OWEZ - pelagic fish, progress report and progression after T1

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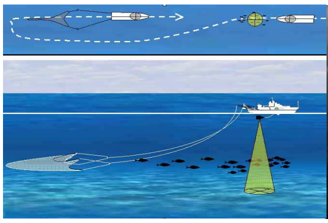
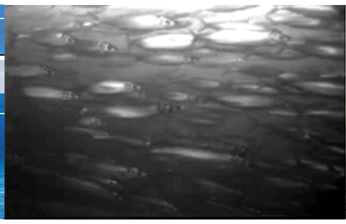
Interim report pelagic fish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Contents

Summary

This report presents the current status of pelagic fish research in the Offshore Windfarm Egmond aan Zee (OWEZ) after having finalized the T0 baseline survey in 2003 and the T1 survey after construction of the wind farm in 2007.

The T0 study indicated a highly dynamic pelagic fish community along the Dutch coast: species composition were found highly variable on a local scale and clear hot-spots appeared abandoned when returning the next day. This picture was confirmed in the T1 survey where the species composition of the catches in the entire coastal zone were found completely different from the ones 4 years earlier.

Although no clear and direct effect of the wind farm has been observed yet, the above described information tells us to look for more local effects where we should focus on underlying processes in fish community behaviour.

The effects of a single windfarm seem difficult to measure but when the Dutch government allows a drastic increase in such wind farms in the North Sea, the local effect will become a regional effect and might start to influence complete fish stocks. Therefore, complementary research will be executed by studying fish behaviour in the wind farm itself.

Acknowledgements

Many thanks go out to Dr. Dirk Lorenzen from the Ecology Centre of the Kiel University, Germany, for his support on data visualisation in GIS.

The Off Shore wind Farm Egmond aan Zee has a subsidy of the Ministry of Economic Affairs under the CO2 Reduction Scheme of the Netherlands.

1 Introduction

This report describes the progress gained in monitoring the effects on the pelagic fish stock community due to the construction of the Offshore Windfarm Egmond aan Zee (OWEZ).

Examples of pelagic fish species found in the Dutch coastal zone. Left panel: upper: Raitt's sandeel, middle: Anchovy, lower: sprat. Right: Greater sandeel.

The monitoring program comprehends a baseline study (T0) before the construction of the windfarm, one study period a year after its construction (T1) and a monitoring study 5 years afterwards (T5). The baseline study was carried out in April and October 2003 (T0 RIVO report nr. C047/04), the T1 in April 2007 and the T5 study will be executed in spring 2011.

The survey design has been evaluated regularly which resulted in altering the T1 survey design and recommended changes for the T5 survey design. An overview of the executed surveys and justification for these changes are given in chapter 2.

The next survey, the so called 'T5 survey' will not be executed until 2011. All relevant information necessary to make the T5 survey fit onto the survey reported here has been described in the report at hand (Appendix).

This document also presents a first comparison between results from the T0 and T1 surveys in chapter 4. Although results are preliminary and will be fully presented after the T5 survey, it already shows interesting and often unexpected findings.

2 Fine tuning of the sampling programme

The occurrence, density, spatial variation and population structure of the pelagic fish fauna in the reference situation, prior to the construction of the windfarm area has been sampled twice in April and October 2003: with a high spatial resolution in the planned location of the windfarm and two reference sites, and with a lower spatial resolution in a larger coastal area. Two main differences between the baseline situation (T0) and the situation after construction of the wind farm were taken into account when planning the T1 sampling procedure. In the baseline situation, spatial patterns mainly occurred at larger scales (north-south, near shore-offshore) and were absent from the scale of the windfarm. Secondly, small scale changes in spatial resolution, in the direct surrounding of monopiles, were to be expected. This made us decide to fine-tune or revise our sampling programme for the T1 situation as described in the paragraphs below. In our revised T1 sampling programme we have taken into account consistency with the methodology and results of the baseline study as well as safety regulations within OWEZ. Surveys were conducted according to current regulations of and in consultation with NoordzeeWind. The sampling scheme has been designed to sample the variation in fish density in wind farm and to replicate this scheme in the two reference areas. Long coastal transects were surveyed to sample seasonal variability in the overall coastal area. The sampling scheme foresees a high resolution coverage of the wind farm area and its two reference areas as well in a low resolution coastal coverage (Figure 2.1 in the appendix).

The monitoring program was based on the hypothesis that the windfarm areas as a whole would attract more fish. It was hypothesized that the abundance of pelagic fish within offshore wind farms would increase as a result of an "artificial reef effect". With this effect pelagic fish are attracted to structures (man-made or otherwise) in the sea. In the likely case of relatively high concentrations in these areas (as illustrated by figure 2.2) the current survey design will lead to underestimations of fish abundance in the wind farm. We are therefore considering including the direct surrounding of the wind mills in the next sampling program (see discussion below).

In contrast to the previous surveys executed in 2003, the T1 sampling program was fully completed due to good weather conditions. The area of the OWEZ and both references sites could even be sampled 3 times. These repetitions allow us to study the observed high, small time scale variations. The long range coastal transects were completed during the T1 survey, but their long distances made those impossible to cover within one day. Instead, two days were needed but it is expected that this minor adaptation has no effect on measuring regional migration of pelagic fish: this is expected to occur only on a more local scale in these two days. Summarizing, the following extra information was gained in the T1 study:

1. more trawl hauls were made which made it possible to get a full descriptive fish distribution based on fishing only. To determine the best sampling strategy for the 2011 survey, these results need to be compared with the distribution and abundance based on acoustic information Although the raw data is presented here, a proper geo-statistical analysis needs to be done prior to the survey in spring 2011.
2. it was possible to survey target areas more than once. Variability in time can therefore be analyzed based on this extra information.
3. different types of water visibility sampling techniques could be used. The value and relationship of these additional techniques will be discussed in the final report, but moreover it will be used to help explain the high variability in space of schooling fish.

Acoustic techniques were used to sample fish abundance whereas trawl sampling was used to get species specific information such as age structure of the population. However, in the T1 survey sandeel was highly abundant which made trawl samples suitable for quantitative results as well.

Because of the unexpected species composition in the catches in 2007 (large quantities of sandeel in 2007 versus clupeids in 2003), effort needed to be put in development of new analysis techniques which automatically recognizes species in the water column. As a result, a full description of acoustic results can only be presented in the final report.

2.1 Implementation of T0 recommendations

- Different survey resolutions have been used

One of the recommendations of the T0 study was that the survey area should extend further offshore. However, this extension would increase the ship time and hence the total costs of the project considerably. For the T1 study we therefore focussed on the fish distribution by surveying parallel to the coast, along a single depth contour. These low resolution observations extending further offshore are expected to provide information on species distribution in the near coast environment versus the off coast environment as we have observed with sandeel in June 2003.

- Target species selection will be narrowed to clupeids only which will result in a single optimal sampling period

While biomass estimates of herring, sprat, anchovy, pilchard (clupeids) and whiting are generally relatively precise, estimates of sandeel species and mackerel are much more uncertain. This difference lies in physical characteristics of the body of the fish and the behaviour of these species. Therefore, after 2003 we intended to focus on clupeids which would have improved the precision of the sampling programme.

Results of the T0 study in 2003 indicated that April should give the best results when targeting clupeid species like herring and sprat compared to October (figure 2.1.1). However, it turned out that the T1 survey yielded hardly any clupeids. Instead, most clupeids were found in the final days of the survey whereas sandeel dominated most catches.

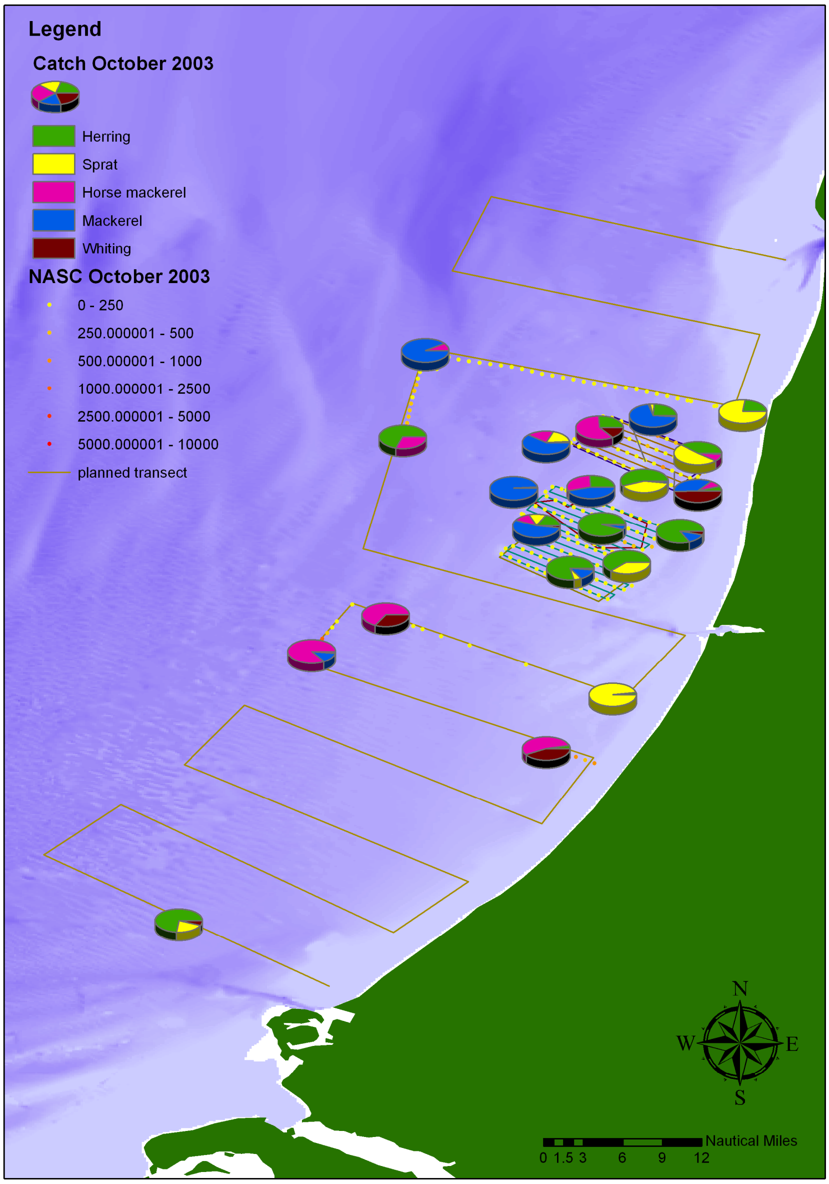


Figure 2.1.1. Catch composition of pelagic fish in the T0-October survey showing a high species diversity but low acoustic abundances of the main species: herring and sprat.

- No need for extra biological fish data

Biological fish data (age, length, weight, gender and maturity) was collected within the T0 study in order to obtain length/age keys for the translation from length frequency distributions to age compositions. Weight information was collected to translate the stock abundance in fish numbers into fish biomass. Based on historical data sources and the T0 study it was decided that the same length/age and length/weight keys can be used again in the T1 and T5 studies. The year by year changes within the relatively short project will be minimal. Biological samples were therefore not taken in the T1 sampling programme.

