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Base line studies North Sea wind farms: pelagic fish survey report 1

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Summary

The Dutch Government has decided to allow the construction of a Near Shore Wind Farm (NSW) demonstration project under the condition that a monitoring programme on - among other things - the ecological impacts is carried out. The Dutch government is responsible for providing a thorough description of the present ecological situation in order to evaluate future effects of planned wind farms. The Netherlands Institute for Fisheries Research is responsible for the baseline study on pelagic fish. Within this study, the pelagic fish community is sampled twice in 2003. It is sampled with a high spatial resolution in the planned location of the wind farm and in two reference sites, and with a low spatial resolution in a larger area along the coast. This report describes the first survey that has been carried out in April/ May 2003. It reports on the execution of the monitoring programme, including a description of the circumstances (days, weather conditions, specific situations, etc.), facilities and materials used, and other relevant information. It also describes preliminary results on the occurrence of species and sizes. It does, however, not contain information on biological data, and densities and biomass data per age and sex because this information will be delivered at the end of the second phase of the project. Finally, the progress of the project and suggestions for the second field work period are discussed. Apart from some minor problems, the survey was executed well. The preliminary results seem promising. The results and the execution of the past survey give no reasons to adapt the survey design for the next survey. This study was commissioned by the National Institute for Coastal and Marine Management/RIKZ.

Acknowledgements

The fieldwork described in this report was carried out on board of the commercial vessel "Jakoriwi" (GO58) and we thank Koos de Visser and his crew for the pleasant and professional cooperation. Ronald Bol and Kees Bakker contributed to the execution of the cruise, André Dijkman Dulkes processed most of the fish in the laboratory of the institute and Rieneke de Jager assisted with the identification of sand-eels.

1. Introduction

The Dutch Government has decided to allow the construction of the Near Shore Wind Farm (NSW) demonstration project under the condition that a monitoring programme on - among other things - the ecological impacts is carried out. The most important objective of monitoring is to acquire knowledge and practical experience in the construction and operation of large offshore wind farms in the North Sea[1]. Both the private party that constructs the wind farm as well as authorities (ministries) need this information for future wind farm projects: for construction as well as for developing policy on this topic. Therefore, the (ecological) knowledge acquired with monitoring programmes for NSW must be made available to all parties involved in the realisation of such large-scale wind farms.

The Dutch government is responsible for providing a thorough description of the present ecological situation as a reference for evaluation of future effects. In October 2002, the National Institute for Coastal and Marine Management (RIKZ), part of the Directorate-General of Public Works and Water Management, procured a base line study on the North Sea situation for 2003. This study will be on behalf of the Monitoring and Evaluation Programme Near Shore Wind Farm (MEP-NSW) in the North Sea. The baseline study must provide data on the occurrence and density of benthic fauna, demersal fish, pelagic fish, sea mammals, marine birds and non-marine migratory birds. The Netherlands Institute for Fisheries Research is responsible for the baseline study on pelagic fish.

The baseline study for pelagic fish should establish the occurrence, density, population structure and migration patterns of pelagic fish fauna in the reference situation. Also, the spatial variation of pelagic fish fauna in the reference situation has to be described. This has to be done in such a way that later (outside this assignment) a quantitative evaluation is possible of the impact of a wind farm on the occurrence, density, population structure and migration patterns of the pelagic fish fauna. The design of the monitoring programme is justified to meet these goals. The objectives and the sampling design of this study are described in a detailed strategy of approach (Grift et al. 2003). Within this study, the pelagic fish community will be sampled twice in 2003. It will be sampled with a high spatial resolution in the planned location of the wind farm and in two reference sites, and with a low spatial resolution in a larger area to provide representative data of the pelagic fish community in the Dutch coastal zone.

As discussed with RIKZ during the kick off meeting, both first field work reports will contain data on the occurrence of species and sizes, and a separate report will be delivered at the end of Phase 2 that contains all biological data, and data on densities and biomass per age and sex. These data can best be analysed after the second field work period when age-length keys for all fish species have been established. Both field work reports present preliminary results that give a first impression of the pelagic fish community and also the progress of the project will be discussed.

This report describes the execution of the first survey of this project which was carried out in April/ May 2003 and presents preliminary results. Chapter 2 summarizes the set-up of the survey. A report of the execution of the survey is given in Chapter 3. Preliminary results are discussed in Chapter 4 and in Chapter 5 the progress of the project is briefly discussed. Tables and Figures of the results are presented in the Appendix, as well as copies of the field forms that were filled out during the survey and lab work.

[1] We define offshore wind farms as wind farms at sea outside the 12 miles zone (22 km offshore).

2. Set-up of the sampling programme

In order to be able to assess the temporal variation in the pelagic fish community, pelagic fish will be sampled twice within the current project, in April and September 2003 (weeks 16,17 and 40, 41). The sampling design is discussed in detail in the strategy of approach (Grift et al. 2003) and will be summarized here. Sampling sites were selected such that they cover the planned location of the Near Shore Wind farm, cover reference sites and provide representative data of the pelagic fish community in the Dutch coastal zone. The reference sites have the same size as the wind farm area, and are similar to the wind farm area regarding species community, water currents, water depth and seabed morphology. The sampling scheme is presented in Figure 1.

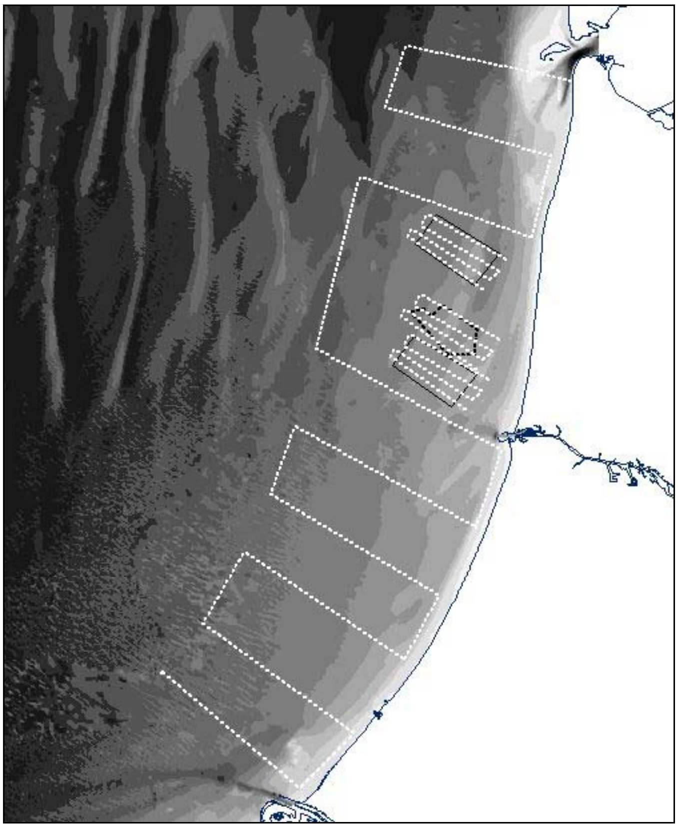

Figure 1. *Survey design to describe the reference situation of the pelagic fish community in the Dutch coastal zone. The white dotted lines indicate the transects along which pelagic fish will be sampled: with a high spatial resolution in the planned wind farm area and both references areas, and with a low resolution in a larger area.*

Pelagic fish will be sampled with a high spatial resolution in the planned location of the wind farm and in the reference sites, and with a low spatial resolution in a larger area in the coastal zone. This resolution is required to be able to detect possible effects of the wind farm on the occurrence of fish in the impact study. If these effects occur, they are small-scaled and a high-resolution sampling scheme is needed. Additional sampling with a lower resolution in a larger area is required because certain pelagic fish species swim in schools and have very patchy distributions. Acoustic information will be sampled along transects, and at several locations trawl hauls will be made to sample the fish present.

3. Survey report

3.1 Introduction

The survey was carried out in week 18 and 19 (21st April - 2nd May) of 2003 with the chartered commercial vessel "Jakoriwi" (GO58). Sampling was not possible for two days due to adverse weather conditions. As a consequence, the full programme could not be completed but the area of the near shore wind farm and both references sites were sampled as planned. The planned sampling transect in the coastal zone could only be covered partially (Figure 2). The north-south transects parallel to the coast were skipped to save time. They would have been skipped anyway during the analysis, because they run more or less along the same depth contours, which would have caused a bias in the numbers of fish estimated. In total, 33 trawl hauls were made.

