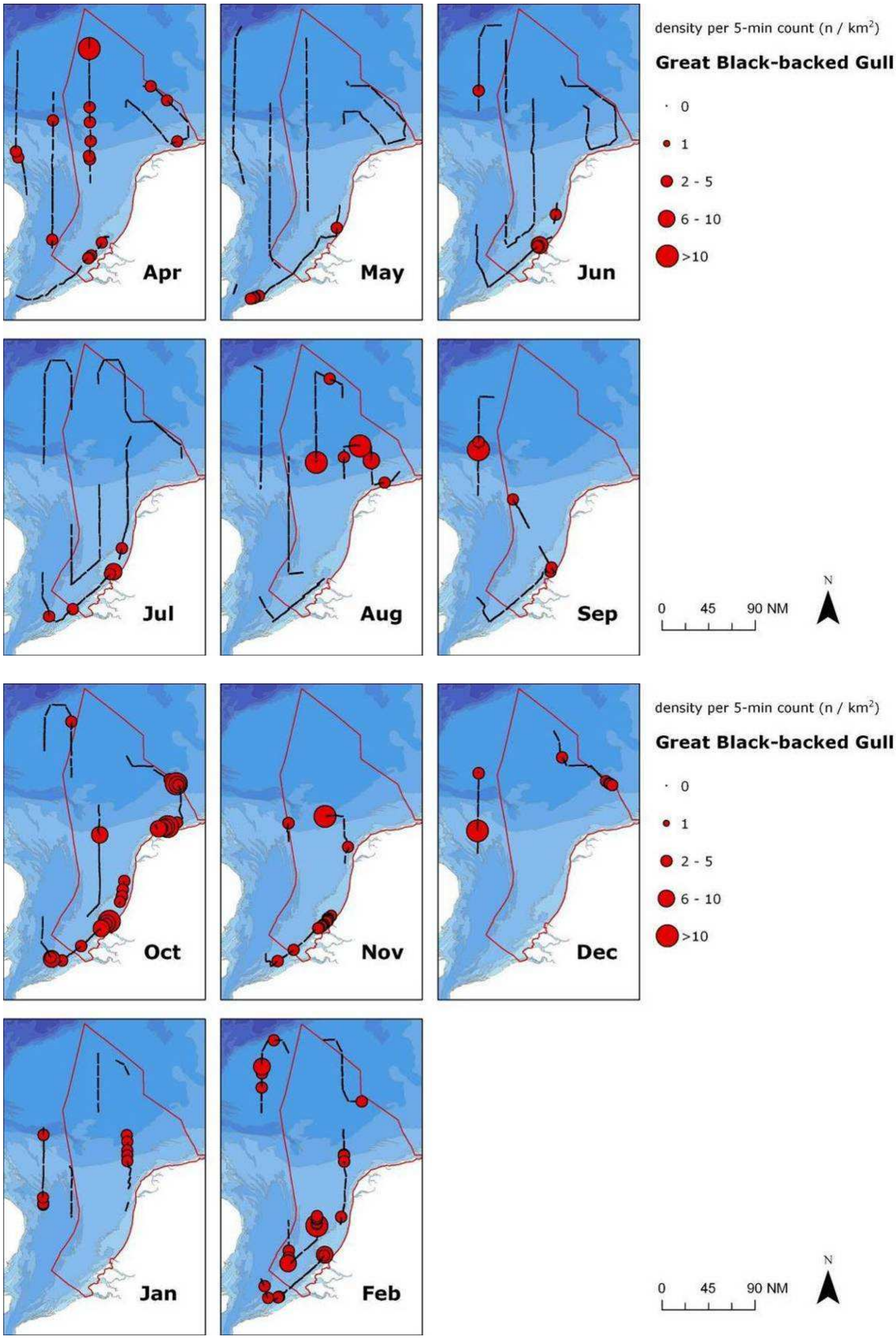

Figure 35 Distribution of Great Black-backed Gulls during surveys in April 2010 - February 2011

Terns

Sandwich Tern Sterna sandvicensis

SSI = 20.0; Conservation status: Annex I Birds Directive; Appendix II Bonn Convention; Appendix II Bern Convention; IUCN (2009): Least Concern)

With an SSI value of 20.0, the Sandwich Tern ranks among the more sensitive species with regard to wind farms.

Sandwich Tern was the most abundant tern during the surveys, with observations between April and September. In general the encountered numbers were low. The highest numbers were seen in April-June in near-coastal waters. In July, when Sandwich Terns stay inshore, numbers dropped steeply, and from October onwards Sandwich Terns had left the North Sea. During the breeding season (Apr-Jun) the coastal distribution reflects the location of breeding colonies in the Dutch Delta, Belgium, the biggest colony in the UK: Scolt Head, Norfolk, and to a lesser extent the colonies in the Wadden Sea (*Figure 36*). Breeding birds feed mainly in the vicinity of their colony. Stienen (2006), for instance, showed that the majority of the breeders from the large colony on Griend feed between Texel and Vlieland, thus well south of the surveyed transects.

Most individuals were seen actively searching for prey (41%; n=229). Plunge dives were seen in 13% (n=72) of the individuals. Apparent transit flights consisted 32% (n=177) of the individuals – of these, five were holding a fish.

Flying Sandwich Terns were predominantly seen at lower altitudes (<25 m), with a median height between 2-10 m. A small proportion of birds was seen flying between 25 and 100 m (*Figure 37*). On average Sandwich Terns fly higher than both Common and Arctic Tern: one of the two reasons Sandwich Tern was assigned a higher vulnerability index by Garthe & Hüppop (2004).

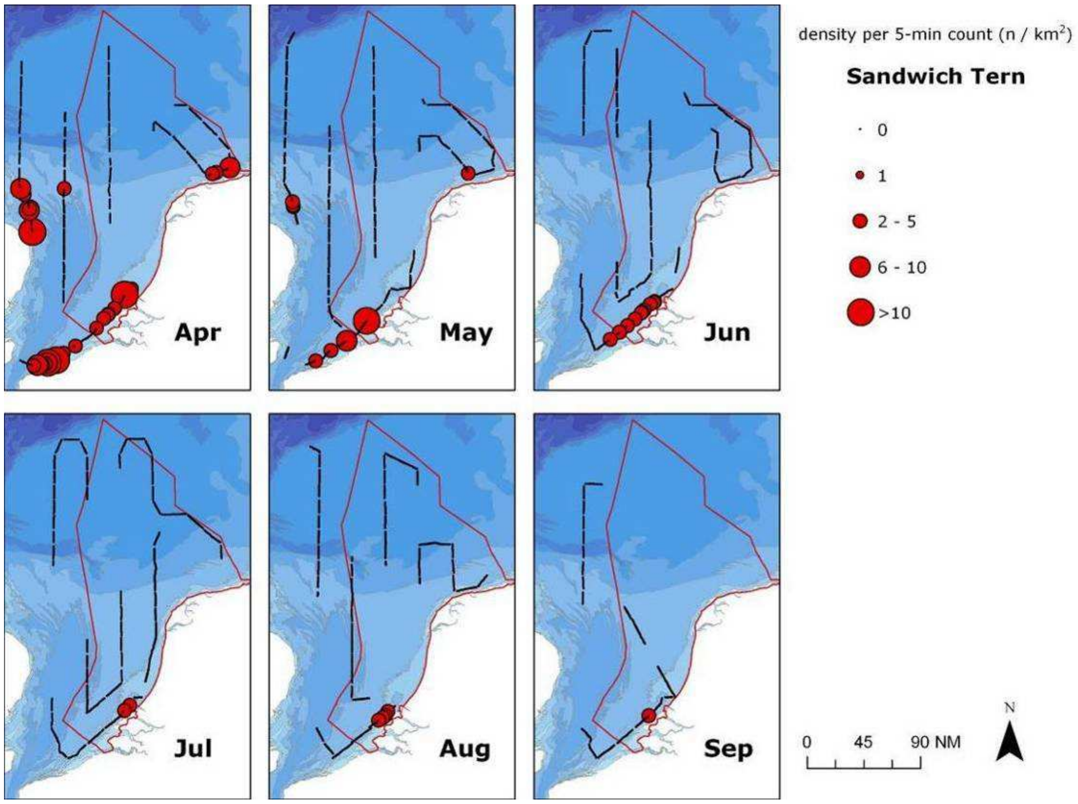

Figure 36 *Distribution of Sandwich Terns during surveys in April – September 2010; in October 2010 – February 2011 no terns were seen*

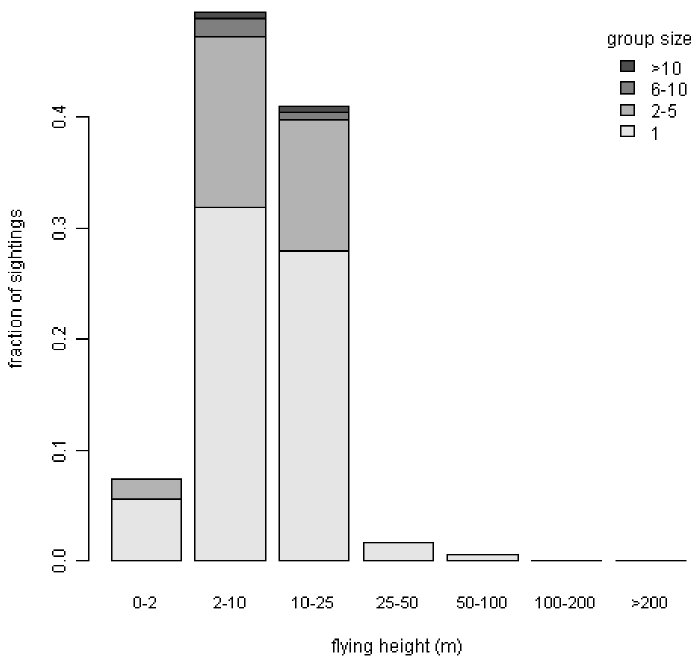

Figure 37 *Flying heights of Sandwich Terns (n=173)*

Common Tern Sterna hirundo

SSI = 12.0; Conservation status: Annex I Birds Directive; Appendix II Bonn Convention; Appendix II Bern Convention; IUCN (2009): Least Concern

Arctic Tern Sterna paradisaea

SSI = 10.7; Conservation status: Appendix II Bonn Convention; IUCN (2009): Least Concern

Common and Arctic Tern were ranked intermediate with regard to their sensitivity for wind farms, with a SSI of 12.0 and 10.7 respectively. The difference between these species is caused by the designation of Common Terns in a higher flight altitude class than Arctic Tern. Remarkably, our data on flying heights suggests higher values for Arctic Tern – but the sample size for this species is small (*Figure 39*; *Figure 41*).

When not seen well Common Terns and Arctic Terns can be difficult to identify to species level. During land-based sea watches the name "Commic Tern" became established for unidentified individuals, which comprise about 45-55% of the individuals seen during these counts (Platteeuw *et al.* 1994). During aerial surveys, the two species are hardly ever identifiable (Arts 2010). During the surveys 28% of all Common and Arctic Terns (n=572) was left unidentified; within the transect this proportion was only 3.6% (n=221).

Numbers of Common and Arctic Tern were low, but both species are almost equally abundant. Though Arctic Terns were not seen in May and September, both species were seen between April and September. Their distribution showed complementary patterns with Common Terns restricted to the Dutch coastal zone (*Figure 40*) and the majority of Arctic Terns offshore (*Figure 40*). In June and August some Common Terns were seen –outside the transect- as far offshore as the Dogger Bank.

From the Common and Arctic Terns whose behaviour was noted, 61% were actively feeding, mainly by plunge-diving (61%; n=157). Actively searching terns comprised 24% (n=63). A remarkable phenomenon described by Camphuysen (1991), was noted in May, when Arctic Terns were seen displaying offshore (12%; n=32).

Flying Common Terns were predominantly seen at lower altitudes (0-10 m) whereas Arctic Terns were seen at slightly higher altitudes (mostly between 2-25m). No 'comic terns' were recorded above 50 m (*Figure 39*, *Figure 41*). These findings seem contradictory with the designation in height classes by Garthe & Hüppop (2004), but they confirm that both species commonly fly between 2-10 m high.