2.2 T5 recommendations and final report

The T0, T1 and T5 survey approaches slightly differ from one another. However, the main concept remains unchanged: studying the pelagic fish community behaviour in and around the windfarm area to identify its effect. The T5 study is improved with the increasing realisation of the huge variability in this community on a coastal scale and the importance of local fish attraction. The coastal survey remains needed to quantify these local effects on a fish community level.

- How to cope with high variability and small scale effects?

The pelagic survey as executed in and around OWEZ is the fourth one executed in the Dutch coastal zone using echo sounding. Having finished two coastal surveys within this (OWEZ) project and two outside this project it becomes evident that the pelagic fish community is highly variable in time and space. The current survey setup however, was designed to compare distributions and abundances in and near the wind farm in a direct way. Taking into account these variability's, this straight forward survey approach proves not to be sufficient enough.

Although these acoustic surveys provide us with snapshot information on community dynamics in the coastal area it provides less insight on the question whether fish is attracted/deterred by the whole OWEZ windfarm. Due to unexpected practical survey restrictions it is impossible to collect data close to the monopiles of the wind turbines. It is expected that the monopiles will attract fish because of the so called "artificial reef effect" (illustrated in figure 2.2). Hence, due to the safety restriction to keep a distance of at least 200m from the vessel to the turbines it is very likely that the fish abundance observed in the windfarm area in 2007 will be heavily underestimated and that the measured fish distribution in the park will be different from the real distribution. This suggests that there is a need for close-up observations in the target area. One such option is a multi frequency high resolution sonar. In order to obtain this equipment and get the necessary experience, IMARES will purchase such a sonar already in 2009. This new approach will be integrated in the 2011 survey plan.

- Final report and recommendations for research

In the final report, comparison of T0 with T1 and T2 data will reveal whether fish community abundance and diversity has changed significantly within the windfarm when compared to the control areas. Results from other studies on fish residence time (tagging) and fish behaviour (telemetry) (report in early 2010) will give an indication of fish residence times and mortality in the windfarm, allowing for an estimate of the population effects of the OWEZ windfarm. However, it will still be unclear as to how an accumulation of windfarms in the north sea will affect fish. For this an integrative approach incorporating data and models of the dynamics of fish and benthos, as well as fishers is to be recommended, but is currently beyond the scope of this project.

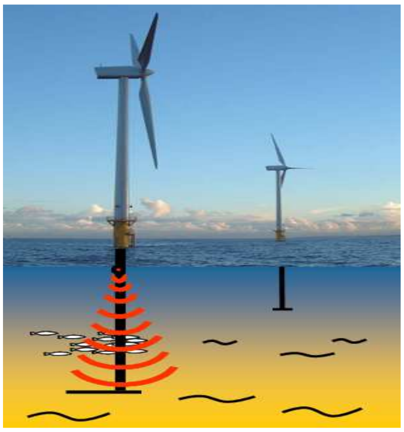


Figure 2.2. A schematic presentation of increased fish concentrations near individual turbines and how a high resolution setup can reveal pelagic fish schools near a wind turbine

3 First results: T0 vs. T1

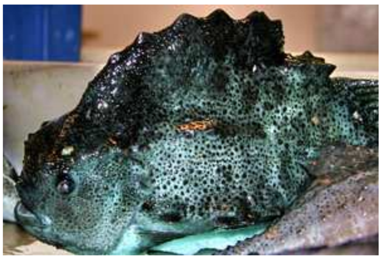
Overall, the T0 and T1 survey observations are totally different in terms of abundance and species composition. Based on T0 observations, the windfarm area but also surrounding areas were expected to be dominated with schools of herring in the T1 survey. However, large quantities of sandeel were migrating daily in and around the windfarm indication no avoidance of the farm at all. Larger aggregations of all kind of pelagic species were found often close together but moving along the coast rapidly. These results were very informative on how this community operates but were unexpected. Therefore a strong recommendation is made in this report to adjust the survey design to these new findings.

In the T1 survey more information on fish schools, such as school size and swimming depth were recorded than planned. The high sandeel density in the coastal area has lead to an unexpected opportunity to sample the fish community with much more trawl hauls than planned. The numerous trawl samples taken, provided enough information to get a first overview of the fish distribution and its variability in space (see figure 4.2.1) and compare it with those based on acoustic observations.

Environmental conditions in the T1 were quite comparable to the T0 situation. However, the average temperature was around 2 degrees Celsius higher which could explain the unexpected abundance of sandeel. This species emerges from the sand in spring when the temperature starts rising. For both T0 and T1 surveys relatively large variations were observed in day by day temperature which indicates that the coastal zone is highly dynamic in terms of its environmental conditions. Both temperature and visibility are believed to drive the pelagic fish community behaviour most and will therefore be analysed in more detail in the 2011 final report.

3.1 Species compositions and implications for the analysis

It was expected that new species in the windfarm area could appear but the high natural variability in the fish community makes it difficult to detect. An overview (table 4.1.1 in the appendix) of the relative occurrence of pelagic species in the trawl catches shows no indication of specific changes in the windfarm area only. Some species like Lumpsucker (picture below) have been observed as a new species in the area but their numbers were too low to quantify any effect.



Herring and sprat were initially the main target species in this study, but sandeel was observed as main species all along the coast (nearly 80% in biomass) in the T1 catches. Clupeids (herring, sprat, pilchard and anchovy) were hardly encountered in that period. Figure 3.1.1 illustrates the T0 and T1 catch compositions.

This – unforeseen - finding will have an impact on the analysis of the data, because sandeel has no swimbladder. Fish with no swimbladder have a very low acoustic target strength which means that “pollution” of a few swimbladdered fishes (like clupeids) may lead to a large bias in the biomass estimations. We expect to overcome this problem by applying multi frequency algorithms developed within the European SIMFAMI project, using differences in acoustic responses for different frequencies.

Apart from the analytical difficulties, the finding of these high sandeel concentrations in the coastal zone is an indication of dynamic character of the coastal ecosystem system where presence of species in a short time window is difficult to predict. In this particular case, the sandeel may either have appeared sooner than normal from the sand after the winter rest (normally from end of April onwards) or the sandeel population has increased since 2003. Anecdotal information from fishers seems to indicate that both explanations may hold truth.

Another challenge was to estimate the relative abundance of sandeel in 2007. Their appearance close to the water surface, outside the range of the standard 38kHz echosounder made the standard approach useless. Therefore a slightly adapted approach was successfully implemented for the surface layer by using another acoustic frequency (200kHz). The associated software approach had not been applied in the Dutch coastal waters before and was therefore tested thoroughly. This extra effort resulted in a new automated analysis technique capable of replacing manual analysis of future work.

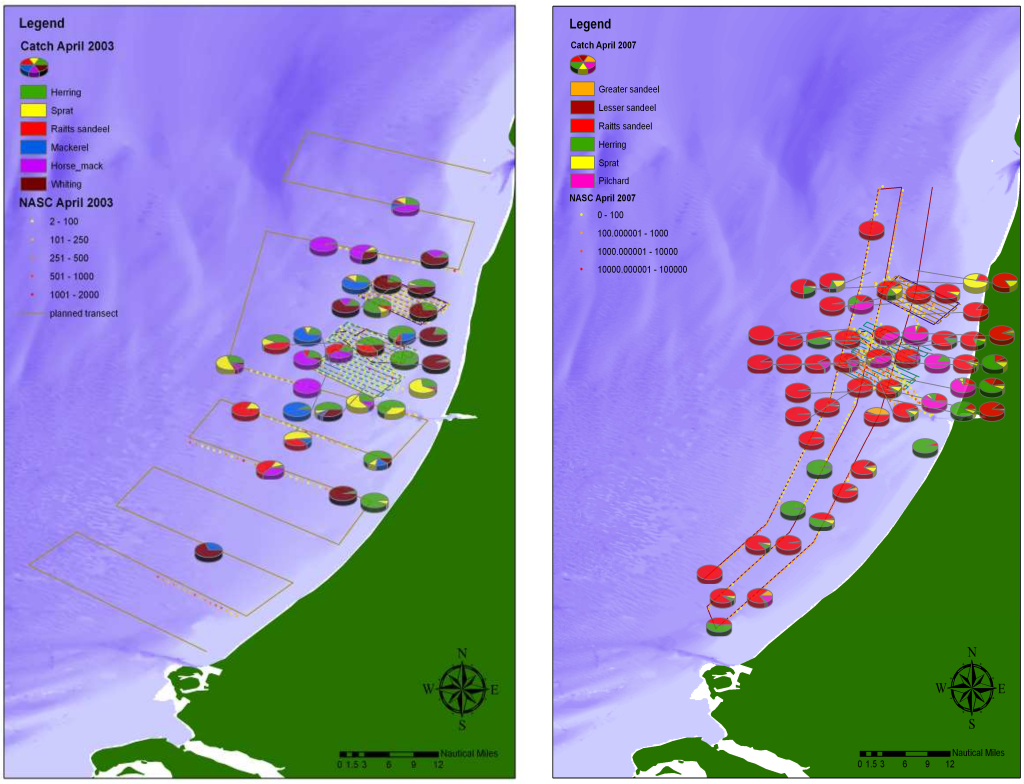


Figure 3.1.1. Catch composition of pelagic fish in the April survey. The T0 survey is displayed in the left panel, the T1 in the right panel.

3.2 Dynamics in the pelagic fish community

As described previously, the Dutch coastal pelagic fish distribution and abundance is highly variable; not only the species composition but also the life stages which inhabit the coastal area rapidly changes over the seasons. Sufficient fish samples have probably been collected in the past to study how fish occupy the Dutch coastal zone throughout their lives. For example, figure 3.2.1 in the appendix shows several pelagic species present year-round as juveniles to young adults but species like Raitt's sandeel have only been found in spring when they emerge from the soil.

We know that most species use the turbid and dynamic coastline to hide from visual predators and an offshore wind farm such as the OWEZ could be a welcome artificial hiding place, especially when present on the transition to clear water. Since turbidity samples are unstable (see section 3.3), the Secchi readings are therefore an important extension of the program.

Thanks to its relatively warm water the primary and secondary production in the coastal zone is high: an ideal feeding habitat for juvenile fish. When introducing windfarms in these areas they boost the abundance of potential prey items even more in the form of epifauna which lives on and near the pillars. For example, the Danish windfarm 'Hornsrev' accommodates around 150x more epifauna biomass then the surrounding area (Larsen, J.K. and Kjaer, J.I., 2005). The OWEZ is a similar wind farm and it is therefore expected that pelagic fish will benefit this potential food supply. Diving exercises have already shown large quantities of amphipods on the turbine pillars.

For acoustic surveys, distribution plots are normally based on acoustic observations combined with trawl information but in the T1 survey trawl information only has been used to get a first impression of the spatial distribution of sandeel in the coastal zone. Since spatial distribution of sandeel was uniform (present in 100% of the catches), trawl information could be used in such way (figure 3.2.1). It was expected that the distribution of (at least) sandeel, based on acoustic data would show a similar pattern as shown in the figure below.

