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Report

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Baseline data on harbour seals, Phoca vitulina, in relation to the intended wind farm site OWEZ, in the Netherlands.

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Commissioned by: NoordzeeWind

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Tagged seal leaves the sandbank 10-10-2005

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1. Introduction

1.1. Goal of this study

Dutch government policy aims at realising sustainable energy production in The Netherlands. One possibility explored is offshore wind power. As an initiative, the government has given permission for the construction of a Near Shore Wind Farm (formerly called NSW, now OWEZ: Offshore Wind farm Egmond aan Zee) as a demonstration project, used for assessing both technological and environmental challenges in relation to construction and operation. In order to evaluate environmental impacts from an offshore wind farm it is necessary to carry out a baseline or T0 study, which provides for a thorough description of the ecological reference (present) situation.
The Nuon-Shell consortium “NoordzeeWind” exploiting the intended wind farm has procured a baseline study on the North Sea situation. The company has granted a contract to Alterra (now IMARES), to carry out the baseline study for harbour seals in the OWEZ area. The objectives of the study are described in the Strategy of Approach “Assessment of the Reference Situation of the Near Shore Windpark (NSW) for Harbour Seals”, as referred to in the Framework Agreement for the Provision of “MEP services” concluded between NSW and Alterra. They read: to estimate density and habitat use of harbour seals in the target area as well as reference areas.
The applied techniques to assess density and habitat use have to be of an internationally recognised standard, and should provide for data sufficient to describe the reference situation in space and time.

This baseline study includes a description of the spatial distribution, activity and migration of harbour seals that haul out both north of the OWEZ area (Wadden Sea) and south of it (Delta area). Seal activity and habitat use is measured by tagging harbour seals enabling to follow the animals on their trips at sea and measure diving activity.

When exploring possible effects of offshore wind farms along the Dutch coast, local effects such as habitat loss through disturbance and physical habitat change should be considered. In addition attention should be given to possible changes in the migration from the Wadden to the Delta area. Figure 1 shows a scheme of the planned study with respect to the effect study for OWEZ. Collection of data at sea will be combined with habitat modelling to estimate the relative importance of the study area and its possible functions. The basis for the assessment of possible effects of wind farms in open sea is the field study in phase two (T1) an evaluation of all collected telemetry data will be made, effects will be tested in comparison to data collected during the operation of the wind farm.
Only the baseline data collected during the T0, are presented in this report. Further analysis will take place after T1

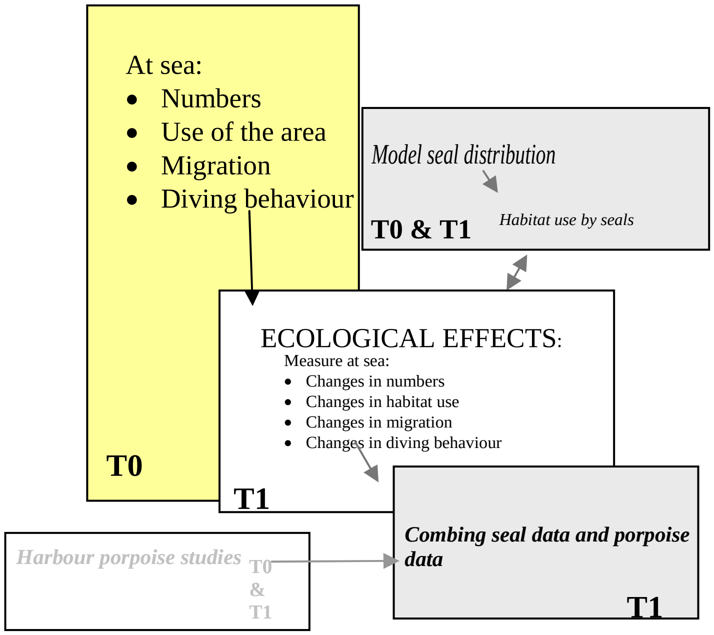

Figure 1. Scheme of the proposed seal study in relation to the building and use of the OWEZ. This paper reports on the first phase: T0 (yellow).

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1.2. Distribution of harbour seals in the Dutch coastal area

Much in contrast to the conspicuous birds, marine mammals exhibit a mostly cryptic behaviour in open oceans, as most of their time is spent under water. The mammals that also show a terrestrial phase such as seals, otters, polar bears can be counted on land and so enable a reliable population estimate. However, these animals are seldom seen in open water and therefore the function of that system is difficult to assess.
In Dutch waters two sympatric seal species are observed: the harbour seal and grey seal (Phoca vitulina and Halichoerus grypus). In this study we concentrate on the former in the same way as the harbour porpoise, as a proxy for the cetaceans, was studied in that baseline study (Brasseur et al. 2004).

It is tempting to conclude that the habitat of seals is limited to only the haulout sites (areas where seals aggregate outside the water, mostly sandbanks in the Wadden Sea and some in the Delta area). The animals are counted there during their breeding and moulting season at low tide when they tend to be most numerous (Reijnders 1978). Relative recent use of telemetry devices allowed to actually follow the animals into the water. This has opened our horizon and provided very different insights (Bowen et al. 1999, Brasseur et al. 2004, Brasseur & Reijnders 2001a, Härkönen et al., 1999, Reijnders et al. 2000, Thompson et al. 1996). In the Netherlands, harbour seals generally forage some tens of kilometres away from the haulout sites often changing haulout sites, ranging up to a few hundred kilometres in all. The bigger species, grey seals, may range hundreds of kilometres away to feed offshore. Their range could amount up to almost 1000 km (Brasseur & Reijnders in prep).

These migration and feeding ranges obviously are of importance to the seal population and should not be neglected when assessing possible impacts of human activities in coastal areas or further offshore. However, the necessity to acquire knowledge of these habitats, does not correspond with the difficulty to actually measure their function and relative importance. Chances of seeing a seal or following an individual to exactly the area of study are slim. In addition to being difficult to observe in open sea, seals seem to be solitary and show very individualistic behaviour. Variation in haul out pattern, distances travelled to feeding grounds and migration to other areas have been demonstrated both in harbour and grey seals in the Netherlands (Brasseur & Reijnders 2004, Brasseur et al. 2001, Reijnders & Brasseur 2000). Seals at sea are mostly alone; this makes them even harder to spot. Modelling seal movements and habitat use based on actual knowledge of seasonal and regional differences seem to be a sensible approach to define, and to some extent quantify, probable use of a specific area.

The Dutch harbour seals are part of the international Wadden Sea population. Most seals in Dutch coastal waters are seen hauling out in the Wadden Sea, but a small colony persists in the so called Delta area, the Scheldt estuary. Historically the ratio of numbers observed in the Wadden Sea vs. the one in the Delta was much greater, the latter consisting of one third of the seals in the Netherlands.