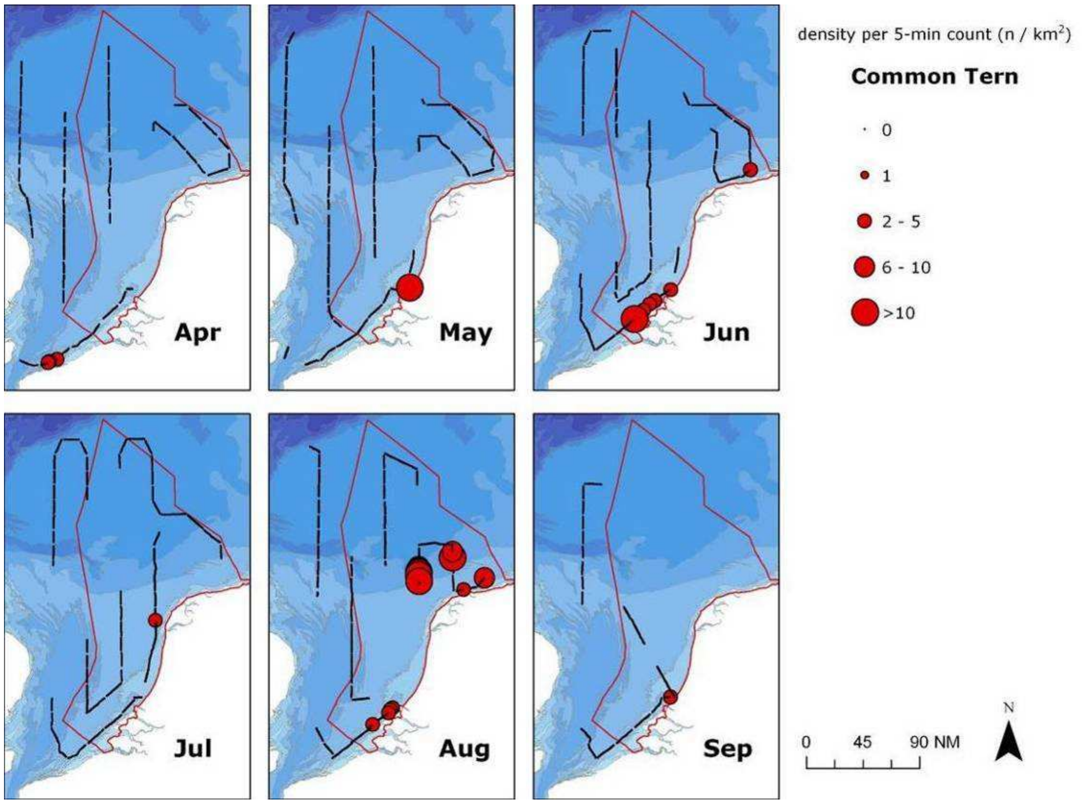

Figure 38 Distribution of Common Terns during surveys in April – September 2010; in October 2010 – February 2011 no terns were seen

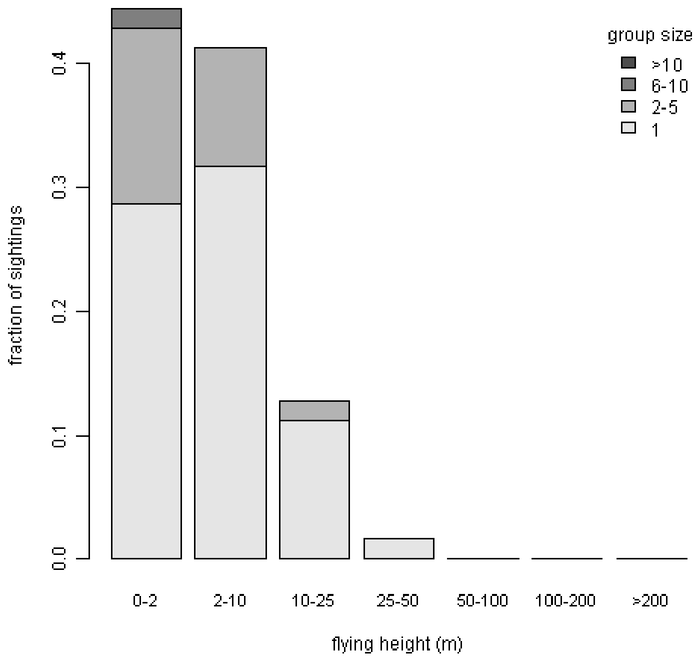

Figure 39 Flying heights of Common Terns (n=63)

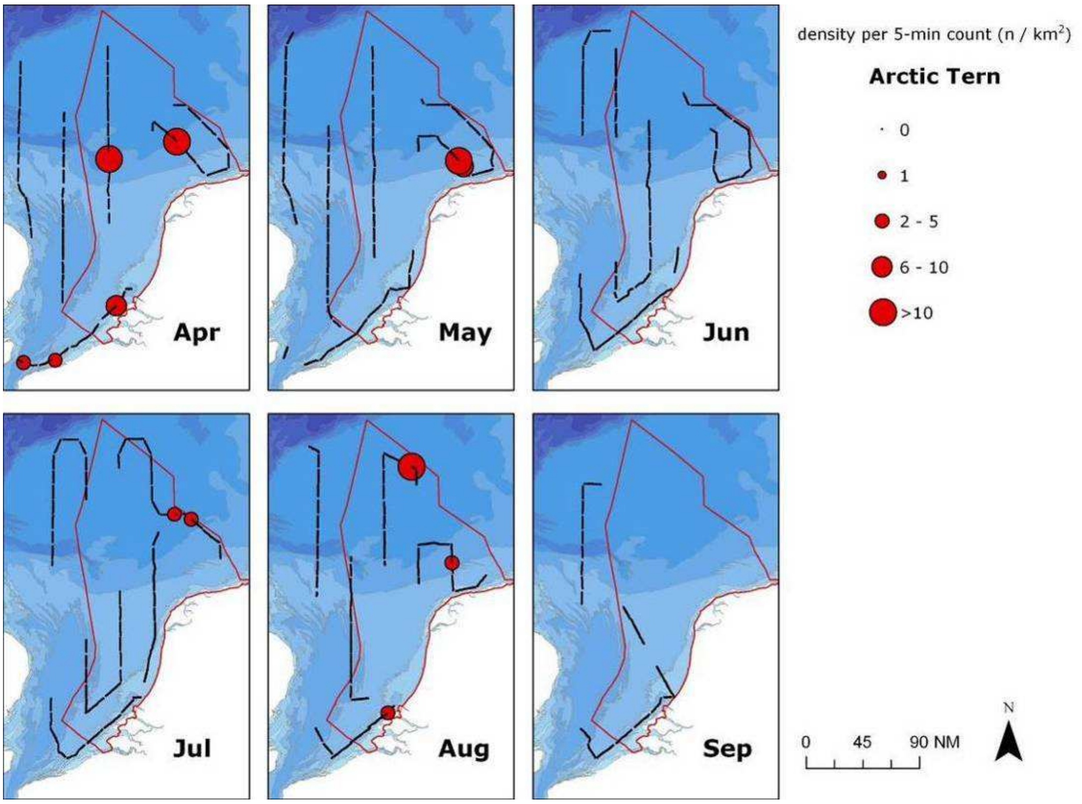

Figure 40 Distribution of Arctic Terns during surveys in April – September 2010; in October 2010 – February 2011 no terns were seen

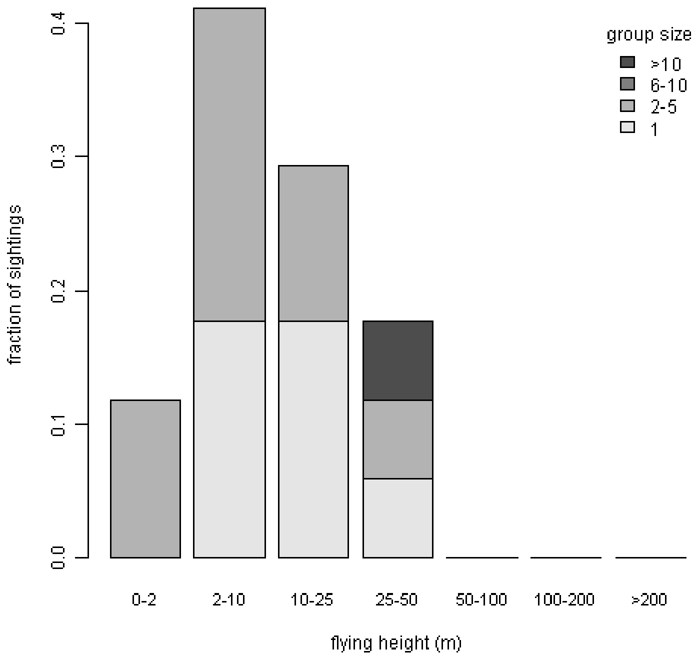

Figure 41 Flying heights of Arctic Terns (n=17)

Alcids

Common Guillemot Uria aalge

SSI = 10.0; Conservation status: IUCN (2009): Least Concern

Razorbill Alca torda

SSI = 13.1; Conservation status: IUCN (2009): Least Concern

Common Guillemots and Razorbills were ranked amongst the intermediate species in terms of sensitivity to wind farms. Due to its smaller population size, the Razorbill was qualified as the more sensitive species of the two. Unpublished reports suggest partial avoidance of wind farms by these species (Leopold *et al*. 2011 in press).

When seen at greater distances Common Guillemots and Razorbills are almost impossible to identify to species level. During the surveys only 0.8% of the large alcids (n = 7,213) was left unidentified. Of the remaining alcids 88.7% was identified as Common Guillemot and 10.6% as Razorbill. In other words, the ratio between Razorbills and Guillemots on average was 1:8.6. However, there are marked temporal changes in the ratio between both species (see *Figure 44*). Guillemots dominated throughout the year, but in November and February high proportions of Razorbills were present. In summer the proportion of Razorbills was virtually zero.

Guillemots were widely distributed throughout the year, showing a distinct spatial and temporal pattern (*Figure 42*). In May densities were at a minimum and the distribution was restricted to offshore areas. In June downy chicks accompanied by one parent, mainly their father (Harris *et al.* 1991), entered the survey area. The first father-chick combination was seen in British waters as far south as IJmuiden on 21 June. Presumably, the first individuals arriving here are from the nearest colony from the Bempton Cliffs, along the Norfolk coast (Mitchell *et al.* 2004). In the Dogger Bank and Frisian Front areas relatively high densities of Guillemots were seen already this month, including tens of father-chick combinations. These birds probably originated from the colonies of St Abbs Head, Berwickshire, Scotland, and more northerly (Mitchell *et al.* 2004), taking advantage of the predominantly south-easterly current. The number of these combinations increased in July. From August onwards Guillemots spread out over the southern North Sea. Concentrations in this month were found at Dogger Bank, Cleaver Bank and Brown Ridge. Unfortunately, the survey effort from September until December was relatively low and unevenly distributed over the DCS. Therefore only scant data on the distribution in these months is available. High densities, however, were found on the Dogger Bank, when it was surveyed in October and January. The Brown Ridge held high densities in January, but the available data does not show when Guillemot numbers build up in this area. All in all, areas with higher densities of Guillemots were encountered in different seasons. Throughout the year, however, high densities were found in the Dogger Bank area. The Frisian Front (and Cleaver Bank) held high densities in summer. The Brown Ridge showed high densities in winter (*Figure 42*).

Razorbills showed an even stronger seasonal pattern (*Figure 43*). In April, high densities were found on the western flank of the Dogger Bank. Numbers in this area declined in May and some scattered concentrations were found on the Dogger Bank and the Frisian Front in June. The species was (virtually) absent during July-August. From September onwards, numbers built up to maximum densities in February. In this month, there were locally high densities in both offshore and near shore areas throughout the studied area (*Figure 43*).