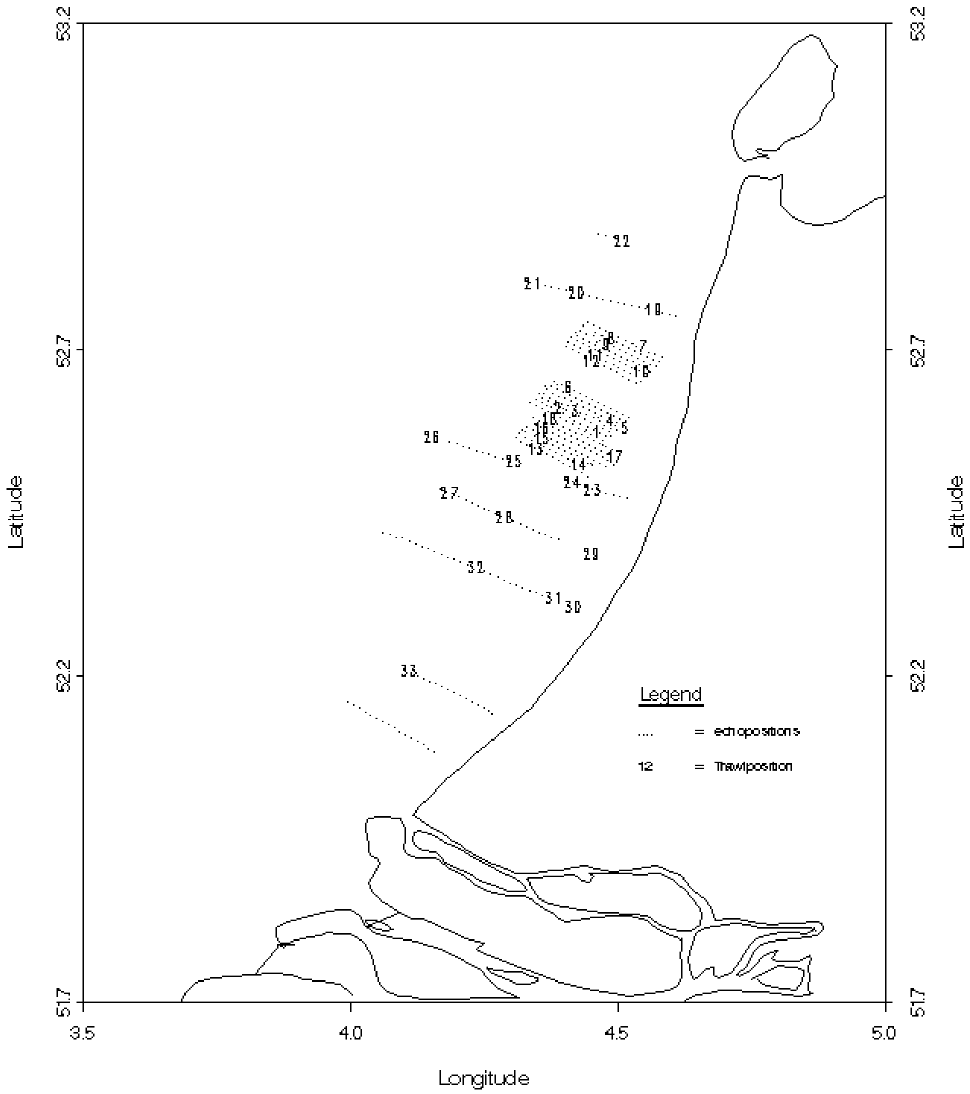

Figure 2. *Positions of the echo survey (dotted line) and of the 33 trawl hauls (numbers) in April and May 2003.*

3.2 Description of the sampling procedure

3.2.1 Week 1

The survey, which was originally planned in week 16 and 17 was postponed by one week due to a mechanical problem with the chartered vessel. The weather forecast for week 17 was very good and the weather conditions in week 17 proved to be excellent.

On Monday 21st April the acoustic and laboratory equipment required for the survey were transported to the chartered vessel GO58 “Jakoriwi” in Stellendam. In the afternoon the acoustic equipment was installed. This took the whole afternoon. After installation the vessel steamed up to the Europahaven, port of Rotterdam. The vessel was fastened at the edge of the "Offshoreput" by means of the ships anchor and with a cable attached to a fixed buoy on the rear. A few last preparations were made for the calibration next morning.

Next morning, the 38 kHz transducer was calibrated before lunchtime. After this calibration, the vessel had to be moved to another site, deeper into the Europahaven, at a quay close to the Maasvlaktecentrale. Here the 200 kHz transducer was calibrated with very poor results, most probably caused by small fish in the vicinity of the reference target. It was decided to operate it during the survey together with the 38 KHz transducer and to use its data in the analysis for species-identification only, and not for estimating densities of fish. It turned out that this additional frequency of 200 KHz was not of much help, because the fish-species were scattered and mixed, without distinctly recognizable schools. After the calibration, a scientific crew member was dropped at the Yangtzehaven and another was picked up. The GO58 headed for IJmuiden to spend the night.

In the morning of 23rd April, the survey started with sampling the transects of the NSW-area. The planned transects of this area were conducted, including 6 trawl hauls. The vessel arrived in IJmuiden, at 21.30. The fish collected for the biological samples was brought to the cold store at the institute. Backups of the raw acoustic data and the log post-processing-data were made. The data from the CTD-logger were downloaded. It turned out that the turbidity data had not been logged. It was decided to try the spare Hydrolab unit the next morning.

On 24th April the transects of the northern reference area were surveyed, again 6 trawl hauls were conducted. At 21.30 the vessel was in IJmuiden again. The fish-samples were brought to RIVO. The turbidity data had again not been logged. The Hydrolab unit was lowered overboard during the night to check whether the data could be logged under conditions with low light. During the day, fish were processed at the lab of the institute by staff other than the crew.

On 25th April half of the southern reference area was surveyed. Three trawl hauls were conducted. In the afternoon, a large part of the biological samples were processed by the crew at the lab of the institute.

3.2.1 Week 2

The GO58 left IJmuiden again on 28th April at 7.00 under poor weather conditions. The remaining half of the southern reference area was covered, after which 2 of the northern transects were surveyed. 7 trawl hauls were conducted. The vessel arrived in IJmuiden at midnight. During the day at the lab, one person started to process the fish and collected length, weight, sex and maturity data and otoliths.

The next day (29th April), the weather conditions were even worse. At 9.00 the transect off IJmuiden was picked up. Halfway offshore, it was decided to stop due to the high waves and strong wind (6-7 beaufort). Arrival at 14.00 in IJmuiden. The samples of the day before were brought to the lab.

On 30th April, the weather was good. The vessel left the harbour at 6.30 with an RIKZ observer who audited the sampling process. Three transects (9 trawl-hauls) were conducted.

On 1st May the GO58 stayed in the harbour of Scheveningen due to the poor weather conditions. Time was spent with making backups, uploading fish sample data and finding a better way to fix the Hydrolab unit to the towed body.

On 2nd May, from 6.30 to 13.00 another two halves of coastal transects were covered (1 trawl haul) under good weather conditions. In the afternoon the equipment was packed and brought back to RIVO.

3.3 Methods

3.3.1 Acoustics

Raw data were collected with a Simrad EK60 echosounder with a splitbeam 38 kHz transducer which was fixed to a towed body (type: "shark"), which was towed from the bow of the trawler. The depth of the towed body was approximately 2.5 - 3 meter. Data were logged and integrated by 0.5 nautical mile intervals with BI500 software (X windows simulated, running under windows 2000). NASC's (acoustic signals) were allocated to a "clupeid"-group, which included the species with swim bladder, herring, sprat, anchovy, pilchard, horse mackerel, using a threshold range of -43 - 60 dB. For this group a joint □ (acoustic cross section) has been calculated, using a TS-length relationship of TS = 20logL - 71.9,
where TS is the target strength and L is the mean length of the fish in the school observed. With this relationship the acoustic signal can be converted into number of fishes observed.

3.3.2 Processing of fish

Fish samples were taken with a small half-pelagic trawl, with a 1 cm cod-end lining. In total 33 trawl hauls were conducted: 6 in NSW, 6 in the southern reference area, 6 in the northern reference area and 15 in the rest of the coastal zone (Table I, in Appendix). From the catch, species could be identified and biological data could be collected.

For each haul, the total weight per species was recorded. For each species[1], length-frequency distributions were assessed with a precision of 0.5 cm for sprat, herring, anchovy and pilchard and of 1 cm for other species. Individuals of species for which biological data were collected, were stored on ice for later processing at the institute. Biological data (length, weight, sex, maturity and otoliths) were collected for 565 fish of seven species (Table 1, below).

Table 1. *Numbers of fish of which biological data have been collected (length, weight, sex, maturity and otoliths).*

Name	Dutch name	Numbers processed
Anchovy	Ansjovis	104
Greater sand-eel	Smelt	47
Herring	Haring	141
Lesser sand-eel	Kleine zandspiering	45
Pilchard	Pelser	53
Raitt's sand-eel	Noorse zandspiering	109
Sprat	Sprot	66
Total		565

[1] All species names (English, Dutch and scientific) are presented in Table IV in the Appendix.

In the strategy of approach, collection of biological data of only four species was planned. We did not expect to catch two species of sand-eels (both lesser and Raitt's sand-eel) and we collected some samples of herring and sprat to check our assumption that we could use biological data from other sampling programmes for these species. Because biological data of herring and sprat are collected routinely, the data can be collected very efficiently in a limited time. Length-frequency distributions of the fish processed for biological data are presented in the Appendix (Figure I, Appendix).

Of sand-eel, the maturity status was difficult to assess for specimens smaller than ca. 15 cm because the gonads were very small. It will be tried to collect additional samples of sand-eel during the survey for demersal fish within the baseline study wind farm. This survey is carried out by the Netherlands Institute for Fisheries Research from the 24th of June untill the 4th of July. Probably, gonads of sand-eel are more developed in this period and perhaps maturity status can be detected more easily. Of all species and of all length classes, otoliths could be collected well.

3.3.3 Hydrography

Temperature, salinity (conductivity), time and depth, were recorded by a Hydrolab data logger (CTD device) which was towed behind the towed body.

3.3.4 Data processing

The acoustic signals were translated into densities per species by combining acoustic data with the trawl catches. In the acoustic data no distinction between clupeid species could be made, and densities per species were estimated by distributing the acoustic signals of the "clupeid" group over species using the proportion of clupeid species in the trawl catches. This was done per area (NSW, northern reference etc.).

