Distribution, abundance and condition of juvenile fish on the western coast of the Netherlands

Report to Project Organization Maasvlakte 2, Rotterdam

Institute of Estuarine and Coastal Studies
University of Hull

18 July, 2008

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Project Organization Maasvlakte 2

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For and on behalf of the Institute of Estuarine and Coastal Studies	
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EXECUTIVE SUMMARY

The Scope of Work for the PMV2-Baseline Juvenile Fish Survey (BJFS) called for the quantitative sampling of demersal and pelagic juvenile fish assemblages within and around the area likely to be influenced by increased silt concentration during the construction of Maasvlakte 2. The fish catches were processed to provide species and site-specific length and weight data (i.e. condition). Although the project was hampered by bad weather in July and October, 98% of the overall original programme was achieved. Demersal and plankton tows were successfully completed at all accessible stations. The positions of a number of pre-selected sites were moved to allow safe operation and only six points out of 300 were not sampled due to overlapping with neighbouring stations. There were very few occasions when the equipment failed. Most incidents were caused by gear damage during marginal weather conditions. Contingency plans effectively dealt with all incidents and impacts on the survey progress were minimal. Survey operations invariably ceased before data quality or personnel safety became compromised. Data quality is very good and data files were checked for consistency and putative data contamination flagged before calculating density and conducting the condition analysis.

The BJFS recorded a total of 51 species. Most of them are small-bodied or juvenile forms of larger species. This was consistent in both surveys suggesting that the survey program effectively sampled the juvenile fish assemblage. Each of the three cruises showed characteristic taxonomical composition emphasising the importance of temporal changes in the fish assemblage across the survey area. Moreover there was a marked depth-related distribution of some species principally in the demersal fish assemblage. Condition estimates at the different areas of the survey grid were generally close to the mean condition value but some seasonal or site-related differences were found. The condition and density estimates are species dependent and suggest an interaction between fish life history and local habitat attributes not studied in this baseline survey program.

1. INTRODUCTION

The Baseline Juvenile Fish Survey (BJFS) was undertaken by the Institute of Estuarine and Coastal Studies (IECS) from the University of Hull (UK) on behalf of the Project Organization Maasvlakte 2. The BJFS is a component of a wider monitoring and evaluation programme aiming to characterise the nature of environmental impacts caused by sand extraction activities associated with the construction of Maasvlakte 2. The overall goal of the survey program is to gain an independent and representative understanding of the diversity, density and condition of juvenile fish along the Dutch coast within the area potentially affected by elevated silt concentrations in connection to the above mentioned sand extraction activities.

The data included in this report were gathered in three separate cruises conducted during spring, summer and autumn 2007. Each contains independent assessments of the species composition, abundance and condition of pelagic and demersal fish using the sampling domain. The data were collected using standard gear systems traditionally used for the quantitative assessment of juvenile fish populations. Standardised survey methods and sample processing were used to guarantee an adequate level of reproducibility and ensure that baseline data can be compared across cruises and to past and future monitoring programs.

This report is intended to introduce the raw data sets compiled during the fish censuses and length and weight measurements. It also provides a full account of methods and data handling along with analytical quality control and quality assurance (AQC/QA) procedures in place during the survey work and later during the data manipulation and analysis. While the main intention is to introduce the data and provide condition estimates, a brief community analysis has been included in the report. Some general points with regards to temporal and spatial differences in fish assemblages and diversity are then discussed.

2. METHODS

2.1 Personnel and survey equipment

The personnel involved in the project and their roles are listed in Table 1. In addition to the survey personnel, three observers (Dr. William Borst, Dr. Onno van Tongeren and Dr. Arjen Boon) joined the survey team regularly during the cruises. IECS personnel were in charge of survey coordination and sample processing and the vessels crew were responsible for boat positioning and gear operation.

Table 1. Survey personnel and role.

Surname	First Name	Company	Title	Role
Perez-Dominguez	Rafael	IECS/ UoH	Senior Fish Ecologist	Survey coordinator & reporting
Kraak	Dirk	Slot Maritiem Holding	Skipper	Vessel and gear operation
Bailey	Michael	IECS	Marine Technician	Survey Operations
Baulcomb	Christopher	IECS	Marine Technician	Survey Operations
Allen	Matthew	IECS	Marine Technician	Survey Operations & data input
Leighton	Ann	IECS/ UoH	Laboratory & Field Coordinator	Survey Operations & data input
Thomson	Shona	IECS/ UoH	Coastal Geographer	Positional data & reporting
McNeil	Lewis	IECS	Marine Technician	Catch processing

2.2 Vessel

The M.F.V. JADE, a double beam trawler based in Den Helder (NL) was used for all three surveys (technical details presented in table 2).

Table 2. Survey vessel main particulars and specifications

Vessel Registration BRA7		
LOA	23.9m	
BOA	6.9m	
Draft	3.8m (max)	
Displacement	Gross	158 tons
	Net	47 tons
Engine output	221kW	
Winch	Luyt 9 (rated at 10 tonnes)	
Navigation	DGPS Quadfish 610	
	Furuno fr2115	

2.3 Positioning

The primary GPS system used during the survey work was the vessel resident system and a portable DGPS (GPSMAP® 76S) as the secondary system. The primary DGPS systems and radar installation were directly input to online navigation PC system and set to record vessel track lines. On the first mobilisation day a positioning integrity check and GPS intercalibration was carried out while the vessel was securely berthed at Den Helder docks. The portable DGPS (WAAS enabled) unit was setup over a reference point on the quayside (52.9501N, 4.78648E) and the observed position was logged at approximately 3 min interval for 30mins. The measurements were accurate to within ±6m on the horizontal. The intercalibration check between GPS devices was carried out on each of the three survey mobilisation days and periodically during the survey work. The portable DGPS unit and vessel real-time GPS positions were always within the combined precision radius. During surveys the position of the vessel was to be resolved using the vessel differential GPS to a minimum accuracy of ±5m and any sampling equipment operated within 2 nautical miles radius from the predetermined stations.

2.4 Deployment periods

All equipment and sampling gear were taken by road to Den Helder port and loaded onto the survey vessel. Spare trawls, nets and accessories were carried, together with the main gear, as backup. IECS staff conducted all necessary safety checks on first boarding the survey vessel on each cruise. The skipper informed the survey team of safe working areas on deck and no-go zones as well as emergency procedures. An emergency drill was conducted after the safety introduction. Sampling dates and times for all three cruises are appended to the document (Appendix 1). All tows were conducted during the night.

2.5 Weather conditions

Survey work was always undertaken under wind and sea conditions favourable to the safe and effective operation of the sampling gear. Invariably work stopped or was not initiated under swells of 1.5m and wind force 5 or greater. Weather conditions allowed survey work throughout the entire 11-days deployment in April but unseasonal weather resulted in down days in July. Consequently, it was not possible to conduct any survey work for 5 days within the total 17-days survey period. Again bad weather resulted in 2 down days during the total 11-days cruise in October.

The deterioration in weather condition during some work days increased working loads on the sampling equipment resulting in damage to the survey gear on several occasions. Emergency repairs or net replacements were conducted to allow sampling to continue during the night. Damaged gear was rebuilt to the original specifications on the day following each incident. Poor weather was also responsible for the damage to the water quality data logger bail that resulted in the loss of the unit on October 30th 2007.

2.6 Survey domain and sequence

The station array was centred in the area that, according to local hydrodynamic model computations, will be influenced by elevated silt concentrations during the sand mining activities. The array also included adjacent zones in which there will be no, or negligible water-column silt increases. In the central area the stations were placed in a regular grid following an east-west transect at the northern boundary and a north-south transect at the eastern boundary. South and north of the central area the stations were laid out in transects perpendicular to the coast and stratified by depth (see Appendix 1).

Since a completely randomised sampling sequence of the stations would take too much sailing time, a partly randomised station sequence was followed as determined prior to each of the three cruises. The sequence was altered on two occasions in April and affected four stations. For the July and October cruise a more flexible sailing was devised with pre-defined station groups. The groups were sized according to the distance between stations and daily available night hours. The order in which the station groups were sampled was chosen at random. In total 292 stations were sampled. Stations 26, 27, 37 and 38 in April and 14, 37, 38 and 100 could not be sampled as the low ground clearance at the time of approaching these positions made it unsafe to conduct the survey (see Appendix 1 for the location of the stations). An electronic copy of the survey log is provided along the master data files and includes records for station sequence, time, depth[1], location of trawl deployments, sea and weather conditions, and sample processing notes. Between 7 and 14 stations were visited during each survey night depending on sailing distance between stations and length of the night.

2.7 Survey work

Before sailing, the towing cable (warp) was measured and tagged at 5 and 10m intervals for the beam (demersal survey) and plankton trawl (pelagic survey), respectively. The plankton sampler was fixed firmly to the ring frame and then secured to the towing line by a 3-point bridle fitted with a 50kg depressor and a 100 or 150kg in-line weight. The beam trawl was fitted with a single tickler chain and a 2-point bridle tied to the trawl shoes. The two trawls were finally rigged to the vessel side trawl beams.

Both surveys, pelagic and demersal, were conducted in parallel throughout the sampling grid and entirely at night time. The sampling gear was deployed once the vessel was approaching the station's fix as instructed by the skipper and followed a straight path across the station. The bearing was decided by the skipper to ensure a good control over the trawling speed and trawl deployment as well as to avoid sharp ridges and known seabed obstructions that could compromise the demersal survey. Towing speed was fixed at 2 knots (1 m sec^{-1}) true speed relative to the ground in order to accommodate the combined undertaking of both surveys. Start and end positions were recorded for all trawls. To prevent contamination of the records all information from a particular haul was recorded on an independent field log form.

The two gears were generally deployed and retrieved at the same time with a maximum sampling time of approximately 15mins. Shorter trawling times were implemented where a large amount of material or quick fouling of the net was consistently detected. The latter problem (fouling) was particularly severe during the last half of the April cruise due to the high abundances of ctenophores and algal slime in the water. This effect could have potentially affected the efficiency of the gear and, on some occasions, rapid gear fouling caused damage to the trawls compromising the quality of the data. Sampling time was reduced from 15 to 12 minutes and from 15 to 6 minutes for the beam trawl and plankton trawl, respectively. The reduction in the sampling time did not significantly affect the

[1] Depth was not tide corrected and represents actual water depth (transducer position offset corrected) at the time of sampling. Station depth was measured using the vessel's echo sounder. The deployment depth of the pelagic gear was measured with a portable data logger fitted with a calibrated pressure transducer.

number of fish collected with any of the two gears and sub-sampling was still needed for the most common species. No such reduction in sampling time was necessary during the July and October cruises.

2.7.1 DEMERSAL FISH SURVEY

Gear description

A 2m wide Beam trawl was used with 13mm stretched square mesh panels and 9mm cod end sleeve during the April cruise and a 19mm mesh during the July and October cruises, respectively. The trawl frame is comprised of two 60mm x 500mm x 500mm steel shoes, with a 2,120mm steel tube brace (Plate 1).

Operation

The beam trawl was always operated with a warp length of approximately three times the station depth as recorded at the start of the tow. The position of the trawl deployment, warp tension and wear marks on the trawl shoes confirmed the effective operation of the gear. The start point of each demersal tow corresponded with the moment in which the beam trawl reached the seabed. The end of the tow was recorded when the winch was engaged after the completion of the sampling run. The length of the segment between start and end points on the vessel DGPS track was taken as the true distance trawled for each demersal tow.

After the sampling period the gear was hauled to the surface at a constant speed. The cod end was untied and the beam trawl hoisted vertically to drive all contents into one or several fish boxes. Finally, the inside of the cod end was inspected for residual fish tangled in the mesh.

Plate 1. Beam trawl used in the demersal survey. The sampler is shown fully rigged ready to be deployed from the side beam of the survey vessel (left). Detail of the cod end during recovery of the sample after a demersal tow (top right) and typical unsorted catch (bottom right).

2.7.2 PELAGIC FISH SURVEY

Gear description

The pelagic survey was undertaken with a large Method Isaac Kitt (MIK) mid water trawl (Plate 2). The device is a 2m conical plankton sampler (1:5 aspect ratio) mounted on a steel ring fitted with a central flow meter (General Oceanics 2030 series). The net has 1.5 mm mesh at the main body and 0.5 mm mesh in the cod end. The last section of the cod end is a solid-fabric nylon tube, which was tied off forming a bag end for holding the sample.

Plate 2. MIK method sampler (right) and water quality (WQ) data logger (left) used in the pelagic survey. The sampler is fitted with a central flow meter (see insert picture for a close up view) and is shown on the vessel's deck. The WQ data logger is shown fitted to the MIK sampler bridle lines.

Operation

MIK tows were set to run at approximately 5m off the bottom by controlling the warp length and the angle of the towing line. Prior to any sampling a series of tests were conducted with the fully-rigged MIK trawl to determine sampling depth (see Appendix 2 for a full description of the calibration tests). The warp length to be paid out at each station was decided based on the echo sounder depth reading at the start of the tow.

Flow meter readings were recorded immediately before and after each tow. The readings were later used to calculate the corresponding volume of water using the appropriate scaling factors generated during the pre-survey calibration trials and manufacturer specifications.

After the completion of the sampling run the MIK sampler was recovered and hoisted vertically over the vessel's deck. The sides of the MIK trawl were rinsed (seawater) to wash all fish and debris to the cod end before emptying the contents into a plastic tray (Plate 3). On only a few occasions the cod end came undone, in all these cases the trawl was rerun. Once the sample was on deck, the survey leader decided whether the gear had fished effectively and all trawl parameters had been recorded before accepting the sample. The checks included visual inspection of the rigging lines, mesh panels, flow meter and positional data.

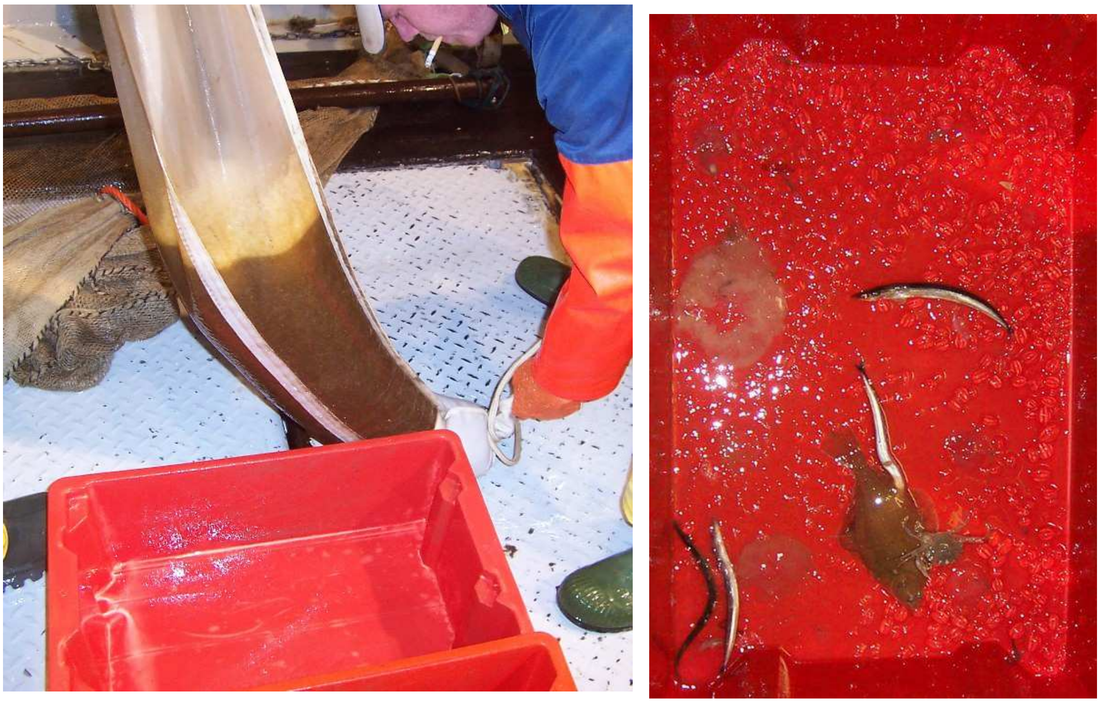

Plate 3. MIK sampler cod end during sample recovery (left) and plankton sample before sorting.