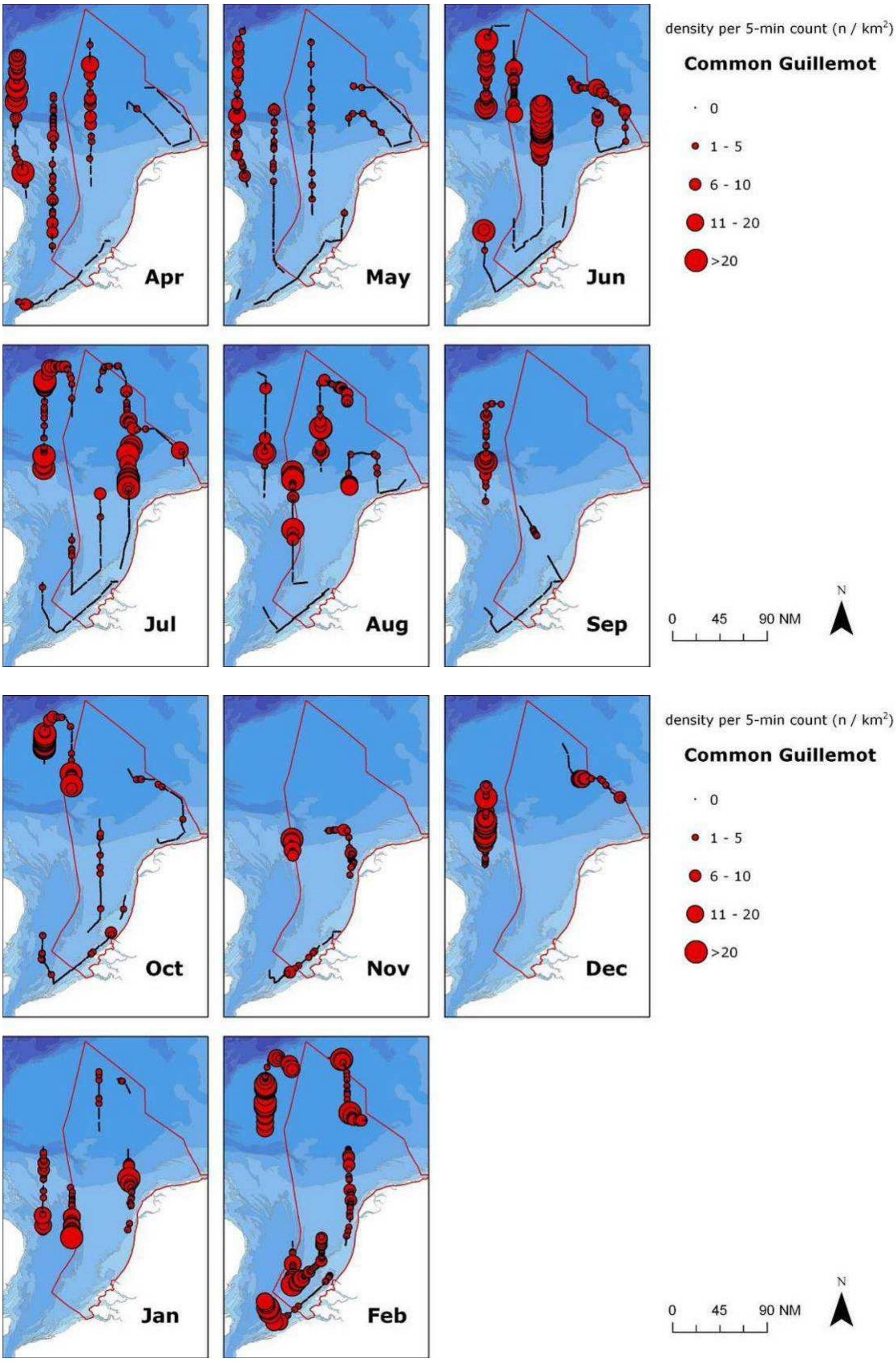

Figure 42 Distribution of Common Guillemots during surveys in April 2010 - February 2011

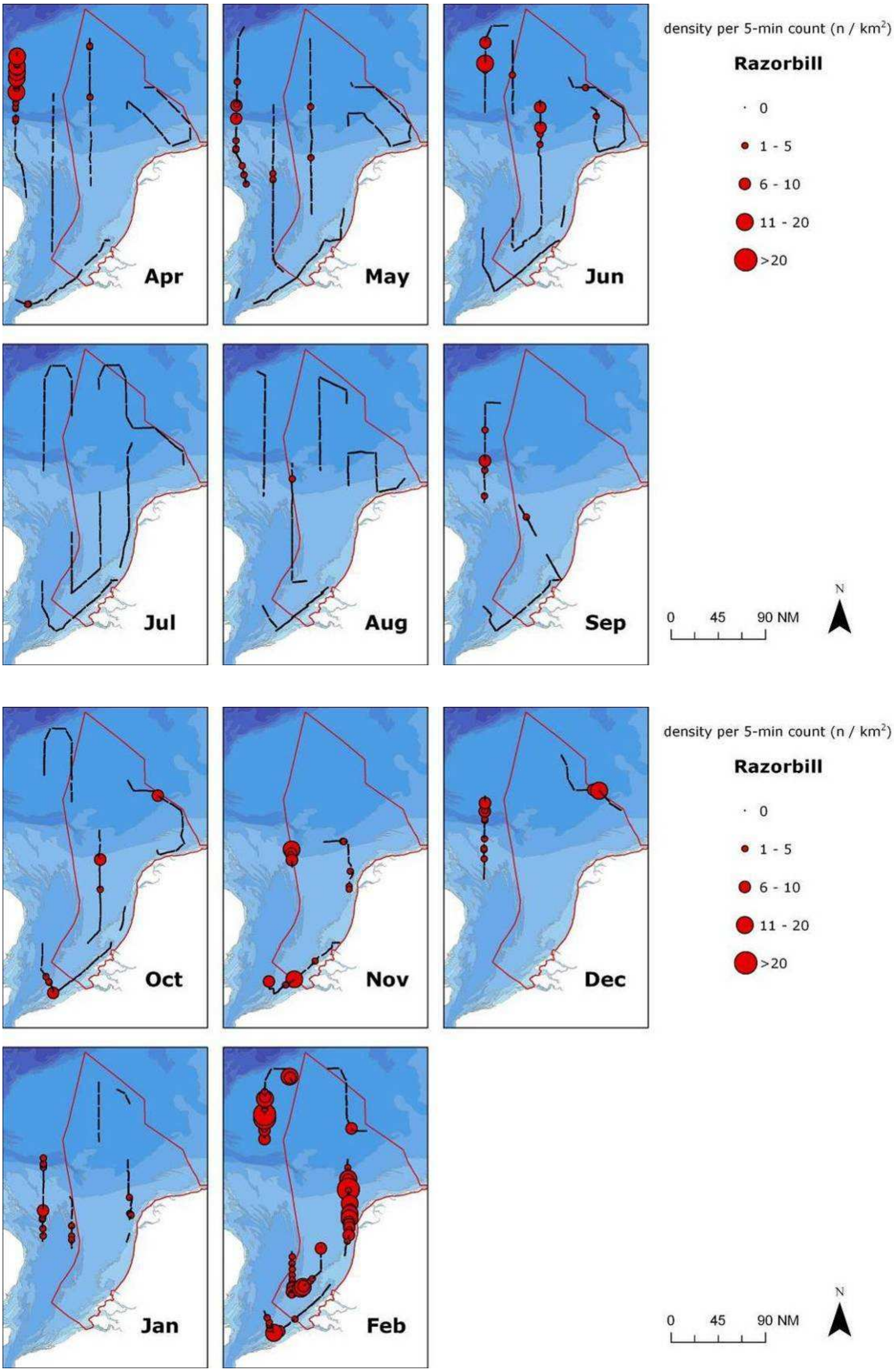

Figure 43 Distribution of Razorbills during surveys in April 2010 - February 2011

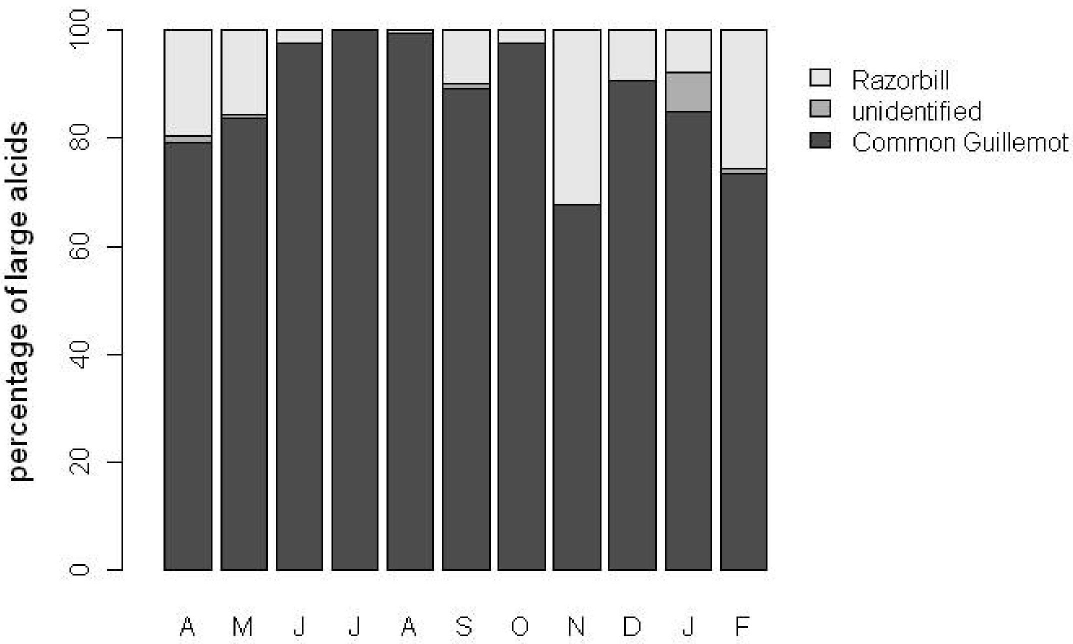

Figure 44   The composition of large alcid species per month. The far majority was positively identified as either Common Guillemot or Razorbill

Identification and species composition

Less than 1% of the total number of large alcids was left unidentified (n=7213). This percentage ranged from 0% in June-August and October-December to 7.2% in January. For comparison, only about 9% to 27% of the large alcids are identified to species level during coastal sea watches (Camphuysen & van Dijk 1983; Platteeuw *et al.* 1994) and only a very small fraction are identified to species level during aerial surveys (e.g. Arts 2010).

From the identified individuals, the far majority (89%; n=6.396) were Common Guillemots, the remaining 11% were Razorbills (n=761). The ratio between the two species showed a marked seasonal pattern, with Razorbills (virtually) absent in June-August. The percentage of Razorbills was particularly high in November.

Moult

In large alcids, moult of body feathers is mainly noticeable on the head, throat and upper breast. In summer, these are all dark brown (Common Guillemot) to jet-black (Razorbill), but in winter, a white patch occurs behind the eye, and the throat and upper breast become white. Adults arrive at the breeding ledges in full summer plumage and moult into winter plumage after the breeding season. The timing of moult of immature birds lags behind – they moult into summer plumage later in the season. The declining percentage of birds in summer plumage after January probably reflects the departure of adults to the breeding grounds. The subsequent increase partly represents the moult of immature birds into summer plumage and the return of adults in summer (June-July) (*Figure 45*).

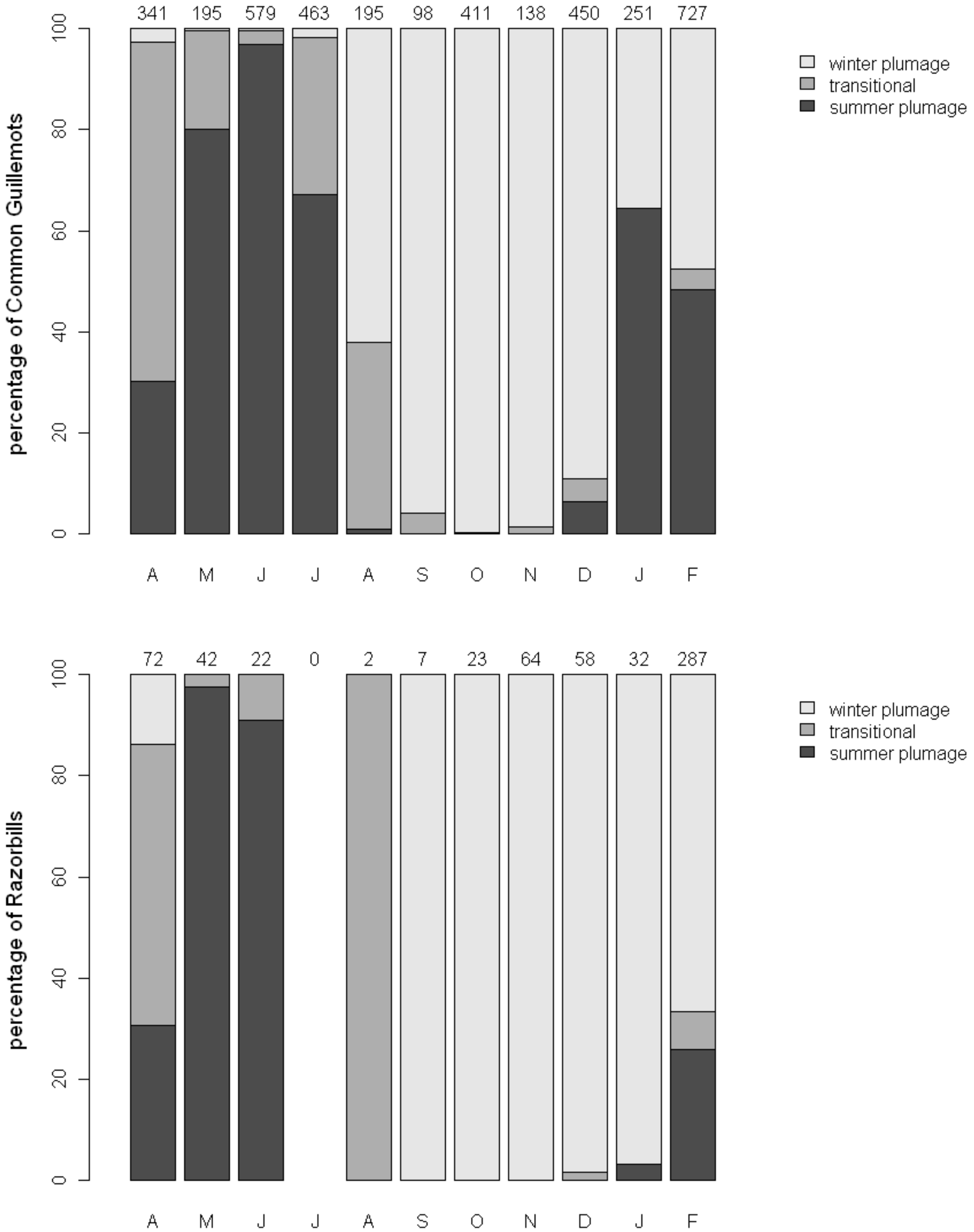

Figure 45 Plumage composition of Common Guillemots (upper panel) and Razorbills (lower panel). Values above the bars represent sample sizes

Multi Species Feeding Associations
Regularly, associations between alcids and Black-legged Kittiwakes or Little Gulls were observed. This was especially common in offshore areas with higher densities of Razorbills. These data has not been extensively analysed.