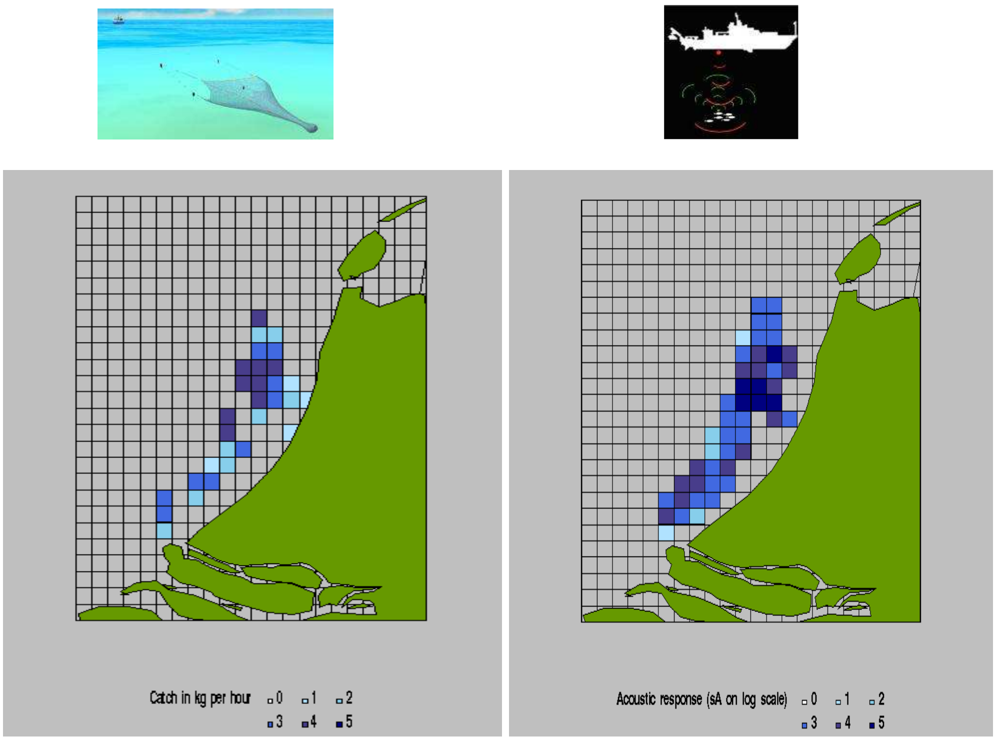


Figure 3.2.1. Geographical distribution of sandeel based on trawl catches (left panel) and acoustic observations (right panel).

In these preliminary, trawl based figures, the spatial distribution of the different species is quite patchy and incomplete for most species. This artificial effect is caused by the fact that the number of trawl hauls is low. Acoustic data is more equally spread over the area.

Local hotspots of both clupeids and sandeel can be identified in all surveys. These hotspots contain more than just a few schools as can be seen in figure 3.2.3. However, when returning shortly after the first visit, these hotspots might have moved to different areas. Figure 3.2.4 shows the sandeel abundance found in the windfarm area in 3 successive sampling weeks. Clearly visible is the presence, disappearance and re-appearance of high densities in the southern reference area best indicated on the single track going from and to the port of IJmuiden in the third picture.

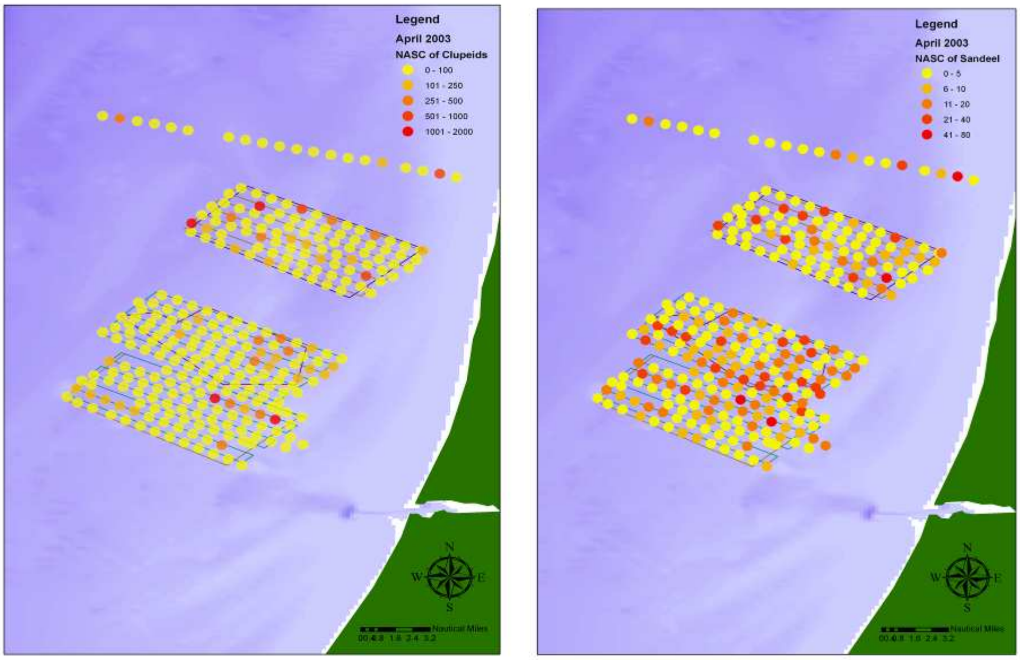


Figure 3.2.3. Mean acoustic densities on the cruise track of both clupeids and sandeel species in the T0 survey indicating high local variation.

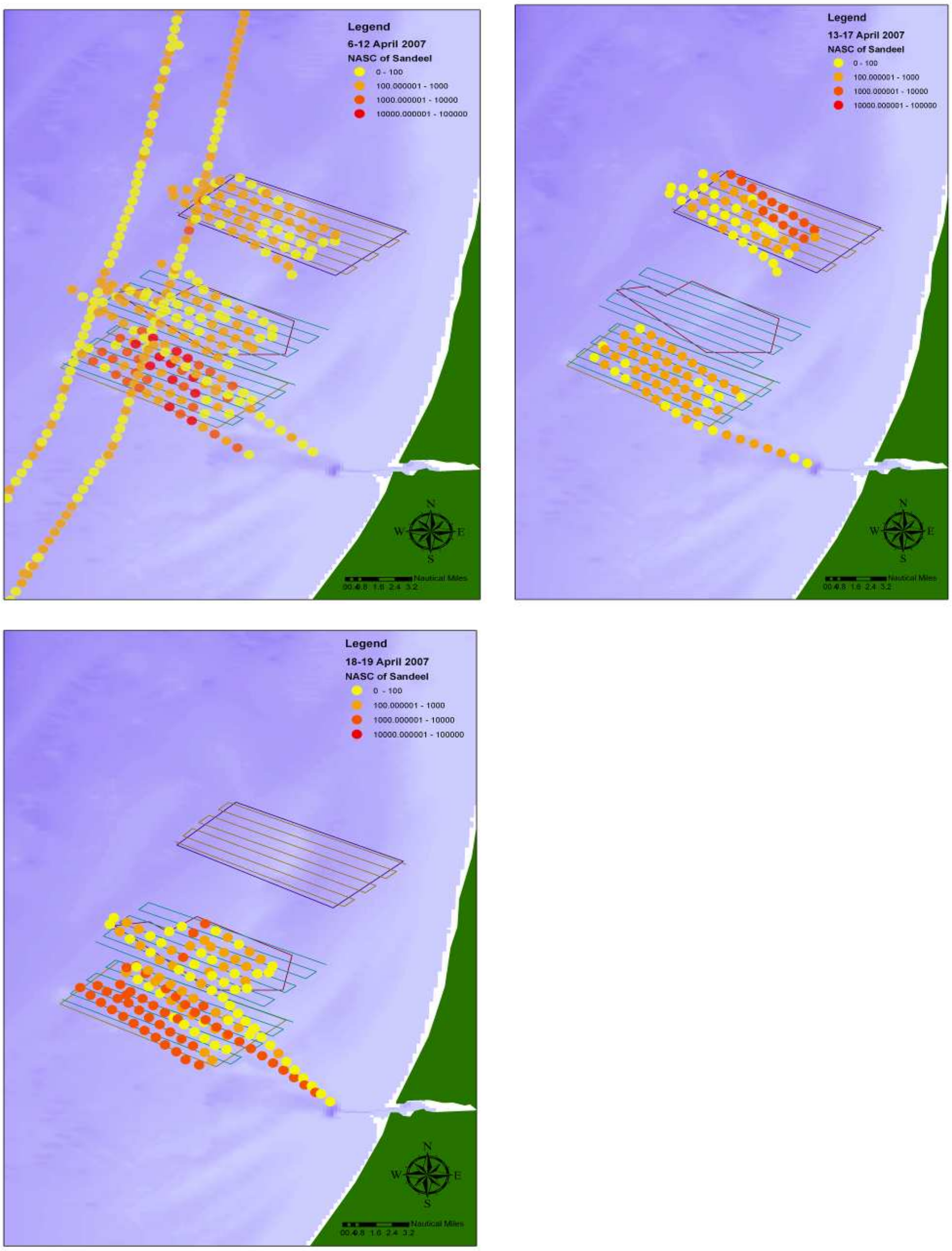


Figure 3.2.4. Weekly acoustic densities on the cruise track of sandeel species in the T1 survey indicating high temporal variations in abundance. Note: acoustic positions show a small deviation which needs to be corrected.

3.3 How to survey the hydrographical environment?

The coastal environment is believed to be highly dynamic, effecting the pelagic fish community directly in its behaviour or occurrence. Survey results support the first part of this hypothesis but in this stage it's too early to link the fish community to the environmental factors in a common way. Based on figures such as 3.2.4 where sandeel abundance show high variation in space and time and figure 3.3.1 where temperatures in the windfarm area are rapidly changing in time, it is strongly suggested to treat each survey day as an individual sample .instead of linking the mean fish densities to the mean dynamic environmental factors such as temperature. Averaging data in time or space would probably eliminate any subtle correlation between the fish community and it's environment.