2.8 Catch processing

Fish were sorted and counted, and either stored on ice to be measured for length and wet weight (demersal survey) or frozen for later measurements (pelagic survey). Species identification was conducted following Whitehead *et al*. (1989) and Hayward and Ryland (1996) taxonomical keys. All fish were finally disposed after a final sample set was taken for stomach content analysis. This sample set was frozen and consisted of ten small juvenile fish per species and sample combination and is currently awaiting analysis.

2.8.1 DEMERSAL SURVEY

Species ID and counting

The whole catch was initially separated on board into individual species, placed in separate containers and counted (Plate 4). All on board identifications were carried out by the same senior member of staff (fish biologist) to ensure consistency throughout, with QA carried out by another technical survey member. After sorting and counting all fish, species with up to 30 individuals were placed in plastic bags on ice to be processed in full for length and weight. Species with more than 30 individuals within any particular station were sub-sampled. The subsample was created by sequentially splitting the catch in half until a final subsample of approximately 25 individuals was created. All fish contained within the final subsample were stored on ice along with the less abundant species. Expert judgment was used to decide whether the whole size range was captured within the subsample. Where the final subsample was not considered to be representative of the whole size range, a larger subsample was taken. Any fish species not identified on board were coded, frozen and later identified at the IECS laboratory. These and a representative collection of other species were preserved in 10% formaldehyde solution for reference and QC.

Plate 4. Demersal sample during species sorting and counting.

Length and weight

Fish initially stored in ice were processed for length and weight within three days of collection at a base port where the balances operated with the required precision (see below). Frozen samples were thawed overnight in ice and were then processed as described for the fresh samples.

Fish total length was measured from the tip of the snout to the end of the tail fin using a fish board and ruler. Length measurements were taken to the closest millimetre below. Biomass was taken immediately after the length measurement by the wet weight method after blotting excess water on paper towels. The balance calibration was revised daily by weighing a 1-g weight standard six times. The acceptable thresholds were ±0.01g (precision) and 1% (coefficient of variation). Larger individuals exceeding the capacity of the primary balance (310g) were measured in a larger scale with up to 3,000g capacity. The calibration of the second scale was similarly tested, but with a 10-g weight standard. The precision and coefficient of variation was always better than ±2g and 1%, respectively. Records were manually noted on a log form recording sheet.

Stomach analysis

The 10-fish samples for stomach analysis were taken randomly from the small-sized juveniles (if present). No large juveniles or subadult fish were preserved for stomach analysis. The only exception was made for adult forms of gobies that, when present in large numbers, were also preserved for stomach analysis. The juveniles making up the stomach analysis sample were placed in a separate bag, labelled with the standard codes and immediately frozen.

2.8.2 PELAGIC SURVEY

Species ID and counting

All coarse debris and large jellyfish were carefully removed and the total residual volume measured. The whole sample was processed for large fish (ca. >35mm). After these fish were removed the survey leader visually assessed the abundance of small juvenile fish and larval forms. Expert judgment was used to decide the level of subsampling based on the former visual assessment. The subsampling was done by volume and ranged from 100% (whole sample) to 10%. All fish (juvenile and larval forms) in the subsampled volume were placed in a double labelled (external label and internal tag) plastic bag and were stored in the bag containing the larger fish. The sample was finally preserved by freezing.

Length and weight

The frozen samples were slowly thawed at the IECS main laboratory facilities. Juvenile forms and larger fish were carefully sorted, identified, counted and immediately measured for total length and wet weight. Fish were measured and weighed using the same method as per the demersal survey. Species identification was conducted by marine technical staff with the appropriate fish training and the AQC was provided by senior taxonomists. A small representative fish collection was retained and preserved in 10% formaldehyde solution under the standard codes for QC.

Stomach analysis

After measuring all fish, or a subsample when necessary, a random subsample of at least ten individuals was frozen and stored at -40°C for stomach analysis.

2.9 Demobilisation day

All gear and equipment was made safe or disassembled for storage. Data derived from each independent haul, fish analysis and water quality data files were compiled initially in independent Excel spreadsheet files. Security copies of all electronic files were made regularly during the cruises and permanently backed up onto secure digital media to prevent data loss. All frozen samples were placed in a portable freezer packed with dry ice to maintain the temperature below -40ºC and were taken to IECS main facilities for processing or storage.

2.10 Data management and quality control

2.10.1 DATA COMPILATION

During each survey catch-related data and every processing step was manually recorded in pre-printed forms and later bounded into two data books. The first data book contains tow related parameters (gear, time, position, subsampling parameters, etc.) and, for the demersal survey, species identification and number of individuals counted. Consequently the data included here covers all on-board survey work. The second data book was produced on-shore during the post-survey fish measuring and contains species identification, total number of fish processed and length and weight of each fish. It is of note that for the demersal survey the on-board abundance records and the on-shore measuring are two independent assessments of the catch made at different times. In contrast the pelagic survey was processed once only and hence species ID, abundance and morphometric measurements were all recorded at the same time. All members conducting data manipulation have at least 3 years marine biological experience of sample analysis and interpretation.

2.10.2 METADATA QUALITY CONTROL

The completed survey forms, log books and data quality files were edited to ensure that they are complete and that no essential information is missing and that the records are accurate. The consistency of positional data for every single sample tow and flow meter reading was specifically checked using standard filters (Table 3). The filters were designed to ensure the data given lie within certain specified limits and aims to reveal illegal values and keypunch mistakes. Once a discrepancy or illegal entry was identified, it was flagged and cross-checked with the original recording. If no transcription error was found, it was then compared with a secondary recording source. Most of the ambiguous data entries were caused by single digit misreads that could easily be fixed. A few anomalous entries for which correction could not be found were replaced when possible by average values (i.e. a missing tow finish time was replaced by the start time plus the average tow time).

Table 3. Filters used to flag errors in the electronic log files

Data	Filters	Primary Recording log	Secondary Recording log
Sample Sequence, date and time of tow	$X_n \geq X_{n+1}$	Fish recording form	Skipper recording form & Water Quality data files
Tow start position	Distance station fix to start-tow ≥ 5Nautical miles	Skipper recording form	On board GPS log tracks
Tow end position	Distance station fix to end-tow ≥ 5Nautical miles	Skipper recording form	On board GPS log tracks
Duration of tow	t_{final}-t_{start}=Target duration ± 1 min	Skipper recording form	Fish recording form & Water Quality data files
Length of tow	Length > 2X X= average length	Skipper recording form	On board GPS log tracks
Flowmeter reading	$X_{start} \geq X_{start,n+1}$ and $X_{start} \geq X_{final}$	Skipper recording form	not available
Warp length (WL)	WL ≠ a (Depth Station) a=slope WL on Station depth regression	Skipper recording form	Water Quality data files

This first quality control step yielded a combined error rate less than 0.01% across all recorded values (approximately 12000 independent records). The proportion of missing entries was 3% of the total number of flagged items and most of them (67%) were missing tow start and finish times.

2.10.3 TRANSCRIPTION AND QUALITY ASSURANCE, OUTLIER ANALYSIS

Survey books were transcribed into two separate master files for each survey. One file contained all abundance and species data (ABUNDANCE MASTER) and the second master file contained all length and weight data (LENGTH & WEIGHT MASTER). The unique sample sequence was used to relate both master datasets during the quality control exercise.

The electronic databases were subjected to a preliminary data exploration exercise aiming to detect errors and ensure fidelity with the source log-book. In a first step, the station sequence was compared between the two master files to ensure consistency. Automated filters were set to detect misspelled species names and illegal entries from the data fields (i.e. no decimals or text was allowed in the length data). Once the overall consistency of the data was ensured a visual assessment of natural variability in the weight and length data was conducted. The presence of very extreme outlying values, suggesting some degree of data contamination, was immediately obvious.

Data contamination is likely to have originated either during the initial fish measuring and data recording, or later during the transcription of the recorded values to the electronic data files. Since the fish were disposed after measuring and hence not available to verify individual records, the focus was on eliminating keypunch errors and then finding extreme outlying observations likely to be data contamination. It was assumed that a wrong data entry (misidentification, length or weight misreporting) will lead to an extreme value in the regression of weight on length. Therefore, an outlier analysis was conducted on the length-weight regressions to identify all extreme observations with the dual purpose of data entry verification and assessment of data contamination.

Length and weight data were log transformed before calculating independent linear regressions for each species present in the dataset. Regressions were then used to estimate the difference between observed and predicted values (i.e. residuals) as an estimate of the likelihood of each particular length-weight observation. Simply stated, the larger the difference the more extreme the observation and hence the more probable that it is an error and hence data contamination. Formally a normalized version of the residuals (studentized residuals) was used to detect observations outside the 95% confidence interval (CI), that is, all extreme observations with an overall probability less than 5% (Table 4). All observations identified outside the 95% CI were verified for keypunch or interpretation mistakes (i.e. mis-interpretation of single digits or decimal point position) and corrected as necessary. If no likely explanation for an outlying observation could be found, the value was flagged as outlying but not removed. During the check, all observations within the survey-station-species group where each outlying observation was detected were also verified to provide an indication of random keypunch mistakes. Among the observations outside the 95% a 3.5% error rate was found and a much lower value, 0.3%, on those that were randomly checked suggesting that the bulk of the keypunch mistakes were effectively removed form the electronic dataset (Table 4).

Table 4. Transcription error level in the LENGTH & WEIGHT MASTER dataset.

	No. of entries	Error rate (%)
Total Entries Checked	9372	
Flagged Entry (95% CI)		
OK	1,372	
Keypunch error	48	3.5
Random Entry		
OK	8000	
Keypunch error	26	0.3
Total Dataset	28149	

To further ensure quality assurance we made a further attempt to distinguish extreme values from data contamination. The regressions were rerun on the keypunch-corrected dataset using species and survey as grouping variables. The studentized residuals were again used to detect outliers at four different stringency levels to identify observations lying outside the 80, 95, 99 and 99.99999% confidence intervals. In a perfect data set with random and normally distributed residuals it is expected that approximately 20, 5, 1 and 0.0001% respectively of the studentized residuals will be flagged as outliers. If the number of extreme observations exceeds these theoretical values data contamination is likely (Table 5). The outlier threshold is largely arbitrary, in our brief analysis twice as many flags were found than would have been expected from a clean dataset at the 99% CI. However, eliminating all these observations will take as many good observations as contamination which is not desirable. It was decided to only flag as outliers those 39 observations with p<1.0E-5 as being extremely unlikely and probably true contamination. In addition to these 39 extreme observations, all observations outside the 95% confidence interval were flagged as contamination if a note warning of an incomplete individual, damaged or otherwise different was attached to the original records. All calculations were conducted in Systat v10 (Systat Software, Inc. San Jose. CA)

Table 5. Outliers analysis (original dataset). Observations with a P<1.0E-5 (flag 4) have been flagged in the final dataset and not included for the computation of fish condition. * indicates excess error rate and probable data contamination. The total number of observations in the dataset is 28149.

	flag1	flag2	flag3	flag4
Confidence Interval (%)	80	95	99	99.99999
Critical Studentized residual	±1.33	±1.96	±2.58	±4.44
Flags total	4249	1420	531	39
Extreme Observations (%)				
Expected	20	5	1	1E-05
Found	15.1	5.0	1.9	0.1
RATIO	0.75	1.01	*1.89	*13854
EXCESS ERRORS	-1380.8	12.55	249.51	39

Further to the outlier analysis a cross check between the on-board abundance records and the total number of length and weight records for each combination of cruise, station and species was conducted. This cross check could only be made for the demersal survey for which two independent assessments were available. All discrepancies were traced to the original survey log books. Two of them were keypunch mistakes and an additional 4 were samples not processed due to damage. The last group of discrepancies (10 observations) cannot be traced further but probably are caused by a lack of recording during the on-board processing or the subsample being missing or not taken. In any case the available observation value was included in the final abundance dataset as a conservative estimate of the true abundance.

2.11 Data analysis

The abundance values in the raw dataset were first raised to the total catch using the appropriate subsampling coefficients and later tabulated alongside the unique sample codes and stations coordinates. Once this step was completed the dataset was used to calculate density estimates and overall taxonomic structure. Estimates of population parameters are always subject to various sources of sampling bias, especially gear selectivity. Usually there is no objective way to be reasonably confident of the proportion captured and the size range retained in the mesh. Consequently, size distributions and total catch have to be considered as estimates based on samples of the whole population.

2.11.1 DENSITY

Demersal survey. The area of habitat covered by the beam trawl was calculated by multiplying the distance trawled by the width of the gear (2m) and was used to raise the catch to comparable units across months and stations. All density estimates are reported as number of individuals caught for every 1,000 square metres.

Pelagic survey. The volume of water sampled in each MIK trawl was calculated form the differences between flow meter counts before and after the tow using flow meter calibration data and manufacturer scaling factors. All density estimates are reported as number of individuals caught every 1,000 cubic metres.

2.11.2 CONDITION

The main objective of the survey program was the assessment of the fish condition as a measure of well being and overall performance with respect to the sampling location. The analysis was conducted on all available length and weight data but excluding those flagged as data contamination (see section on outlier analysis).

Length-weight relationships were calculated for all fish species using a linear model after logarithmic transformation of the length and weight data.

Ln(Weight) = Lna + b * Ln(Length)

Where Lna is the intercept and b is the condition coefficient (i.e. slope). All regressions were conducted in Systat v10 (Systat Software, Inc. San Jose. CA).

For each species, all observations in the three cruises were used to estimate the intercept and the slope. For each observation in each station the expected weight of the individual fish were computed using the regression coefficients obtained.

$Weight_{exp}=exp(Lna+b*Ln(Length_{obs}))$

Condition of each individual fish was estimated as the ratio between observed weight and estimated weight. For each station in each cruise the condition was estimated as the average value of the individual conditions and was presented as percentage deviation from the estimated average condition for the species.

$C_{ind}=(Weight_{obs}/Weight_{exp})*100$

2.11.3 ASSEMBLAGE STRUCTURE

Multivariate techniques were used to visualise similarities between samples and to identify general factors affecting the taxonomical organisation of the fish assemblages. The multivariate dataset contains species density for each particular station with month (i.e. cruise), depth strata, station depth, longitude and sample sequence added as factors. Similarities between samples were scored in Ln(n+1) transformed abundance values using Bray-Curtis similarity index (Clarke, 1993). The resulting similarities between stations were graphically presented into a 2-dimensional space using non-metric Multidimensional Scaling. The data were further analysed using an ANOSIM two-way crossed permutation test (month x depth range) and Similarity Percentage Analysis (SIMPER). The ANOSIM test provides an indication for the degree of separation between station groups based on taxonomical similarities through R values (R=1, perfect separation; R=0, complete overlapping). SIMPER provides fish assemblage structure and complementary information on the degree to which each species contribute to the overall difference between groups (pair-wise tests). The same analysis was conducted for the demersal and pelagic surveys.

Finally, common diversity indexes were calculated together with K-dominance curves to further show structure relative to dominant species and abundance by cruise and depth strata as possible mechanisms driving observed differences between fish assemblages. All multivariate analyses were conducted in Primer v.6 (PRIMER-E Ltd. Plymouth, UK) (Clarke, 1993; Carr, 1996).

3. RESULTS

3.1 Species recorded

Overall the BJFS recorded 51 species from 32 families (Table 6). The range of species found during the survey program was typical of previous monitoring and research programs conducted in the area (Daan *et al*. 1990; Greenstreet and Hall 1996; Rogers and Millner 1996; Beyst *et al*. 1999; Callaway 2002; Perry *et al*. 2005,). The species number was higher for the demersal survey with a total of 46 species. The pelagic survey produced a much lower figure of 30 different species. The difference in species composition across the two surveys clearly reflects the lifestyle of the fishes recorded. Total abundance in the demersal survey was dominated by sand goby (*Pomatoschistus minutus*), solenette (*Buglossidium luteum*) and dab (*Limanda limanda*) (Table 6), all of which are typical bottom-dwelling species from inshore sandy bottom. The pelagic survey was in turn dominated by transparent goby (*Aphia minuta*), juvenile lesser pipefish (*Syngnathus rostellatus*) and sprat (*Sprattus sprattus*) (Table 6), all water-column species found in coastal and estuarine areas across the North Sea (Whitehead *et al*. 1989).