Detection functions
Combining all large alcids noted in the transect strip, the percentage of flying birds on the total number of birds is 0.81% (sd=0.95; n=5,144). Flying birds are assumed to always be detected when in the transect strip. Swimming birds are missed at greater distances from the transect line (*Figure 46*). To estimate the percentage of birds not seen, detection functions were estimated for swimming individuals. Sea state heavily influenced the detection of swimming alcids (*Figure 47*). Detection probability decreases strongly after 50m. See *Table 4* for estimated effective strip width and associated correction factors.

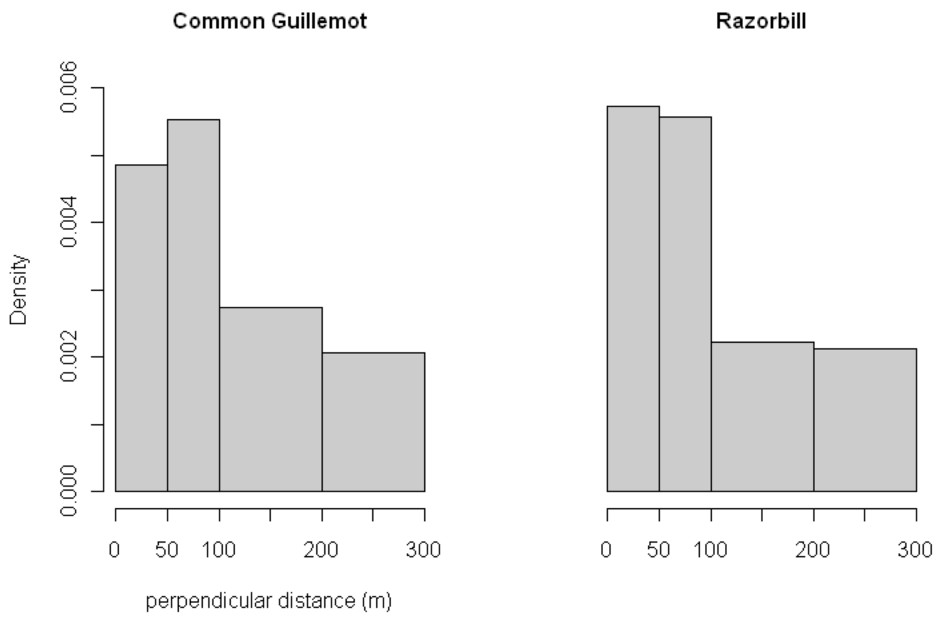

Figure 46 Histograms of (groups of) Common Guillemots (left panel) and Razorbills (right panel) per distance band. If all clusters of birds were detected, each bar would be equally high. This is clearly not the case. These figures are not corrected for sea state

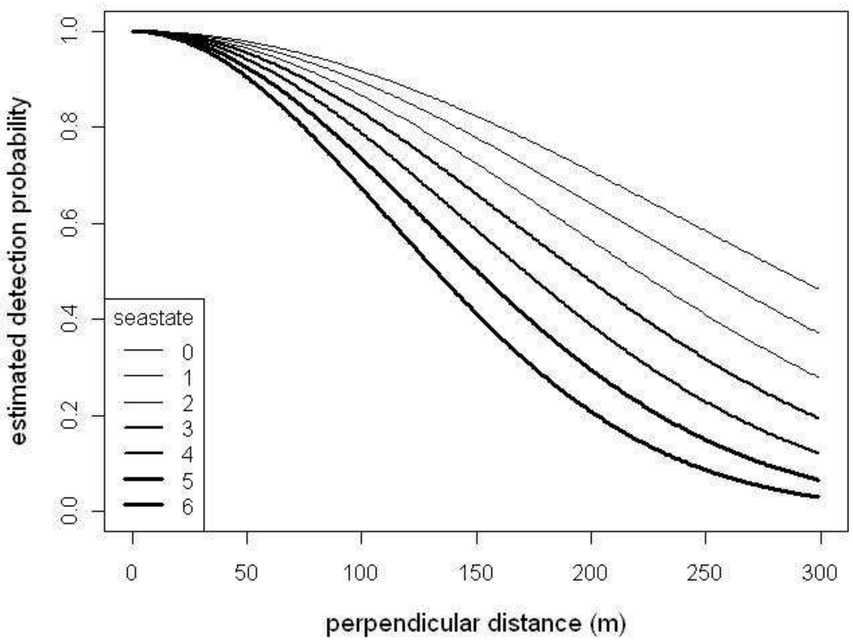

Figure 47 Detection curves of large alcids (Common Guillemots and Razorbills) per sea state (Bft) (n=2169). The percentage missed increases with sea state

Flying Guillemots were predominantly seen at lower altitudes (<10 m), with a median height below 2 m. A few birds were seen flying between 10 and 50 m (*Figure 48*). Razorbills showed a similar flying height distribution, although no birds were seen above 10 m (*Figure 49*).

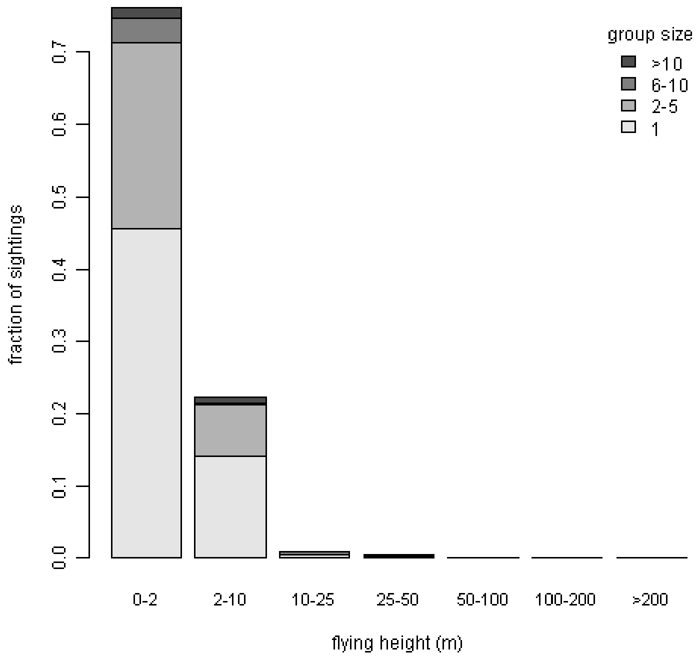

Figure 48 Flying heights of Common Guillemots (n=362)

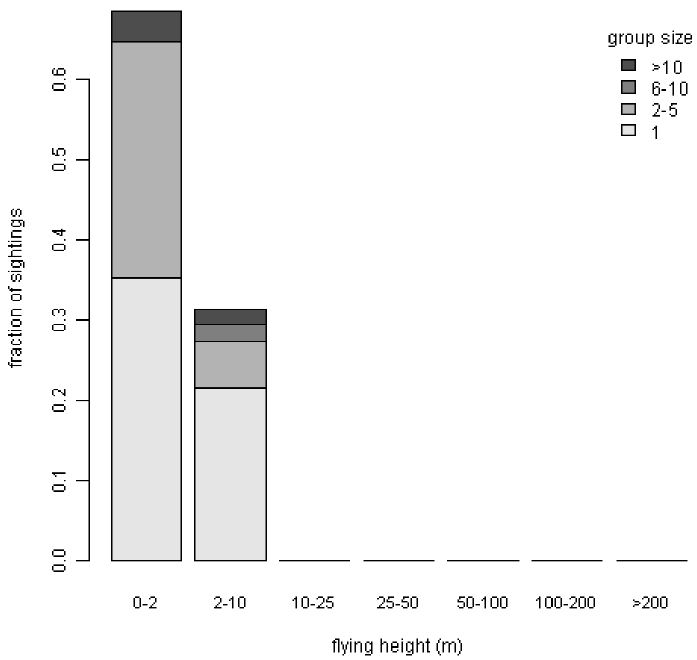

Figure 49 Flying heights of Razorbills (n=51)

Atlantic Puffin Fratercula arctica

SSI = 18.0; Conservation status: IUCN (2009): Least Concern

Little Auk Alle alle

SSI = 16.0; Conservation status: IUCN (2009): Least Concern

The Atlantic Puffin was assigned a wind farm sensitivity index equal to that of the Razorbill; the Little Auk was qualified slightly less sensitive.

During the surveys Atlantic Puffin was the most abundant of the two species. This might be effort-related, since the northwestern part of the survey area was low in effort during November-January. Little Auks are known to aggregate in the Dogger Bank area during this period (Camphuysen & Leopold 1994).

The distribution of Atlantic Puffins showed a distinct emphasis on the north western and western part of the area, with highest numbers in the Dogger Bank area in February and April (*Figure 50*). These months the densities as well as the distribution reached their maximum. Puffins stayed far offshore and were not seen in the Southern Bight. From June till September Puffins almost completely vacated the survey area. From October onwards very low densities were seen again. In combination with the low survey effort in November and December this resulted in a lack of records in these months.

Little Auks were much less numerous than Puffins and were noted during the surveys in November – February, with most records in February. As noted above, effort allocation was not optimal for mapping Little Auk distribution, as no surveys crossed the Dogger Bank during November – January. All records except one (November, near Texel) are confined to the Dogger Bank and its surroundings (*Figure 53*).

Detection of swimming small alcids at greater perpendicular distances from the ship's transect line is difficult – especially in harsh weather conditions (*Figure 51*). Therefore it is not surprising that beyond 100 m, the detection curve for these small alcids is much steeper than for the large alcids (Common Guillemot and Razorbill) (*Figure 52*, cf. *Figure 47*). For the estimated strip width per sea state and the associated correction factors, see *Table 4*.

Flying Little Auks were seen below 10 m, with equal numbers flying below and above 2 m (*Figure 49*). Puffins were only discovered swimming; hence, no flight altitudes were recorded. However, fleeing birds typically stayed close to the water surface and would thus not be vulnerable for collisions with turbine rotors.