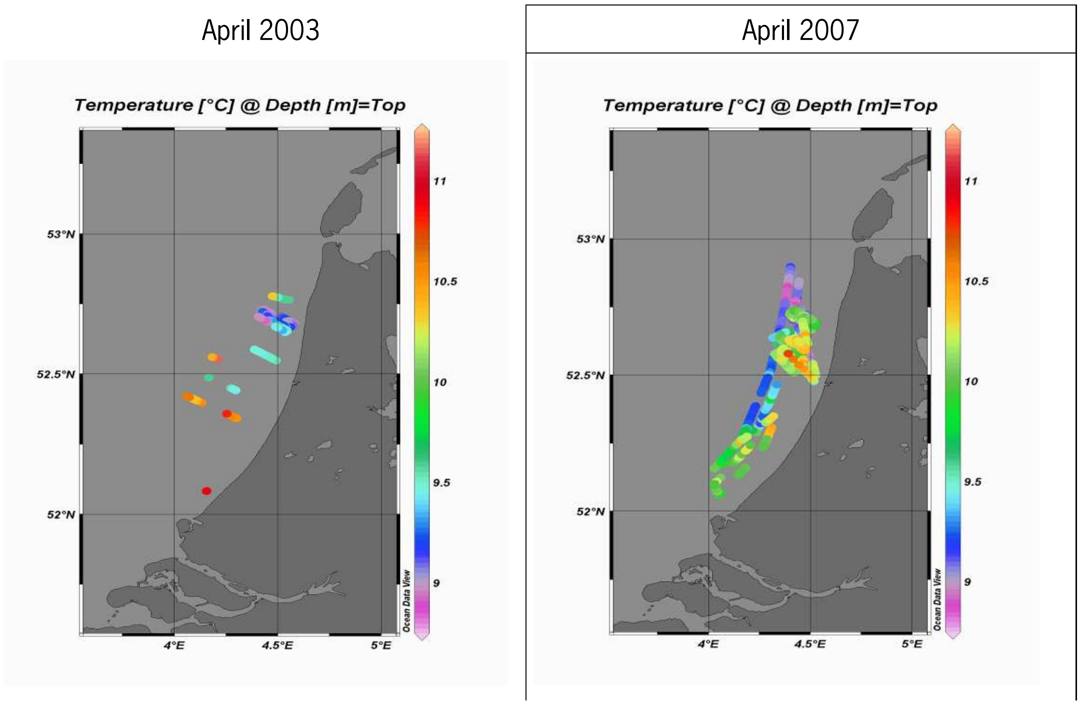


Figure 3.3.1. Temperature distributions in April 2003 (left panel) and April 2007 (right panel). High temporal variation can be observed in the raw data points particularly around the windfarm in April 2007

The temperature maps show a high temporal variability as can be seen as the most western part of the windfarm area where temperature changed with 2 degrees in a single week. These changes might be current driven or could be mean coastal changes. This question could easily be answered when third party continuous recorded data such as available from the wind park itself is available.

The CTD device has been measuring temperature and turbidity which are expected to drive the pelagic fish community behaviour most. Geographical distributions of these variables from both T0 and T1 surveys in April are presented below (figure 3.3.2). Water clarity measurements (Secchi) were taken as a quick reference for the turbidity sensor. At a first glance Secchi or water clarity distribution shows little resemblance to the CTD turbidity data. This indicates that the CTD turbidity sensor can not replace manual water clarity readings. *Clarity* indicates how deep light can penetrate into the water, and can be measured with a secchi disk at any site where the water is deep enough. *Turbidity* or cloudiness in water is caused by suspended solid matter, which limits sunlight's ability to pass through water. There are many possible sources of turbidity. This difference is important for example when focussing on the availability of fish for diving birds. An additional concern for using turbidity values is the instability of the turbidity sensor on a specific type of CTD (minisonde) which has already lead to the loss of many data points in the past. The minisonde was then replaced by a datasonde which is capable of measuring while sailing.

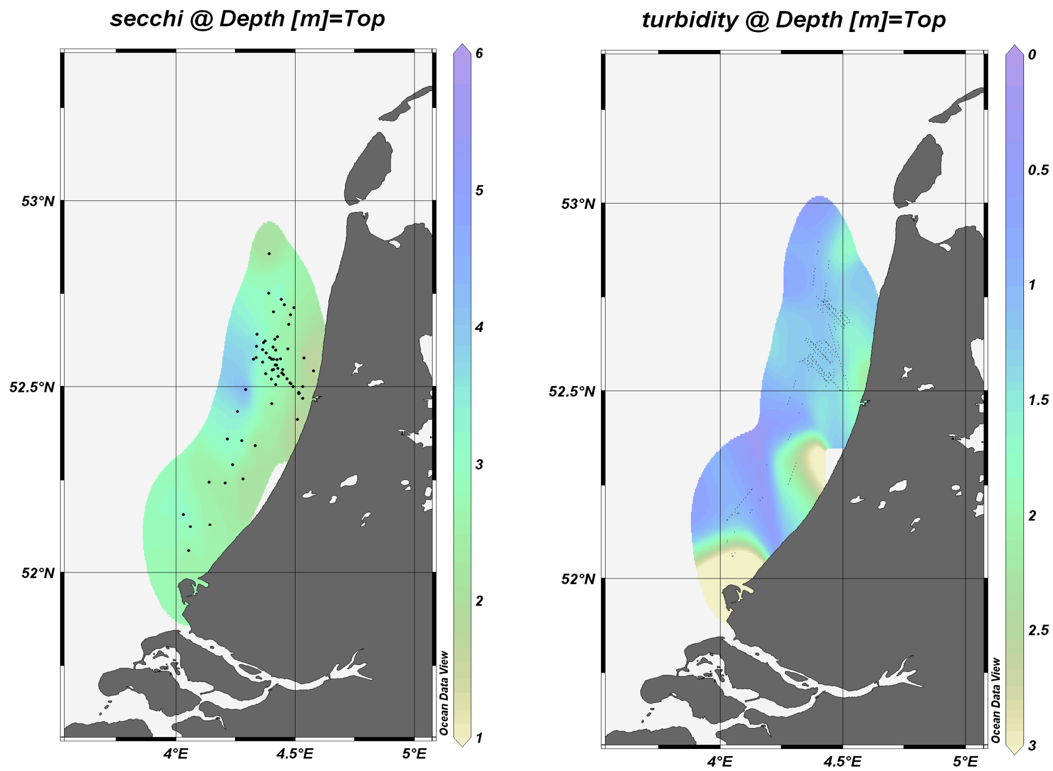


Figure 3.3.2. Comparison between water clarity distribution as recorded by Secchi observations in April 2007 (left panel) and water turbidity recorded by the CTD device in April 2007 (right panel).

The water clarity which is believed to be an important factor for fish occurrence was measured in both April 2003 and 2007. The maps below (figure 3.3.3) show similar patterns for both years. The Dutch coastal zone is most turbid in the first 10 miles from shore. Being highly dynamic by wind and waves, turbid by algae, silt, mud or even dirt from our rivers, those areas are believed to accommodate the highest densities of small pelagics, where they can perfectly hide from visual predators.

April 2003	April 2007

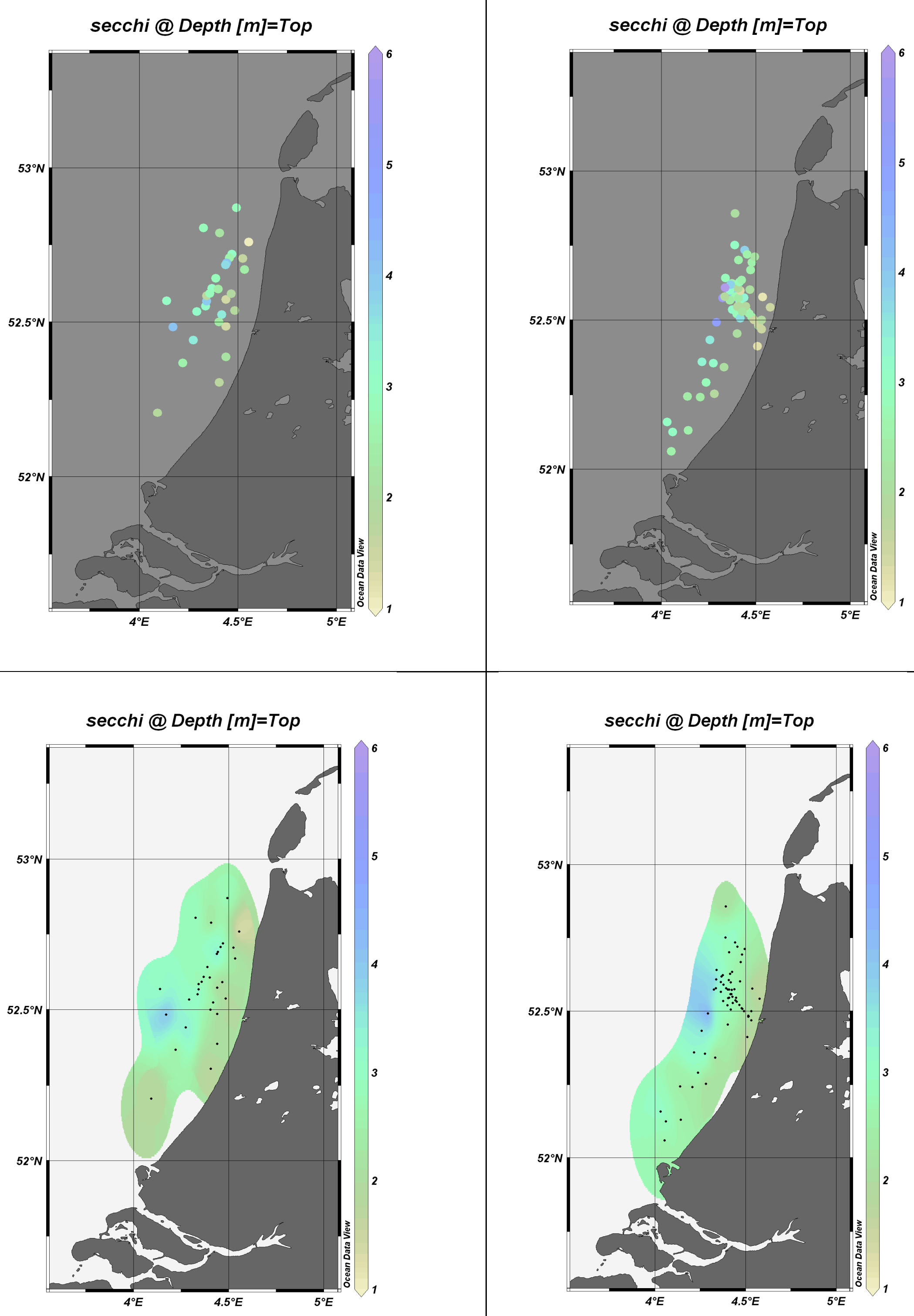


Figure 3.3.3. Comparison between water clarity distribution as recorded by Secchi observations in April 2003 (left panel) and April 2007 (right panel).

References

The following related reports have been issued since the start of the project in 2003 and contain all necessary information for reviewing the T0 study. These reports should be consulted when dealing with the T2 survey.