A combination of initially over hunting, that almost eradicated the population, followed by habitat loss, disturbance, pollution, prevented or slowed down the growth of the local population (Reijnders 1984). The number of harbour seals in the Delta remains low, this emphasises the urge to protect these colonies. IMARES (formerly Alterra) has almost 10 years of experience in satellite tagging harbour seals in both areas (Brasseur & Reijnders 2001a, Brasseur et al. 2004). In these studies a number of seals were shown to migrate from the southern Delta area north to the Wadden Sea and back. All tagged pregnant females left the Delta Area before parturition to give birth in the Wadden Sea (Brasseur & Reijnders 2001b). In lack of births in the Delta area, growth of the colony is dependent on immigration from other areas. The Wadden Sea is the most likely source population.

Existing data on seal movement indicates that the harbour seals are likely to travel along the coast, within a few tens of kilometres off the coast. These are the areas targeted for wind farms. One should take into consideration that beside affecting seal feeding habitat, wind farms could influence migration between the colonies. In the case of the Delta area a negative effect on migration could be devastating for the colony.
This project was carried out on behalf of NoordzeeWind, through a sub contract with ECN.

2. Material and methods

The OWEZ is intended to be a demonstration project, and therefore the assessment of possible effects will have a greater scope than only this area. Results should also yield a more general insight on the interaction between the seals and intended wind farms. Therefore the ultimate goal of the complete project (T0 and T1) includes, in addition to the impact study, the modelling of the use of the Dutch coast by seals, providing information on the relative importance of specific areas for the species. The Dutch North Sea coastal zone is known to play a role as foraging area, but also as a migration route between the Wadden Sea and the Delta area, vice versa. Therefore knowledge on individual seal behaviour (tracking) will be combined with population surveys (aerial counts). Using these methods we will establish migration, dispersal and density of the seals in the study area (wind farm location) and beyond. It is realistic to say that the latter will only be obtained through modelling. Data on actual presence of seals will remain limited.

2.1. Counts

Seals are usually counted during aerial surveys at low tide, when the maximum of haul-out sites are available. Harbour seals have been counted in the Wadden Sea during pupping and moult (June, respectively August) since the mid-1970 by the authors (IMARES), contracted by the Ministry of Agriculture, Nature and Food Quality. Multiple counts (5-8 counts a year) in this period provide the necessary accuracy for long term monitoring and population studies (Reijnders 1978; Reijnders 1997). The results also yield the spatial distribution of the seals and their pups, when present. In the southern Netherlands (Delta) seals are counted during a monthly count (Biologisch Monitoring Programma Zoute Rijkswateren van het RIKZ, Rijksinstituut voor Kust en Zee). Latest survey data will be procured from these monitoring programs and used in the final model.

2.2. Study Area's

The OWEZ area is located offshore at 8 - 18 km from the North Sea coast of Egmond aan Zee. It consists of about 40 km2, holding a total of 36 windmills with a hub height of 70 meters above MSL , each producing 3 MW. Though occasionally, seals are seen hauled out on the beach near Egmond, the area is relatively far from their major haul out sites (figure 2). The constrcution and operation of the wind farm could, however, still intervene with the migration or feeding of the seals.

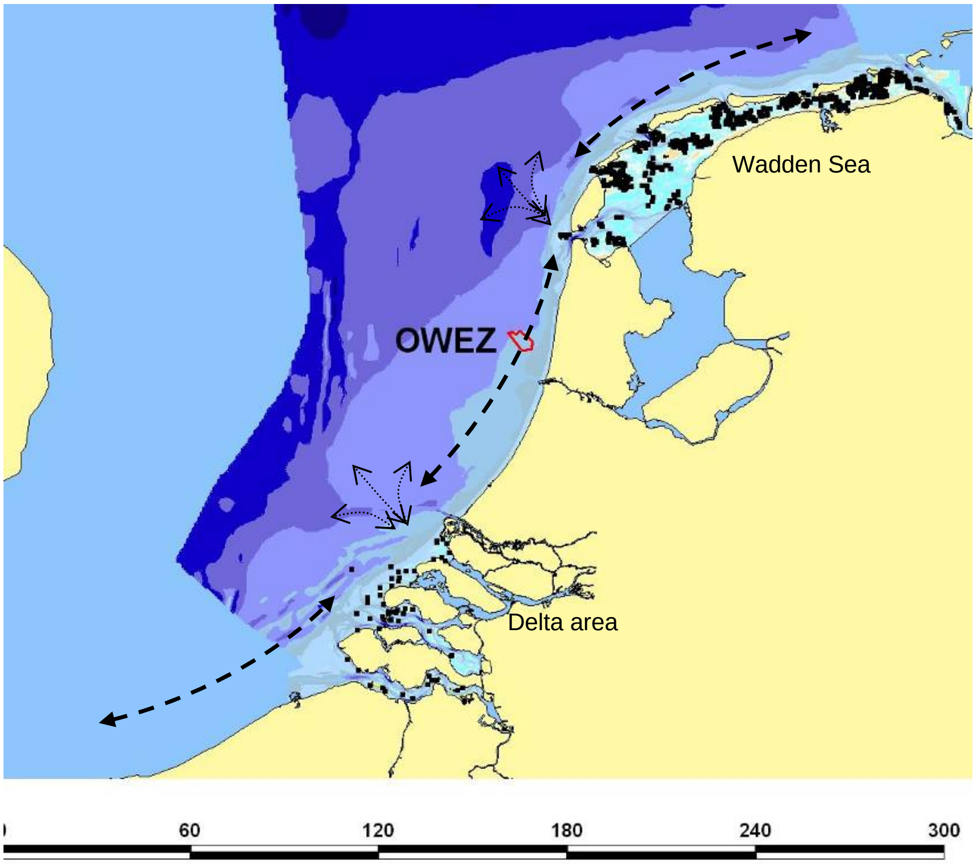

Figure 2. Wind farm site OWEZ (red polygon) and known seal haul out sites (black squares). Arrows indicate possible tracks during feeding (fine dotted lines) or migrating (dashed lines).

2.3. Individual seals

In former studies it was shown that seals easily migrate up to several hundreds of km to other colonies or swim tens of km, apparently to feed (Brasseur & Reijnders 2001a, Brasseur et al., 2004, brasseur et al., in press). In order to define the use of the area by the seals 2 x 6 seals were tagged with satellite tags. As there are no haulout sites in the immediate vicinity of the study area, six animals were tagged in the north (near Texel, the Steenplaat) and 6 in the south (in the western Scheldt, at Hansweert). This data will be used to model the behaviour and movement of the harbour seals in the Netherlands. In addition, existing data will be used to define the temporal and spatial if possible, to define the use of the area by the individuals (Reijnders et al. 2000, Brasseur & Reijnders 2001a, Brasseur et al. 2004, Brasseur et al., in press). This new data together with the data collected during T1, will make it possible to define year variation and specific use of the North Sea coast. This project was scrutinised and approved by the Dutch animal ethics committee of the Royal Netherlands Academy of Sciences.