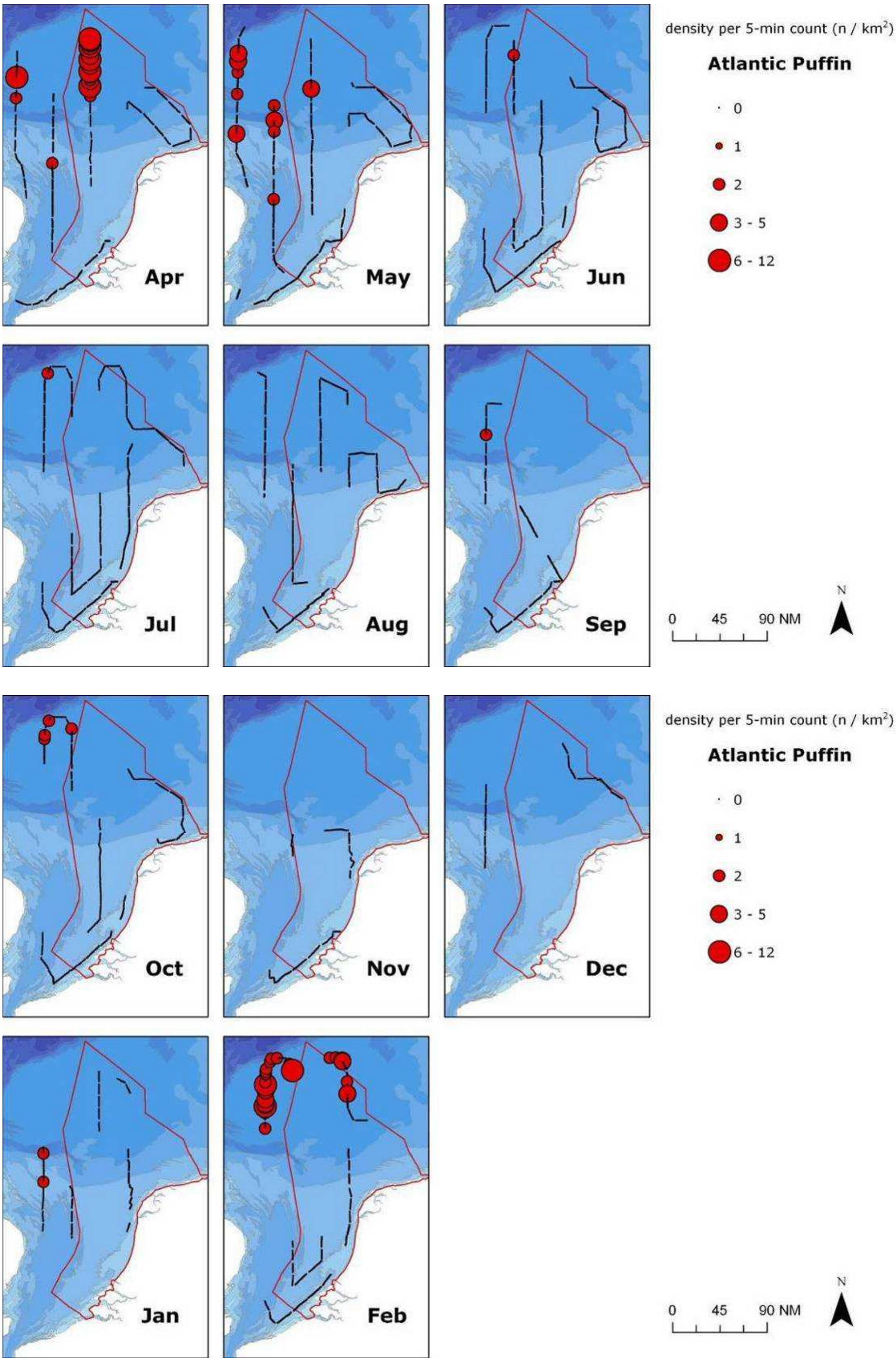

Figure 50 Distribution of Atlantic Puffins during surveys in April 2010 - February 2011

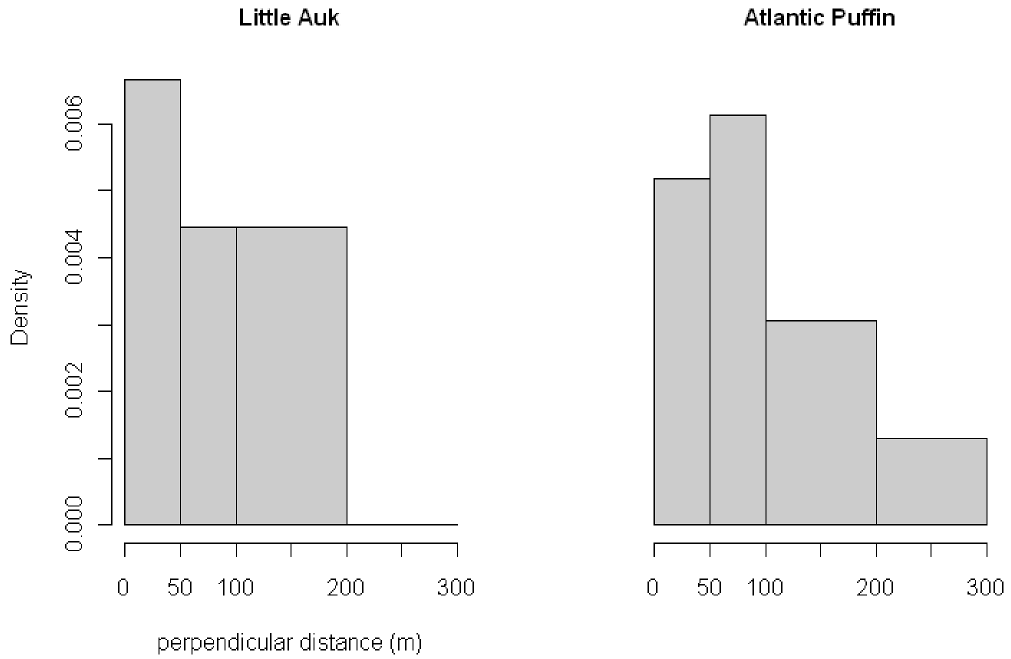

Figure 51 *Histograms of (groups of) Little Auk (left panel) and Atlantic Puffin (right panel) per distance band. If all clusters of birds were detected, each bar would be equally high. This is clearly not the case. Note that no Little Auks were detected beyond 200m distance from the ship. These figures are not corrected for sea state*

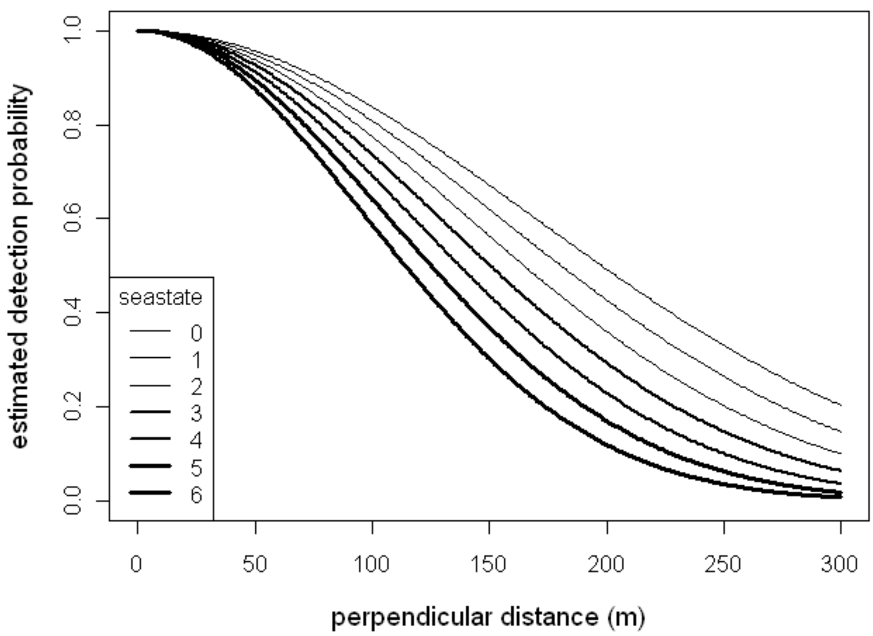

Figure 52 *Modelled detection functions of (groups of) small alcids (Atlantic Puffins and Little Auks) per sea state (Bft) (n=94). The percentage missed increases with sea state*

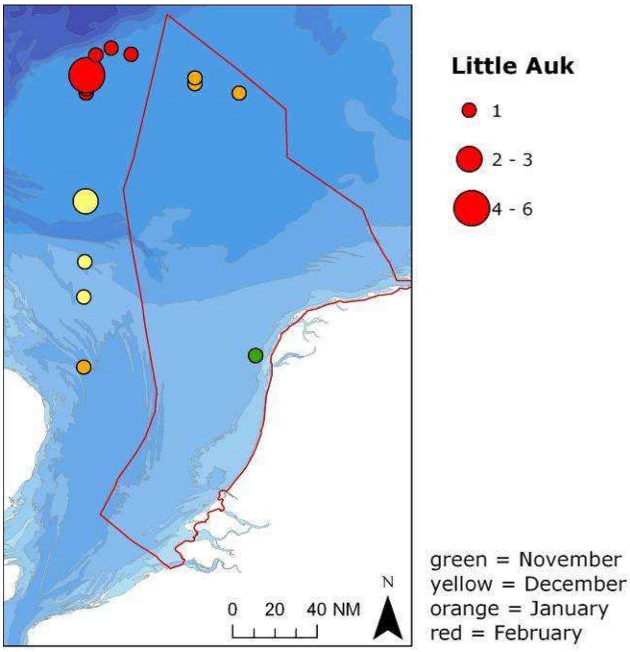

Figure 53 *Distribution of records of Little Auk. Note that most sightings originate from the Dogger Bank areas in February, where no effort was spent during November-January*

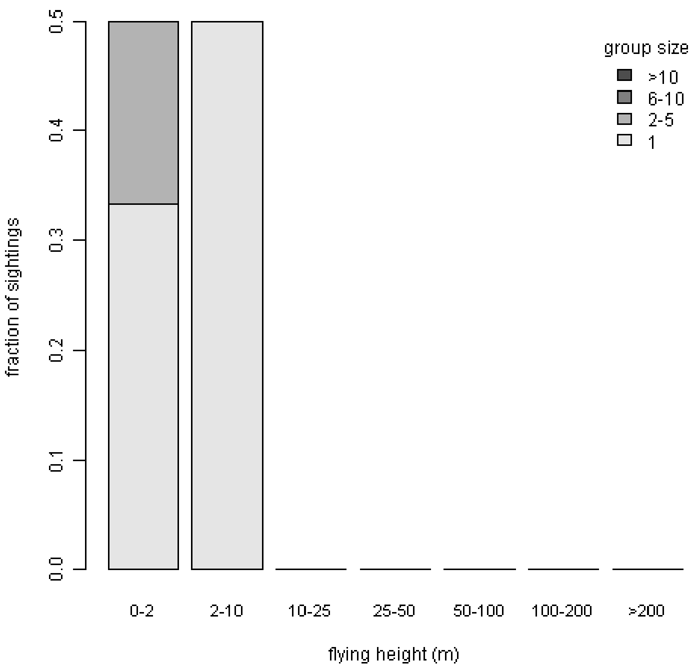

Figure 54 *Flying heights of Little Auks (n=6). Atlantic Puffins were not recorded in flight*

Beside the ‘true’ seabirds, many ducks and geese, waders and migrant passerines were observed – often far offshore (*Figure 55*). The number of species involved is large and therefore, these were pooled in the maps below. From the non-passerines, Great Cormorants (n=608) and Common Scoter (n=454) were the most common species. The SSI values of these species are 20.0 and 16.8 and they thereby rank within medium SSI values. Common Scoter is mentioned in appendix II of the Bonn convention and under EU Bird directive appendix II and III. The largest flock numbered 245 individuals seen in nearshore Belgian waters in May. In other months, virtually all scoters were seen flying, but flight directions do not show a clear pattern – apparently these were no large-scale migrations. Migrants can be encountered year-round, but peak in spring (especially April) and autumn (especially September-October). Species-specific deviations from this general pattern are widespread, however.