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- Poot, M.J.M.; Lieshout, S.M.J.; Witte, R.H.; Ybema, M.S.; Couperus, A.S.; Grift, R.E. (2004) Seabird distribution in the Dutch North Sea in relation to pelagic fish, fisheries, and abiotic parameters: Ecological studies based on four ship-based surveys in 2002 and 2003. RIVO Biologie en Ecologie, (Report / RIVO 04-194) - p. 78.
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Justification

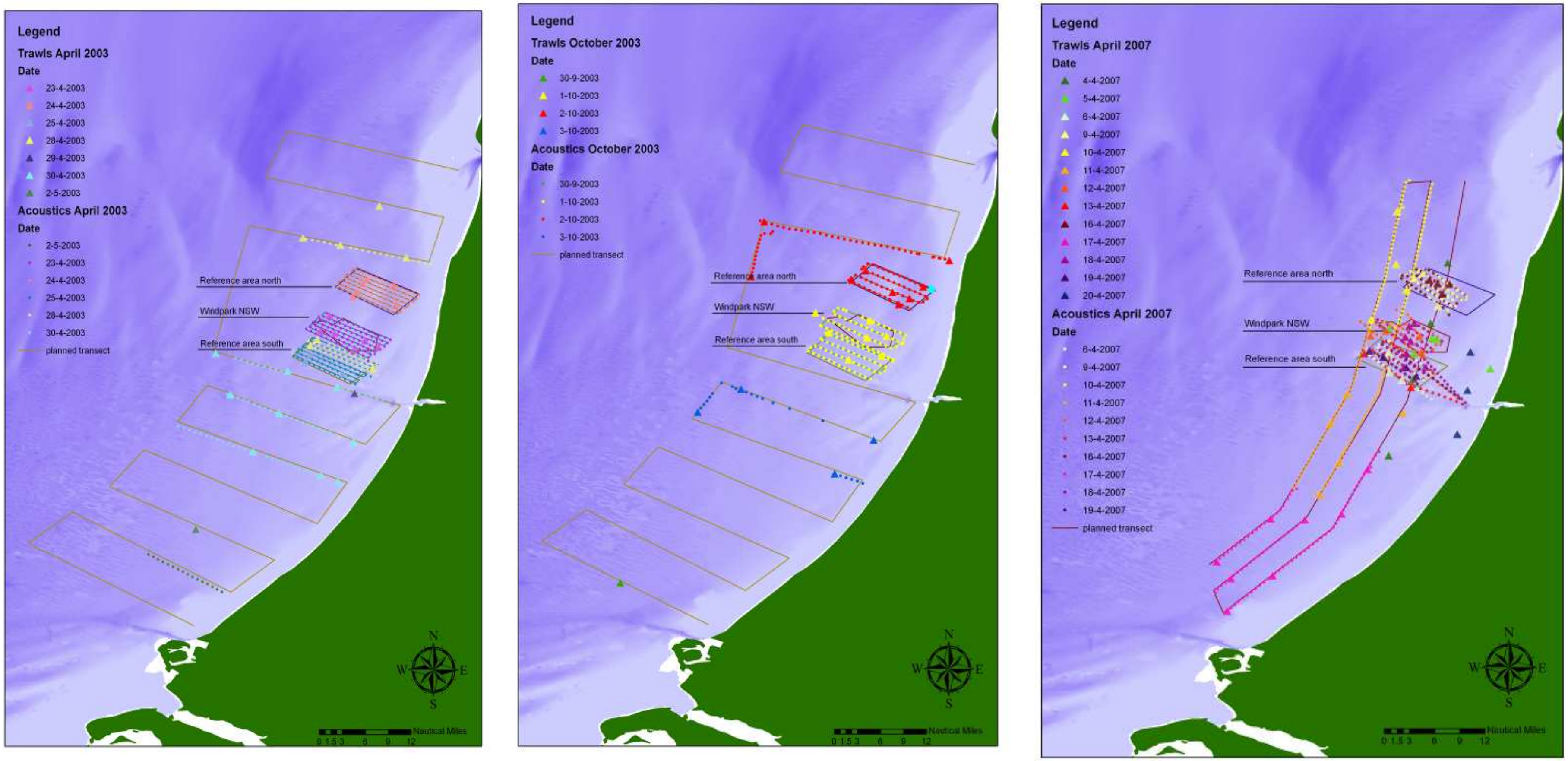
Report	OWEZ_R_264_T1_20091110 (pelagic)
Project Number:	439.25008.03

This report has been professionally prepared by Wageningen IMARES. The scientific validity of this report has been internally tested and verified by another researcher and evaluated by the Scientific Team at Wageningen IMARES.

Approved: Dr. A.D. Rijnsdorp

Approved: Dr. H.J. Lindeboom

Appendix A.



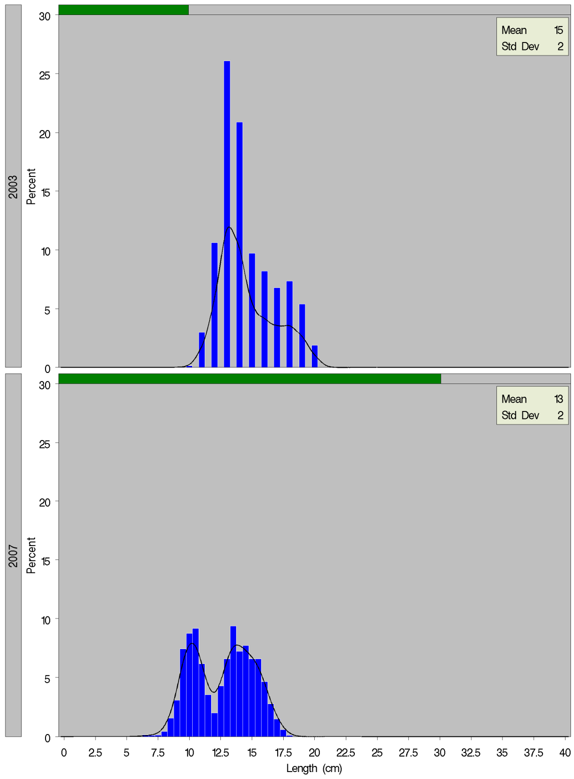
April 2003 October 2003 April 2007

Figure 2.1: Temporal progression of both T0 and T1 surveys based on trawl catches and acoustic samples. The OWEZ area (middle rectangle) and neighbouring reference areas are indicated.

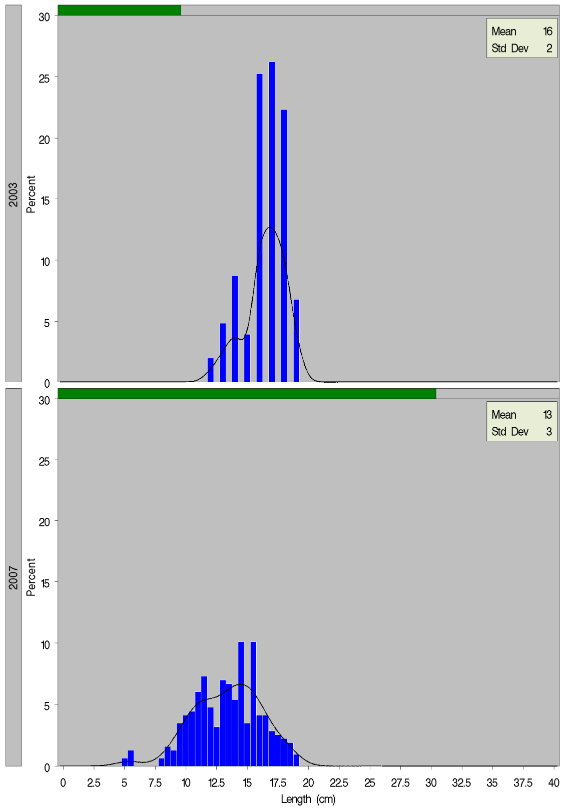
Tabel 4.1.1. Relative pelagic species occurrence in the windfarm (OWEZ), both reference areas and the outer coastal area. Typical pelagic species are indicated in bold.

		REFZ		OWEZ		REFN		COAST	
Species name	**Nederlandse naam**	**2003**	**2007**	**2003**	**2007**	**2003**	**2007**	**2003**	**2007**
Ammodytes marinus	**Raitt's sandeel**	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Ammodytes tobianus	**Lesser sandeel**	xxx	xxx	x	xxx	x	xxx	xxx	xxx
Clupea harengus	**Herring**	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Engraulis encrasicolus	**Anchovy**	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Hyperoplus lanceolatus	**Greater sandeel**	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Sprattus sprattus	**Sprat**	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Trachurus trachurus	**Horse mackerel**	xxx	x	x	x	xxx	x	xxx	x
Sardina pilchardus	**Pilchard**	x	xxx		xxx		x	xxx	xxx
Scomber scombrus	**Mackerel**	xxx		xxx		x		xxx	
Alloteuthis subulata		x	xxx	xxx	x	x	xxx	xxx	xxx
Echiichthys vipera		x	x	x	x	x	xxx	xxx	xxx
Myoxocephalus scorpius		x	x	x		x	x	xxx	x
Merlangius merlangus	**Whiting**	xxx		xxx		xxx	x	xxx	xxx
Eutrigla gurnardus	Grey gurnard			x		x		x	
Gadus morhua	Cod			x		x	x	x	
Pomatoschistus	Painted goby			x				xxx	x
Loligo	Loligo	xxx		x		x		xxx	x
Aphia minuta	Transparant goby			x					x
Syngnathus rostellatus	**Pipefish**				x				x
Cyclopterus lumpus	**Lumpsucker**				x				
Alosa alosa	Allis shad							x	
Rhinonemus cimbrius	Four-bearded rockling							x	
Trisopterus minutus	Poor cod					x		x	
Trisopterus luscus	Pouting	x						x	
Lampetra fluviatilis	**River lamprey**							x	x
Gasterosteus aculeatus	**Three-spined stickleback**		x						x
Entelurus aequoraeus	**Snake pipefish**								x
Sepia									x
Syngnathus	**Pipefish spec.**		x				x		x
Salmo salar	**Salmon**						x		