Densities of species without swim bladders, mackerel and three sand-eel species, lesser sand-eel, Raitt's sand-eel and greater sand-eel were estimated by applying the proportion of numbers in the catch to the estimated numbers of the "clupeid"-group. Because they have no swim bladder, these species reflect the acoustic signals very weakly (for example: a mackerel of 30 cm has a Target Strength (TS) which is 40 times lower than a herring of 30 cm). In echo-integration, it is only possible to discriminate recordings from swim bladdered species if the schools are dense and also physically separated, which was not the case in this survey.

4. Preliminary results

4.1 Trawl catches

In total, ca. 106.000 fish of 29 species were caught to which three species contributed 92 % of the total numbers: Raitt's sand-eel (43 %), sprat (34 %) and herring (15 %; Table II, in Appendix). Average length of each species in each haul is presented in Table III. The table shows numerous demersal species appearing in the catches in low numbers. Small numbers of Lesser sand-eel were caught, mixed with Raitt's sand-eel.

Herring consisted of specimens in the range of 9 - 18 cm (Figure II, Appendix). According to data available from RIVO surveys, they were probably from the year class 2001 (1 winter-ring). Sprat ranged from 11 to 19 cm. Anchovy seems to consist of two groups, with peaks at 15 and 18 cm. The specimens of lesser sand-eel were generally larger than the specimens of Raitt's sand-eel. Greater sand-eel consisted of a group ranging from 17 to 29 cm and a distinct group of very small specimens (7 - 11 cm).

Among the four areas, abundance of species varies mostly between the larger coastal zone and the other three areas (Figure 3; Figure III, Appendix). Among the three other areas (NSW and both references areas), species composition and densities of the pelagic species were comparable. The first results indicate that the reference areas have comparable pelagic fish communities and seem to be chosen well.

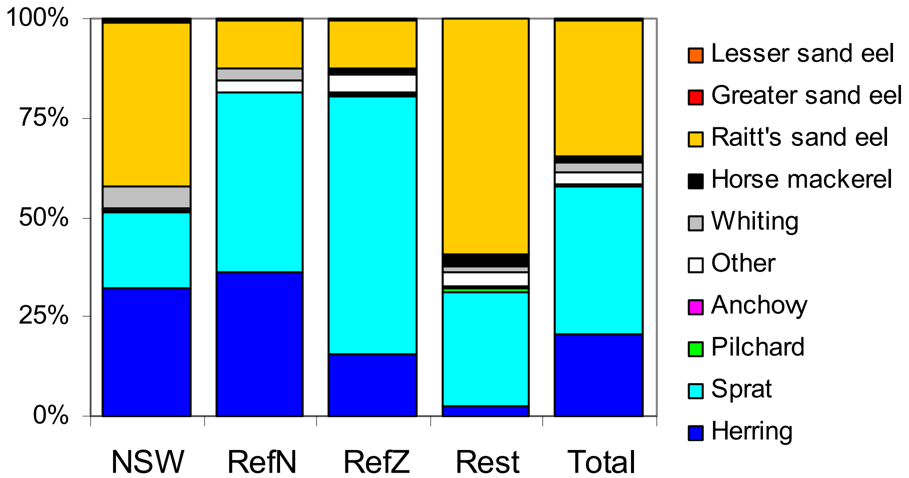

Figure 3. *Numerical species composition in each of the four areas and over all. Numbers per species as percentage of the total catch, after standardizing all catches to numbers caught per hour trawling. Data based on trawl catches. Areas: NSW: near shore wind farm area; RefN: northern reference area; RefZ: southern reference area; Rest: the larger coastal zone; Total: over all species composition.*

4.2 Spatial distribution of species

The data can be used to get a first impression of the spatial distribution of pelagic fish in the coastal zone. The figures presented in Appendix VII are very preliminary. They present the acoustic information, split into species by applying the weight-proportions in the hauls conducted in each area. The bubbles representing densities of fish are plotted at the start positions of half nautical mile intervals and not on the trawl-positions. In the figures in Appendix VII, one transect is missing due to some problems with the software used to log the acoustic data. These problems have been solved but the data of this transect were not readily available at the time of writing this report. In future analyses the data from this transect will be included.

In these preliminary figures, the spatial distribution of the different species look similar. This artificial effect is caused by the fact that the contribution of the species in the "clupeid" group is calculated from the proportion in the catches for each area. Only the absolute densities vary (see the legends) but not the relative densities. During the rest of the project, data will be analysed further to estimate density per species more accurately.

At first sight clupeids (herring, sprat, pilchard and anchovy) and horse mackerel are randomly distributed over all four area's (Figures IV-IX, Appendix). The majority of sand-eel consists of Raitt's sand-eel. Lesser sand-eel occurs only in small numbers mixed with Raitt's sand-eel. Greater sand-eel is widely distributed in the Dutch coastal area. According to the catches, Raitt's sand-eel is more abundant offshore than close to the coast. Because mackerel occurred in very low numbers In the catches, and it gives a very weak acoustic signal, we cannot estimate densities of mackerel yet.

4.3 Hydrography

The hydrographic data have to be linked to the geographical positions by the time recorded. At the time of preparing this report, this still had to be done and preliminary results cannot be presented yet. In the next field work report, we will try to present the first hydrographic data.

5. Discussion

The execution of the first survey of the baseline study for pelagic fish was successful. Almost the whole programme could be executed and the NSW area and both reference areas could be sampled as planned. The acoustic sampling and the trawl catches went very well, only the collection of data on the turbidity and the calibration of the 200 kHz transducer did not succeed. The CTD measuring device did not adequately measure turbidity, probably because the speed at which it was towed (7-8 knots) was too high and measuring turbidity at a depth of only 2.5-3 m is difficult. At present, this problem is being solved in an experimental set up. Calibration of the 200 kHz transducer failed because of disturbance by small fish around the object whose signal is used to calibrate the equipment. Because of its high frequency, this transducer is very sensitive to this type of disturbance. The 200 kHz and the 38 kHz can both be used for echo integration. The 200 kHz is more sensitive for small fish and fish without swimbladder. By comparing both frequencies it might have been easier to identify species from the acoustic information. The 38 kHz transducer is, however, adequate to sample the pelagic fish community well and only this transducer will be used in the next survey. We will try, however, to solve the problem with calibrating the 200 KHz transducer before the next survey.

The distribution of pelagic fish off the Dutch coast is very scattered but the species were very mixed at the time of the survey, there were no clear single species schools. As a consequence, it appeared to be impossible to distinguish species within schools of fish based on the acoustic signals only. It could be that in this season, species mix more than later in June. This was only our second survey of this type in the coastal zone and in the previous survey, within the Flyland project in June 2002, species were better separated and could be discerned better. In the next survey, it is therefore important to make enough trawl hauls to be able to distinguish species based on catches. We think, however, that the number of hauls made in the past survey was adequate to estimate densities of single species well.

Regarding fish community composition, the chosen reference areas seem to be comparable to the area of the nearshore wind farm. First analyses showed that there were clear differences in the occurrence of species between the larger coastal area and the three other areas, whereas among these three areas, the occurrence of species varied only slightly. Data should be analysed further to support this hypothesis. We have, however, the impression that the reference areas were selected well.

The results and the execution of the past survey give no reasons to adapt the survey design for the next survey.

In the coming months, a start will be made with age-determination from the otoliths collected. This may influence the collection of biological data in the next survey. We will, for example, check whether it is necessary to collect any further biological data of herring and sprat. Moreover, contact will be made with fisheries institutes abroad to gain information of processing and reading otoliths of sand-eels.

References

Grift R, Couperus AS, Ybema MS (2003) Base line studies North Sea wind farms: strategy of approach for pelagic fish. Report No. C013/03, RIVO, IJmuiden.

Appendix

Appendix I. Trawl list

Table I. *List of trawl hauls with position, date, time and haul duration.*

Area	Haul	Position	Date	Time	Haul duration (minutes)
NSW	1	52 34N 04 26E	23/04/2003	07:55	16
	2	52 36N 04 22E	23/04/2003	09:08	15
	3	52 36N 04 24E	23/04/2003	11:03	16
	4	52 35N 04 28E	23/04/2003	13:15	18
	5	52 35N 04 29E	23/04/2003	13:49	10
	6	52 38N 04 23E	23/04/2003	16:33	24
Rerence area North	7	52 42N 04 31E	24/04/2003	07:09	20
	8	52 43N 04 28E	24/04/2003	08:40	15
	9	52 42N 04 27E	24/04/2003	10:34	16
	10	52 40N 04 32E	24/04/2003	12:27	14
	11	52 41N 04 26E	24/04/2003	13:59	15
	12	52 41N 04 26E	24/04/2003	15:42	34
Rerence area South	13	52 33N 04 20E	25/04/2003	06:09	34
	14	52 31N 04 25E	25/04/2003	07:40	15
	15	52 34N 04 20E	25/04/2003	09:10	14
	16	52 35N 04 20E	28/04/2003	08:56	15
	17	52 32N 04 29E	28/04/2003	10:33	15
	18	52 35N 04 21E	28/04/2003	12:03	20
Coastal zone	19	52 45N 04 33E	28/04/2003	14:02	15
	20	52 47N 04 24E	28/04/2003	15:21	15
	21	52 48N 04 19E	28/04/2003	16:31	16
	22	52 52N 04 29E	28/04/2003	19:25	20
	23	52 29N 04 26E	29/04/2003	08:08	20
	24	52 30N 04 24E	30/04/2003	05:22	14
	25	52 32N 04 17E	30/04/2003	06:31	15
	26	52 34N 04 08E	30/04/2003	07:59	15
	27	52 29N 04 10E	30/04/2003	09:01	15
	28	52 26N 04 16E	30/04/2003	10:11	17
	29	52 23N 04 26E	30/04/2003	11:43	16
	30	52 18N 04 24E	30/04/2003	13:22	14
	31	52 19N 04 22E	30/04/2003	14:08	20
	32	52 22N 04 13E	30/04/2003	15:43	16
	33	52 12N 04 05E	02/05/2003	05:50	16

Appendix II: Numbers caught.