Seals are caught on the haul out areas with a large seine net, and tagged directly on location. The tags are glued to the fur of the neck using two component quick setting epoxy. Captured seals are weighed and measured before release usually within 1:30 hour after capture. As a result of the incoming tide in combination with strong winds, the seals caught on Texel were only released after 3 hrs as the gluing had to be continued on board a ship.

Table 1. Details of the seals tagged in the western Scheldt, Hansweert and north of Texel, Steenplaat.

Program	Animal ID	Sex	location	date	Date max	Duration (days)	In captivity (hrs)	Length TOT
T0	A	F	Hansweert	08/10/2005	01/04/2006	175	00:59	135
T0	B	F	Hansweert	08/10/2005	23/05/2006	227	01:13	156
T0	C	F	Hansweert	10/10/2005	22/02/2006	135	01:17	124
T0	D	F	Hansweert	10/10/2005	21/01/2006	103	00:52	144
T0	F	M	Hansweert	10/10/2005	23/03/2006	164	00:45	134
T0	G	F	Hansweert	10/10/2005	30/05/2006	232	00:56	161
T0	E	F	Steenplaat	14/11/2005	15/05/2006	182	03:05	136
T0	H	M	Steenplaat	14/11/2005	16/04/2006	153	02:30	132
T0	I	M	Steenplaat	14/11/2005	25/03/2006	131	02:00	163
T0	J	M	Steenplaat	14/11/2005	09/02/2006	87	02:10	176
T0	K	M	Steenplaat	14/11/2005	10/04/2006	147	02:20	169
T0	L	M	Steenplaat	14/11/2005	22/04/2006	159	02:00	173

2.3.1. Telemetry System

The satellite relayed data recorders (SRDLs) were constructed by the Sea Mammal Research Unit and consisted of a data logger interfaced to a 0.5-W Argos radio frequency unit (Fedak et al. 1996). Detailed dive behaviour information is collected and transmitted via satellite. The average daily uplink rate was 7 per day (ranging between 12 and 2) this includes all locations (irrespective of location quality). The SRDL weighed 0.3 kg and could resist pressure to a depth of 1000m. In order to prolong battery life, the SRDLs switched to an energy saving mode after 5 hrs when transmissions were continuous (haulout).

Data from a depth sensor (0.5 m resolution) and a submergence sensor were used to determine the activity of the seal: “diving” (deeper than 0 m for at least 4 s), “at surface” (no dives for 180 s) or “hauled out” (continuously dry for at least 600 s, stops when wet for 40 s). Individual dive records included maximum dive depth, duration and previous surface interval durations. Dives were divided into shallow dives (<10m) and deep dives. From the latter dive shape was additionally recorded: four points per dive using dive characterisation algorithm, i.e. depth and time was recorded on four most significant flexing points in the dive.

Six hourly summary records, including the percentages of time spent diving and at the surface, were also calculated. Dive, haulout, and summary records were stored in memory and selected for transmission so that times of day when the Argos satellites were not available were adequately represented.

2.3.2. Data Processing

Location data

Argos location fixes were filtered by two algorithms: one described by McConnell, et al., (1992) using a 'maximum speed parameter' of 8 km.h-1. The principle of the filter was to reject locations that would require an unrealistic rate of travel to achieve. The other will be referred to as the Keating index, allowing unrealistic pathways to be filtered out based on the angle of the trajectory (Keating 1994). This filtering was done stepwise., starting with the highest quality data, gradually adding data of less quality. The accent of correction was thus put on the lesser quality data keeping as much high quality data as is.
Distance to known haulout areas was determined and two states were defined: “ at sea”= more than 1000m away from any haulout, “haulout”= within 1000 m of a haulout site. A trip was defined as a number of consecutive locations “at sea”. The trip or haulout period was estimated to start on the midpoint between the previous location and the next location. The distance from each acquired location to the last visited haulout site and the distance to the site where the seals were tagged were determined.
Tracks were plotted in Arc-view (version3.0)

Behavioural data

In this report, summary diving data is presented. These will be used in the final report to define foraging areas. Behavioural data (haul out, surface, dive) is presented as daily percentage of time for each seal. Number of dives (shallow and deep) and daily maximum depths are shown for each seal.
Dive shapes were compared by calculating the similarity between separate similarity matrices that were constructed for each single dive based on (normalised) time and depth data. This technique is known as Second-stage Multidimensional Scaling (Clarke et al 2006). The dive shapes are compared and the resemblance between the separate dives is determined by the Spearman rank order correlation coefficient. This results in a matrix of correlations that can be further analysed. In order to determine the function of the dives, needed in the

final habitat use model, the Second-stage matrix was clustered by agglomerative hierarchical clustering (Legendre & Legendre 1998). This way different groups or clusters of dives could be distinguished. Finally for each cluster the average dive profile was calculated. This was done for one seal as a test for the method. The dive depth and duration at the 4 points in the dive (see 2.3.1.) were used for the characterisation of the individual dives.

Computations

All calculations use options available in the PRIMER software package (Plymouth Routines In Multivariate Ecological Research, version 6), Clarke and Gorley (2006).