Table 6. List of all fish species caught during the BJFS with their taxonomic classification and relative occurrence across all sites and dates in the demersal (D) and pelagic (P) survey. '-' absent, '+' = <0.1%, '1' 0.1-0.9%, '2' 1-9%, '3' 10-19+ and '4' = >20%

ORDER	FAMILY	LATIN NAME	ENGLISH NAME	DUTCH NAME	P	D
Petromyzontiformes	Petromyzontidae	*Lampetra fluviatilis*	Lamprey river	Rivierprik	+	+
Carcharhiniformes	Triakidae	*Mustelus asterias*	Starry smooth hound	Gevlekte gladde haai	-	+
Salmoniformes	Osmeridae	*Osmerus eperlanus*	Smelt	Spiering	+	+
Atheriniformes	Atherinidae	*Atherina presbyter*	Sand-smelt	Koornaarvis	1	+
Gasterosteiformes	Gasterosteidae	*Gasterosteus aculeatus*	Stickleback	Driedoornige stekelbaars	+	-
Clupeiformes	Clupeidae	*Clupea harengus*	Herring	Haring	2	+
Clupeiformes	Clupeidae	*Sardina pilchardus*	Pilchard	Pilchard	+	-
Clupeiformes	Clupeidae	*Sprattus sprattus*	Sprat	Sprot	3	2
Clupeiformes	Engraulidae	*Engraulis encrasicolus*	Anchovy	Ansjovis	+	+
Beloniformes	Belonidae	*Belone belone*	Garfish	Geep	1	+
Anguilliformes	Anguillidae	*Anguilla anguilla*	Eel	Paling	-	+
Gadiformes	Gadidae	*Ciliata mustela*	Five-bearded rockling	Vijfdradige meun	1	1
Gadiformes	Gadidae	*Gadus morhua*	Cod	Kabeljauw	-	1
Gadiformes	Gadidae	*Merlangius merlangus*	Whiting	Wijting	2	2
Gadiformes	Gadidae	*Pollachius pollachius*	Pollack	Witte koolvis	+	-
Gadiformes	Gadidae	*Trisopterus luscus*	Bib	Steenbolk	1	2
Pleuronectiformes	Bothidae	*Arnoglossus laterna*	Scaldfish	Schurftvis	-	2
Pleuronectiformes	Soleidae	*Buglossidium luteum*	Solenette	Dwergtong	+	3
Pleuronectiformes	Soleidae	*Solea solea*	Sole	Tong	-	2
Pleuronectiformes	Pleuronectidae	*Limanda limanda*	Dab	Schar	+	3
Pleuronectiformes	Pleuronectidae	*Microstomus kitt*	Lemon sole	Tongschar	-	+
Pleuronectiformes	Pleuronectidae	*Platichthys flesus*	Flounder	Bot	-	+
Pleuronectiformes	Pleuronectidae	*Pleuronectes platessa*	Plaice	Schol	+	2
Pleuronectiformes	Scophthalmidae	*Psetta maxima*	Turbot	Tarbot	-	+
Pleuronectiformes	Scophthalmidae	*Scophthalmus rhombus*	Brill	Griet	-	+
Scorpaeniformes	Agonidae	*Agonus cataphractus*	Pogge	Harnasmannetje	1	2
Scorpaeniformes	Cottidae	*Myoxocephalus scorpius*	Sea scorpion short-spined	Zeedonderpad	-	1
Scorpaeniformes	Cottidae	*Taurulus bubalis*	Sea scorpion long-spined	Groene zeedonderpad	-	+
Scorpaeniformes	Cyclopteridae	*Cyclopterus lumpus*	Lump sucker	Snotdolf	+	-

Scorpaeniformes	Liparidae	*Liparis liparis*	Seasnail common	Slakdolf	-	1
Scorpaeniformes	Liparidae	*Liparis montagui*	Seasnail montagui	Kleine slakdolf	+	1
Scorpaeniformes	Triglidae	*Trigla lucerna*	Gunard Tub	Engelse poon	+	1
Syngnathiformes	Syngnathidae	*Entelurus aequoreus*	Pipefish snake	Adderzeenaald	+	+
Syngnathiformes	Syngnathidae	*Hippocampus hippocampus*	Seahorse	Zeepaardje	-	+
Syngnathiformes	Syngnathidae	*Syngnathus acus*	Pipefish greater	Grote zeenaald	+	+
Syngnathiformes	Syngnathidae	*Syngnathus rostellatus*	Pipefish lesser	Kleine zeenaald	3	2
Perciformes	Ammodytidae	*Ammodytes tobianus*	Sandeel lesser	Zandspiering	1	2
Perciformes	Ammodytidae	*Hyperoplus lanceolatus*	Sandeel greater	Smelt	-	1
Perciformes	Blennidae	*Parablennius gattorugine*	Tompot blenny	Gehoornde slijmvis	-	+
Perciformes	Callionymiidae	*Callionymus lyra*	Dragonet Common	Pitvis	+	2
Perciformes	Carangidae	*Trachurus trachurus*	Atlantic horse mackerel	Horsmakreel	2	+
Perciformes	Gobiidae	*Aphia minuta*	Goby transparent	Glasgrondel	4	1
Perciformes	Gobiidae	*Pomatoschistus minutus*	Goby sand	Dikkopje	2	4
Perciformes	Gobiidae	*Pomatoschistus pictus*	Goby painted	Kleurige grondel	-	+
Perciformes	Moronidae	*Dicentrarchus labrax*	Seabass	Zeebaars	-	+
Perciformes	Mugilidae	*Liza aurata*	Golden grey mullet	Goudharder	+	-
Perciformes	Mullidae	*Mullus surmuletus*	Red-mullet striped	Mul	-	+
Perciformes	Pholidae	*Pholis gunnellus*	Gunnel	Botervis	-	+
Perciformes	Sparidae	*Spondyliosoma cantharus*	Sea-bream black	Zeekarper	-	+
Perciformes	Stichaeidae	*Lumpenus lampretaeformis*	Snake blenny	Ijslandse bandvis	+	+
Perciformes	Trachinidae	*Echiichthys vipera*	Weewer lesser	Kleine pieterman	-	1

In this report taxonomical hierarchy (order and family) of abundant species (those contributing 1% or more) has been used to highlight prominent features of the overall fish assemblage with respect to habitat, life history and feeding habits. The summary is intended to provide a brief introduction to the more relevant species and indications of ecological (and commercial if applicable) role in the area.

Clupeiformes, Clupeidae

Clupeidae are streamlined pelagic species with bright silvery coloration. They are short lived and rarely attain an age of more than five years. Fishes from this family are extremely important for many predators (fish and birds) and support important fisheries in the North Sea. Reproduction usually takes place in well-defined areas. The larvae are pelagic and develop into the juvenile forms that remain in the water column feeding on diatoms, copepods, marine larvae, and larger planktonic organisms such as krill. Young clupeidae, as the adults do, are found in very large schools that remain in the water column. They follow definite migrations to estuarine nursery areas and back to coastal areas for overwintering. Herring (*Clupea harengus*) and Sprat (*Sprattus sprattus*) were frequently found during the pelagic survey. They are very similar and closely related species often occurring in mixed schools.

Gadiformes, Gadidae

Members of the Gadidae are important fish in the North Sea with traditional fisheries. These fish have several dorsal (usually three) and anal fins (usually two), lanceolate caudal peduncle and barbels around the mouth and chin. They are characteristic of temperate coastal waters where most species are found. They are pelagic spawners and after a relatively short larval phase the juveniles shift habitat and become benthic. Juvenile forms concentrate in inshore waters where they use shallow habitats and estuaries as nurseries. They predate on benthic invertebrates mostly crustaceans and small fish species. Two species were abundant in the BJFS, whiting (*Merlangius merlangus*), and bib (*Trisopterus luscus*), both moderately sized and fairly abundant in previous surveys in the area.

Pleuronectiformes, Bothidae

Pleuronectiformes pelagic larvae undergo a dramatic metamorphosis to compressed flatfish that involves the relocation of the eyes to one side of the body. After the metamorphosis the juvenile fish definitively settle on the bottom. As would be expected flatfish are, after acquiring the asymmetric body shape, benthic fish that lie buried in the sediment while not searching for food. In fact they are superbly adapted to the life on the bottom and often change coloration to better blend with their surroundings. The beam trawl used in the demersal survey is particularly efficient for catching flatfishes. Bothidae are small left-eyed flatfishes- that are species with their eyes and coloration on the left side of the body. They are characteristic of sandy bottoms. The scaldfish (*Arnoglossus laterna*) was the only species of the Bothidae recorded in large numbers. It features a very flat and slender body and has no commercial importance. This species is fairly common across the inshore waters of the North Sea.

Pleuronectiformes, Soleidae

The soles are a right-eyed flatfish family that can be easily differentiated from the former by the more oval, tongue-like, body shape. The Soleidae also possess a well-developed skin folds around the mouth on the blind side that has a sensorial role. The fish uses this structure to find prey, mostly marine worms, buried in the sandy and muddy bottoms they inhabit. Two species were found in large numbers, the Solenette (*Buglossidium luteum*) and the common sole (*Solea solea*). Solenette, abundant but small, rarely grow larger than 10-12cm, and are not exploited commercially. Solenette can use the blind side to adhere firmly to hard surfaces. Similar in body shape to juvenile common sole they can be distinguished by the stripes along the dorsal and anal fins. The common sole grows to a much larger size and they represent an extremely important fishery asset along coastal and estuarine areas in the North Sea. Juveniles occupy shallow inshore waters and estuaries where they use brackish habitats as nursery grounds.

Pleuronectiformes, Pleuronectidae

Right-eyed flatfishes, many of them are important commercially. Pleuronectidae are large-bodied species, mostly oval but with more angular profile than soles. Their blind side is usually white and their ocular side has circular blotches. All species spawn small pelagic larvae. Settlement and nursery areas are usually inshore or in estuaries, some can be found in fresh water environments. Two examples of this family were commonly found throughout the entire survey area, dab (*Limanda limanda*) and plaice (*Pleuronectes platessa*). The dab is easily distinguished by the arching lateral line on the ocular side that circles the pectoral fin, the much larger eyes and uniform coloration. It is principally found on sandy bottoms and is one of the commonest flatfish across coastal areas of the North Sea. The juvenile is often very abundant in shallow coastal waters where it has extensive nursery grounds. It feeds on small crustacea and marine worms. However, the best know species and more important fishery fish of the Pleuronectidae family is the plaice. It has similar habitat preferences to dab but is also frequent in gravely or rocky areas. The juveniles enter the estuaries and generally inhabit very shallow (<1m) subtidal or intertidal areas and are frequently found in brackish environments. Plaice are ferocious predators and feed on a wide range of prey such as clams, worms, crustaceans, brittlestars and fish.

Scorpaeniformes, Agonidae

The scorpion fishes are grouped under the order Scorpaeniformes but their systematic classification is still under debate. The scorpion fish are small to middle-sized fish often armed with bony plates with large spines capable of inflicting painful wounds. Several Scorpaeniformes were recorded but only the Pogge (*Agonus cataphractus*) was found in large numbers. This is a small-bodied fish, harmless and with no commercial importance. It is completely covered by bony plates bearing numerous tubercles and spines, and has two prominent hook-like spines in the snout, a feature that is responsible for one of its common English names ‘hooknose’. Pogge spend most of their time buried in sandy sediments hunting small prey items. The chin is laid with multiple barbels probably used to detect buried prey.

Syngnathiformes, Syngnathidae

This is a marine group, inhabiting structured habitats such as seagrass beds and complex rocky and high relief bottoms. However, some can be found in estuaries and brackish areas. It comprises pipefishes and sea-horses, all species that have males with brood pouches. The only species found in large numbers, especially in the pelagic survey, was the lesser pipefish (*Syngnathus rostellatus*) also known as Nilsson's pipefish. This is a small pipefish that lives in sandy to coarse-gravely areas. The adult-like miniature juvenile is released by the male pipefish and drifts with the plankton for some time before settling onto the adult habitat. The majority of the lesser pipefish found were early juveniles still in their planktonic phase in July and October. It predates on small planktonic invertebrates that it sucks from the water using its long tube-like mouth. It has no commercial importance.

Perciformes, Ammodytidae

The sandeels are marine and estuarine migrants and support important fisheries. They are elongated, dart-shaped and form tight schools that swim close to the bottom. During the night or once disturbed they quickly bury themselves in the clean sand or shell gravel areas they inhabit. They overwinter buried in the sediment. Sand eels feed on small zooplankton, some large diatoms, fish eggs, worms, small crustaceans and small fish (or larvae). Sandeels are in turn consumed by seabirds and large predatory fish such as gadoids and flatfishes and are, as the clupeids, very important to inshore North Sea ecosystems. The lesser sand eel (*Ammodytes tobianus*) was especially abundant in the April survey.

Perciformes, Callionymiidae

The dragonet family is composed by several small-bodied marine species that live partially buried in the sandy sandy-gravely sediments they inhabit. Males are often more colourful than females, especially during the breeding season, but this characteristic is absent in the juvenile forms. Common Dragonet (*Callionymus lyra*) was very abundant across the entire

BJFS program and indeed one of the most common fish in the coastal areas of the North Sea. There are no commercial fisheries associated to this species.

Perciformes, Carangidae

Carangidae or 'jacks' are fast-swimming predatory fish often found in schooling aggregations. They have deep bodies and a narrow caudal peduncle and often forked tail. They are pelagic fish during their entire lifecycle and feed on small planktonic animals early in life to quickly switch to larger prey items including fish, squids and crustaceans. All are voracious predators, some can reach considerable size and are often target of recreational fisheries. During the BJFS one species was found belonging to this family, the horse mackerel (*Trachurus trachurus*) also known as 'scad'. All individuals found were captured in the pelagic survey and all were early juvenile forms. Horse mackerel is an important fishery resource in the North Sea.

Perciformes, Gobiidae

The Gobiidae is a large family that includes a large number of species. All are small-bodied inshore fish which are very abundant across all marine and estuarine habitats. Gobiidae are not fished commercially. They are mostly benthic, having specially adapted pelvic fins forming an adhesive disk that helps them to cling on to the substratum. Gobies were by far the most frequently recorded fish in the BJFS. Two species of the Gobiidae were caught in extremely large numbers with single haul numbers in excess of a thousand individuals. The transparent goby (*Aphia minuta*) is a translucent, slender bodied fish with a pelagic lifestyle. The second species is the sand goby (*Pomatoschistus minutus*), a bottom-dwelling small fish extremely abundant in coastal waters that often enters the estuaries and even fresh water areas. The life history of the transparent goby is quite unusual in the family. It has, like most gobies, benthic adhesive eggs but unlike most never undergoes the morphological changes and habitat shift needed to live at the bottom and remain pelagic. They feed on small crustaceans and are important components of coastal communities, both as predators and prey. The lack of coloration is an adaptation to make them less conspicuous to predators. They spawn in summer and lay their eggs in empty bivalve shells. Adults die after breeding. There are several species of the genus *Pomatoschistus* in the North Sea, all very similar in size and shape, but the sand goby is by far the most abundant. Sand gobies also lay benthic eggs in shells or nests built by the male fish that also guard the eggs during the incubation period. The larvae are planktonic and transform into juveniles after a short period but the young fish will not start to live at the bottom immediately and will remain in the water column feeding on planktonic crustaceans for a few more weeks. Benthic juveniles and adults are found almost everywhere from coastal areas to lower estuaries.

3.2 Catch structure

In general, the catch was dominated by small-bodied species in both surveys. The efficiency of the gear used is not precisely known but other studies have shown that fishing device efficiency varies with both species and body size (Kaiser *et al.* 1994; Fraser *et al.* 2008). It is expected that smaller individuals such as juvenile fish, which were the target of the survey, were better represented in the captures than larger and faster swimmers. Furthermore the research gear used for the surveys is common to international sampling and monitoring efforts in the North Sea such as the Demersal Fish Survey (DFS) and

International Bottom Trawl Survey (IBTS), programme where the Dutch government is an active member. Results of the BJFS will be a valuable addition to the current knowledge of fish assemblages in the area.