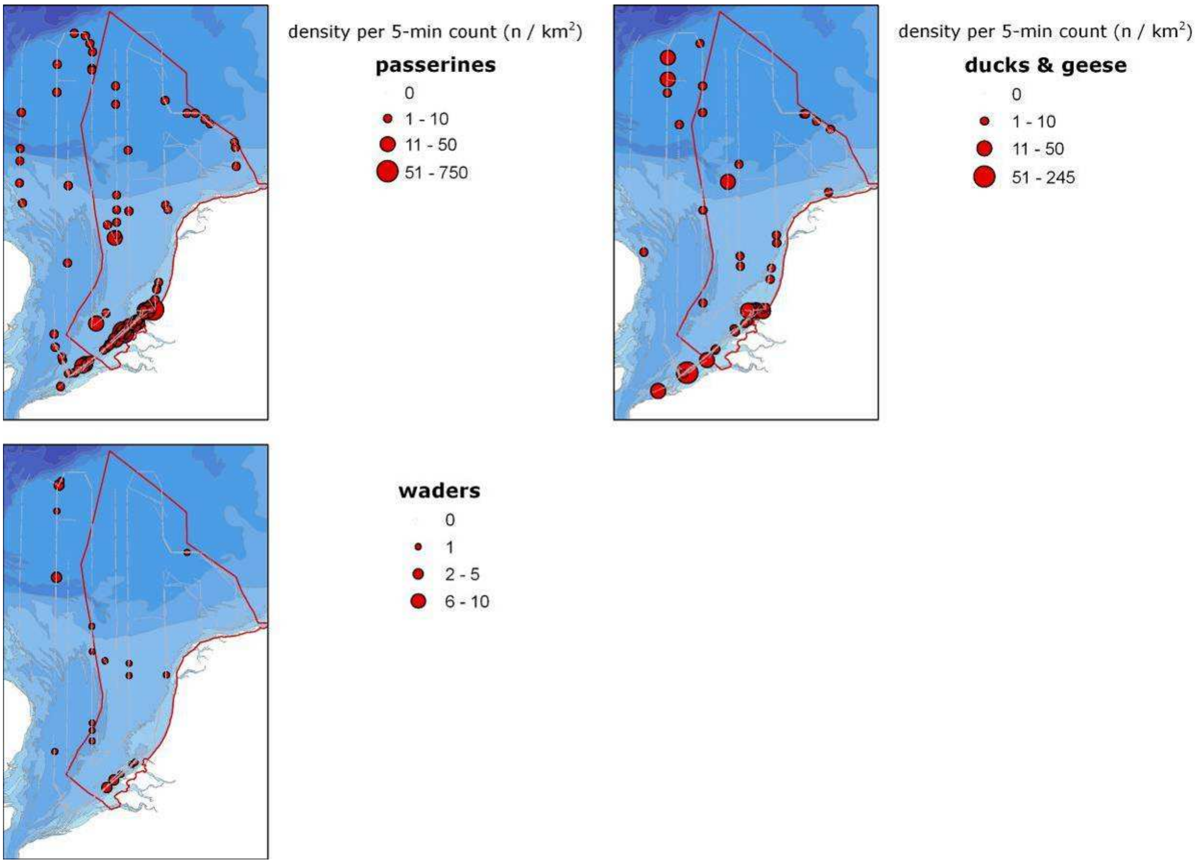

Figure 55 *Maps showing sightings of passerines, ducks and geese and waders. Virtually all of these sightings concern flying birds*

Marine Mammals

White-beaked Dolphin Lagenorhynchus albirostris

Conservation status: IUCN (2009): Least Concern

Bottlenose Dolphin Tursiops truncates

Conservation status: IUCN (2009): Least Concern

Short-beaked Common Dolphin Delphinus delphinus

Conservation status: IUCN (2009): Least Concern

Minke Whale Balaenoptera acutorostrata

Conservation status: IUCN (2009): Least Concern

Apart from Harbour Porpoises, four cetacean species were recorded (*Figure 9*). Of these, White-beaked Dolphin was the most abundant species, but records were restricted to May. During this survey three small pods were seen on the northern slopes of the Dogger Bank (2,1 and 2 animals); two small pods in the south-western part of the Southern North Sea (1 and 2 animals) and another pod near the Cleaver Bank (2 animals). In October two Short-beaked Common Dolphins, accompanied by searching Gannets, were seen off the Belgian coast. A day later three Bottlenose Dolphins were seen southeast of the Dogger Bank. This pod was associated with a feeding frenzy of Gannets, Kittiwakes and one Great Skua.

Single Minke Whales were seen in May and June, along the flanks of the Dogger Bank. Two animals surfaced a few times and disappeared, one animal showed more conspicuous behaviour and was seen breaching on the south(western) slope of the Dogger Bank. These observations are in line with recent discoveries of concentration areas of Minke whales in the Botney Cut area (Leopold & Camphuysen, 2006; de Boer, 2010).

Harbour Porpoise Phocoena phocoena

Conservation status: IUCN (2009): Least Concern

Harbour Porpoise was the most abundant cetacean, seen during every survey, but highest numbers were seen in winter (*Figure 56*). In all months the distribution was patchy. In April-May high densities were found in an offshore area off Norfolk, United Kingdom. In this area many individuals were apparently feeding. In May several clustered sightings were made at the Botney Cut (Cleaver Bank) and in June a fair number of sightings was done at the Frisian Front and north of the Wadden Sea Islands. In July most sightings were done in near shore waters of the Southern Bight. With deteriorating conditions during August-January, the number of sightings declined and no clear patterns emerge from these surveys. In February virtually all observations were made in the southern part of the study area.

At greater distances detection probability of Harbour Porpoises declines (*Figure 57*). Detection of Harbour Porpoises is heavily influenced by sea state (*Figure 58*). Detection may be increased by using obvious cues like searching Northern Gannets, who often associate with Harbour Porpoises. For estimated effective strip widths per sea state and the associated correction factors, see *Table 4*.

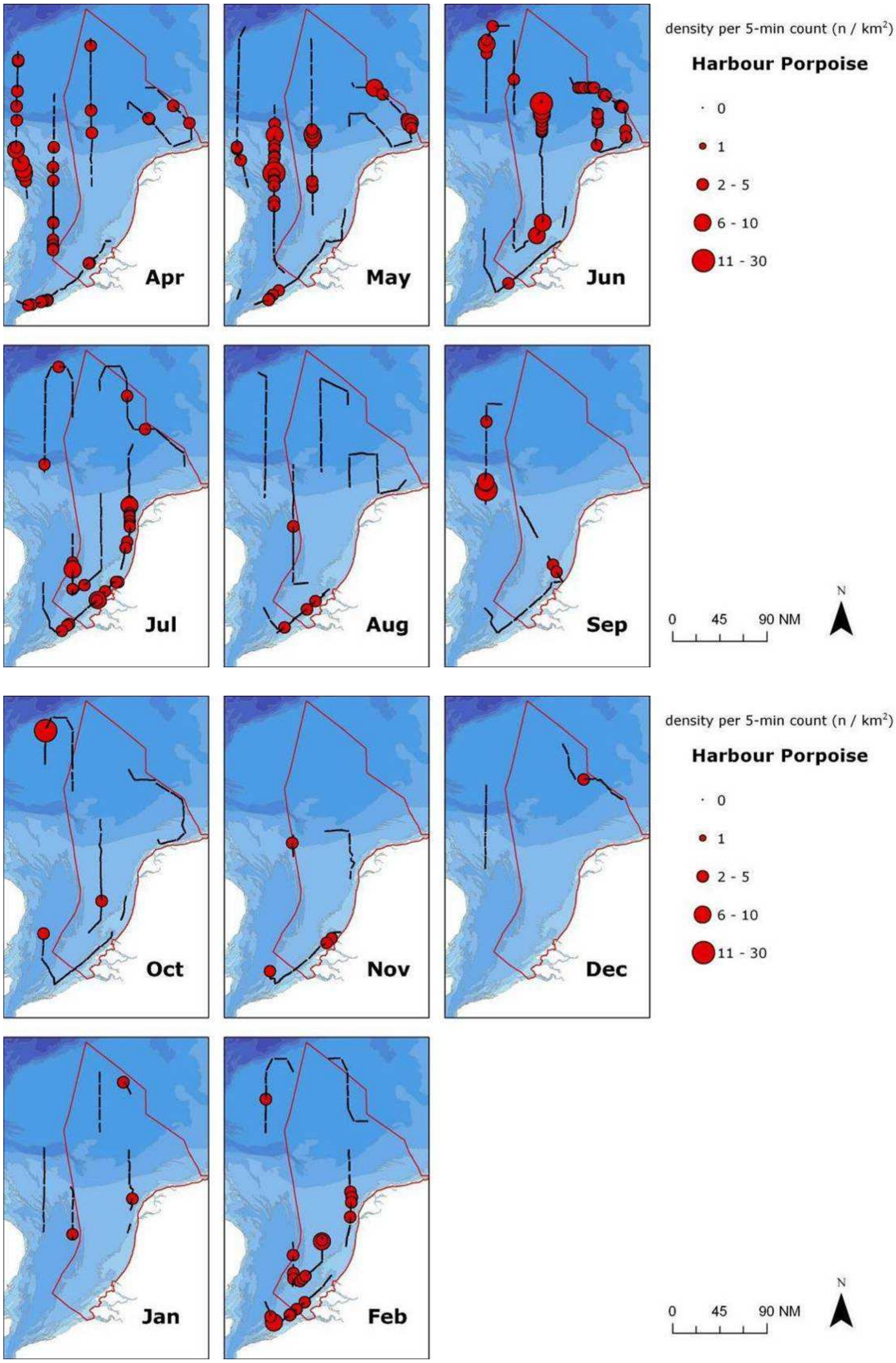

Figure 56 Distribution of Harbour Porpoises during surveys in April 2010 - February 2011

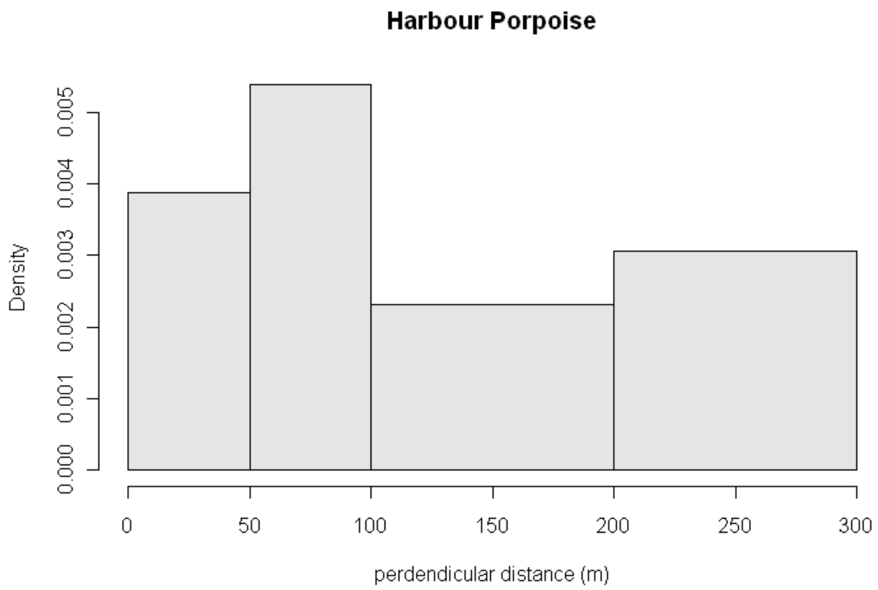

Figure 57 Histograms of (groups of) Harbour Porpoise per distance band (n=212). If all clusters of animals were detected, each bar would be equally high – this is clearly not the case. These figures are not corrected for sea state

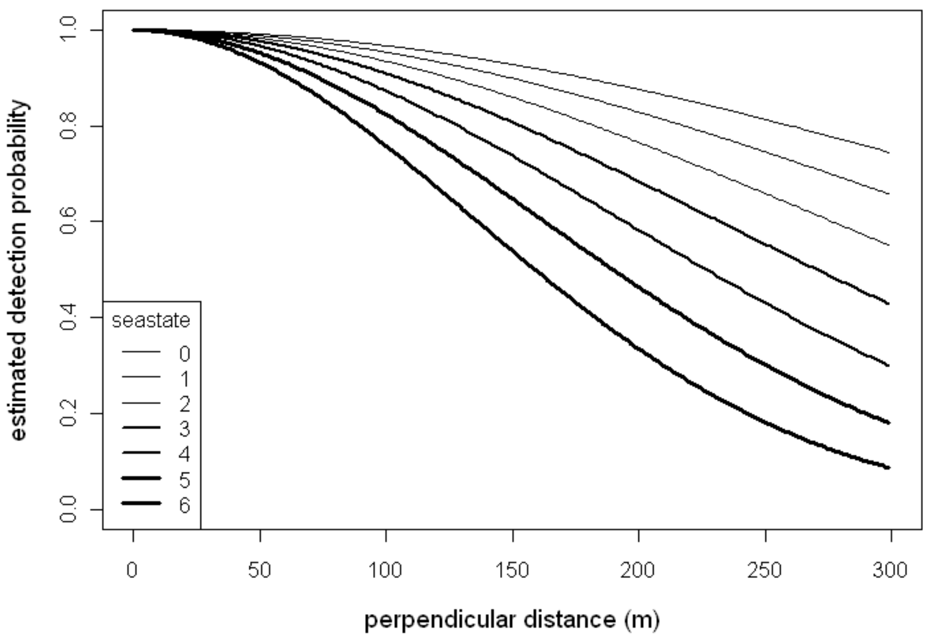

Figure 58 Modelled detection functions of (groups of) Harbour Porpoises per sea state (n=212)

Grey Seal Halichoerus grypus

Conservation status: IUCN (2009): Least Concern

Harbour Seal Phoca vitulina

Conservation status: IUCN (2009): Least Concern

During the surveys both Grey and Harbour Seals were seen; 5 seals could not be identified to species level. Numbers were low, with 15 and 18 records of individuals respectively.

The distribution showed an emphasis on the coastal zone (*Figure 9*). South of Scheveningen numbers of Grey Seal and Harbour Seal were in the same order of magnitude. In the northern part of the DCS Harbour Seal by far outnumbered Grey Seal. In British waters some scattered observations of both species were made.