Table II. *Numbers of fish caught in each trawl haul (numbers per hour trawling).*

Haul number	area	Total	Bull rout	Dab	Greater sand eel	Herring	Lesser weever	Mackerel	Plaice	Raitt's sand eel	Solenette	Sprat	Whiting	Anchovy	Grey gurnard	Horse mackerel	Sole	Cod	Transparent goby	Lesser sand eel	Poor cod	Dragonet	bib	Pilchard	Allis shad	Lamprey	Flounder	Tub gurnard	Four bearded rockling	Reticulated dragonet	Scaldfish
1	nsw	2370	4	86	11	75	8	4	45	4	4	795	1335																		
2	nsw	28876		8		4640		4	4	16960		7200	4	40	4	8	4														
3	nsw	3409			38	945				1980		356	75	11		4															
4	nsw	1807	7	47	3	523			80	33			1107					3	3												
5	nsw	8778		24	6	7872						588	12							276											
6	nsw	3735		3	205	1640		88		1200		590	3	8																	
7	refn	1155	3	27	6	702			12	111			282	3		3		3			3										
8	refn	1220		28		376			24			72	640		4	64	4	8													
9	refn	2561		713	4	705	11		23	19		49	1005			19					11	4									
10	refn	879		69	81	360			9				360																		
11	refn	30616			208	5836		1088		3904		19456	64	60																	
12	refn	38195			169	19098			4	4744		14118		7						56											
13	refz	1662	2		9	577		653		64		316	2	39		2															
14	refz	1208		24		616	4	4	4			420	128			4							4								
15	refz	12133			9	2786		806		849		7543				26	4			64				47							
16	refz	1664		12	4	420				832		36	44	64		252															
17	refz	13968		4		660				196		13056		36		4				12											

Haul number	area	Total	Bull rout	Dab	Greater sand eel	Herring	Lesser weever	Mackerel	Plaice	Raitt's sand eel	Solenette	Sprat	Whiting	Anchovy	Grey gurnard	Horse mackerel	Sole	Cod	Transparent goby	Lesser sand eel	Poor cod	Dragonet	bib	Pilchard	Allis shad	Lamprey	Flounder	Tub gurnard	Four bearded rockling	Reticulated dragonet	Scaldfish
18	refz	2685		6	60	207				1977		222	15	45		108				45											
19	rest	420	4	12		20				36		16	200	4		44				72		4	8								
20	rest	748		12		8	8			4		524	116		4	68					4										
21	rest	1774			4	15	11	4		293		356	11			1080															
22	rest	822				30		3		48		153		12		9								564	3						
23	rest	10485			9	2181				12		8232		33										18							
24	rest	8511				360		4		13		7303				26								806							
25	rest	4992		8	12	52	4	4		64		196	20			4608		4		16				4							
26	rest	2736		4	8	112	20	12		168		2400	8	4																	
27	rest	151148			4	64	4			116736		34304		36																	
28	rest	5894		4	4	21		21		1694		4009		141																	
29	rest	2325	4	26	8	1065	4	41	4	71		990	68	19						15			4			8					
30	rest	2314			21	1149				13				1131																	
31	rest	2334	3	216	15	114	3		75	12		117	1728	39		3											3	6			
32	rest	6915		15		75			4	4920		1680		11		210															
33	rest	7631	49	4616	8	8	30	375	690		248	34	1290				4					203		41			8		11	4	15
Total		365971	75	5963	905	53311	107	3110	976	156955	251	125131	8516	1743	12	6541	16	18	3	557	18	210	16	1480	3	8	11	6	11	4	15
Percentage		100	0.0	1.6	0.2	14.6	0.0	0.8	0.3	42.9	0.1	34.2	2.3	0.5	0.0	1.8	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III. Average lengths.

Table III. *Average length of each species in each trawl haul (cm).*

Haul number	area	Average	Bull rout	Dab	Greater sand eel	Herring	Lesser weever	Mackerel	Plaice	Raitt's sand eel	Solenette	Sprat	Whiting	Anchovy	Grey gurnard	Horse mackerel	Sole	Cod	Transparent goby	Lesser sand eel	Poor cod	Dragonet	bib	Pilchard	Allis shad	Lamprey	Flounder	Tub gurnard	Four bearded rockling	Reticulated dragonet	Scaldfish
1	nsw	17.7	21.0	14.7	12.0	15.4	14.5	36.0	19.6	18.0	10.0	8.8	25.0																		
2	nsw	18.5		17.5		16.1		30.0	20.0	14.5		9.9	22.0	14.8	13.0	32.0	14.0														
3	nsw	18.7			23.0	16.6				15.5		10.0	25.9	15.2		25.0															
4	nsw	19.8	20.5	17.0	21.0	16.4			19.0	14.2			18.2					47.0	5.0												
5	nsw	17.4		18.3	27.0	13.2						9.3	21.0							15.5											
6	nsw	18.9		18.0	18.8	18.4		33.9		14.0		9.9	23.0	15.0																	
7	refn	21.7	17.0	18.5	22.0	16.2			19.3	15.6			22.3	14.5		32.0		46.0			15.0										
8	refn	22.3		17.3		16.8			17.5			9.5	23.5		14.0	28.4	22.0	51.5													
9	refn	17.0		17.6	21.0	14.8	14.0		17.8	17.0		10.2	25.5			28.7					9.0	11.0									
10	refn	16.9		19.4	11.4	15.8			15.0				22.7																		
11	refn	19.3			19.8	17.6		33.5		14.6		10.3	24.0	15.5																	
12	refn	14.0			9.0	17.5			18.0	14.5		9.5		14.3						15.0											
13	refz	18.1	16.0		12.7	17.4		34.0		14.6		10.0	21.0	14.0		23.0															
14	refz	20.9		22.4		16.4	12.0	36.0	18.0			9.4	24.5			28.0							21.0								
15	refz	21.4			25.0	15.1		33.0		15.5		10.5				28.8	23.0			17.0				24.9							
16	refz	18.9		15.3	20.0	19.5				15.5		10.8	26.4	15.3		28.5															
17	refz	17.4		19.0		18.9				16.0		9.3		16.3		30.0				12.5											
18	refz	18.5		20.5	16.0	19.1				15.5		10.5	23.4	15.9		28.9				17.0											

Haul number	area	Average	Bull rout	Dab	Greater sand eel	Herring	Lesser weever	Mackerel	Plaice	Raitt's sand eel	Solenette	Sprat	Whiting	Anchovy	Grey gurnard	Horse mackerel	Sole	Cod	Transparent goby	Lesser sand eel	Poor cod	Dragonet	bib	Pilchard	Allis shad	Lamprey	Flounder	Tub gurnard	Four bearded rockling	Reticulated dragonet	Scaldfish
19	rest	16.5	16.0	22.3		21.1				15.5		10.6	24.5	14.0		27.1				17.0		10.0	3.5								
20	rest	18.3		17.0		26.0	11.0			14.0		10.2	23.1		20.0	30.5					13.0										
21	rest	20.6			25.0	16.7	12.0	34.0		14.5		10.1	24.7			28.1															
22	rest	20.6				18.7		28.0		14.4		10.5		15.1		32.3								24.9	20.5						
23	rest	17.2			19.0	17.2				16.7		9.3		15.9										25.1							
24	rest	21.4				17.6		32.0		14.7		9.6				29.0								25.3							
25	rest	22.9		19.0	25.3	19.1	14.0	32.0		14.8		9.7	25.0			26.3		47.0		17.5				24.5							
26	rest	19.6		23.0	26.5	20.3	12.0	25.7		14.4		10.2	28.5	15.5																	
27	rest	16.2			24.0	19.7	14.0			14.4		9.9		15.2																	
28	rest	18.8		16.0	28.0	16.1		30.4		15.5		10.5		14.8																	
29	rest	16.5	18.0	19.2	21.0	19.1	13.0	29.3	17.0	13.7		10.4	21.6	14.8						15.5			5.0			13.5					
30	rest	15.4			13.5	14.8				16.7				16.5																	
31	rest	19.6	21.0	21.4	10.0	19.4	9.0		26.7	15.3		9.1	24.5	16.4		29.0											36.0	17.5			
32	rest	18.5		23.0		18.6			20.0	14.6		9.8		17.5		26.1															
33	rest	17.4	20.0	17.9	9.0	18.5	13.3	25.2	20.1		9.0	9.0	25.7				19.0					17.0		25.3			33.0		16.0	9.0	8.3
Average		18.7	18.7	18.8	19.2	17.7	12.6	31.5	19.1	15.2	9.5	9.9	23.7	15.3	15.7	28.5	19.5	47.9	5.0	15.9	12.3	12.7	9.8	25.0	20.5	13.5	34.5	17.5	16.0	9.0	8.3