3.1. Seal Numbers

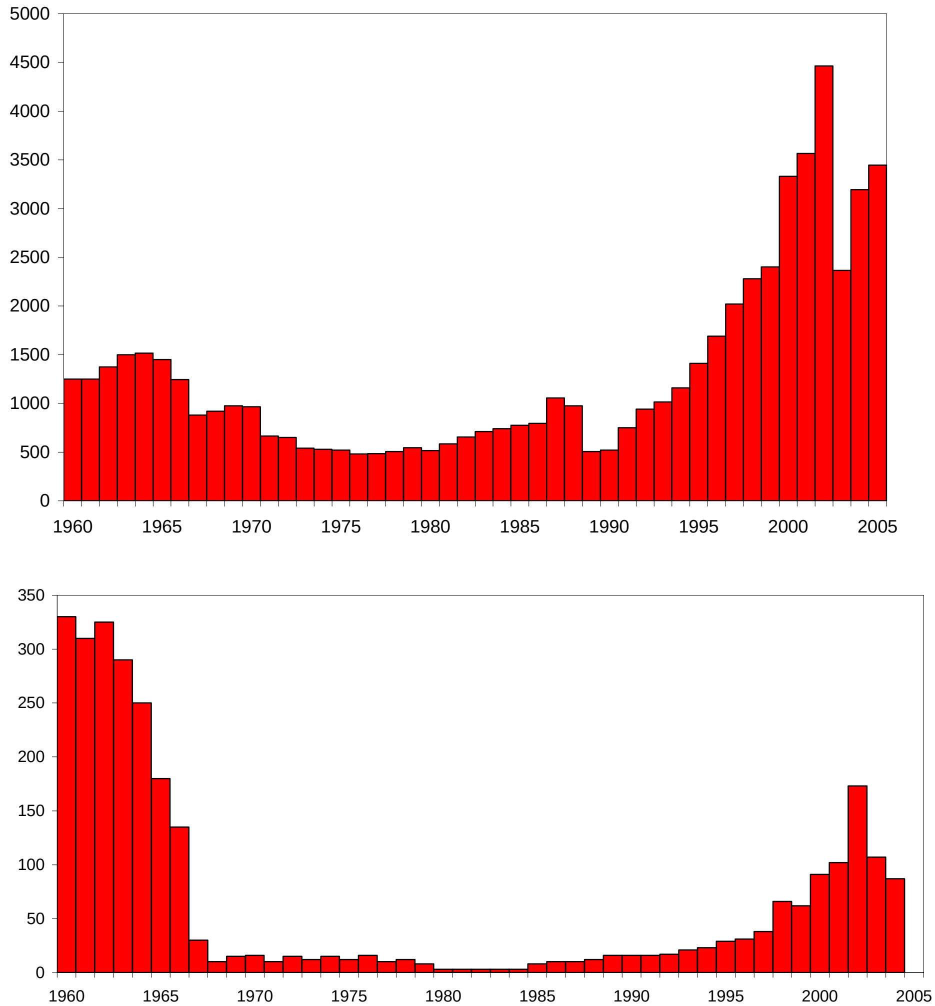

Figure 3 Number of harbour seals counted in the Netherlands during the moult (August). Top: the Dutch Wadden Sea (data: IMARES), Bottom, the Delta Area (Data RIKZ & provincie Zeeland; data available up to June 2005).

In the Dutch Wadden Sea a yearly maximum number of seals is determined in relation to the international population, ranging from Den Helder in the Netherlands to Esbjerg in Denmark. The numbers counted represent the amount of seals counted in the Dutch part of the International Wadden Sea, during a trilaterally synchronised count (Figure 3). As not all the seals are on the sandbanks during such a count a correction factor was determined. In the summer months an average 68% of the seals are counted during low tide (Ries et al., 1998). This implies that in 2005 there were approximately 5000 seals in the Dutch part of the Wadden Sea and 130 in the Delta area.

3.2. Telemetry

3.2.1 Tracking and seal records

Though some variation is seen, the tags in this study performed particularly well, Seals were tracked for 100-240 days. The last seals were still being tracked while the construction of the wind farm had started (April 17th).
In general, the seals were relatively light in weight relative to their length (Figure 5), but this can be expected as the seals were caught in autumn at the end of the breeding and moulting period. Then they can be up to 30% less in weight than in spring when they start to breed.

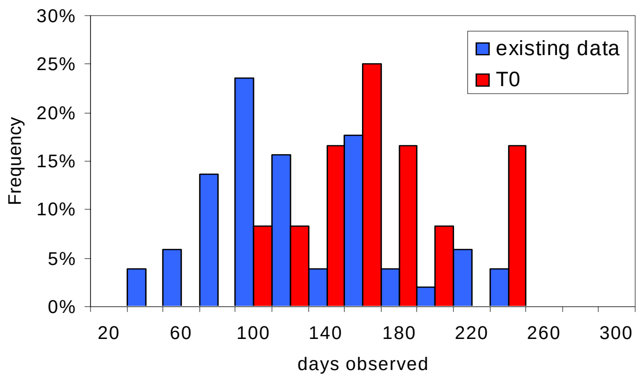

Figure 4 Longevity of the tags compared to earlier results (Brasseur & Reijnders unpublished data)

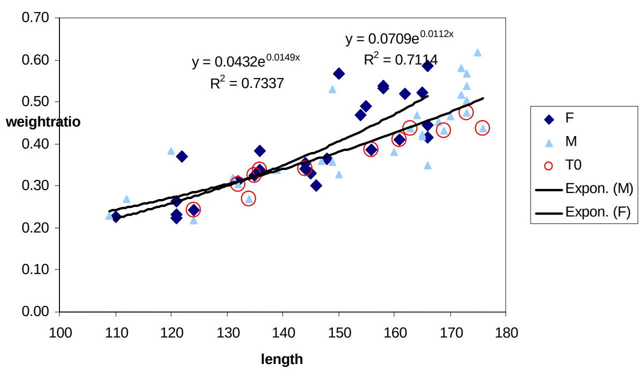

Figure 5. Length/weight relation of the seals tagged for this project (T0) compared to seals studied earlier by IMARES. F = female; M=male.

3.2.2 Tracking results: movements, foraging and migration

Movements

As in earlier studies (e.g. Brasseur et al 2004) the seals studied show a large individual variation (Figure 6) in their movements. During the period that the seals were followed they often switched haul out sites (Table 2). Interestingly, the animals in the southern Netherlands show more site fidelity to particular haulouts than the seals in the Wadden Sea.

Table 2 Number of haulout sites visited during the study. Number of general area's is given between brackets.

Animal_ID (Delta Area)	No of haulout sites visited	Animal_ID (Texel)	No of haulout sites visited
A	14	E	26 (15)
B	12	H	65 (22)
C	7 (6)	I	46 (17)
D	12 (11)	J	43 (17)
F	10 (9)	K	68 (23)
G	13 (12)	L	39 (14)

In contrast to earlier findings, migration from the Wadden Sea to the south or vice versa was not recorded in this study. However, almost half the seals travelled more than 100 km away from their last haul out area. Several animals in the south, left on multiple occasions to go to the French coast. Local naturalists, active in seal observing, declared that the area near Calais, where the animals are seen to go, is frequently visited by seals. Apparently this area is of quite an interest given the fact that it is visited several times by two different seals (C: orange and G: brown).