Balloons

Apart from November and December balloons were encountered during all surveys. Numbers, however, fluctuated strongly (*Figure 59*). Densities were highest in April and July. Beside seasonal effects, depending on festivities, wind force and direction are likely to be the main factors determining the densities and distribution of balloons at sea.

By means of digital photographs the origin of some balloons could be determined. Identified origins included UK or Scandinavia (fast food chain TGI Fridays) in February, UK (restaurant Chiquito Mexican grill) in August, UK (Lambeth, a London suburb) in July, and UK (Vauxhall, a British car manufacturer) in April.

Though the expectation was that balloons have a more even detection curve, they “behave” like seabirds, in that they get more difficult to detect at greater distances (*Figure 60*), despite their brighter colours. However, in contrast to alcids and Harbour Porpoises, sea state did not have an effect on detectability of balloons (*Figure 61*).

Photo 2 This Great Skua Stercorarius skua apparently ingested a balloon. Brown Ridge, September 2010 (Hans Verdaat)

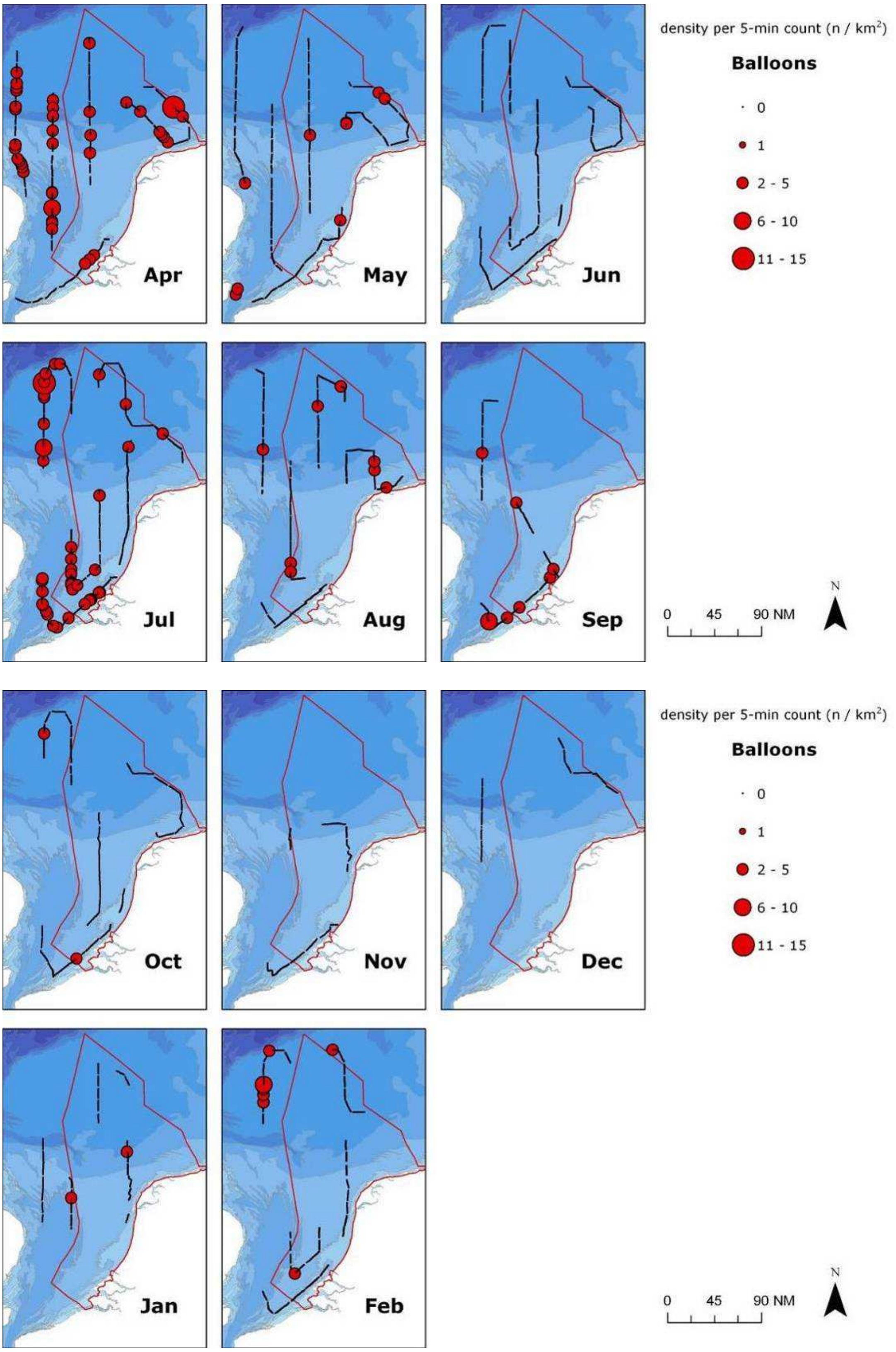

Figure 59 Distribution of balloons during surveys in April 2010 - February 2011

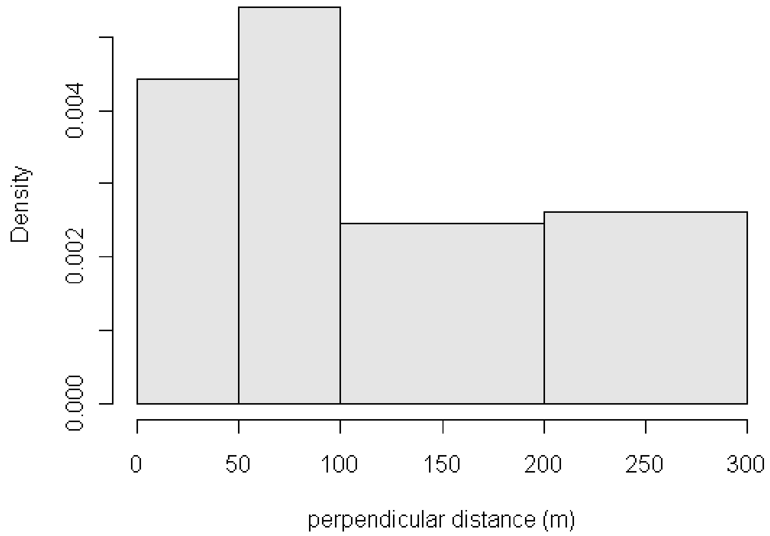

Figure 60 *Histograms of (clusters of) balloons per distance band. If all clusters of balloons were detected, each bar would be equally high. This is clearly not the case. These figures are not corrected for sea state*

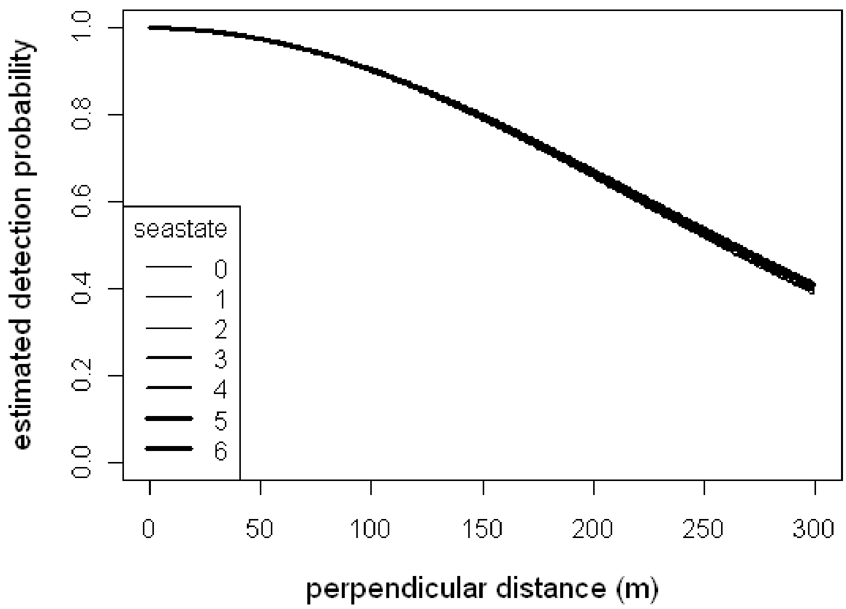

Figure 61 *Modelled detection functions of (clusters of) balloons ("classic" and foil balloons pooled) per sea state. Note that sea state has little effect on the detection of balloons*

4. Discussion and conclusions

After many years of little or no ship-based effort in far offshore areas of the DCS, this series of surveys provided the first recent ship-based data on seabirds, covering a large area (the entire DCS plus some Belgian, British and German waters) almost year-round. These surveys were conducted on a ship dedicated to sampling fish eggs and fish larvae, thus acting as a 'vessel of opportunity' for the seabird surveys. Due to changes in the survey design, a larger than expected variance in ships used (with different sailing speeds), but particularly bad weather during some of the autumn and winter surveys, the resulting coverage is not evenly spread over space and time. This spatial variation in data complicates inferences about temporal changes in local bird densities. To tackle these problems, dedicated bird and marine mammal surveys, using either ship (e.g. Leopold *et al.* 2004, 2010) or aircraft (Petersen *et al.* 2006; Poot *et al.* 2010) should be conducted. The choice for either platform should ideally be tailor-made for specific questions. The advantages and disadvantages of ship based and aerial surveys have been extensively discussed elsewhere (e.g. Camphuysen & Leopold, 1994; Camphuysen *et al*. 2004).

Both in terms of areas covered and detailed data gathered, this series of surveys complement the dedicated, dense, but rather near-shore network of aerial surveys carried out under the same program Shortlist Masterplan Wind (Poot *et al*. 2010). Virtually all individuals seen were identified to species level and a large body of data was collected on ecologically relevant phenomena such as moult and behaviour. Detailed species identification may be combined with the aerial survey data, to get a better picture of distribution patterns and densities of several look-alike species, such as guillemots and razorbills. Also density estimates for various species can be cross-validated between ship and plane survey data. From the behavioural observations, especially flying heights are of interest for planning of offshore wind farms. It should be noted, however, that ship-based observers focus on birds at the sea surface and therefore, high-flying birds may not always be detected. Thus, although the gathered data reflects 'normal' flying heights, there is a bias towards lower-flying birds. Furthermore, flying heights may sometimes be influenced by the presence of the boat from which the observations were conducted, especially in opportunistic species (such as gulls) and species exhibiting escape behaviour in relation to the boat.

By surveying beyond the designated areas for round II offshore wind farms on the DCS, areas that might be targeted for round III, such as the shallow Dogger Bank area, got a first boost in T-zero survey effort. The UK-parts of the Dogger Bank are currently being surveyed extensively and our surveys are – to some extent- complementary to that work. This might prove important in the near future as developments in faraway offshore parts of the North Sea will probably be taken on.

Despite the spatial and temporal variation in effort, hotspots with high bird densities have been identified, some of which were consistent over time. Most notable in this respect are the Cleaver Bank, the Dogger Bank, the Frisian Front and the entire Southern Bight. These patterns are consistent with earlier studies on the distribution of birds and highlight areas with increased bird densities (Camphuysen & Leopold 1994, Lindeboom *et al.* 2005, Leopold *et al.* in prep.). Bird populations of these areas appear particularly sensitive to the development of offshore wind farms, as is indicated by the Wind farm Sensitivity Index (WSI), a combination of SSIs and bird densities, which have been mapped by Leopold & Dijkman (2010) and repeated as Appendix B in this report.

These surveys have identified several issues to be dealt with in future planning of wind farms or at least certain aspects of seabird and cetacean distribution patterns that should be further studied. Migration of divers, which are the highest ranked species in terms of sensitivity to wind farms, not only takes place inshore, but can also be intensive anywhere in offshore waters. Furthermore, the indications found of an wintering population of the near-threatened White-billed Divers at the Dogger Bank calls for dedicated surveys to assess the size of this population and the extent to which this population uses the Dutch part of the Dogger Bank. Up till now, wind farms have only been constructed at more or less near shore sites where abundances of offshore species, such as Northern Fulmars, Atlantic Puffins, Little Auks and Minke Whales, are low. Therefore, the effect of offshore wind farms on these species is not known while wind farms might be built in round III in the Dogger Bank area, where concentrations of these animals may occur.