Appendix IV. Species names

Table IV. *English, dutch and scientific names of fish species.*

Name	Dutch name	Species	Family
Allis shad	Elft	*Alosa alosa*	Clupeidae
Anchovy	Ansjovis	*Engraulis encrasicolus*	Engraulidae
Bib	Steenbolk	*Trisopterus luscus*	Gadidae
Bull-rout	Zeedonderpad	*Myoxocephalus scorpius*	Cottidae
Cod	Kabeljauw	*Gadus morhua*	Gadidae
Dab	Schar	*Limanda limanda*	Pleuronectidae
Dragonet	Pitvis	*Callionymus lyra*	Callionymidae
Flounder	Bot	*Platichthys flesus*	Pleuronectidae
Four-bearded rockling	Vierdradige meun	*Enchelyopus cimbrius*	Gadidae
Greater sand-eel	Smelt	*Hyperoplus lanceolatus*	Ammodytidae
Grey gurnard	Grauwe poon	*Eutrigla gurnardus*	Triglidae
Herring	Haring	*Clupea harengus*	Clupeidae
Horse mackerel	Horsmakreel	*Trachurus trachurus*	Carangidae
Lamprey	Rivierprik	*Lampetra fluviatilis*	Petromyzonidae
Lesser sand-eel	Kleine zandspiering	*Ammodytes tobianus*	Ammodytidae
Lesser weever	Kleine pieterman	*Echiichthys vipera*	Trachinidae
Mackerel	Makreel	*Scomber scombrus*	Scombridae
Pilchard	Pelser	*Sardina pilchardus*	Clupeidae
Plaice	Schol	*Pleuronectes platessa*	Pleuronectidae
Poor cod	Dwergbolk	*Trisopterus minutus*	Gadidae
Raitt's sand-eel	Noorse zandspiering	*Ammodytes marinus*	Ammodytidae
Reticulated dragonet	Rasterpitvis	*Callionymus reticulatus*	Callionymidae
Scaldfish	Schurftvis	*Arnoglossus laterna*	Bothidae
Sole	Tong	*Solea vulgaris*	Soleidae
Solenette	Dwergtong	*Buglossidium luteum*	Soleidae
Sprat	Sprot	*Sprattus sprattus*	Clupeidae
Transparent goby	Glasgrondel	*Aphia minuta*	Gobiidae
Tub gurnard	Rode poon	*Trigla lucerna*	Triglidae
Whiting	Wijting	*Merlangius merlangus*	Gadidae

Appendix V. LF distributions

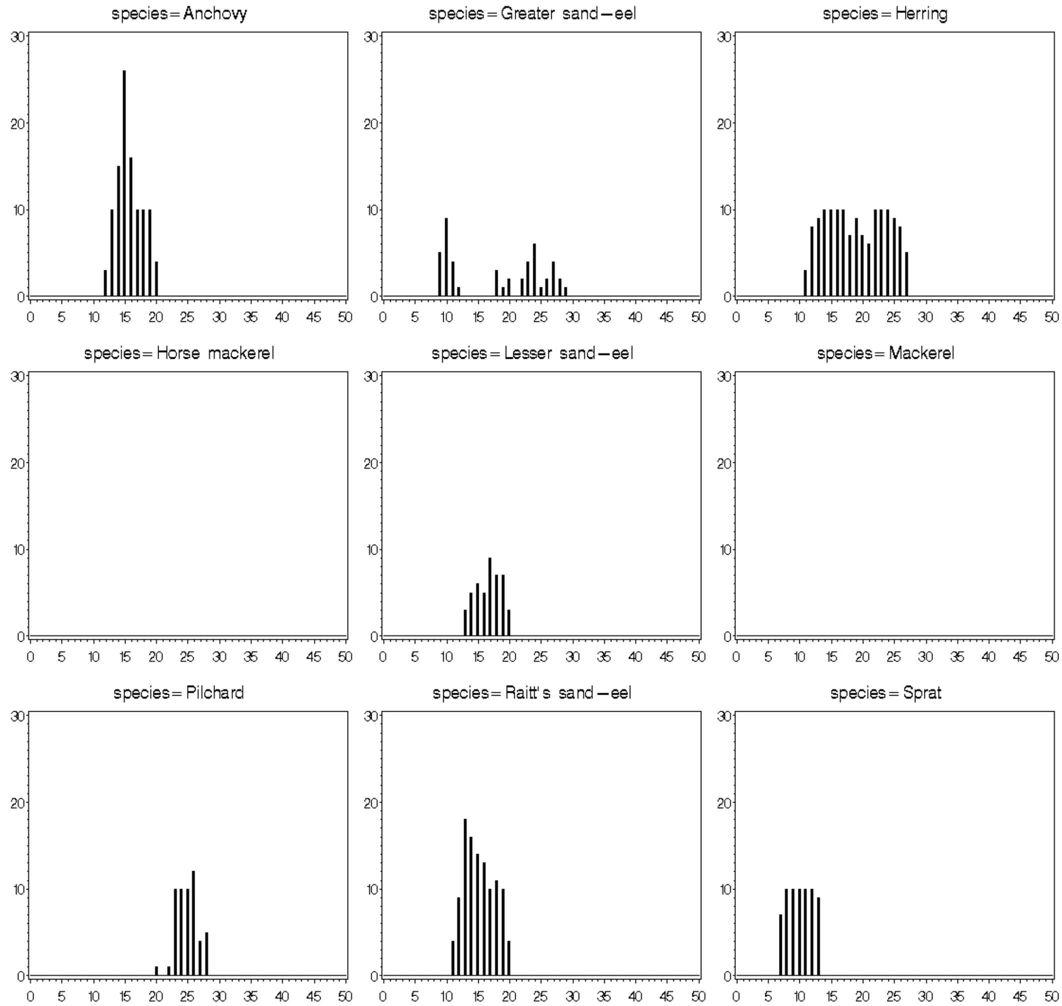

Figure I. *Length frequency distributions of fish of which biological data were collected. Total length on the x-axis (cm) and total number of fish of which data were collected on the y-axis (-).*

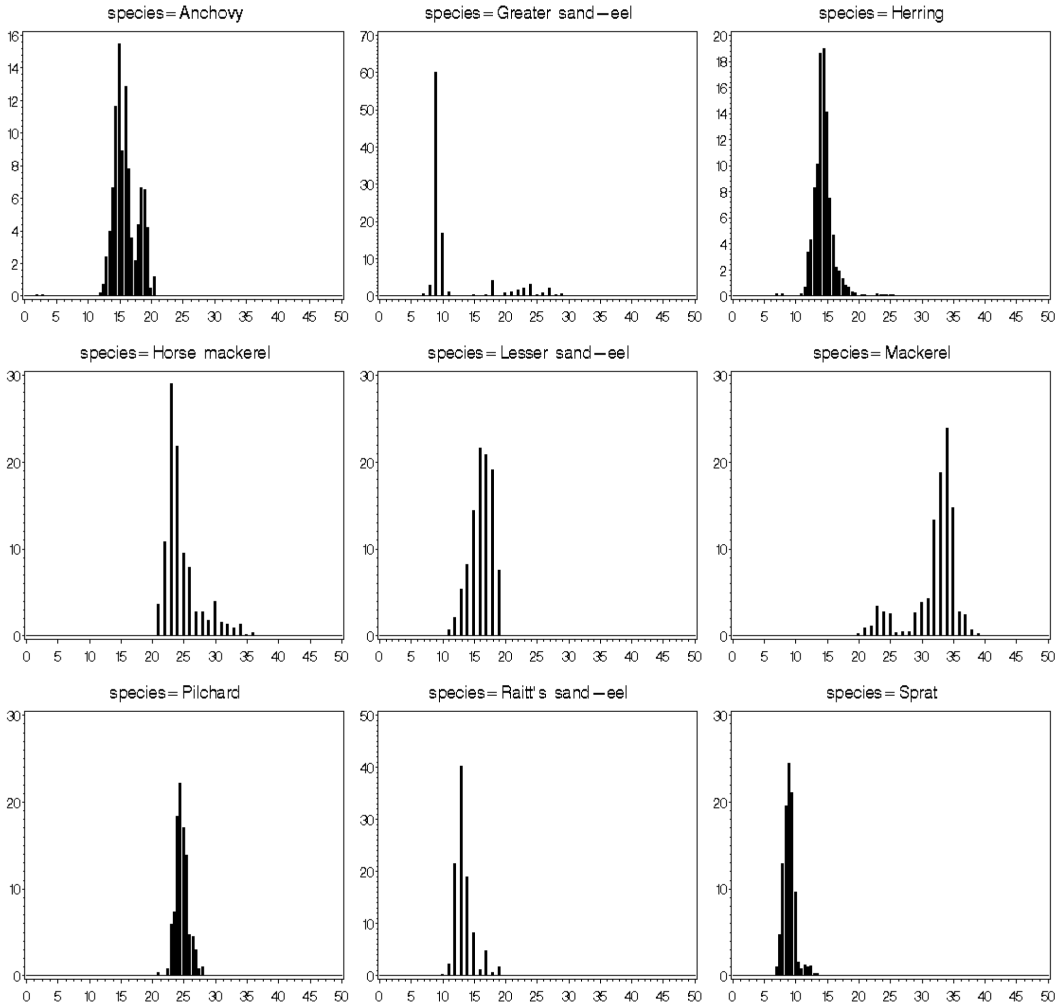

Figure II. *Length frequency distributions of fish from trawl catches for nine pelagic species. Total length on the x-axis (cm) and total number of fish caught on the y-axis (-).*