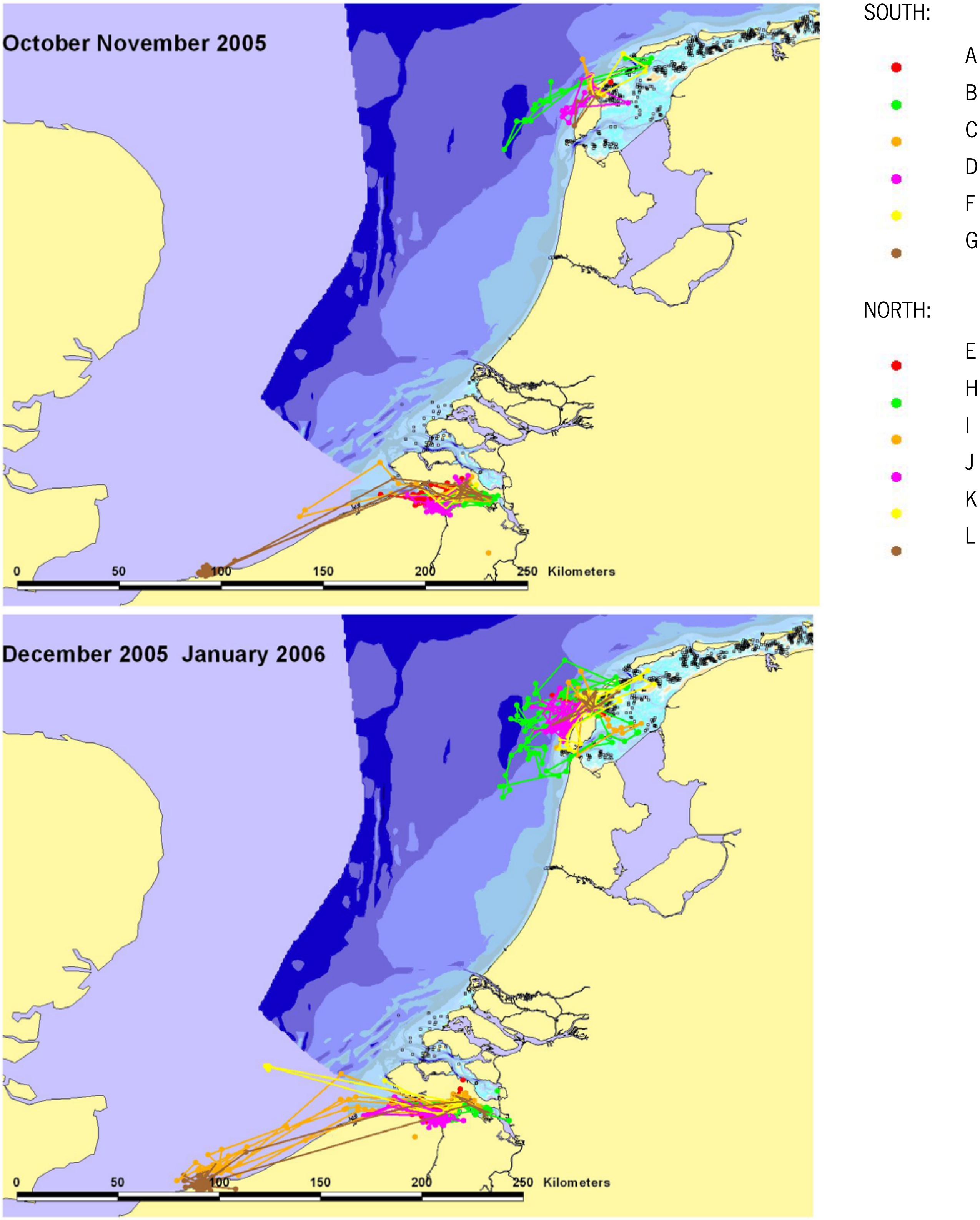

Figure 6. Individual bi-monthly movements of the tagged seals October 2005- January 2006.

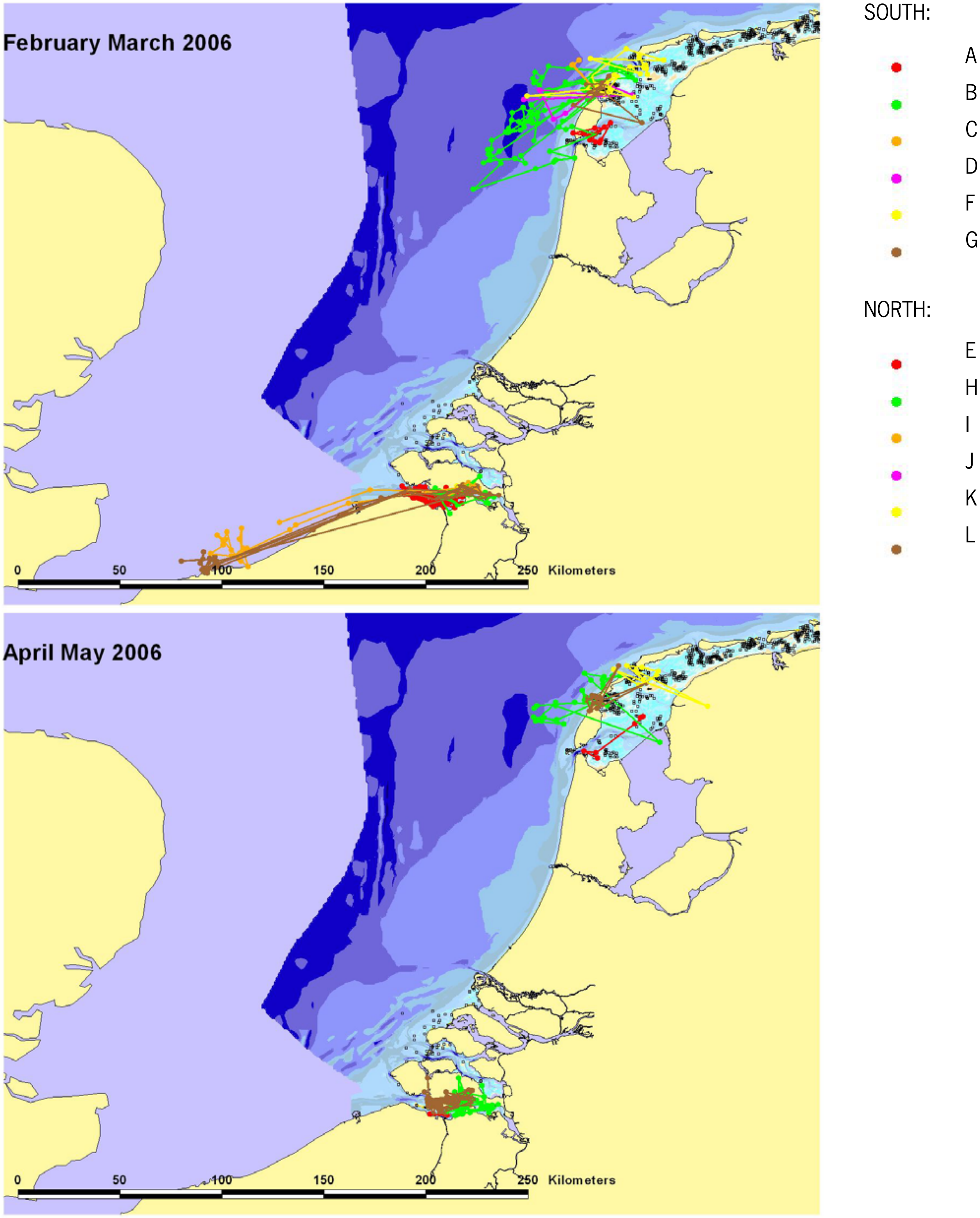

Figure 6. continued, February 2006- May 2006.