Photo 3 Adult Northern Gannet Morus bassanus (Hans Verdaat)

5. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 57846-2009-AQ-NLD-RvA). This certificate is valid until 15 December 2012. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

Rapport C099/11
Project Number: 430.25015.02

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: dr. Ingrid Tulp
Researcher

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Date: 15 August 2011

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Date: 15 August 2011

Appendix A. Specific sensitivity index for offshore wind farms

Table 1 Summed wind farm sensitivities (last column) for the main North Sea seabirds (first column), based on underlying factors A-I: A: flight maneuverability, B: flight altitude, C: percentage flying, D: nocturnal flight activity, E: disturbance by ship traffic; F: habitat use flexibility, G: biogeographical population size, H: adult survival rate, I: European Threat and Conservation

Bird species	A	B	C	D	E	F	G	H	I	SSI	Comment
Red-thr. diver	5	2	2	1	5	4	4	3	5	45.0	Disturbance by shipping put at 5
Black-thr. diver	5	2	3	1	5	4	4	3	5	49.5	Disturbance by shipping put at 5
Gr.Northern Diver	5	2	3	1	5	4	5	3	5	53.6	Not in Garthe & Hüppop
White-billed Diver	5	2	3	1	5	4	5	3	5	53.6	Not in Garthe & Hüppop
Unid. Diver										45.0	Most are Red-throated
Gr. Crested Grebe	4	2	3	2	3	4	4	1	1	19.3	Conform Garthe & Hüppop
Red-necked grebe	4	2	1	1	4	5	5	1	1	21.0	Disturbance by shipping put at 4
Northern Fulmar	3	1	2	4	1	1	1	5	1	5.8	Conform Garthe & Hüppop
Northern Gannet	3	3	3	2	1	1	4	5	3	11.0	Disturbance by shipping put at 1
Great Cormorant	4	1	4	1	3	3	4	3	1	20.0	Disturbance by shipping put at 3
Greater Scaup	3	1	2	3	4	4	5	2	5	36.0	Not in Garthe & Hüppop
Common Eider	4	1	2	3	4	4	2	4	1	23.3	Disturbance by shipping put at 4
Long-tailed Duck	3	1	2	3	4	4	2	2	1	15.0	Not in Garthe & Hüppop
Common Scoter	3	1	2	3	5	4	2	2	1	16.9	Conform Garthe & Hüppop
Velvet Scoter	3	1	2	3	5	4	3	2	3	27.0	Conform Garthe & Hüppop
Goldeneye	3	1	2	3	4	4	4	2	1	21.0	Not in Garthe & Hüppop
Red-br. Merganser	4	1	2	3	4	4	4	2	1	23.3	Not in Garthe & Hüppop
Pomarine Skua	1	3	5	1	2	2	4	3	2	15.0	Not in Garthe & Hüppop
Arctic Skua	1	3	5	1	2	2	4	3	1	13.3	Disturbance by shipping put at 2
Long-tailed Skua	1	3	5	1	2	2	4	3	1	13.3	Not in Garthe & Hüppop
Great Skua	1	3	4	1	2	2	5	4	2	16.5	Disturbance by shipping put at 2
Unid. skua										14.0	Not in Garthe & Hüppop
Mediterranean Gull	1	3	2	3	1	2	5	2	1	9.0	Not in Garthe & Hüppop
Little Gull	1	1	3	2	2	3	5	2	4	16.0	Disturbance by shipping put at 2
Black-headed Gull	1	5	1	2	1	2	1	3	1	5.6	Disturbance by shipping put at 1
Common Gull	1	3	2	3	1	2	2	2	4	9.0	Not in Garthe & Hüppop
Lesser BB Gull	1	4	2	3	1	1	4	5	2	9.2	Disturbance by shipping put at 1
Herring/LBB Gull										8.3	Not in Garthe & Hüppop
Herring Gull	2	4	2	3	1	1	2	5	1	7.3	Disturbance by shipping put at 1
Great BB Gull	2	3	2	3	1	2	4	5	2	13.8	Disturbance by shipping put at 1
Unid. BB Gull										11.5	Not in Garthe & Hüppop
Kittiwake	1	2	3	3	1	2	1	3	1	5.6	Disturbance by shipping put at 1
Unid. gull										8.3	Not in Garthe & Hüppop 5920 6020
Sandwich Tern	1	3	5	1	1	3	4	4	4	20.0	Disturbance by shipping put at 1
Common Tern	1	2	5	1	1	3	3	4	1	12.0	Disturbance by shipping put at 1
Arctic Tern	1	1	5	1	1	3	3	4	1	10.7	Disturbance by shipping put at 1
Commic Tern										11.3	Not in Garthe & Hüppop
Little tern	1	1	4	1	2	3	4	4	4	17.5	Not in Garthe & Hüppop
Black tern	1	1	4	1	2	3	4	4	4	17.5	Conform Garthe & Hüppop
Common Guillemot	4	1	1	2	2	3	1	4	1	10.0	Disturbance by shipping put at 2

Razormot										11.6	Not in Garthe & Hüppop
Razorbill	4	1	1	1	2	3	2	5	2	13.1	Disturbance by shipping put at 1
Black Guillemot	3	1	1	2	2	4	3	4	2	15.8	Not in Garthe & Hüppop
Little Auk	3	1	1	3	2	4	2	5	1	16.0	Not in Garthe & Hüppop
Atlantic puffin	3	1	1	1	3	3	2	5	5	18.0	Disturbance by shipping put at 3

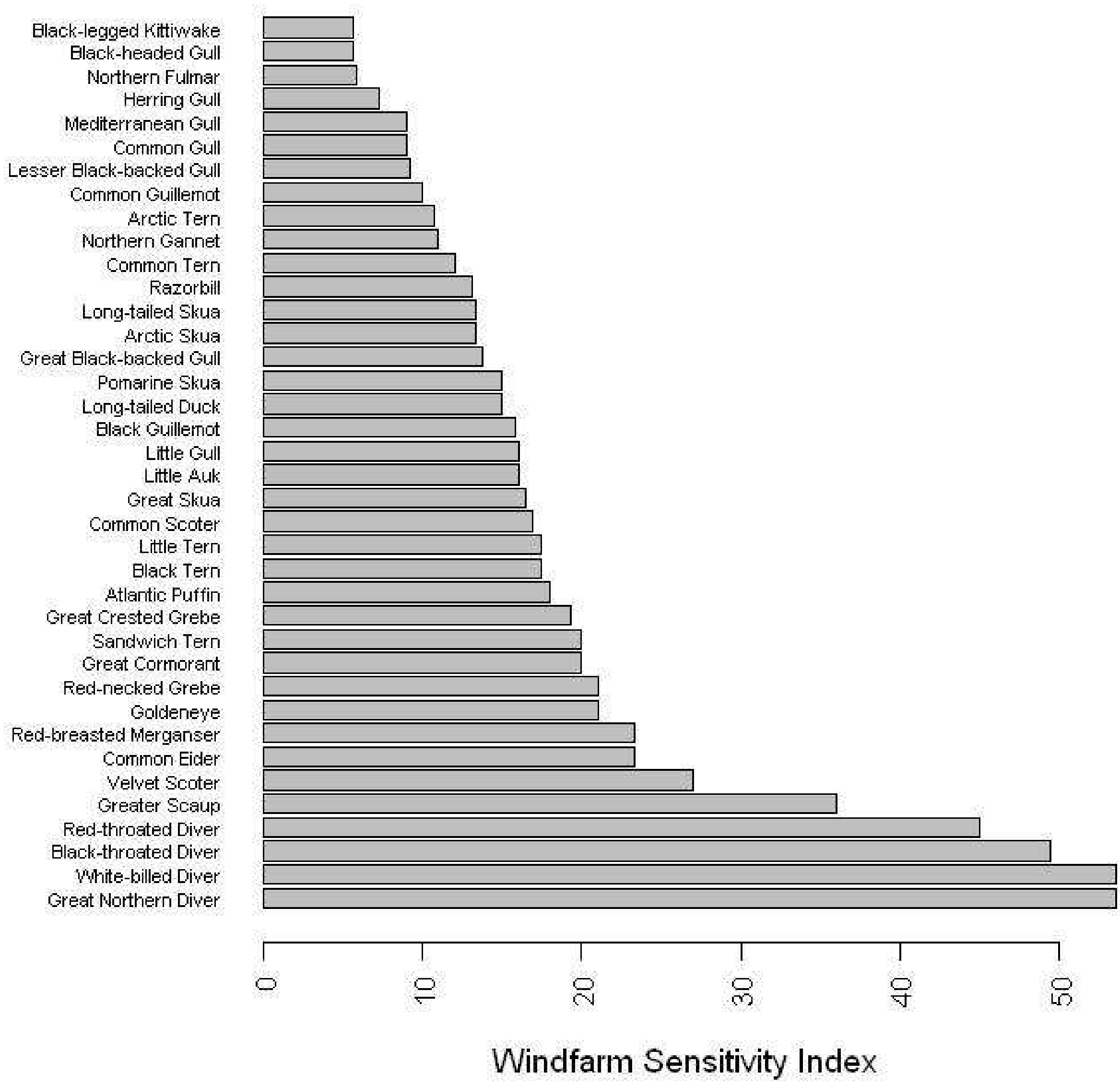
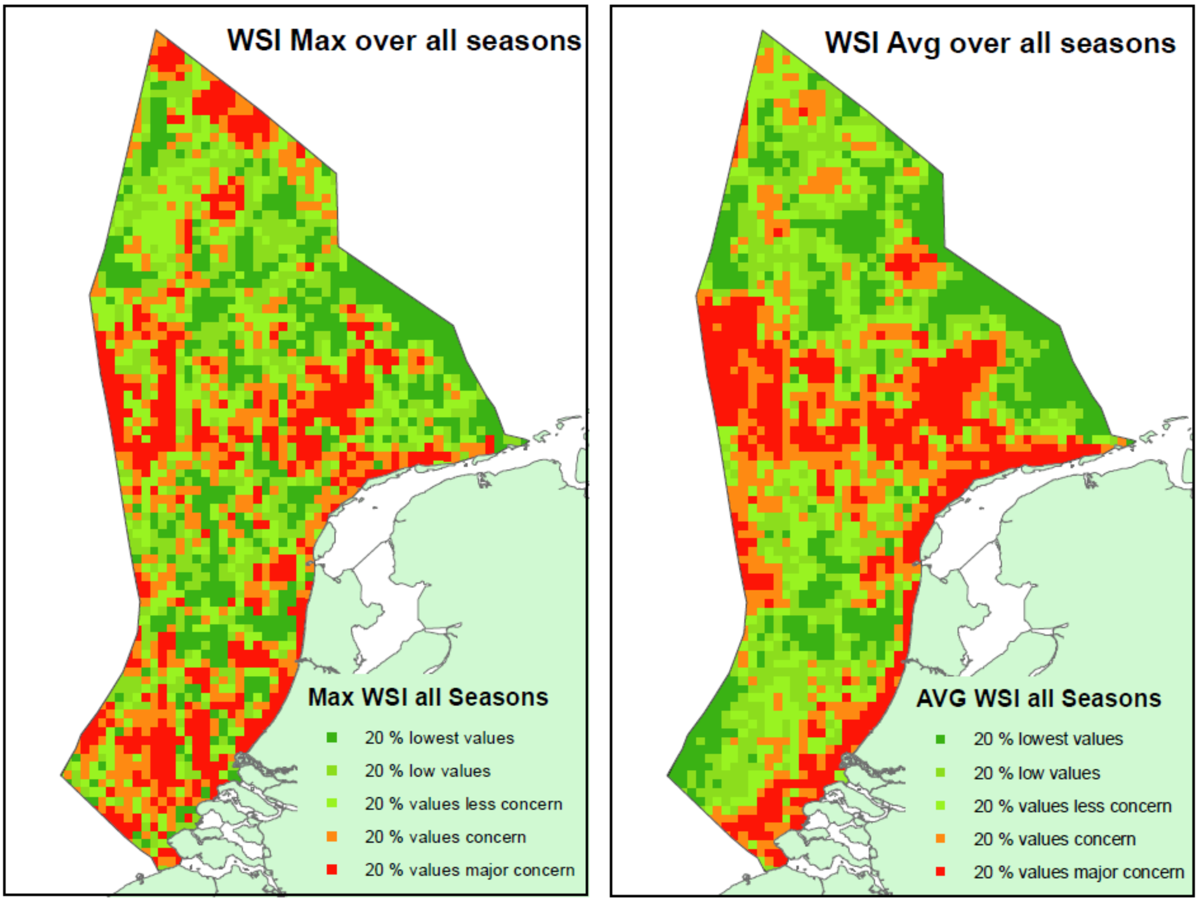


Figure 62 Ranked SSI values

Sensitivity of cetaceans to wind farms

Sensitivity values for cetaceans are not given, as the sensitivity to wind farms by cetaceans and the species in this sensitivity is poorly understood.

Appendix B. Wind farm Sensitivity Index



Taken from Leopold & Dijkman (2010). The left panel represents the maximum WSI over six bimonthly periods, the right panel shows the average over these six maps. Note the dominance of the coastal zone, the Frisian Front, the Cleaver Bank and surroundings, (parts of) the Dogger Bank and the Southern Bight. WSI is the summation of the multiplication of bird densities and SSIs.