The surveys also confirmed differences in the assemblage composition of the samples across cruises. The dominant pool of species (those comprising 95% of total abundance) ranged from 17 in the July and October demersal surveys to only 5 in the October pelagic survey (Table 7). Diversity differences were clear in the pelagic survey where K-dominance curves change elevation suggesting a steady decrease in overall diversity during the BJFS program (Figure 1). This effect is probably due to the increased abundance of juvenile pipefish, transparent goby and clupeids fish towards the end of the survey program (Table 7 and 8). In contrast, the overall diversity of the demersal assemblage increased in July and October (Table 8) (Figure 1, lower elevation of the K-dominance curves). It is possible that this apparent decrease was caused by the smaller mesh used in the April cruise and the expected larger abundance of small fish early in the growing season. Although direct comparisons are not possible due to the gear differences, the apparent change is directly caused by the much higher contribution of sand goby in April (due to gear efficiency) and subsequent reduction in the diversity estimates (Table 7).

Table 7. Ranked list of species caught in the BJFS by survey and cruise. The species are arranged in descending order of importance with total abundance, coefficient of variation (CV) and percentage occurrence for those comprising 95% of the catch. All other species are listed in the last row of each table section.

English Name	Latin Name	Total Catch	% Catch	CV	% Station
Demersal Survey, April					
Goby sand	*Pomatoschistus minutus*	13207	45.6	1.3	95.8
Solenette	*Buglossidium luteum*	3322	11.5	1.3	59.4
Sandeel lesser	*Ammodytes tobianus*	3087	10.7	1.7	88.5
Dab	*Limanda limanda*	1918	6.6	1.6	93.8
Sprat	*Sprattus sprattus*	1808	6.2	4.1	45.8
Pipefish lesser	*Syngnathus rostellatus*	1494	5.2	1.8	75.0
Dragonet Common	*Callionymus lyra*	1406	4.9	1.5	68.8
Goby transparent	*Aphia minuta*	629	2.2	1.7	29.2
Plaice	*Pleuronectes platessa*	629	2.2	2.6	68.8
Scaldfish	*Arnoglossus laterna*	389	1.3	0.9	75.0
Bib	*Trisopterus luscus*	243	0.8	1.3	59.4
Pogge	*Agonus cataphractus*	199	0.7	1.4	63.5
Sole	*Solea solea*	165	0.6	1.4	45.8
Sandeel greater	*Hyperoplus lanceolatus*	103	0.4	1.7	26.0
Seasnail common	*Liparis liparis*	80	0.3	1.5	19.8
Liparis montagui, Merlangius merlangus, Myoxocephalus scorpius, Ciliata mustela, Platichthys flesus, Trigla lucerna, Echiichthys vipera, Pholis gunnellus, Taurulus bubalis, Gadus morhua, Entelurus aequoreus, Microstomus kitt, Pomatoschistus pictus, Clupea harengus, Engraulis encrasicolus, Lumpenus lampretaeformis, Dicentrarchus labrax Scophthalmus rhombus, Syngnathus acus					

Table 7 continued.

Demersal Survey, July					
Dab	*Limanda limanda*	5145	21.9	1.6	90.8
Solonette	*Buglossidium luteum*	4740	20.1	1.0	64.3
Plaice	*Pleuronectes platessa*	4077	17.3	2.2	92.9
Bib	*Trisopterus luscus*	1895	8.0	0.8	87.8
Dragonet Common	*Callionymus lyra*	1645	7.0	1.3	75.5
Whiting	*Merlangius merlangus*	1475	6.3	0.9	89.8
Goby sand	*Pomatoschistus minutus*	967	4.1	1.3	82.7
Sole	*Solea solea*	923	3.9	1.3	80.6
Pogge	*Agonus cataphractus*	767	3.3	1.7	65.3
Seasnail montagui	*Liparis montagui*	576	2.4	1.3	63.3
Scaldfish	*Arnoglossus laterna*	420	1.8	0.9	43.9
Cod	*Gadus morhua*	251	1.1	1.3	36.7
Sprat	*Sprattus sprattus*	166	0.7	1.5	39.8
Pipefish lesser	*Syngnathus rostellatus*	124	0.5	1.2	38.8
Weewer lesser	*Echiichthys vipera*	67	0.3	1.3	22.4
Sandeel greater	*Hyperoplus lanceolatus*	63	0.3	2.1	17.3
Sea scorpion short-spined	*Myoxocephalus scorpius*	61	0.3	1.4	25.5
Pomatoschistus pictus, Ammodytes tobianus, Platichthys flesus, Microstomus kitt, Mullus surmuletus, Psetta maxima, Ciliata mustela, Scophthalmus rhombus, Belone belone, Trigla lucerna, Mustelus asterias, Aphia minuta, Engraulis encrasicolus, Entelurus aequoreus, Lampetra fluviatilis, Pholis gunnellus, Syngnathus acus, Taurulus bubalis					
Demersal Survey, October					
Dab	*Limanda limanda*	4796	22.2	1.3	95.0
Goby sand	*Pomatoschistus minutus*	4783	22.2	1.7	96.0
Solonette	*Buglossidium luteum*	4695	21.8	1.1	59.0
Dragonet Common	*Callionymus lyra*	1963	9.1	1.4	72.0
Plaice	*Pleuronectes platessa*	1085	5.0	2.1	90.0
Pogge	*Agonus cataphractus*	1037	4.8	1.3	78.0
Scaldfish	*Arnoglossus laterna*	938	4.3	0.9	79.0
Whiting	*Merlangius merlangus*	591	2.7	1.1	67.0
Sole	*Solea solea*	505	2.3	1.7	72.0
Bib	*Trisopterus luscus*	375	1.7	1.2	40.0
Pipefish lesser	*Syngnathus rostellatus*	125	0.6	1.3	42.0
Five-bearded rockling	*Ciliata mustela*	124	0.6	1.6	28.0
Seasnail montagui	*Liparis montagui*	97	0.4	0.8	29.0
Gunard Tub	*Trigla lucerna*	81	0.4	0.8	43.0
Cod	*Gadus morhua*	79	0.4	1.3	25.0
Sandeel lesser	*Ammodytes tobianus*	71	0.3	1.5	24.0
Sprat	*Sprattus sprattus*	70	0.3	1.2	28.0
Myoxocephalus scorpius, Echiichthys vipera, Hyperoplus lanceolatus, Platichthys flesus, Taurulus bubalis, Aphia minuta, Clupea harengus, Entelurus aequoreus, Psetta maxima, Cantharus cantharus, Syngnathus acus, Hippocampus hippocampus, Osmerus eperlanus, Pomatoschistus pictus, Scophthalmus rhombus, Anguilla anguilla, Atherina presbyter, Belone belone, Lampetra fluviatilis, Microstomus kitt, Mullus surmuletus, Parablennius gattorugine, Pholis gunnellus, Trachururs trachurus					

Table 7 continued.

English Name	Latin Name	Total Catch	% Catch	CV	% Station
Pelagic Survey, April					
Whiting	*Merlangius merlangus*	191	21.6	1.4	47.9
Pipefish lesser	*Syngnathus rostellatus*	178	20.1	1.3	38.5
Sandeel lesser	*Ammodytes tobianus*	131	14.8	2.9	44.8
Sprat	*Sprattus sprattus*	129	14.6	1.5	26.0
Goby sand	*Pomatoschistus minutus*	96	10.9	1.7	31.3
Goby transparent	*Aphia minuta*	81	9.2	0.9	25.0
Herring	*Clupea harengus*	38	4.3	1.8	6.3
Pogge	*Agonus cataphractus*	18	2.0	0.4	13.5
Pollack	*Pollachius pollachius*	10	1.1	0.4	3.1
Bib	*Trisopterus luscus*	5	0.6	0.3	5.2
Buglossidium luteum, Lampetra fluviatilis, Belone belone, Entelurus aequoreus, Lumpenus lampretaeformis					
Pelagic Survey, July					
Sprat	*Sprattus sprattus*	1790	38.1	1.6	52.0
Pipefish lesser	*Syngnathus rostellatus*	1471	31.3	1.2	82.7
Herring	*Clupea harengus*	623	13.3	1.8	32.7
Atlantic horse mackerel	*Trachururs trachurus*	370	7.9	1.6	35.7
Goby sand	*Pomatoschistus minutus*	223	4.7	1.2	36.7
Goby transparent	*Aphia minuta*	74	1.6	1.9	13.3
Whiting	*Merlangius merlangus*	57	1.2	2.2	13.3
Five-bearded rockling	*Ciliata mustela*	16	0.3	0.6	10.2
Garfish	*Belone belone*	14	0.3	0.5	11.2
Sandeel lesser	*Ammodytes tobianus*	13	0.3	0.5	11.2
Bib	*Trisopterus luscus*	11	0.2	0.9	6.1
Gasterosteus aculeatus, Sardina pilchardus, Limanda limanda, Entelurus aequoreus, Engraulis encrasicolus, Cyclopteros lumpus, Buglossidium luteum, Callionymus lyra, Liparis montagui, Lumpenus lampretaeformis, Pleuronectes platessa, Syngnathus acus					
Pelagic Survey, October					
Goby transparent	*Aphia minuta*	5836	64.5	4.3	62.0
Pipefish lesser	*Syngnathus rostellatus*	1175	13.0	1.0	91.0
Goby sand	*Pomatoschistus minutus*	840	9.3	2.8	26.0
Sprat	*Sprattus sprattus*	699	7.7	2.3	28.0
Herring	*Clupea harengus*	437	4.8	1.3	29.0
Atherina presbyter, Ciliata mustela, Belone belone, Osmerus eperlanus, Limanda limanda, Merlangius merlangus, Engraulis encrasicolus, Trachururs trachurus, Ammodytes tobianus, Agonus cataphractus, Entelurus aequoreus, Liza aurata, Pleuronectes platessa, Trigla lucerna					

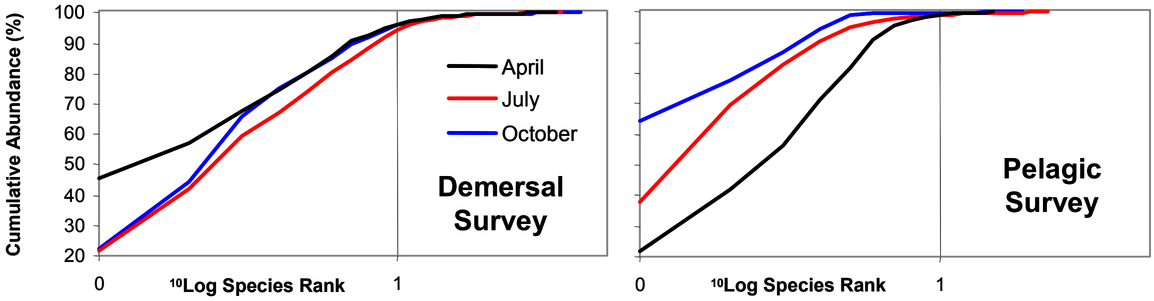

Figure 1. K-dominance curves by cruise for the demersal survey (left) and the pelagic survey (right). Note that all stations are combined.

Table 8. Common indices of diversity by cruise (top) and depth band (bottom) for the demersal and pelagic survey. The values represent mean sample values with coefficient of variation (CV) in parenthesis. The theoretical ranges for each diversity index are given in the table. (*range based on the total number of species recorded).

	Species number S	Mean Abundance N	Species richness (Margalef) d	Pielou's Evenness J'	Shannon-Wiener diversity H'	Interspecific encounter probability 1-D
Demersal survey by cruise			(0 to ~11.8)*	(0 to 1)	(0 to ~3.8)	(0 to 1)
April	10.6 (0.3)	169.2 (0.9)	2.23 (0.33)	0.61 (0.28)	1.38 (0.26)	0.66 (0.33)
July	11.2 (0.3)	99.7 (0.9)	2.39 (0.24)	0.71 (0.17)	1.68 (0.21)	0.74 (0.16)
October	10.7 (0.3)	90.9 (0.9)	2.39 (0.31)	0.64 (0.27)	1.52 (0.30)	0.68 (0.30)
Pelagic survey by cruise			(0 to ~8.5)*		(0 to ~3.4)	
April	2.8 (0.5)	6.7 (1.4)	1.75 (0.98)	0.85 (0.19)	0.76 (0.54)	0.88 (0.95)
July	3.4 (0.6)	15.4 (1.5)	2.02 (3.28)	0.60 (0.40)	0.62 (0.76)	0.79 (3.68)
October	2.8 (0.6)	25.2 (3.7)	1.30 (2.04)	0.66 (0.36)	0.57 (0.76)	0.54 (1.86)
Demersal survey by depth band			(0 to ~11.8)*		(0 to ~3.8)	
0-5	9.8 (0.3)	104.0 (1.2)	2.28 (0.41)	0.61 (0.34)	1.37 (0.37)	0.64 (0.39)
5-10	10.5 (0.2)	99.8 (1.3)	2.40 (0.29)	0.63 (0.30)	1.48 (0.33)	0.66 (0.32)
10-15	11.4 (0.3)	93.4 (0.9)	2.59 (0.26)	0.70 (0.19)	1.67 (0.21)	0.74 (0.24)
15-20	11.2 (0.2)	149.5 (0.7)	2.19 (0.23)	0.65 (0.18)	1.54 (0.19)	0.71 (0.18)
20-25	11.8 (0.1)	184.8 (0.7)	2.16 (0.17)	0.72 (0.10)	1.76 (0.11)	0.77 (0.07)
Pelagic survey by depth band			(0 to ~8.5)*		(0 to ~3.4)	
0-5	3.8 (0.5)	36.2 (3.1)	1.58 (1.92)	0.71 (0.32)	0.82 (0.52)	0.69 (1.67)
5-10	3.4 (0.5)	20.7 (1.4)	1.25 (0.75)	0.63 (0.42)	0.72 (0.64)	0.56 (0.84)
10-15	2.9 (0.5)	8.6 (1.3)	2.97 (3.01)	0.72 (0.33)	0.65 (0.59)	1.30 (3.03)
15-20	2.3 (0.6)	4.7 (1.0)	1.31 (1.22)	0.73 (0.33)	0.47 (0.96)	0.53 (1.23)
20-25	2.8 (0.4)	8.1 (1.7)	1.42 (0.59)	0.75 (0.27)	0.72 (0.53)	0.66 (0.54)

3.3 Assemblages

The three cruises making up the whole survey BJFS program were distinguishable as well-defined clusters of stations (Figure 2). Additional differences were found in the demersal assemblages by depth bands. No such depth structure was immediately apparent in the pelagic survey. The SIMPER analysis confirmed the overall separation and further suggests greater assemblage overlapping between the July and October surveys (Tables 9 and 10) (see methods for the interpretation of the R statistic values). Pairwise comparison of the different depth bands suggests a contrasting demersal assemblage between shallow and deep areas with a noticeable transition zone at the 10-15m depth band. The overlapping in the pelagic assemblage is much greater in the demersal survey but the R-values suggest a separation point at the same depth band. The controlling effect of depth on coastal fish communities is well known (Callaway 2002, Perry *et al.* 2005). Depth generally correlates with distance from the coast and type of substratum, both important factors often associated with fish distribution in coastal areas. The link between depth, distance from the coast or type of substratum is easy to visualise on fish communities that live in close association with the bottom such as those collected in the demersal surveys. However, it is interesting to note that a depth effect is probably present in the pelagic assemblage. The link between depth and pelagic assemblage of juvenile fish might be mediated by the physics of the survey areas, for example dominant currents, tide effects, source of juvenile fish, etc. All of these factors have not been measured during the fish surveys.