Appendix VI. Abundance of fish

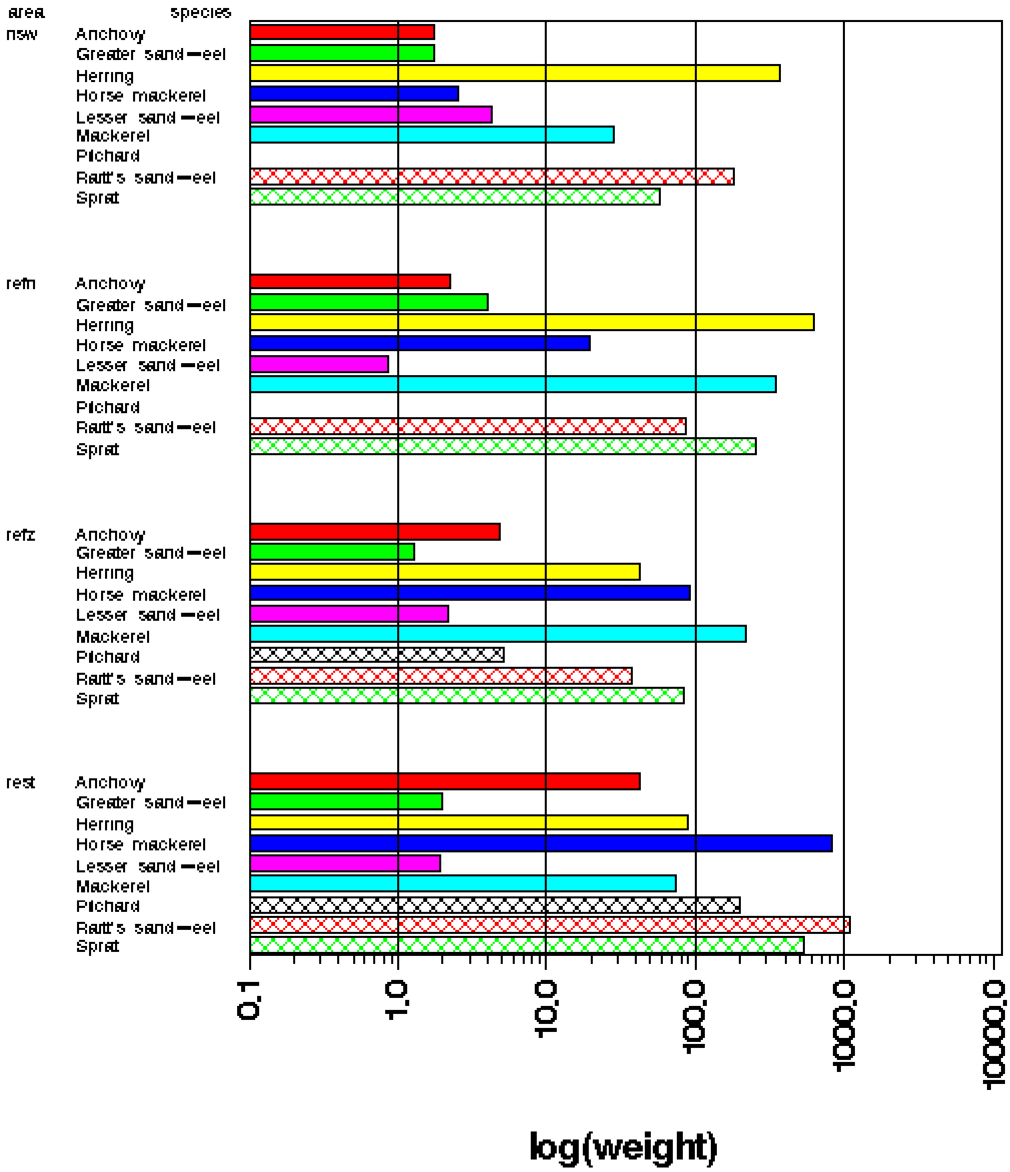

Figure III. *Abundance of nine pelagic species in terms of biomass in four areas: Near Shore Wind park area (NSW); northern reference area (RefN); southern reference area (RefZ) and the larger coastal area (rest). The weight on the x-axis is the trawl catch in kg per hour trawling.*

Appendix VII. Spatial distribution of pelagic species.

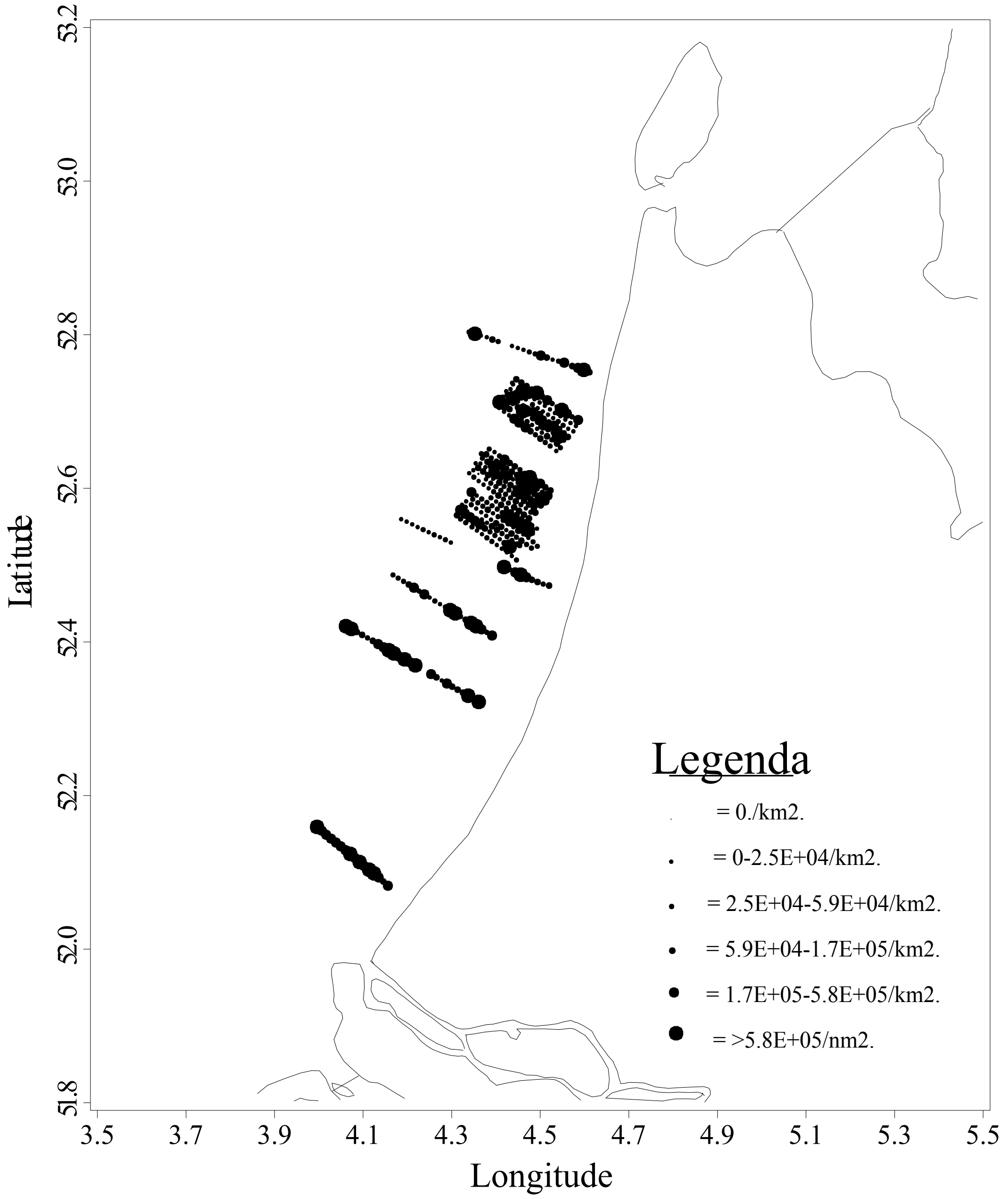

Figure IV. *Spatial distribution of herring.These data are only preliminary to give an impression of the distributions.*