Raitt's sandeel

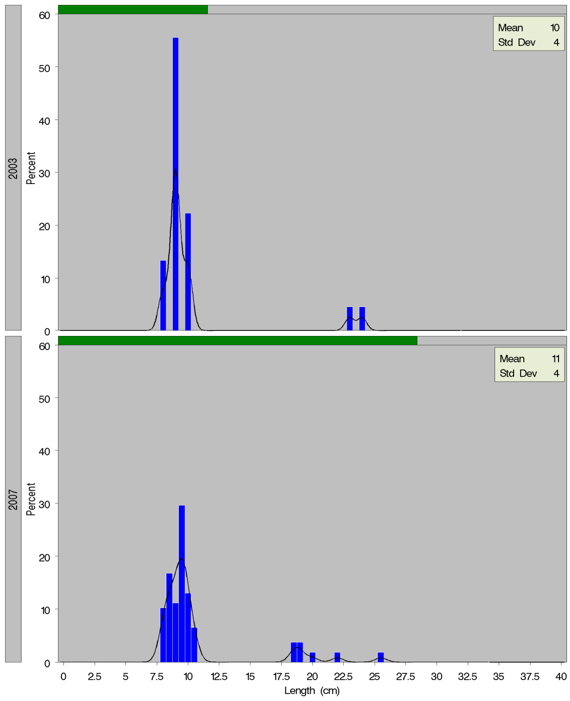


Lesser sandeel

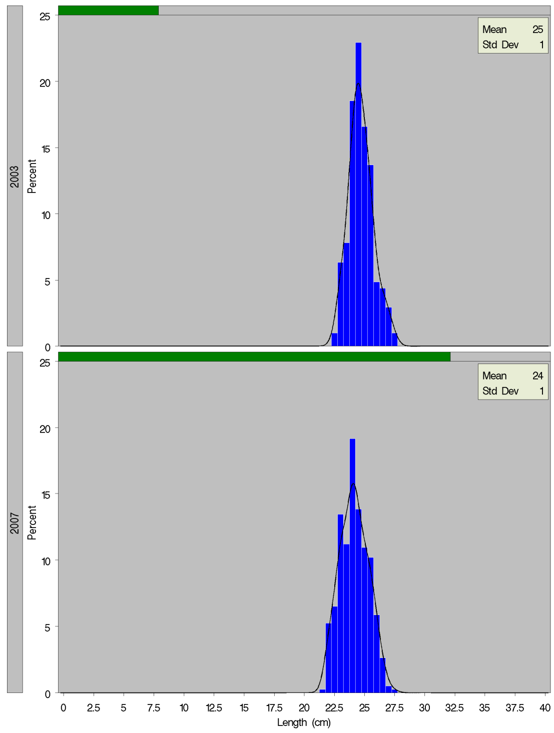


Greater sandeel

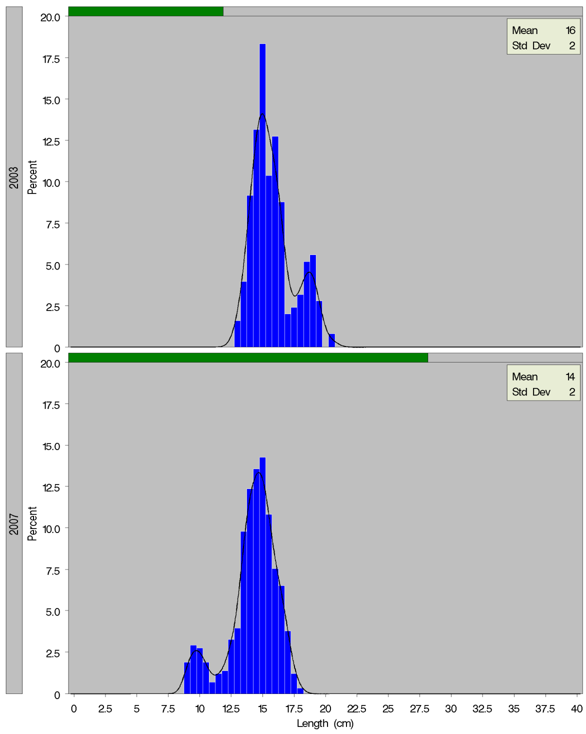
Pilchard



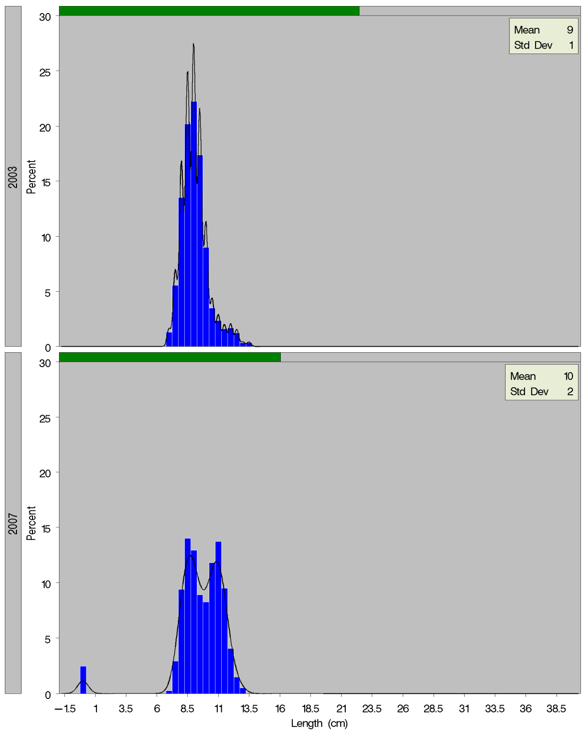
Anchovy



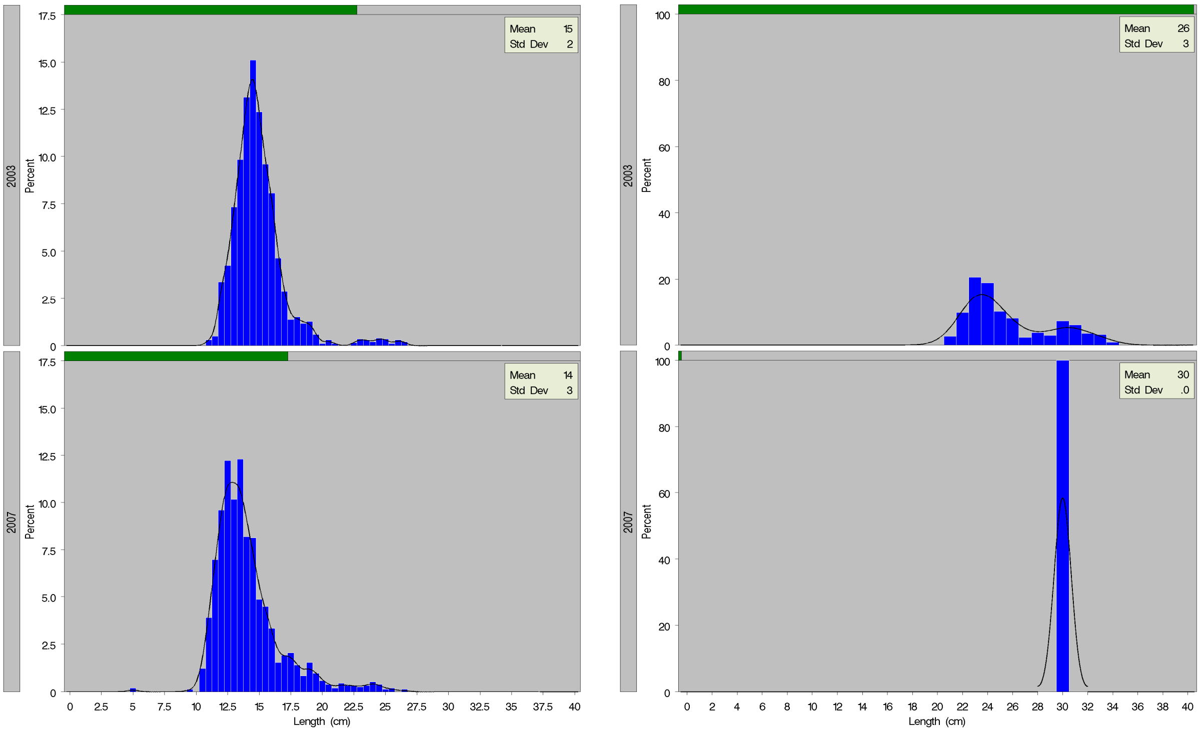
Sprat



Herring



Horse mackerel



Mackerel

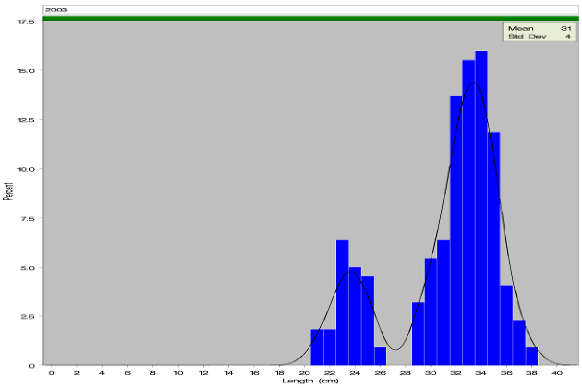
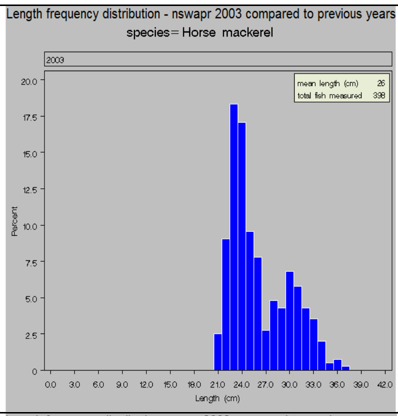
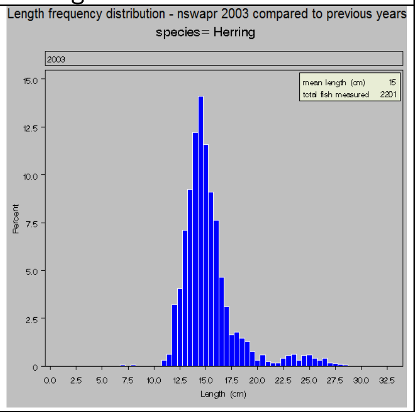
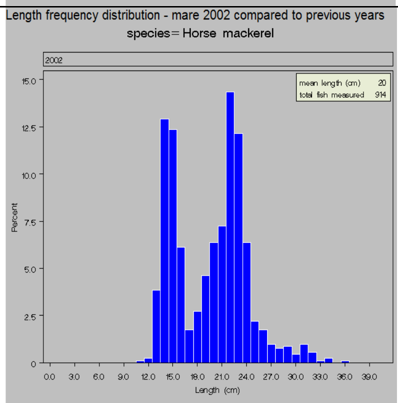
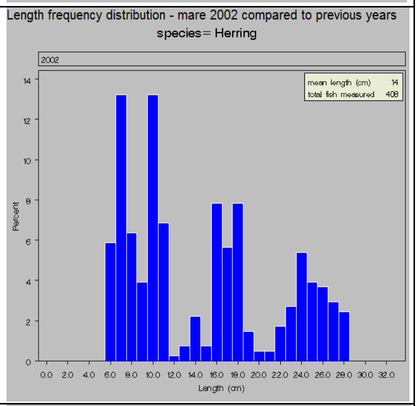
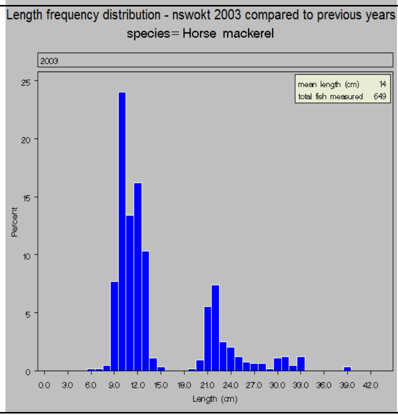
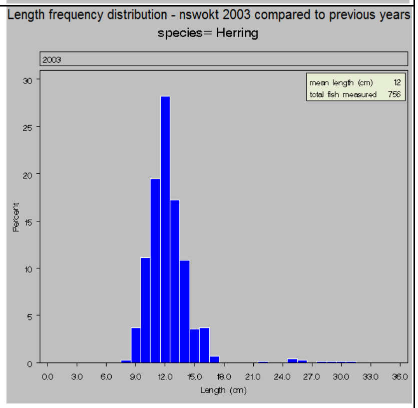


Figure 4.1.2. Length frequency distributions of fish from trawl catches for the 7 most common pelagic species in both T0 and T1 surveys. Total length on the x-axis (cm) and total number of fish caught on the y-axis (percent of all fish caught). The green bar indicated the relative amount of fish used for a frequency distribution.