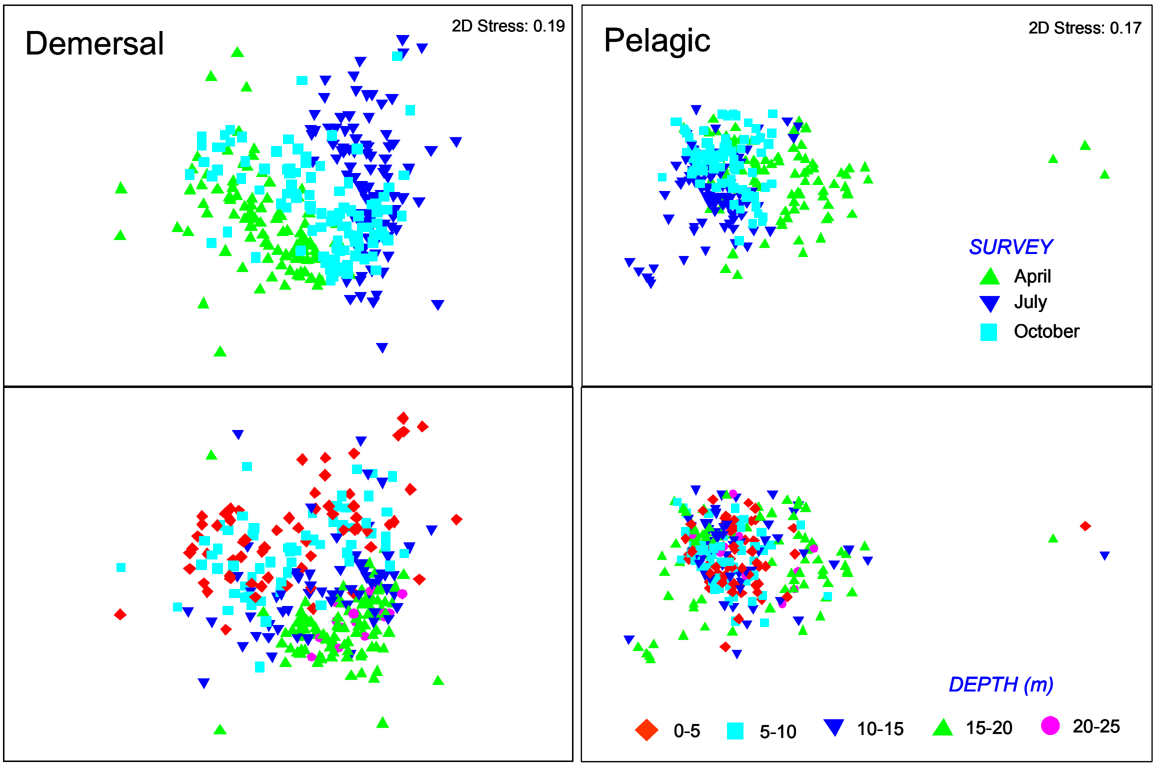

Figure 2. Nonmetric multidimensional scaling (nMDS) representation of sample similarities (Bray Curtis similarity) based on taxonomical composition and species abundance (Log(X+1) transformed). Sample labels are coded by cruise (top) and by depth band (bottom). Sample keys are given in the figures.

Table 9. Analysis of similarity (SIMPER) by survey cruise and depth for the demersal survey. The significance levels in the pair-wise tests are adjusted (Bonferroni) for multiple comparisons. * p<0.001.

By Cruise (Global R= 0.453) *		
	April	July
April	-	
July	0.659 *	-
October	0.407 *	0.307 *

By depth band (Global R= 0.391) *				
	0-5	5-10	10-15	15-20
0-5	-			
5-10	0.004	-		
10-15	0.244 *	0.225 *	-	
15-20	0.672 *	0.699 *	0.323 *	-
20-25	0.391 *	0.581 *	0.068	0.043

Table 10. Analysis of similarity (SIMPER) by survey cruise and depth for the pelagic survey. The table organization is as in Table 9.

By Cruise (Global R= 0.369) *		
	April	July
April	-	
July	0.427 *	-
October	0.48 *	0.219 *

By depth band (Global R= 0.16) *				
	0-5	5-10	10-15	15-20
0-5	-			
5-10	-0.008	-		
10-15	0.088*	0.052	-	
15-20	0.334*	0.287 *	0.127 *	-
20-25	0.214	0.233	-0.068	-0.033

Further to the overall multivariate treatment of the catch, a brief analysis of the fish assemblages can be found in Appendix 3. The analysis focuses on the diagnostic fish species responsible for the clustering and hence responsible for the structure of the fish assemblage.

3.4 Condition and species abundance

Abundance and condition data are presented for the most relevant species in terms of density estimates and percentage deviation form average condition (Figures 3.1 to 3.23).

There are changes in abundance across cruises and spatial structure associated with most fishes. This is likely to reflect life history traits and distribution of suitable habitat particular to each species. For example whiting is found in large numbers in the April cruise among the pelagic catch and much less in the demersal catch. The situation is reversed in the following cruise where increasing numbers of whiting occur in the demersal survey. This combined effect is likely to be a direct consequence of the life history sequence of young whiting as growing juveniles leave their planktonic life to become benthic predators and hence are then available for the bottom trawl. The area surveyed may function during late spring and summer months as settlement and nursery grounds not only for whiting, but also for bib, lesser pipefish, and especially flatfishes. It is also apparent that seasonal migrations appear as distinctive changes in abundance among cruises. This is remarkable for the lesser sandeel and sole among others.

In the demersal survey abundance tends to be higher at the deeper stations, contrasting with the pelagic survey where higher abundance was recorded at the shallower areas. This marked trend in the pelagic fish results from the abundance pattern of the more abundant species such as transparent goby and lesser pipefish suggesting active retention of these species in shallower areas.

Differences in condition are likely to reflect seasonal trends and local habitat quality, most importantly food availability. Above average condition tends to coincide with areas of higher abundance. However, condition in most species and areas did not strongly depart from the average suggesting an overall uniform food availability and homogeneous nature of the survey domain.

Figures 3.1 to 3.23. Relative density distribution of main species with percentage deviation from average condition by survey type and cruise. Each figure is divided into three GIS maps each corresponding to one of the three cruises. Density and condition keys and gear type is given in the figure (note that the scales are uniform across species). Bottom trawl, demersal survey; MIK trawl, pelagic survey. The calculations assume 100% gear efficiency for all species and size classes. The closed polygons represent sand extraction zones and the two contour lines indicate the 20m depth contour (solid line) and the line 2km seaward of that contour (dotted line) that defines Maasvlakte 2 consent limit for sand extraction. GIS figures produced by Project Organization Maasvlakte 2, RSC-GIS. Source of fish drawings is Whitehead *et al.* 1989, and FishBase 2000 (ICLARM, The WorldFish Center/FishBase, Makati City, Philippines)

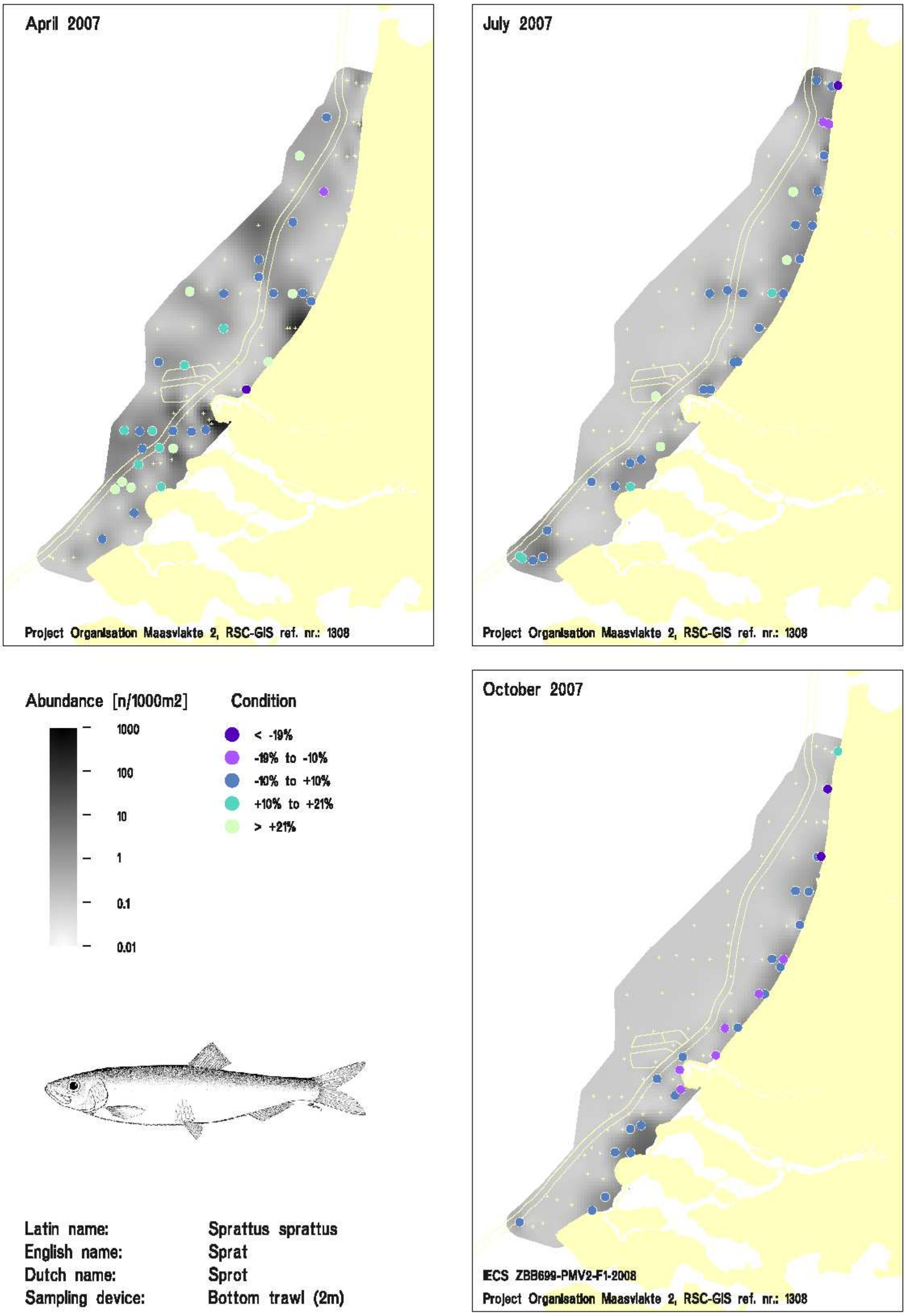

Figure 3.1. *Sprattus sprattus* (Sprat)

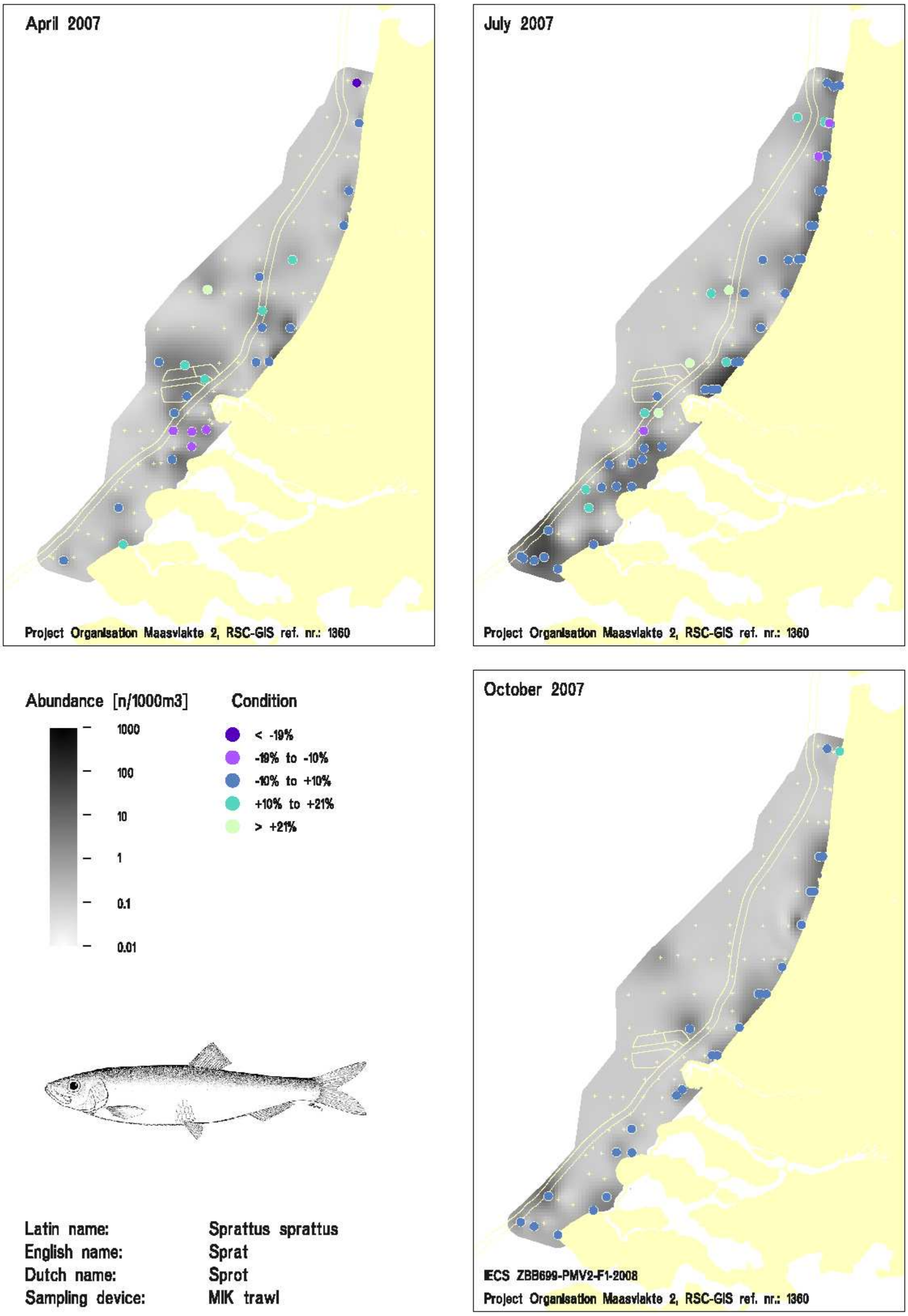

Figure 3.2. *Sprattus sprattus* (Sprat)