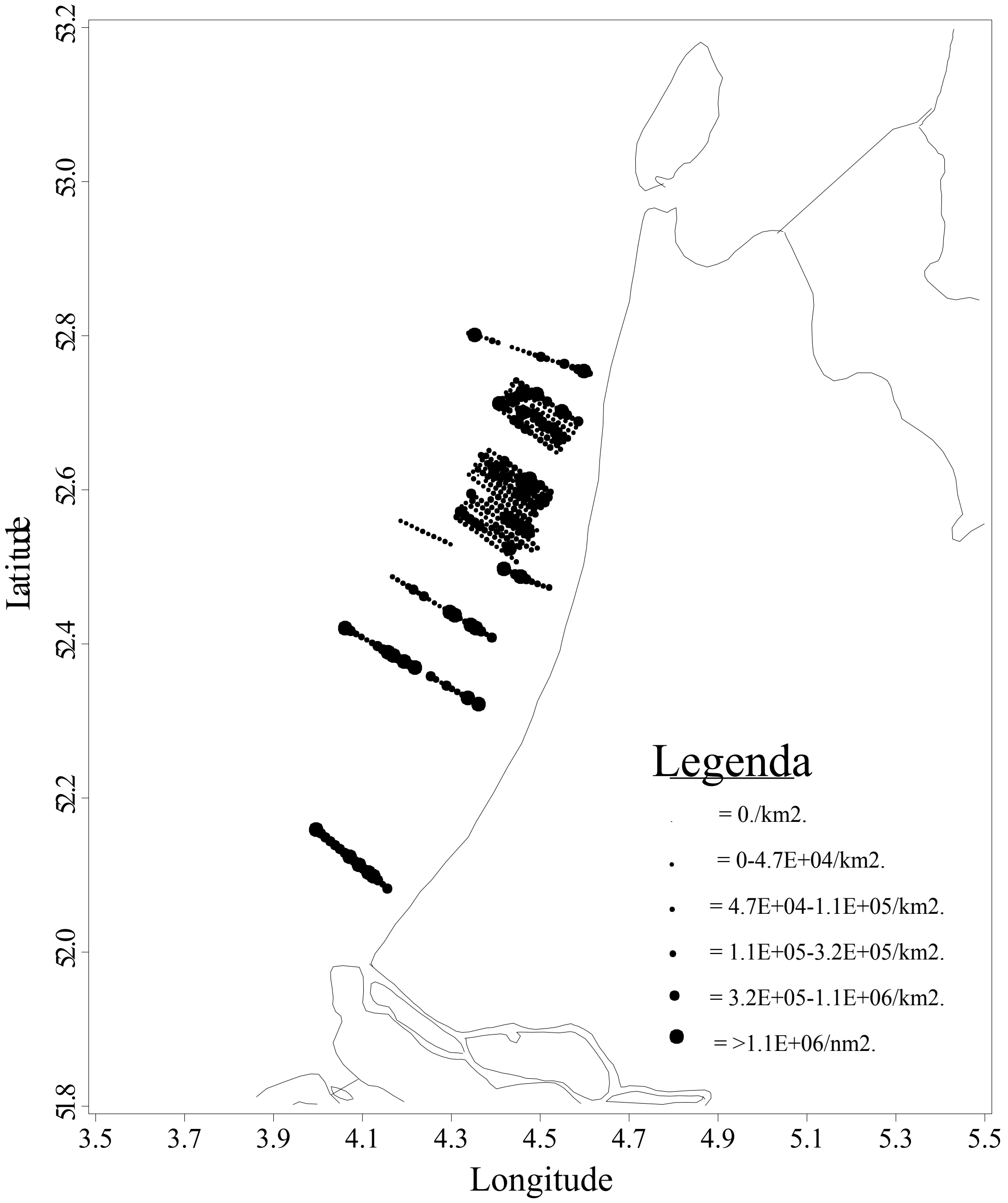

Figure V. *Spatial distribution of sprat.These data are only preliminary to give an impression of the distributions.*

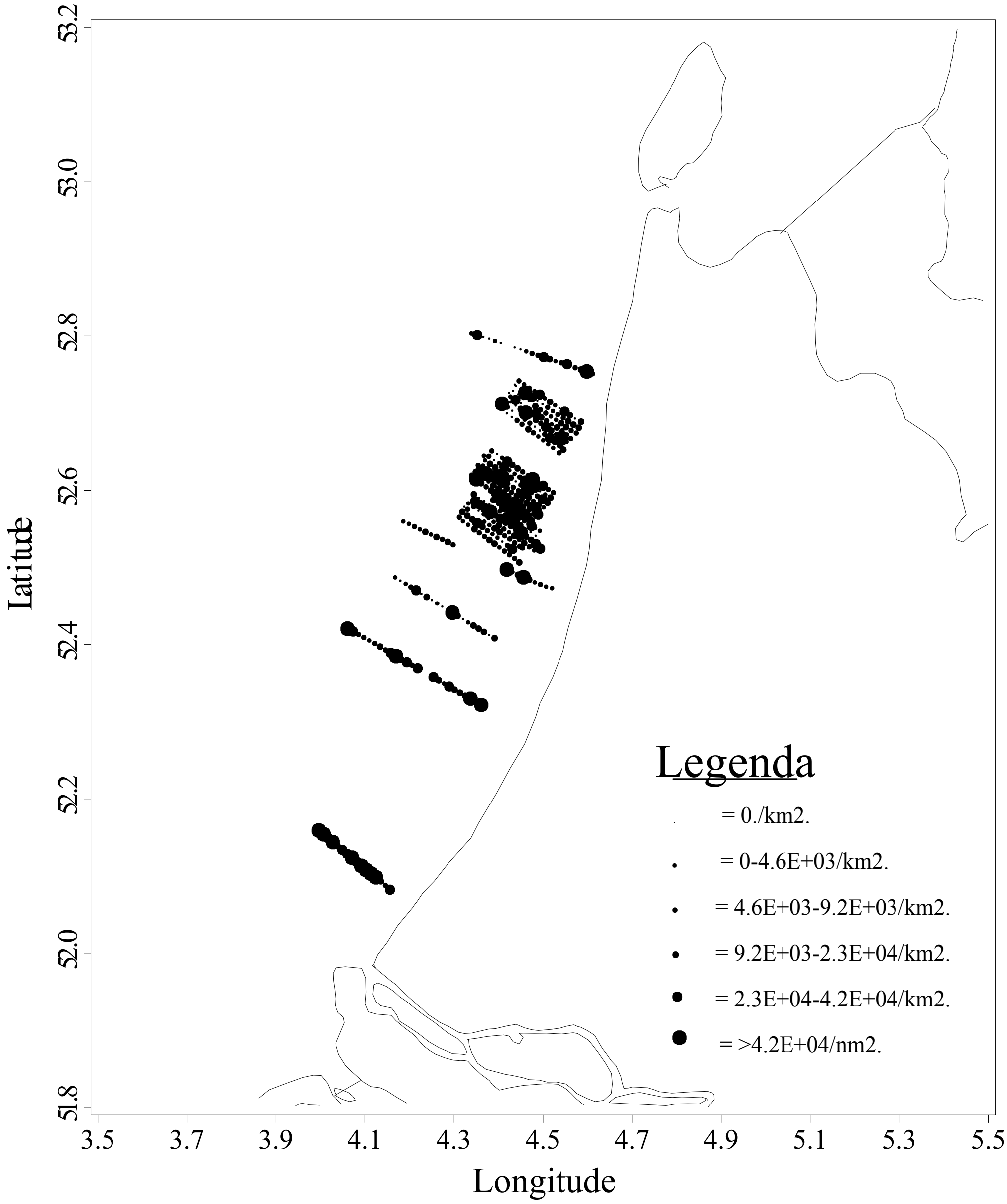

Figure VI. *Spatial distribution of greater sand-eel.These data are only preliminary to give an impression of the distributions.*

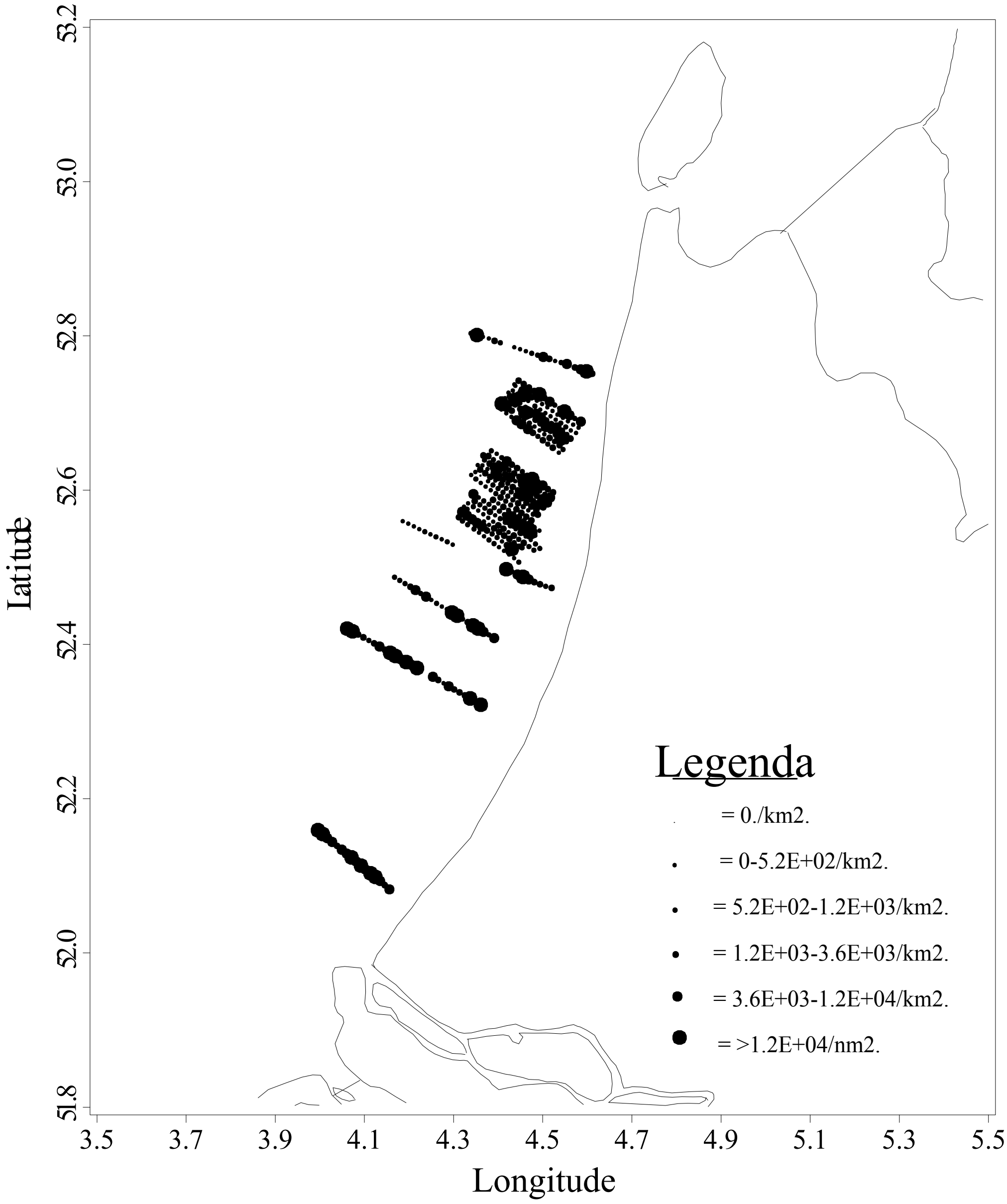

Figure VII. *Spatial distribution of pilchard.These data are only preliminary to give an impression of the distributions.*