In the north the “Texel seals” don’t exhibit such large range travels,, though trips of up to 100 km were observed. In both areas some of the seals remain very local in this season hardly moving more than 20 km away from any haul out site. In April and May the seals seem much less mobile and from mid-April onwards remain within the respective Wadden Sea and Scheldt. This coincides with the onset of the construction of the wind farm. One can exclude that this is due to breeding activity as the pregnant animals are known to still be very active up to a week or two before parturition in June-July (Brasseur & Reijnders 2001b). Seals tracked in the same season some years earlier showed long distance travelling on the North Sea in this period (Brasseur et al 2004). Detailed analysis planned in the next phase should give more insight in the possible effects of the wind farm construction on the seals movements.

3.2.3. Dive data

Figure 7 and Figure 8 show the activity patterns of the individual seals in relation to the distance from a haul out site.

These figures show, once again, the large individual variation between the seals. Typically most seals show a drop in percentage of time hauled out and a rise in time diving when they are far from a haul out site. The percentage of time at the surface remains relatively constant, about 20% of the diving time.

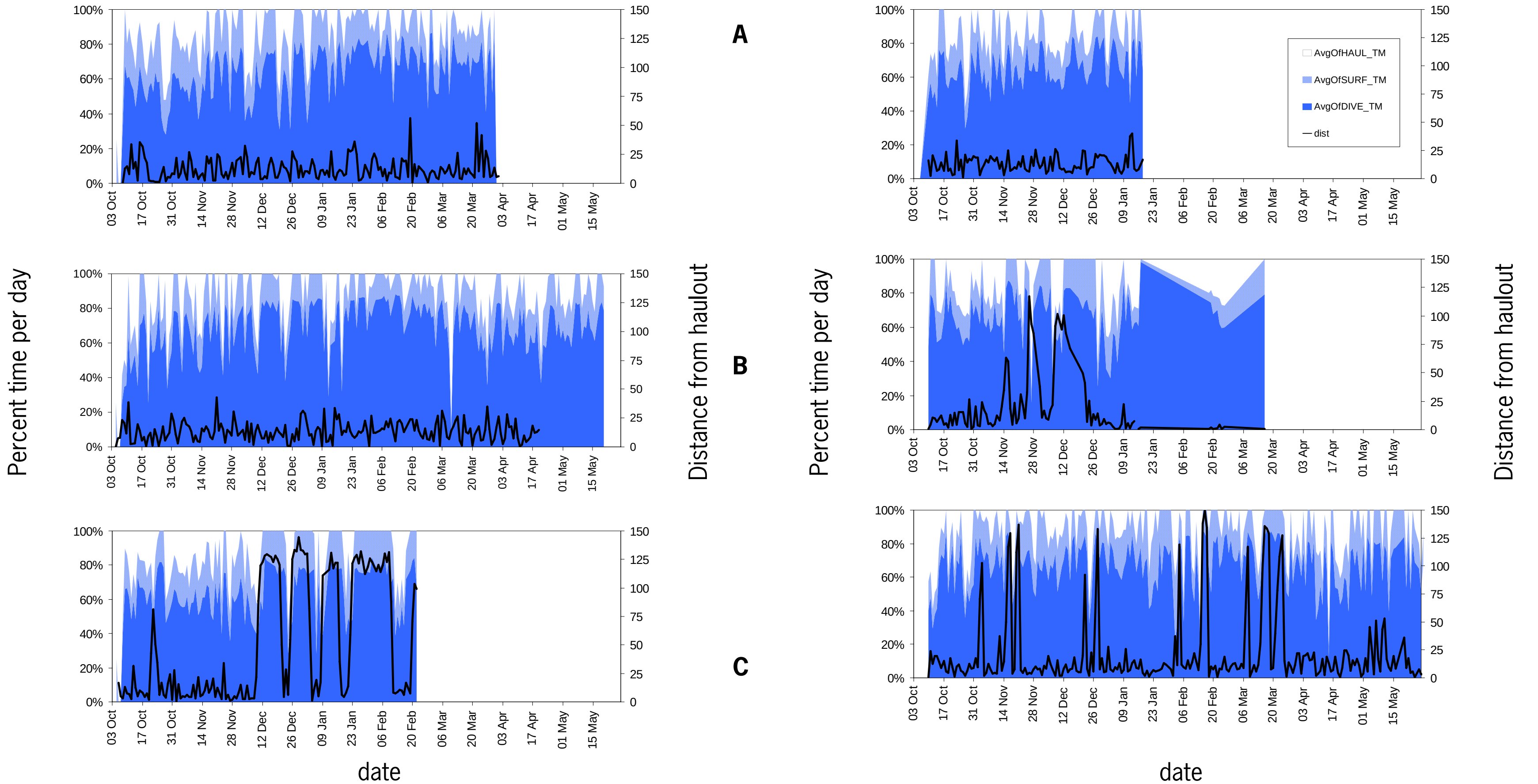

Figure 7. Activity patterns (respectively haul-out/surface/dive) and distance from home of the seals tracked in the Delta area. Letters coincide with the seal ID.