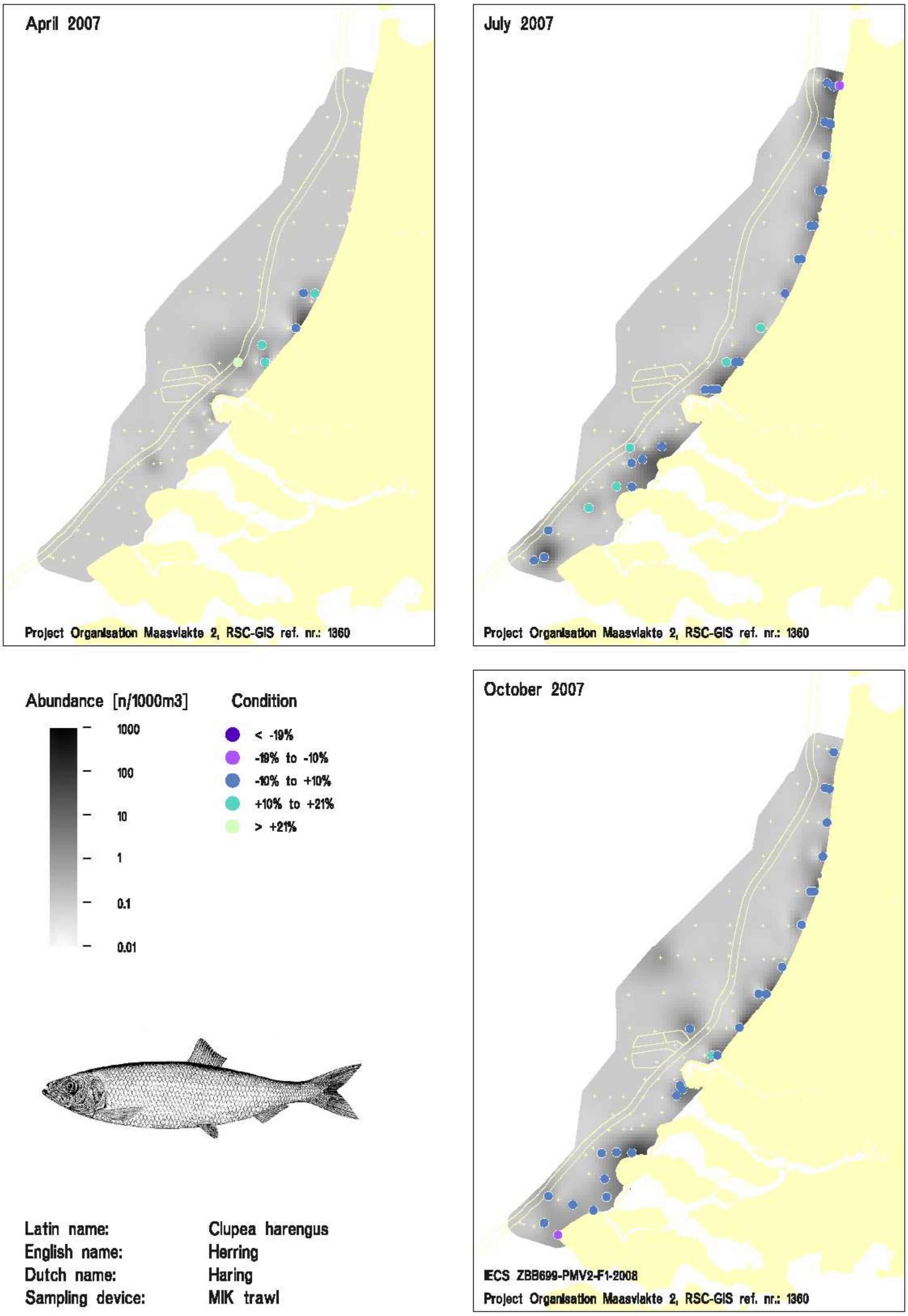

Figure 3.3. ***Clupea harengus*** **(Herring)**

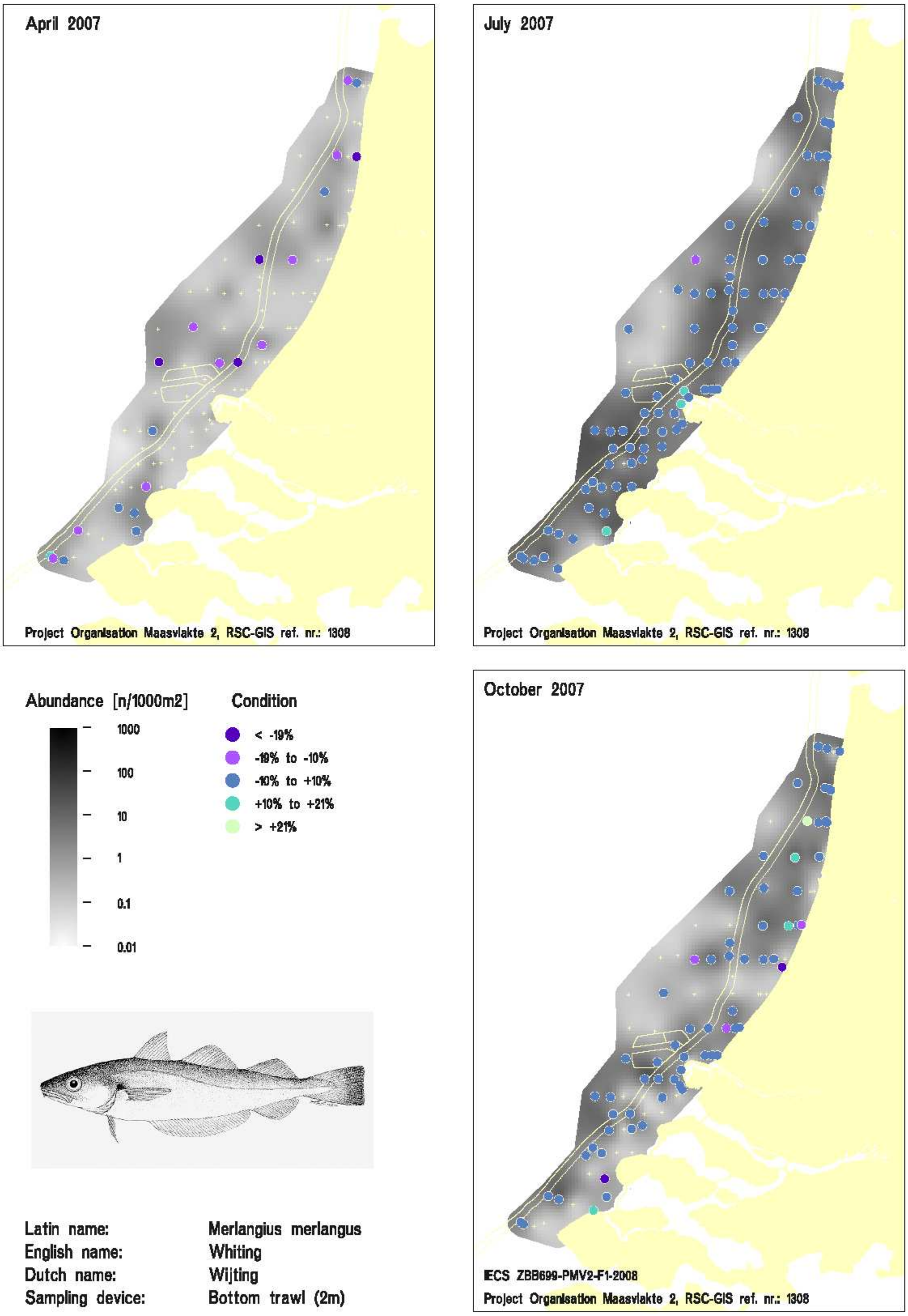

Figure 3.4. ***Merlangius merlangus*** **(Whiting)**

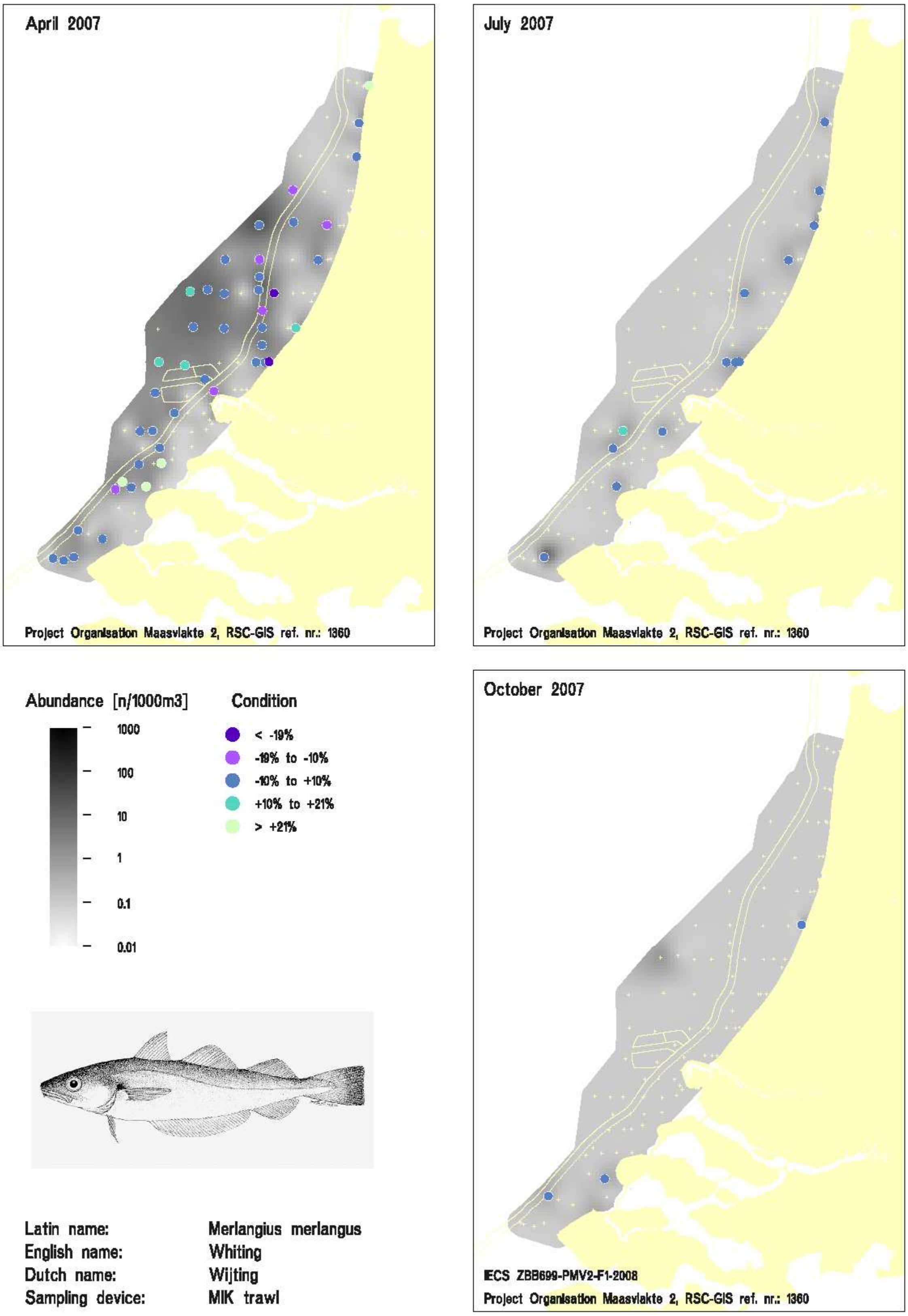

Figure 3.5. *Merlangius merlangus* (Whiting)

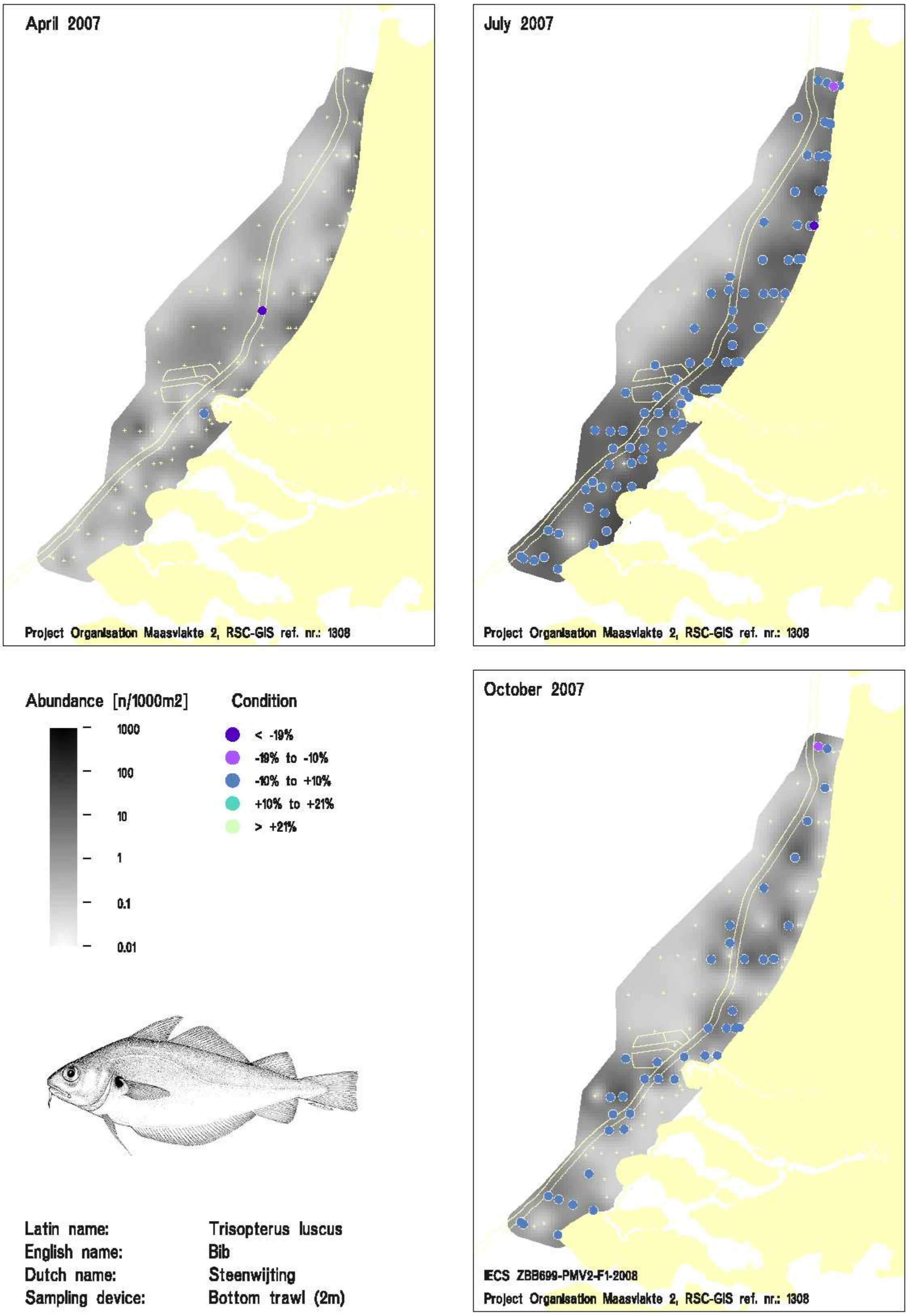

Figure 3.6. *Trisopterus luscus* (Bib)