<table>
<tr><th></th><th>Horse mackerel</th><th>Herring</th></tr>
<tr><td>April</td><td>
</td><td>
</td></tr>
<tr><td>May</td><td>
</td><td>
</td></tr>
<tr><td>October</td><td>
</td><td>
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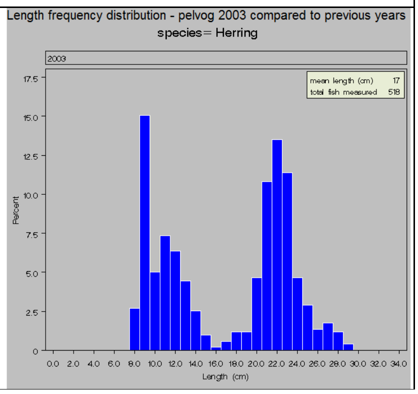
<tr><td>November</td><td></td><td>
</td></tr>
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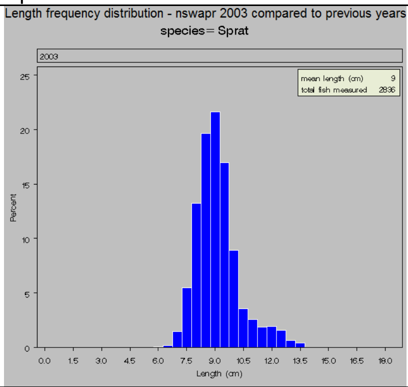
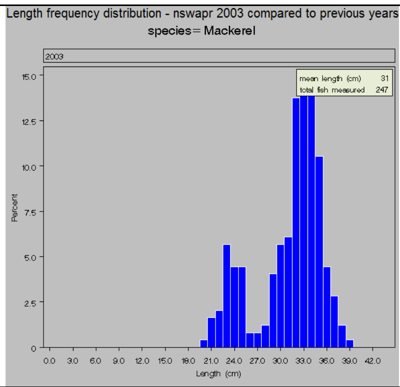
Figure 4.2.1. Length frequency distributions of fish from trawl catches for the 4 most indicative pelagic species in all coastal surveys. Total length on the x-axis (cm) and total number of fish caught on the y-axis (percent of all fish caught).

<table>
<tr><th>Season</th><th>Sprat</th><th>Mackerel</th></tr>
<tr><td>April</td><td>
</td><td>
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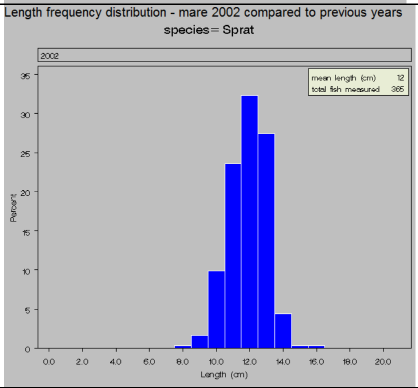
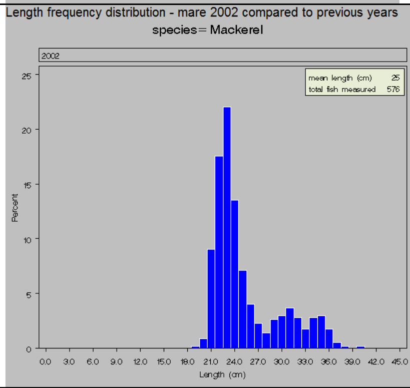
<tr><td>May</td><td>
</td><td>
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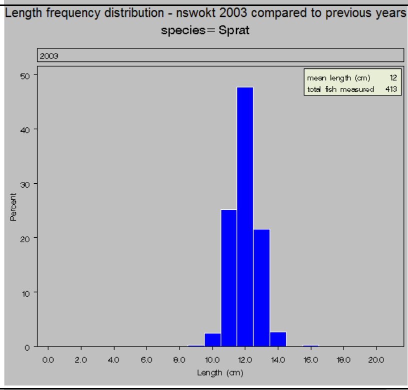
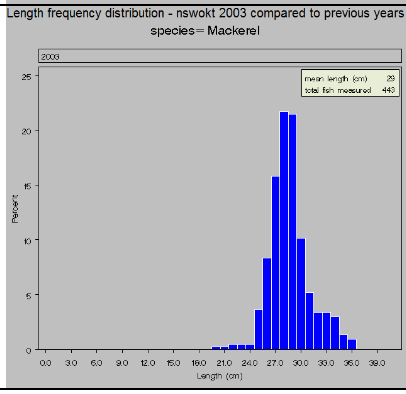
<tr><td>October</td><td>
</td><td>
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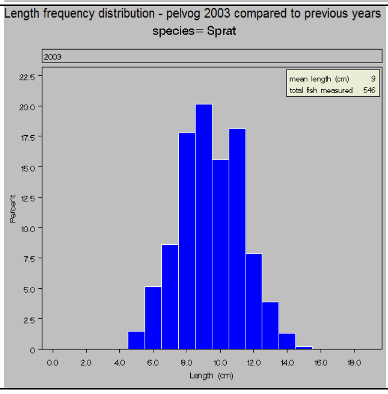
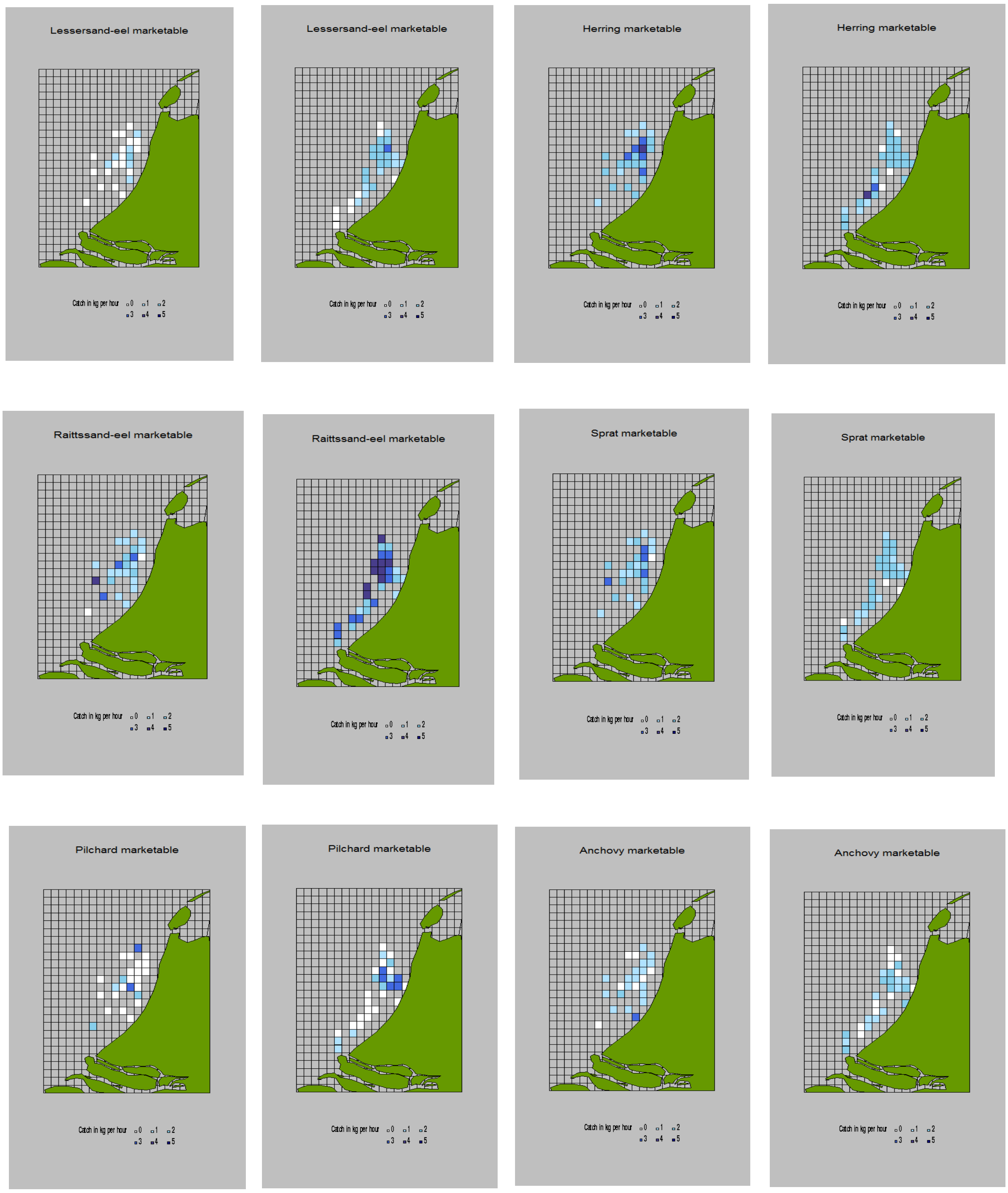
<tr><td>November</td><td>
</td><td>Figure 4.2.1 (continued). Length frequency distributions of fish from trawl catches for the 4 most indicative pelagic species in all coastal surveys. Total length on the x-axis (cm) and total number of fish caught on the y-axis (percent of all fish caught).</td></tr>
</table>

2003 2007 2003 2007



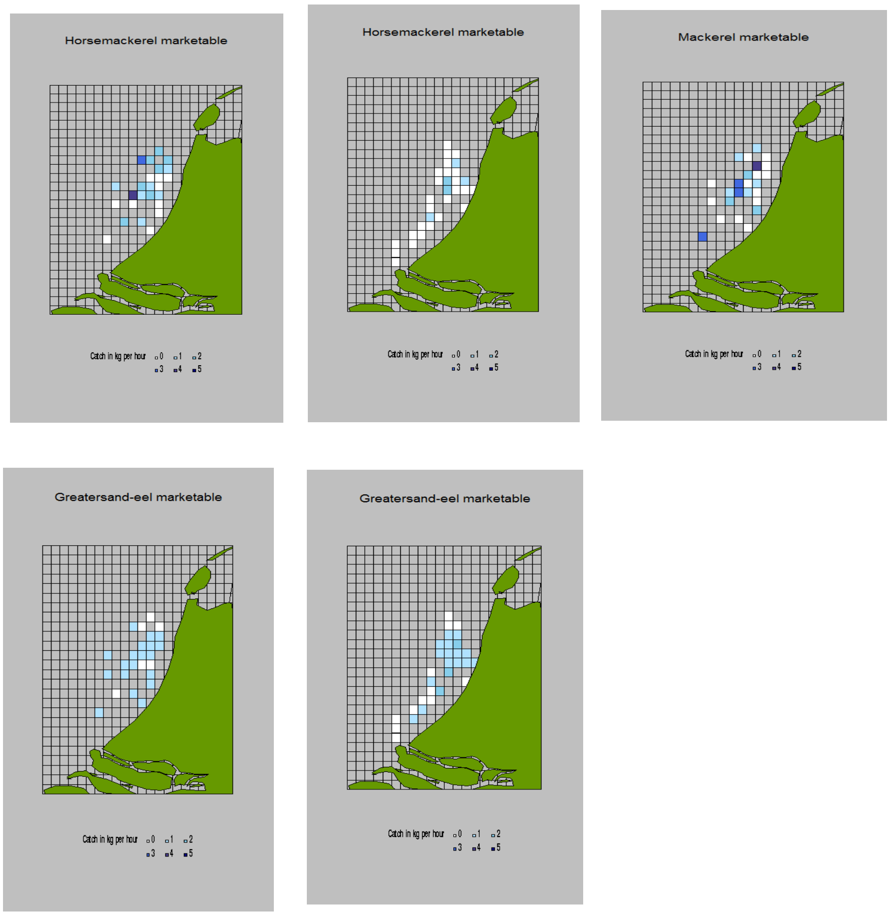


Figure 4.2.2. Spatial distribution of the most common pelagic species based on trawl catches in 10log (kg/hour) fishing.