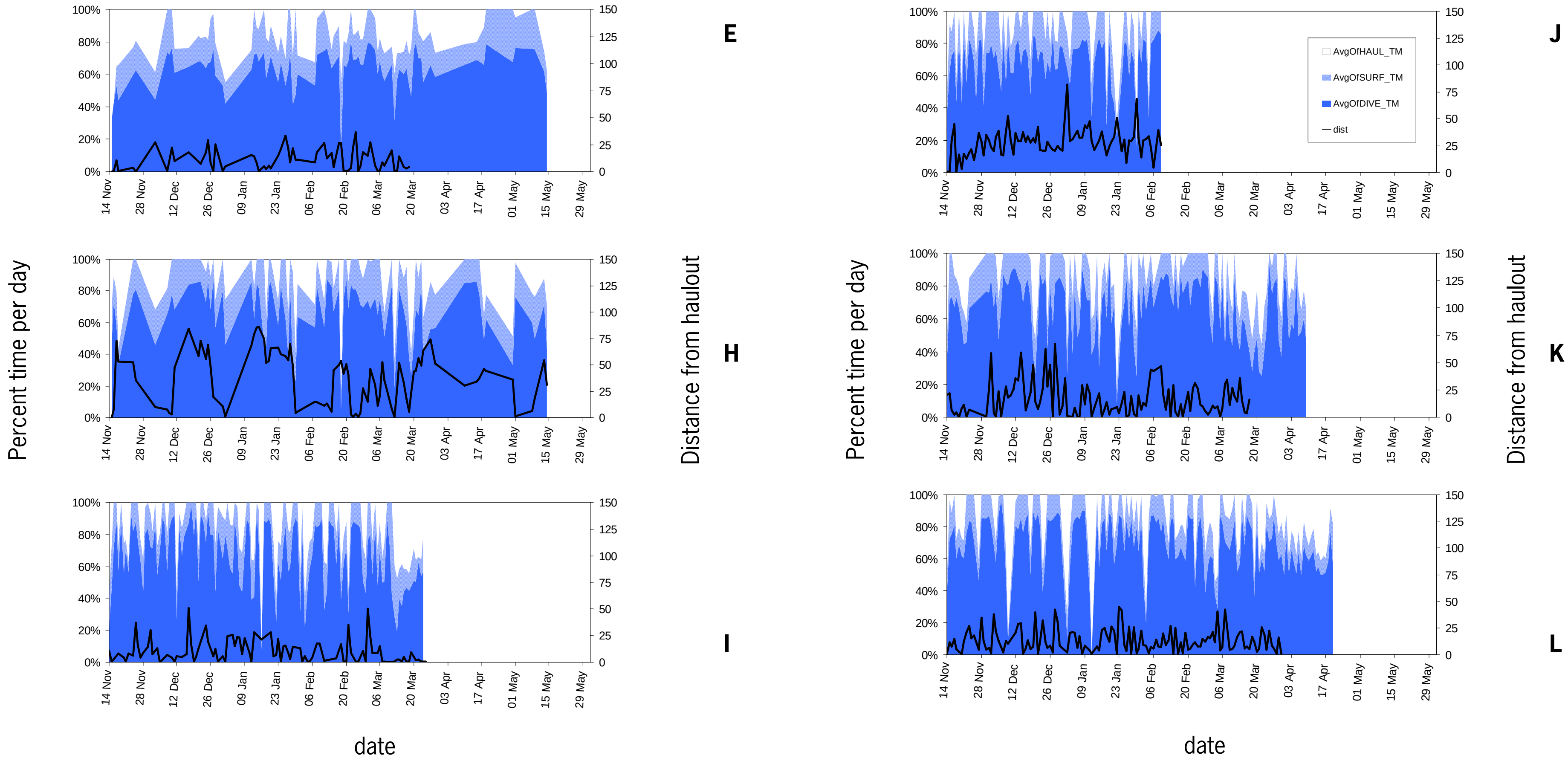

Figure 8. Activity patterns (respectively haul-out/surface/dive) and distance from home of the seals tracked in the Delta area. Letters coincide with the seal ID.

Though some variation occurs, about 2/3 of the dives recorded were less than 10 m deep (shallow dives) 1/3 of the dives recorded were deeper than 10 m (Figure 9).

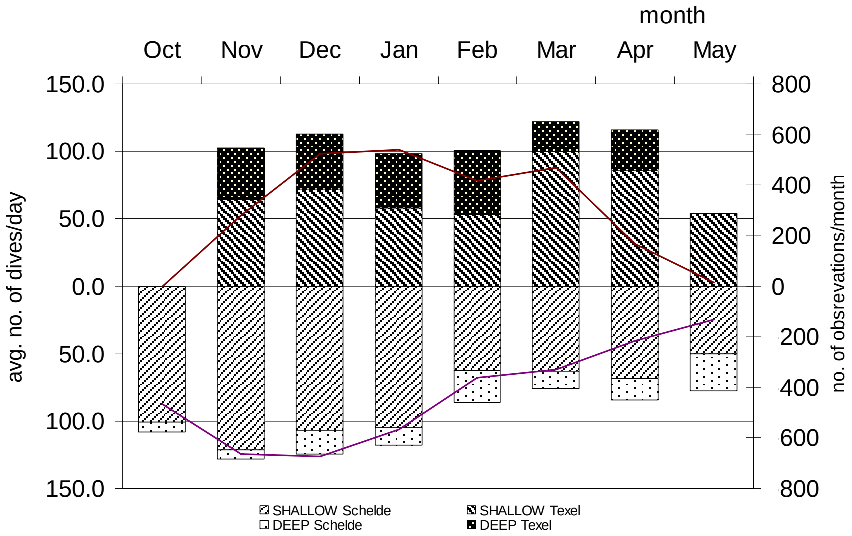

Figure 9. Average number of dives per day divided in two categories: deep dives (>10 m) and shallow dives (< 10m). For comparisons sake the data collected in the Delta area is presented under the Wadden sea data. Right axis shows the number of observations (6hr period) /month.

The deepest dive is recorded at >80m. Seasonal variation is observed both in the total number of dives and in the relative amount of deep dives. In general, the seals in the south show less deep dives. Interesting is the discrepancy between the two areas in March and April.

3.2.4. Defining behaviour in dives

Dives that exceeded 10m were recorded with more detail. In addition to the moment of emersion and submersion, three most significant inflicting points are recorded. This provides information on dive shape, and could indicate differences in behaviour (Baechler et al. 2002). Clustering these dives for seal A (Delta area) shows that 7 groups can be defined significantly, 5 of which are dominant (b,c,d,e and g).

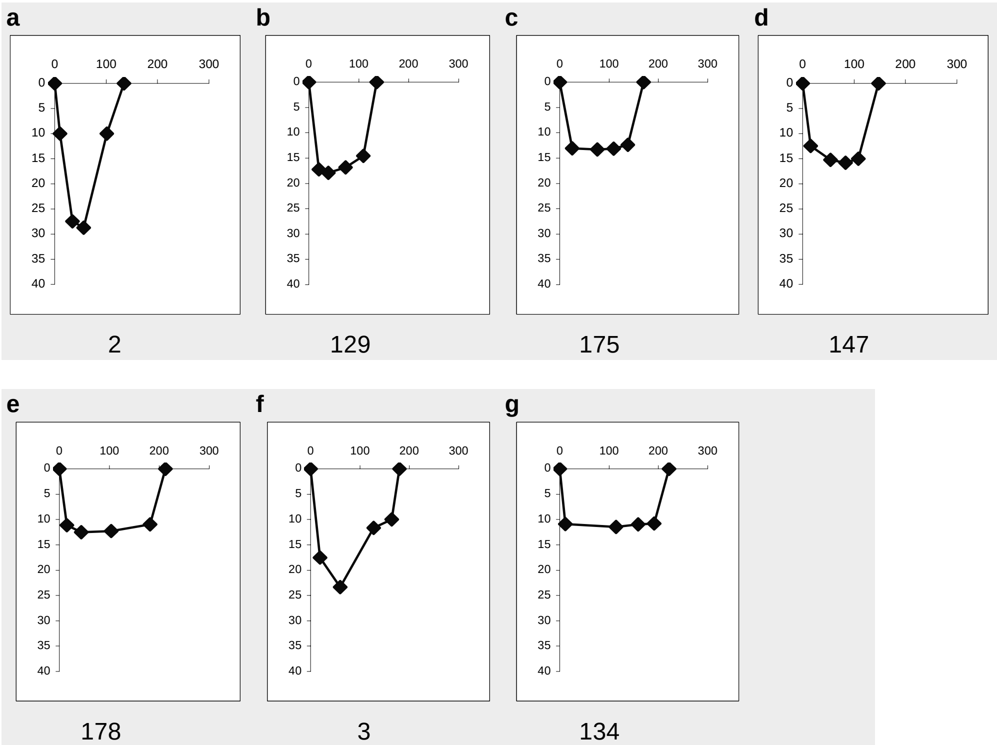

Figure 10 Clusters of dives as determined by clustering for animal A. Dive duration (seconds) is expressed on the horizontal axis; depth on the vertical (meters) The number of dives included in the cluster is given below each graph is.