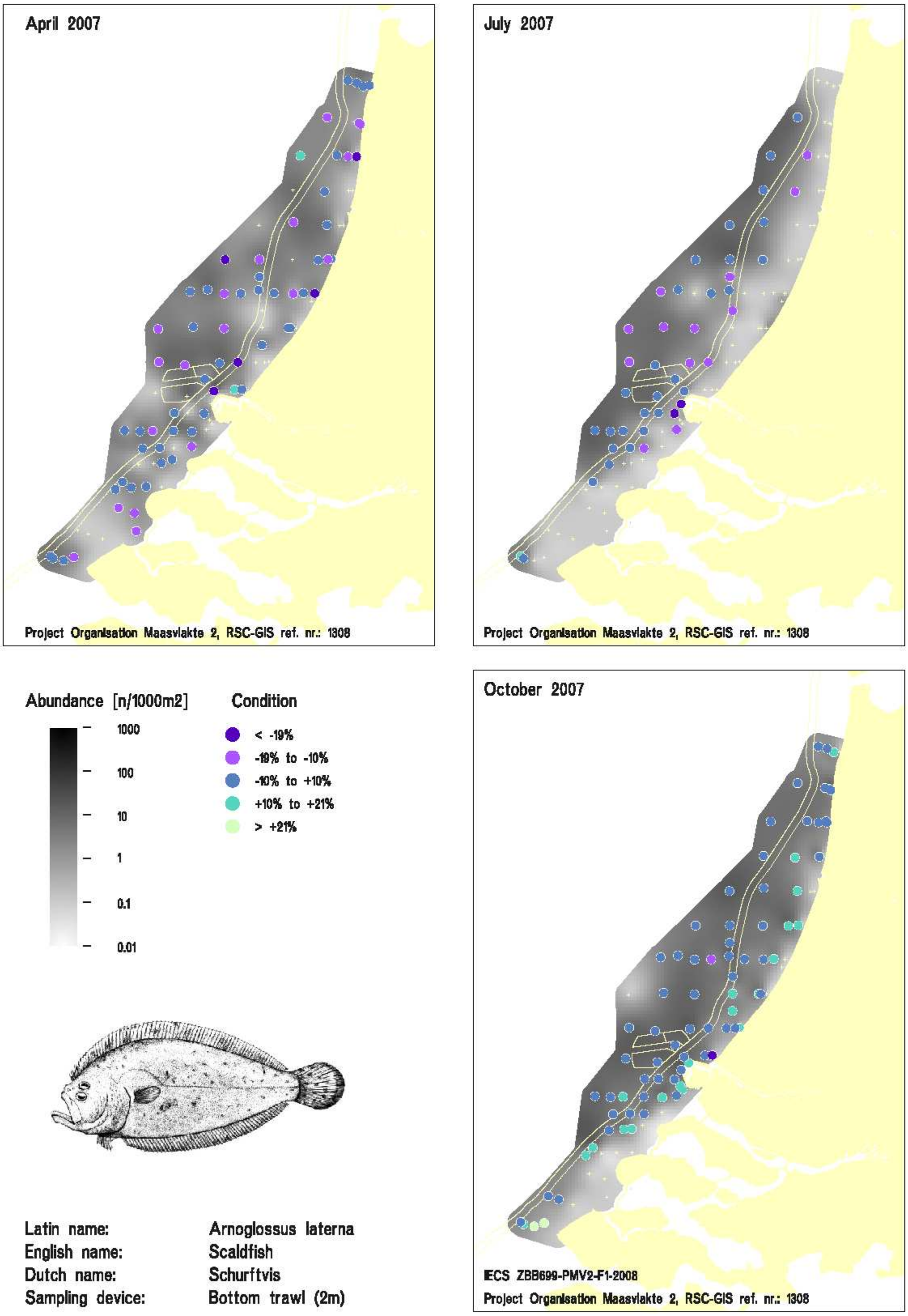

Figure 3.7. ***Arnoglossus laterna*** **(Scaldfish)**

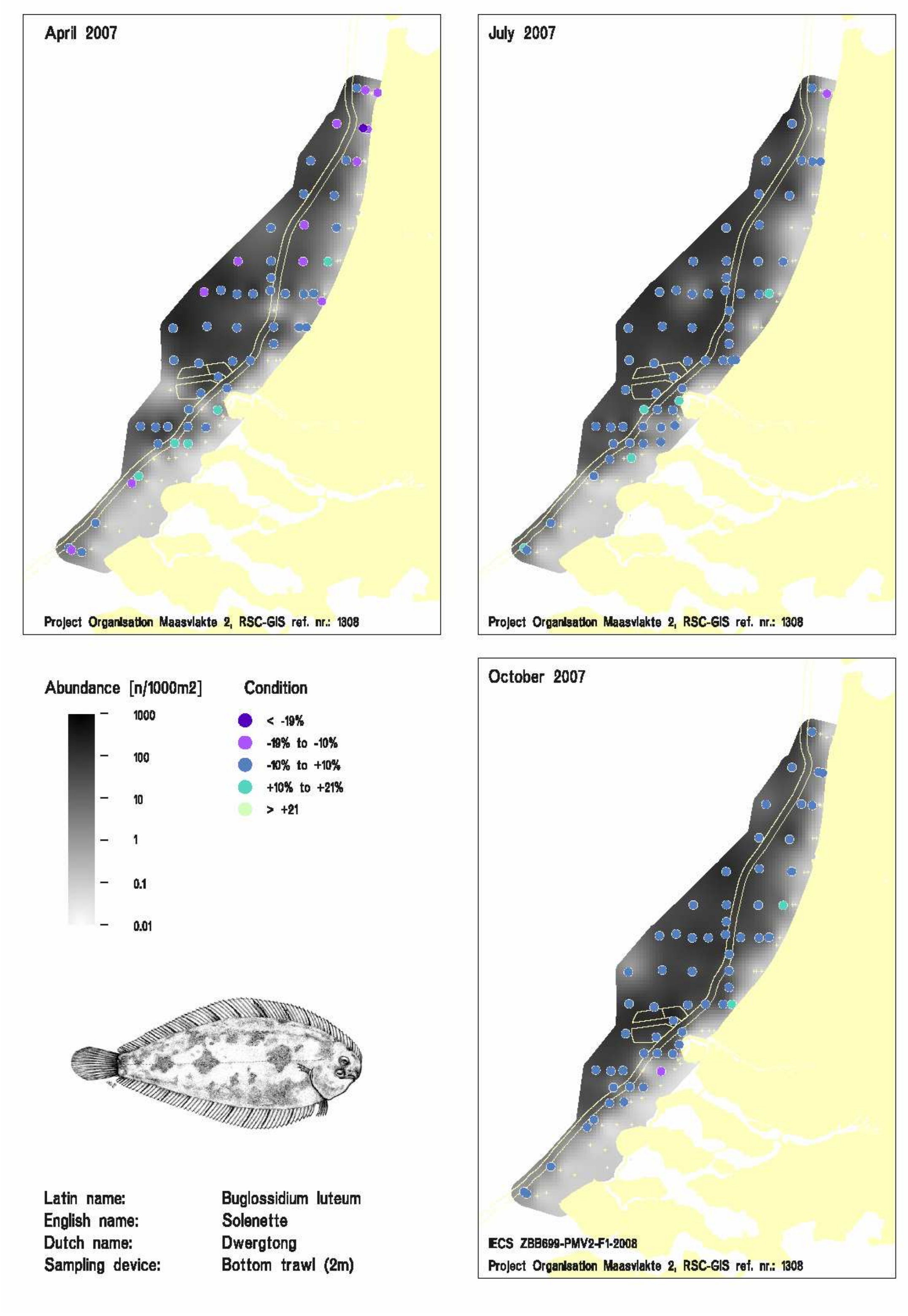

Figure 3.8. *Buglossidium luteum* (Solenette)