Appendix B. - Preparing the pelagic project for future work

Due to the long time before the T5 survey will be carried out 2011 the current state of the project needed to be thoroughly documented before 'frozen'. Besides a thorough documentation on data management the following activities have also been taken into account:

→ *Adjusting historical data analysis to new understandings*
New technical developments and improved understanding of the coastal fish community will keep altering data analysis techniques. A good example is the technique to separate clupeid species like herring and sprat from sandeel or mackerel. This technology is purely software based and allows us to re-analyse our historical data with new information resulting in more accurate results. As a consequence, extra effort was put into data standardisation to make this exercise possible. See table 3.1 for details.

→ *Adjusting data management to new opportunities*
Acoustic surveys are more frequently used as a basic tool for fish community research which improves its efficiency. A good example is the opportunity to collect extra information such as water samples or multi-frequency acoustic data during the T1 survey. Taking into account the possible extra information that can be used from related surveys such as the Flyland/MARE and bird/fish surveys in the Dutch coastal zone data from these surveys have been adapted to the standards of the windfarmproject.

The following sections summarize all relevant information necessary to minimize the start-up time of the project in 2011. Each section ends with future analysis considerations where we have tried to put current thoughts on paper. This will help focussing when the project is started in 2011.
Section 3.1 describes the status for acoustic data; a relatively new approach has been used in the T0 phase. Since the coastal fish community proved more dynamic than expected survey design and data analysis methods needed to be adjusted in the T1 phase.
Section 3.2 describes fish sampling: no major changes were applied but next to abundant clupeid species such as herring and sprat, extra focus was on sandeel. This species has been in the international spotlight since many species of seabirds are failing to breed along the North Sea coast because of a sharp decline in the population of sand eels, which is the main prey item of the birds.
Section 3.3 describes the hydrographic situation. Along the way it becomes clear that behaviour of the fish community responds heavily to local environmental factors such as water clarity and food availability. Therefore new and spontaneous sampling strategies were applied during the T1 survey. These new data sources needed to be integrated into existing databases and sampling protocols.

The following overview shows the type of data collected, how different format were standardised and where it has or will be stored:

Table B.1. Overview of data standardisation effort.

Survey name in FRISBE DB	Data format	2002 May MARE	2003 April NSWPEL	2003 October NSWPEL	2003 November PELVOG	2007 April NSWPEL
Fish data	Billie (version 5)	Integrated into Billie version 6	Integrated into Billie version 6	Integrated into Billie version 6	Integrated into Billie version 6	
	Biology files	Integrated into Billie version 6	Integrated into Billie version 6	Integrated into Billie version 6		
	Billie (version 6)	To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE
Acoustic data	Raw data files	Acoustics HD	Acoustics HD	Acoustics HD	Acoustics HD	Acoustics HD
	BI500 Excel files		Present			
	Echoview files	Converted into EV 4 version		Converted into EV 4 version		Converted into EV 4 version
		To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE
Hydrographic data	Hydrolab Excel files		Converted into ODV files	Converted into ODV files	Converted into ODV files	
	Secchi Excel files		Converted into ODV files		Converted into ODV files	Converted into ODV files
	Hydrolab text files					Converted into ODV files
	OceanDataView files		To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE	To be inserted into FRISBE

Both fish, acoustic and hydrographic data have been prepared for integration into the IMARES database. This implementation is currently in a testing phase and is expected to be operational in the beginning of 2009. The EU new data collection regulation (DCR) has initiated this process so a quick finalization is guaranteed.

3.1 Acoustic data

During the baseline survey in 2003 (T0), SIMRAD BI500 post processing was used to process raw data files. During the T1 survey a new, more flexible post processing system was introduced. The raw acoustic files from the first part of the T1 survey are missing. That means this part can not be re-analysed with the new Echoview package when new scientific insights require re-analysis of this data. For example, when identifying other species than currently studied (e.g. plankton) is required, historical data raw data can not be re-scrutinized to calculate their biomass or distribution. All other raw data from both the T0 and T1 surveys have been re-scrutinized in Echoview to provide equal output variables.
A new developed analysis routine (SAS, statistical analysis software) was used to merge old and new processed data files. In this way all data could be uploaded to the IMARES database.

Summary

- Data storage location: External hard drives ACOUSTICS
- Data storage format:
    - Raw: Simrad BI500 (only T0 April 2003) and Myriax Echoview files
    - Processed: available in the IMARES database
- Available data sources:
    - 2002 May – Mare or Flyland survey (38kHz and 200kHz)
    - 2003 April – T0 baseline study OWEZ (38kHz and 200kHz)
    - 2003 October – T0 baseline study OWEZ (38kHz and 200kHz)
    - 2003 November – Interaction pelagic fish and birds survey (PELVOG) (38kHz and 200kHz)
    - 2007 April – T1 study OWEZ (38kHz and 200kHz)

Future analysis considerations

Sandeel issue

During the T1 survey in April 2007 large concentrations of sandeel have been observed visually in the eddy caused by the propeller of the vessel. On the acoustic echogram this sandeel was clearly visible as a dense surface layer. Sandeel might have been scrutinized as 'air bubbles' in the T0 study in 2003 when a similar surface layer was observed but then classified as air bubbles. It was decided to re-scrutinize the 2003 data on sandeel schools using improved semi-automated acoustic identification techniques. This exercise needs to be included into the future project planning

Clupeids issue

Clupeids have been found impossible to identify to species level in the acoustic files. Therefore all schools scrutinized as 'Clupeids' have been split up according to the trawl catch in the same geographical area. Important to realise is that not the species composition in kilograms should be used but the species composition where kilograms are converted into acoustic values for each particular species.

Mixed species issue

Often large quantities of small schools are found closely together, almost forming a layer of acoustic backscatter. Trawl hauls on these aggregations reveal multiple species. That means it's impossible to allocate schools to individual species. Instead the schools have been given the ID of the trawl haul. A SAS routine developed will split up the acoustic value of these schools to the species composition found in the accompanied trawl haul.

Plankton

Acoustic recordings generally also provided plankton density information which influences the visibility in the water column. This non-target present in acoustic data has therefore future potential.

Analysis resolution consideration

The power of Echoview post-processing software is the ability to re-process raw data with time. New detection algorithms or species recognition techniques could provide more information on schooling behaviour of individual species. This could be of interest when looking at food availability for birds or other predators or sheltering behaviour. In the T0 study these new techniques were not available yet and therefore the information of individual schools is poor. Aggregated data however is comparable to the T1 resolution.

3.2 Fish data

Fish data has been collected using standard IMARES software. In 2003 fish length data was collected using 'Billie' and individual fish data was collected using 'Snij' software. However, between T0 and T1 the two software packages merged into a new version of 'Billie' with the consequence that T0 data needed to be updated into the new format. New 'Billie'-files were created and uploaded into the IMARES database. This exercise has been performed for all coastal surveys (see below).

The length measurement resolution for clupeids is historically set to 0.5cm whereas other species are measured with 1.0cm resolution. However, in the T1 study it was decided to standardise length measurements to 0.5cm increments for all species.

During the first coastal acoustic surveys in 2002 and 2003 biological data of individual fish was gathered to create biological keys such as length/weight- and length/age relationships. These keys were then used for any future survey such as the T1 in 2007. Changes in these relationships may occur but this lays outside the scope of this research.

Summary
- Data storage location:
    - Raw data files: project shared drive / “MEP-NSW”
    - processed files: IMARES database
- Data storage format:
    - Raw (files: Billie 6 format)
- Available data sources:
    - 2002 May – Mare or Flyland survey
    - 2003 April – T0 baseline study NSW
    - 2003 October – T0 baseline study OWEZ
    - 2003 November – Interaction pelagic fish and birds survey (PELVOG)
    - 2007 April – T1 study OWEZ

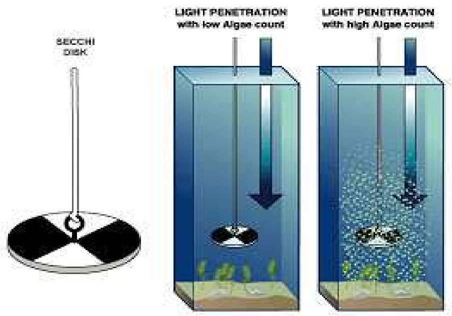
Future analysis considerations
While in 2003 only clupeids were measured in 0.5cm, in 2007 all species were sampled with this higher resolution (figure 4.1.2).

Data remarks
The position of the trawl hauls listed in the acoustic log file (paper sheet) do not exactly match the positions stored in the Billie fish files. This discrepancy is not relevant for future analysis: the data entered into Billie have been used in all analysis. In order to plot the Length/frequency images the standard SAS code

(plot_LF_target_sp) of a single survey was slightly adapted by adding both 2003 and 2007 dataset together and plot the data by the 'year' variable.

3.3 3.3 Hydrographic data

Hydrographic data has been collected in both T0 and T1 studies. A CTD device was in both cases attached to the acoustic towed body. Since the device does not record GPS positional data, it had to be merged with GPS data points from simultaneously collected acoustic data. Having geographical positions, it can now be presented on maps. It also allows data to be stored in the IMARE database.



CTD device

Secchi disk measurement

Displayed on a coastal map, it was evident that average temperatures were highly variable within a single survey, even though it lasted no longer then 2 weeks. This finding supports the hypothesis of high variations in environmental conditions along the coast. This high variation might have a similar effect on the fish community or its behaviour. Therefore it was decided to use as much data sources for future analysis as possible. We treated and stored hydrographic data from multiple historical coastal surveys (see below).

Since the CTD recorder had been operating continuously, bad data blocks such as during trawl hauls or on deck time had to be deleted. Based on a X/Y-plot of depth and temperature a 4.5m depth was set as minimum depth threshold for data use. The figures are displayed below.

All CTD, Secchi and water sample data from a single survey have been merged into 1 OceanDataView file. This data has not been stored in the IMARES database yet since a standard upload and storage method is currently in development.

Summary

- Data and report storage location: project shared drive / “MEP-NSW”
- Data storage format: OceanDataView (TAB delimited text files)
- Available data sources:
    - 2002 May – Mare or Flyland survey
    - 2003 April – T0 baseline study OWEZ
    - 2003 October – T0 baseline study OWEZ
    - 2003 November – Interaction pelagic fish and birds survey (PELVOG)
    - 2007 April – T1 study OWEZ

Future environmental considerations

It is hypothesised that the pelagic fish community would respond strongly to water clarity factors caused by the coastal river and algae or plankton concentration. Since no plankton recording was included in the study other options for data collection were used. Besides a CTD probe collecting turbidity data also a Secchi disk (water clarity) was frequently used and also some water samples have been collected during the T1 survey. Acoustic

recordings could be used for plankton detection. Since we have no idea how these variables are correlated we collected water samples, Secchi observations and turbidity samples on a standardised transect from the windfarm towards IJmuiden port. The activities are mentioned in the ship's log. After drying the samples, the total suspended solids, fixed solids and volatile solids were measured. This exercise has been performed on a single, standardised transect only where also turbidity was sampled by the CTD device. These data still need to be analysed.
Acoustic data has only been scrutinized for fish purposes but could be re-scrutinized focussing on plankton layers. This distribution could then be used as an overlay with turbidity or Secchi observations in the area.

It has been suggested to use external environmental data sources such as currents, tides and temperature from the “meetmast” in the windfarm itself.