In the next phase this analysis will be elaborated and used to define areas were certain behaviour takes place *i.e*. long shallow dives vs. short deep dives.

4. Discussion and evaluation

The presented data on seal numbers shows that in the Wadden Sea, the number of seals has been growing exponentially. Despite the 2002 epizootic the harbour seal population recovered swiftly. This is in contrast with the Delta area where the harbour seal numbers seem more variable and generally small, despite the observed growth. The data show the variation between the Wadden Sea and the Delta in the same period. Also diving behaviour is different between seals from the two areas. This data will be used in the final model in T1.

One can tentatively calculate that the number of animals from the Wadden Sea migrating south and necessary to realise the growth observed in the Delta population despite virtually no reproduction there amounts to a few tens of animals. This is less than 1% of the numbers in the Dutch Wadden Sea. Though convincingly important for the Delta area, the telemetry results acquired in this phase have not shown this migration. Next to the low numbers tagged and the low chance to detect migration at all, this could also be caused by the fact that most of the seals tagged in the Wadden Sea were (sub-)adult males. These might not be eager to migrate in the same way young animals would. Analysis of existing data and tagging of more seals, aiming at acquiring a better representation of the population in the following phase will help us to better define the migration patterns.
In the same way, one could question why migration from the south to the Wadden Sea did not occur given the observations made in 1999-2001 were 3 out of 15 animals were seen to travel north. Possibly, this is related to the season, the exchange observed earlier was in spring and summer, coinciding with reproductive period, whereas the current data is collected in winter and early spring. Analysis in the next phase should help quantify the exchange between the two areas. Migration from the Delta towards the south (Belgium, France) had been observed earlier and was to be expected.

Table 3. Overview of seals tagged between 1997 and 2006

Area	Season	Tot.	Female	Male	F	M	sum per area
Delta	spring	8	4	4	7%	7%	
Delta	autumn	13	8	5	14%	9%	
							21
Wadden	spring	17	9	8	16%	14%	
Wadden	autumn	18	6	12	11%	21%	
							35
			27	29	48%	52%	
total							56

It is clear that the seals show a large individual variation in behaviour both in the Wadden Sea and in the Delta Area. This justifies a model approach such as planned, aiming at creating a usage map for the “Dutch” harbour seal (this includes seals hauling out in Dutch estuaries and coastal waters) in an attempt to define in- and offshore areas of importance to the species. In the light of the current results it is clear that seasonal patterns should be one of the variables used in the model. Year to year variation should also be analysed and corrected for. Classification of dives will be used to discriminate behaviours.

Plans for next phase:

During T1 two tagging sessions are planned: one in spring and one in autumn. The aim will be to tag seals from different age/ gender groups in order to be able to quantify the effect of age and gender on the use of the target area. We must take into account that this is not always possible as, especially in the Delta area, there is little choice.

Ameliorations:

- good maps

in order to define the seals' habitat use properly, a definition of the areas the seals use (maps) should be available . High quality bathymetrical maps are available for the Dutch NCP. However the seals do not respect these borders and may also utilise Belgian, French, German or British waters. Efforts should be made to collect recent data on bathymetry but also morphology and sediment of the Dutch waters and adjacent areas.

- higher quality location

We will keep track of new development in tags as they have recently been ameliorated, though not yet reliably. The new generation tags should in the near future collect GPS data yielding more accurate locations. By using the same logger for diving data, the more accurate locations could be combined with existing data. It is still questionable whether the tags will be operational on time.

References

Some of the data used in this report were provided by Rijkswaterstaat National Institute for Coastal and Marine Management / RWS RIKZ. The data were collected for the biological monitoring programme of the marine and coastal waters, which forms a part of the National Dutch Monitoring Program (MWTL). RWS / RIKZ is not responsible for any of the conclusions presented in this report based on the data they have provided.

5. Literature

Baechler J., C.A. Beck, and W.D. Bowen 2002. Dive shapes reveal temporal changes in the foraging behaviour of different age and sex classes of harbour seals (Phoca vitulina) Can. J. Zool. 80: 1569–1577 (2002)

Brasseur & Reijnders 2001a, Zeehonden in de Oosterschelde, fase 2 Effecten van extra doorvaart door de Oliegeul. Alterra-rapport 353 issn 1566-7197 60pp.

Brasseur S.M.J.M & P.J.H. Reijnders 2001b.Tracking Breeding Harbour Seal (Phoca vitulina) Females in Dutch Waters, Diving, Haulout and Movement. Abstract for society for Marine Mammals 14th biennial conference.

Brasseur, Sophie,Ingrid Tulp, Peter Reijnders, Cor Smit, Elze Dijkman, Jenny Cremer, Michiel Kotterman & Erik Meesters Voedselecologie van de gewone en grijze zeehond in de Nederlandse kustwateren; I Onderzoek naar de voedselecologie van de gewone zeehond , II Literatuurstudie naar het dieet van de grijze zeehond, gepubliceerd: Nov 2004, 116 pp

Brasseur Sophie, Peter J.H. Reijnders Erik H.W.G. Meesters Elze M. Dijkman & Jenny S.M. Cremer in press Onderzoek naar Voedselecologie van gewone en grijze zeehonden: Fase II.

Clarke KR, Somerfield PJ, Airoldi L, Warwick RM (2006) Exploring interactions by second-stage community analyses. J Exp Mar Biol Ecol in press

Clarke, K.R., Gorley, R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Keating K.A. 1994 An alternative index for satellite telemetry location errorJ Wildl Manage 58(3):414-421

Legendre L, Legendre P (1998) Numerical ecology. Elsevier, Amsterdam. Pp. 853

McConnell B.J., Chambers C., Nicholas K.S., Fedak M.A. (1992) Satellite tracking of grey seals (Halichoerus grypus) J Zool, Lond 226:271-282.

Reijnders P.J.H., S.M.J.M. Brasseur & A.G.Brinkman 2000, Habitatgebruik en aantalsontwikkelingen van gewone zeehonden in de Oosterschelde en het overige Deltagebied. Alterra-rapport 078 issn 1566-7197 56pp

Ries E.H., Hiby L.R., Reijnders P.J.H. 1998 Maximum likelihood population size estimation of harbour seals in the Dutch Wadden Sea based on a mark-recapture experiment J. Appl. Ecol. 35(2):332-339

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