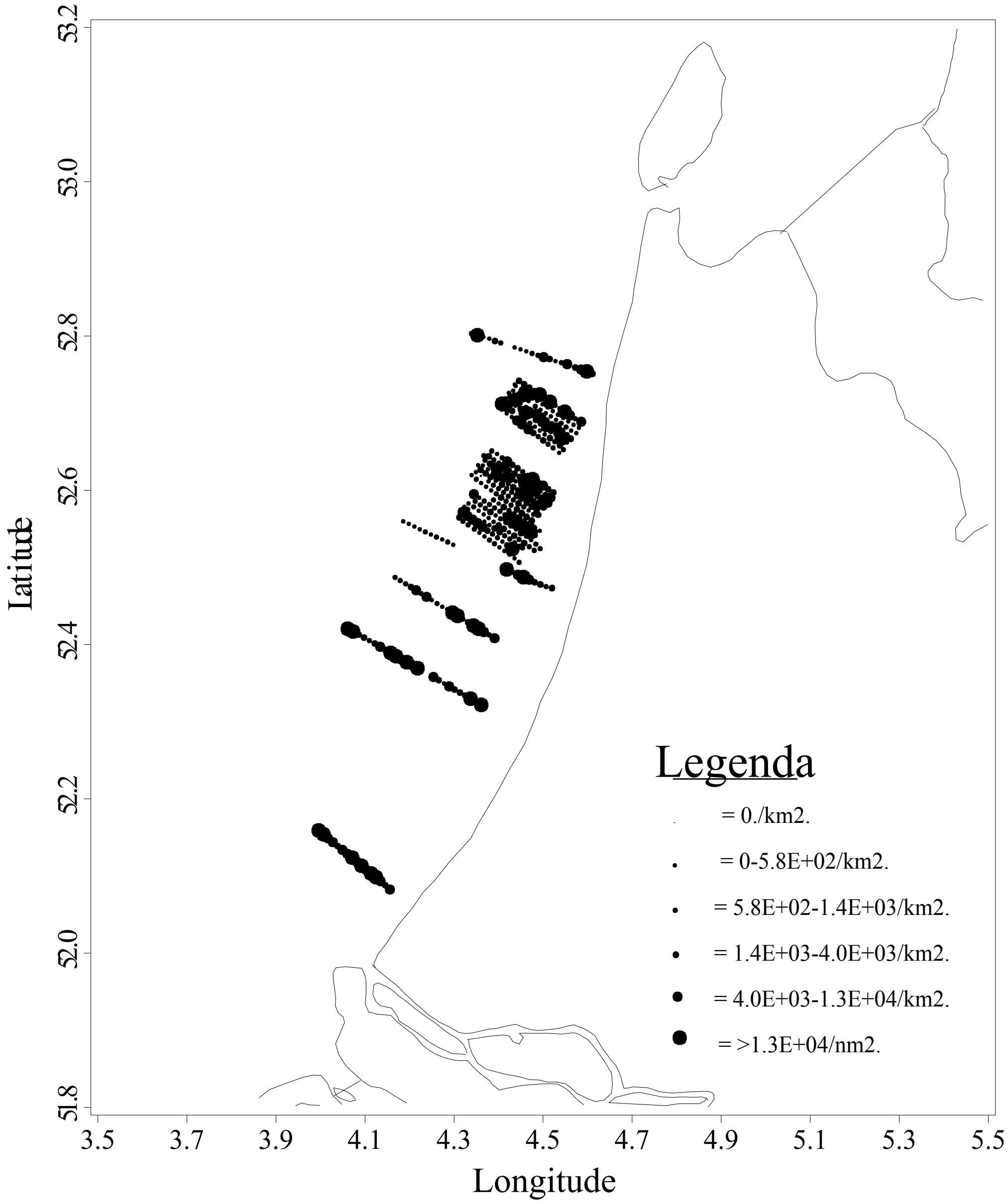

Figure VIII. *Spatial distribution of anchovy.These data are only preliminary to give an impression of the distributions.*

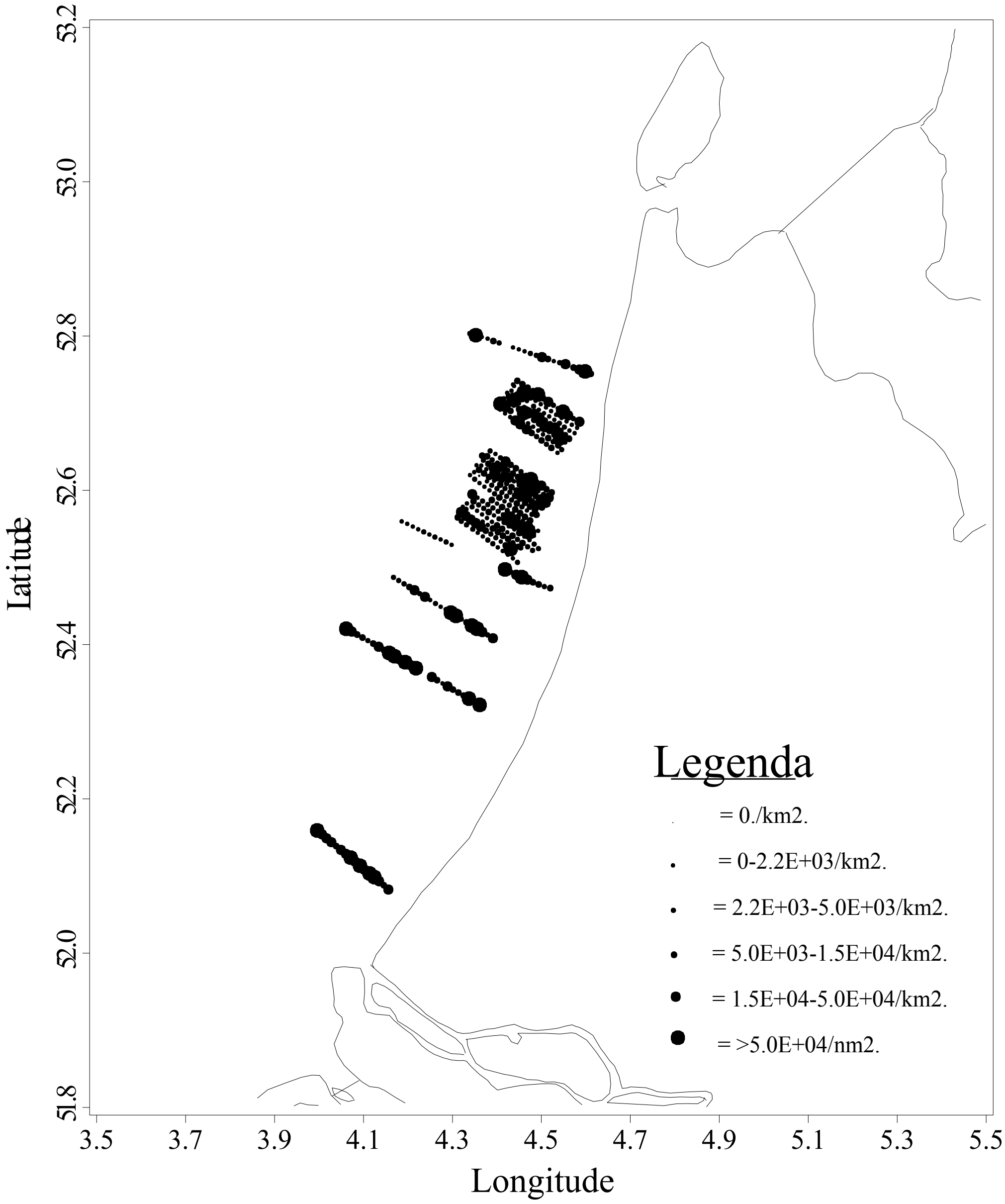

***Figure IX**. Spatial distribution of horse mackerel.These data are only preliminary to give an impression of the distributions.*

Appendix VIII: Copies of the field forms used

Three types of field form used are included in this report:

1. Field forms on which information on the trawl hauls (position, time etc.) was filled out;

2. Field forms on which length frequency distributions were filled out;
   These forms were filled out on board the trawler where length frequency distributions of all species were assessed. Also the total weights caught per species were recorded on the forms.

3. Field forms on which biological data were recorded;
   These forms were filled out at the lab where length, weight, sex and maturity were assessed and otoliths were collected.