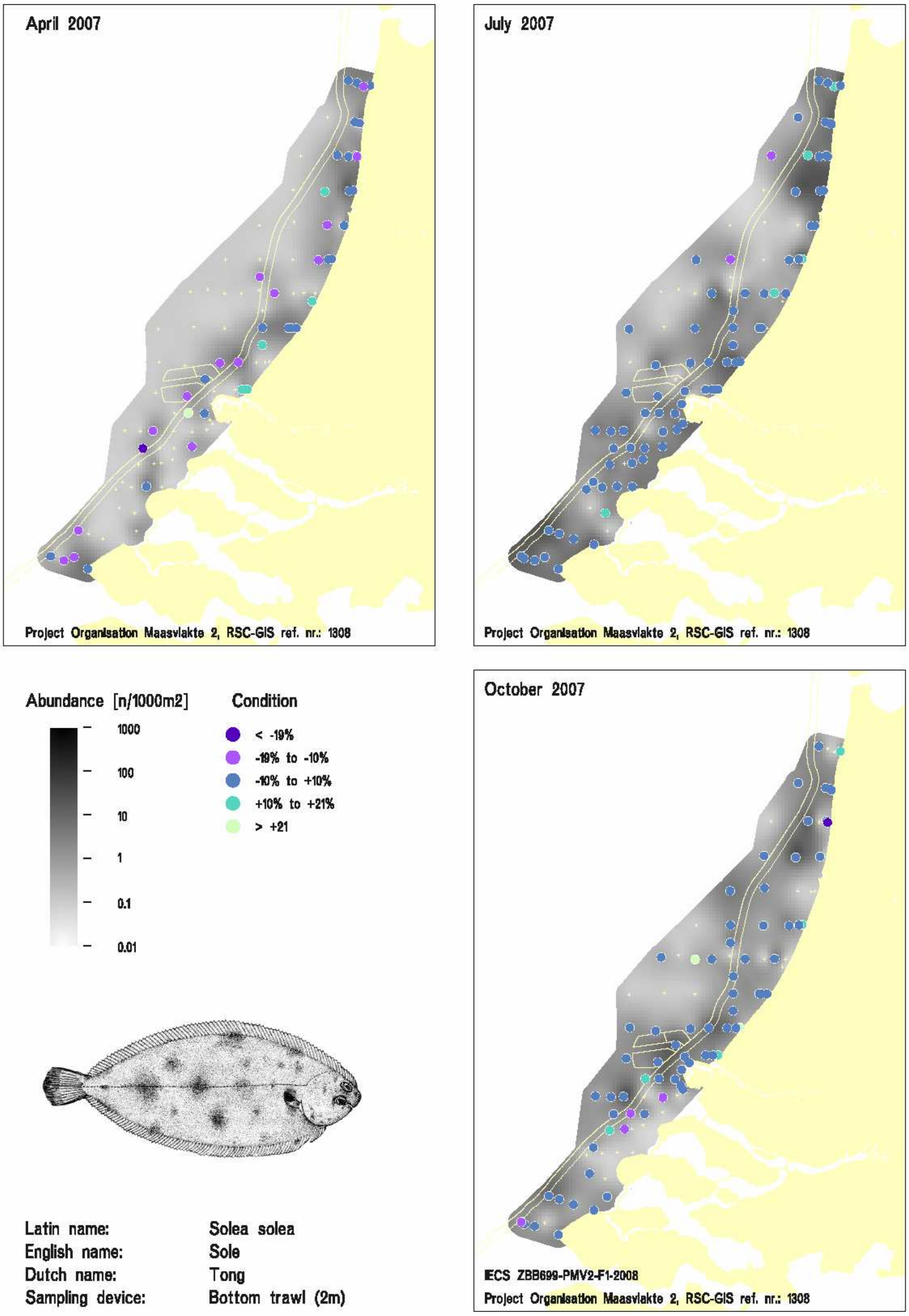

Figure 3.9. ***Solea solea*** **(Sole)**

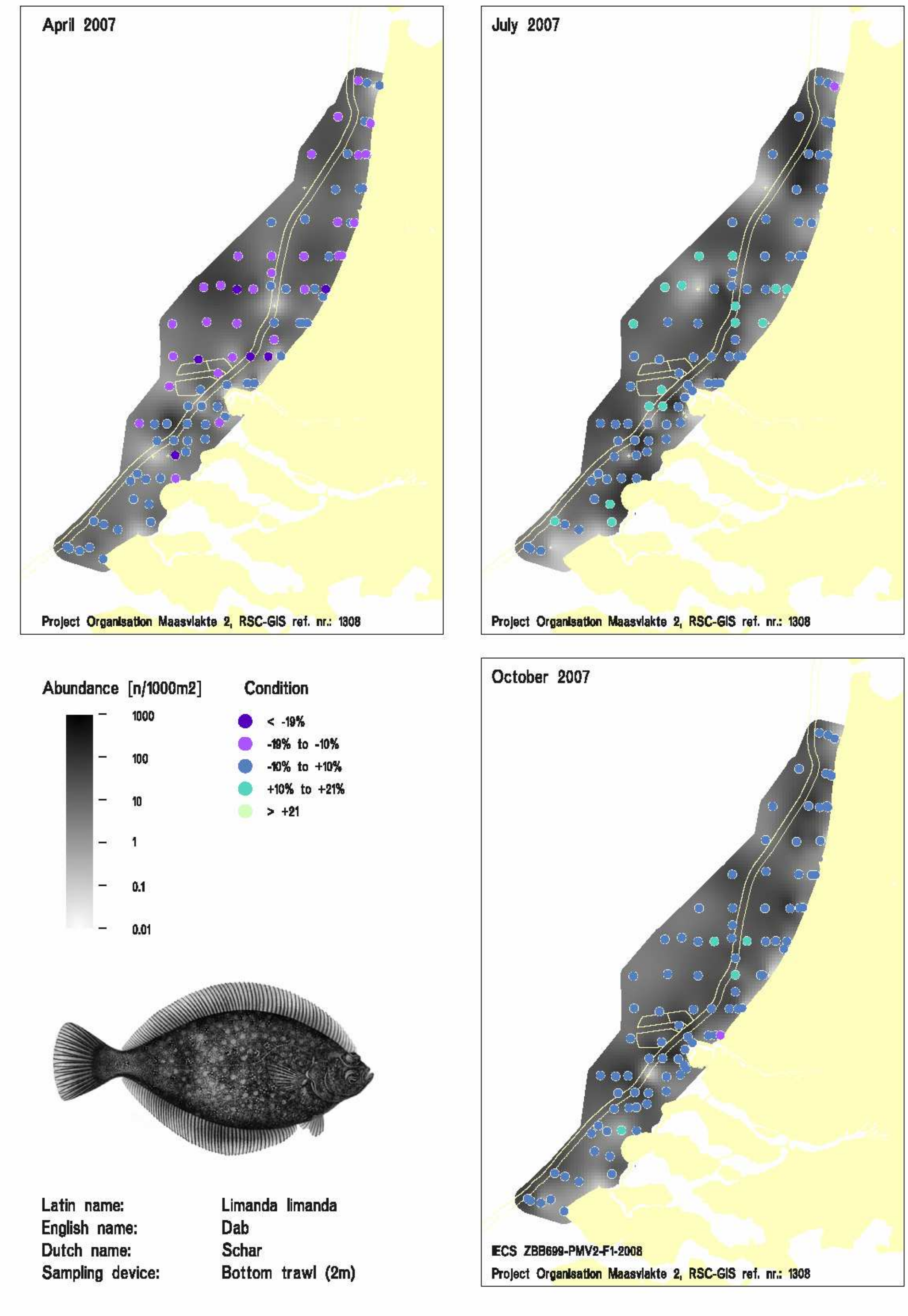

Figure 3.10. ***Limanda limanda*** **(Dab)**

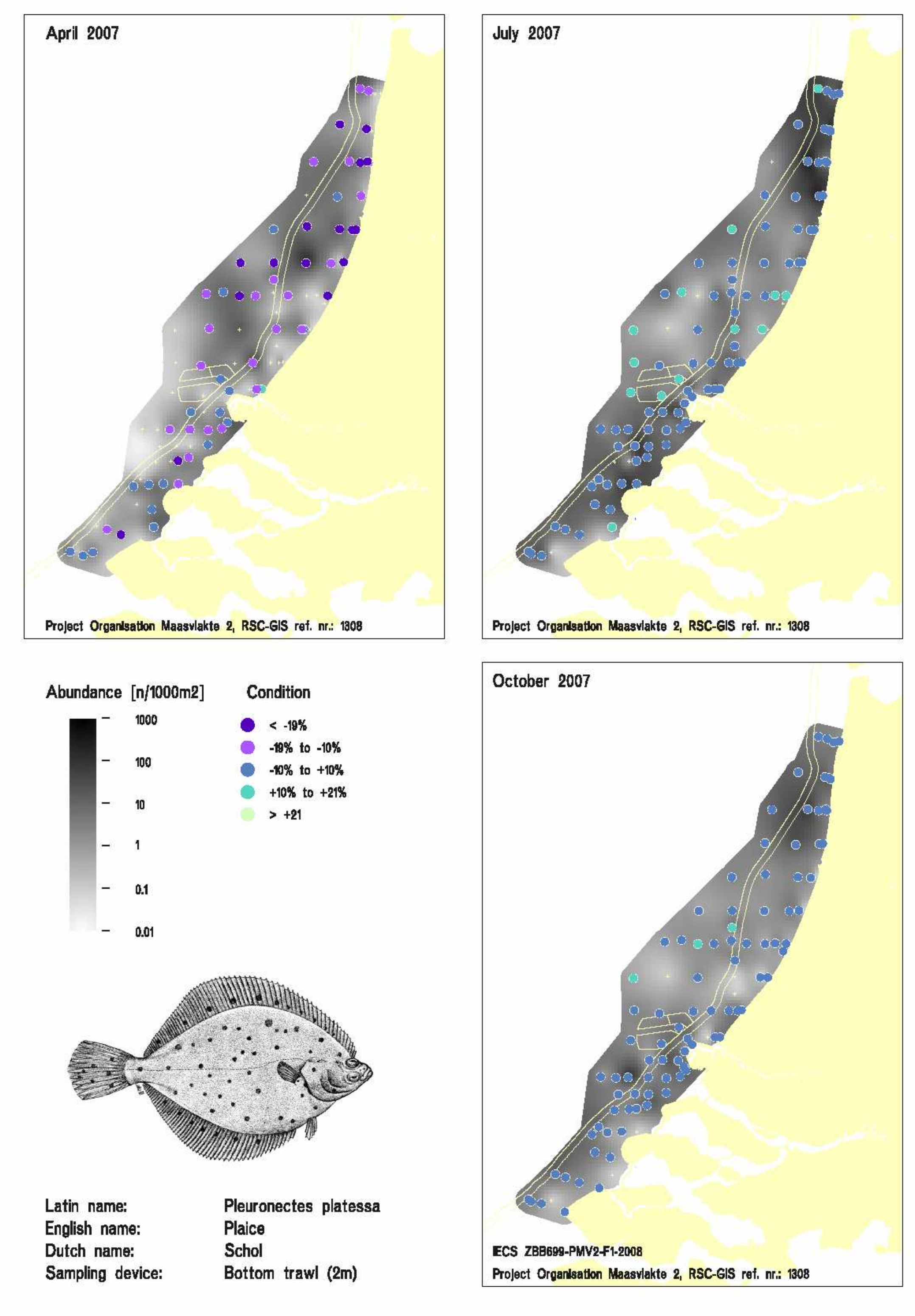

Figure 3.11. ***Pleuronectes platessa*** **(Plaice)**

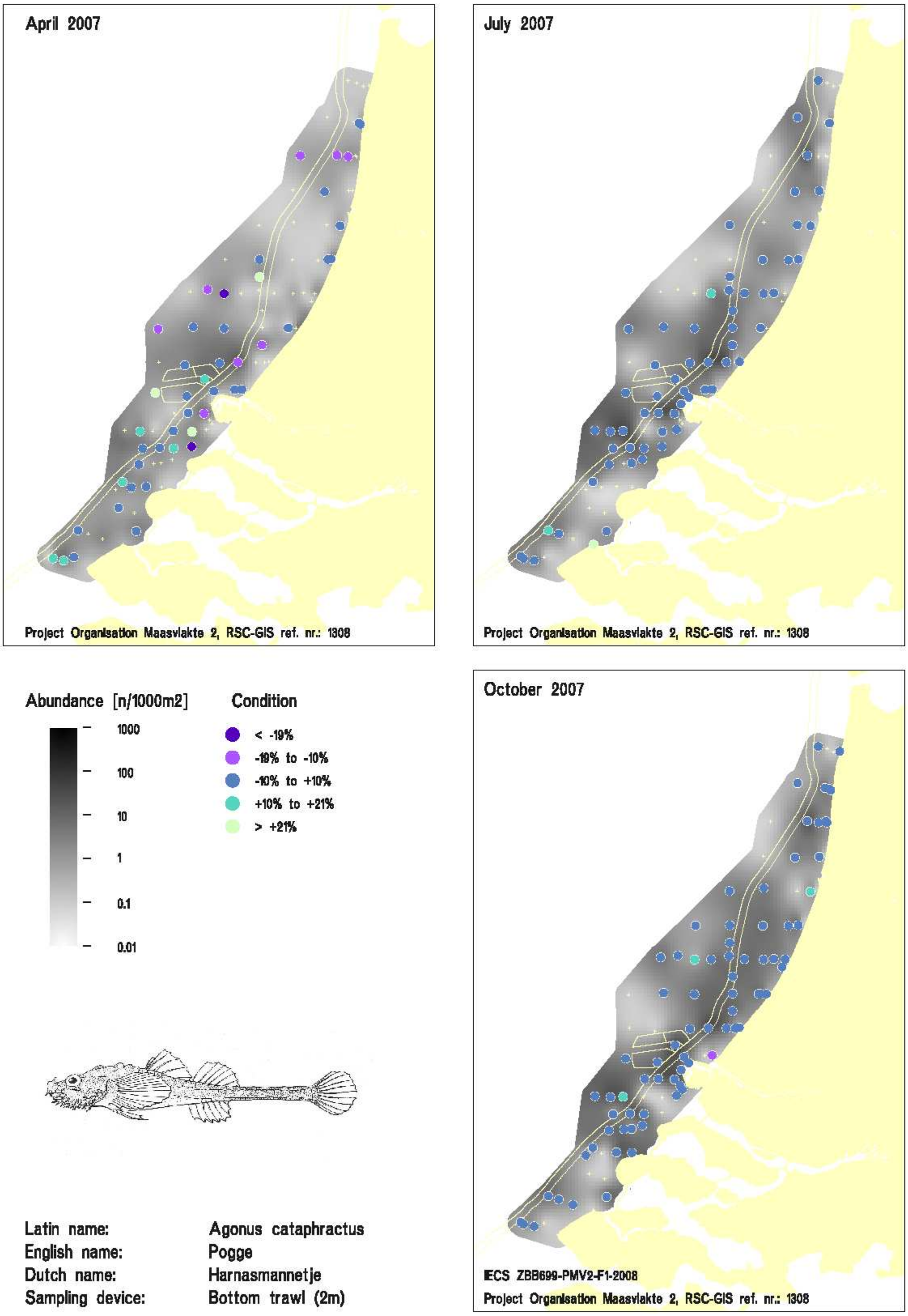

Figure 3.12. ***Agonus cataphractus*** **(Pogge)**

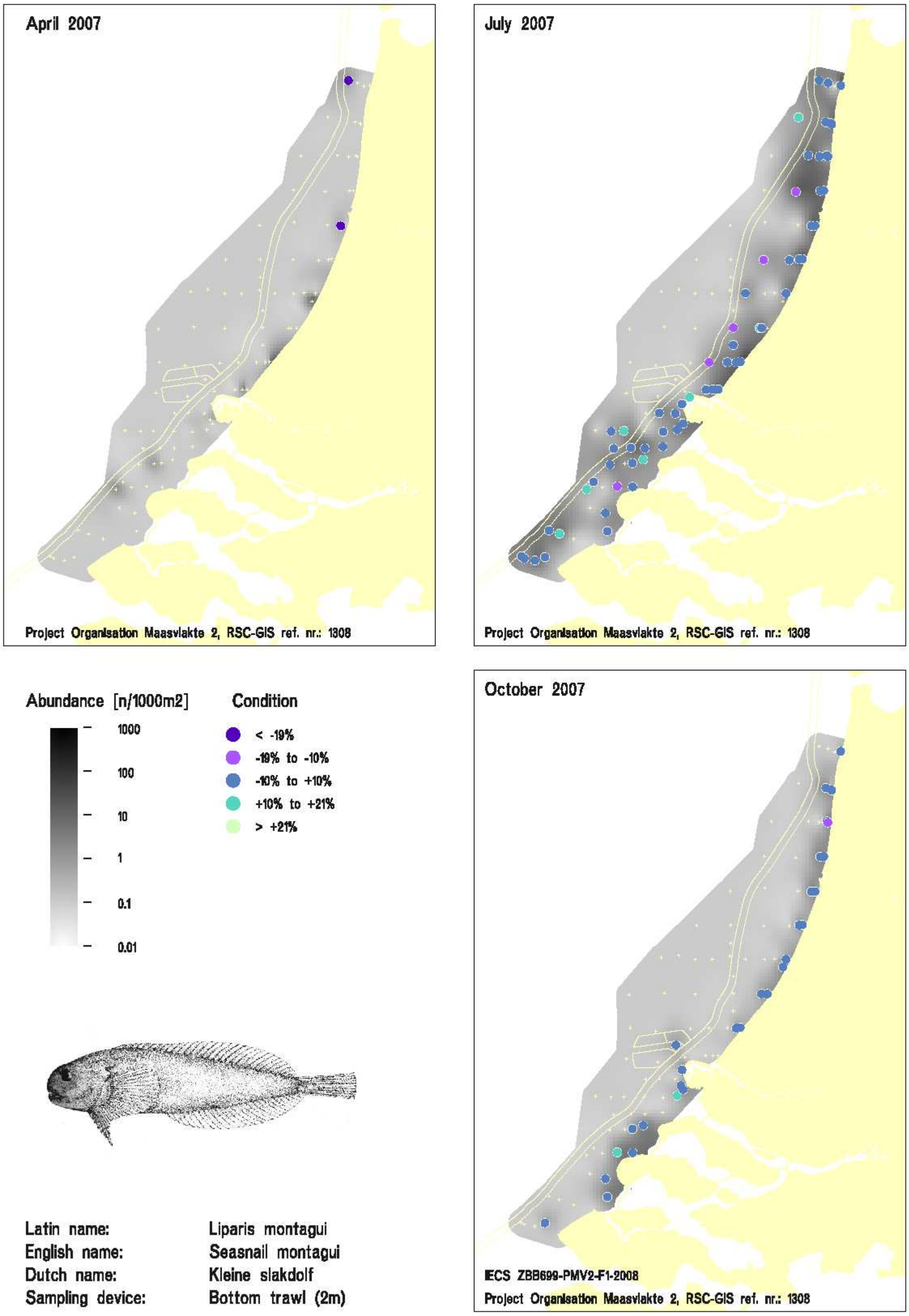

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Figure 3.13. *Liparis montagui* (Seasnail montagui)

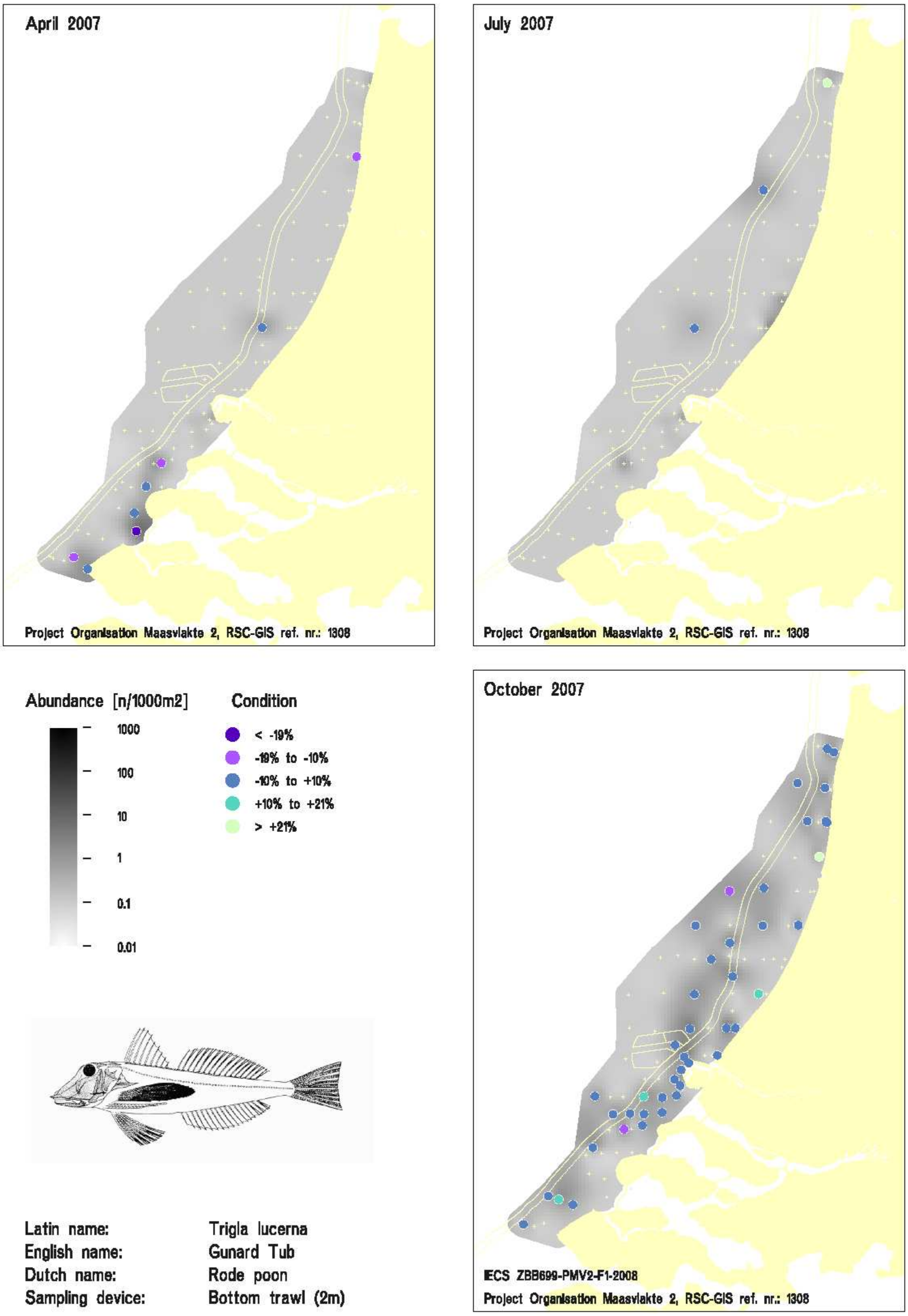

Figure 3.14. ***Trigla lucerna*** **(Gunard Tub)**

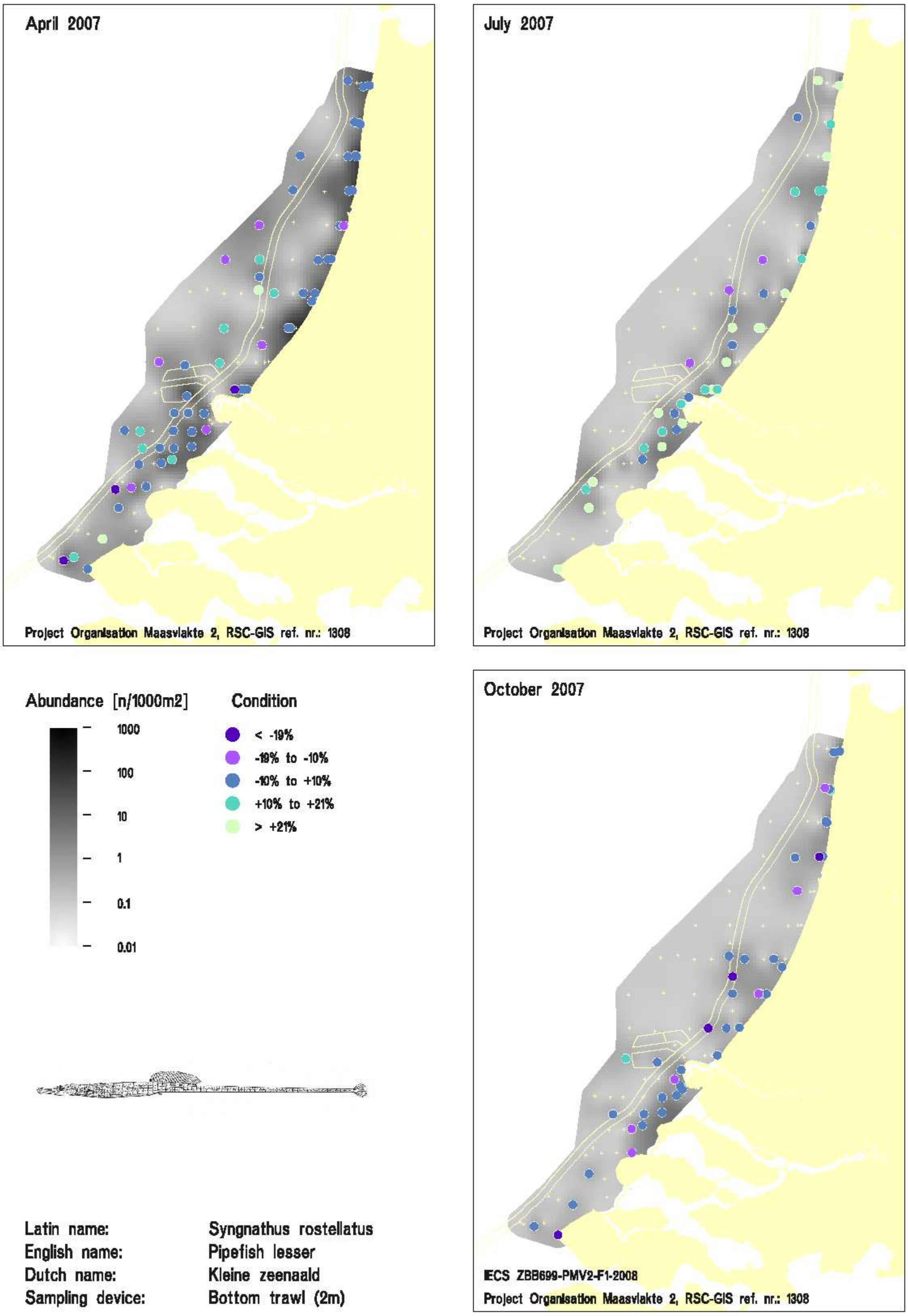

Figure 3.15. *Syngnathus rostellatus* (Pipefish lesser)

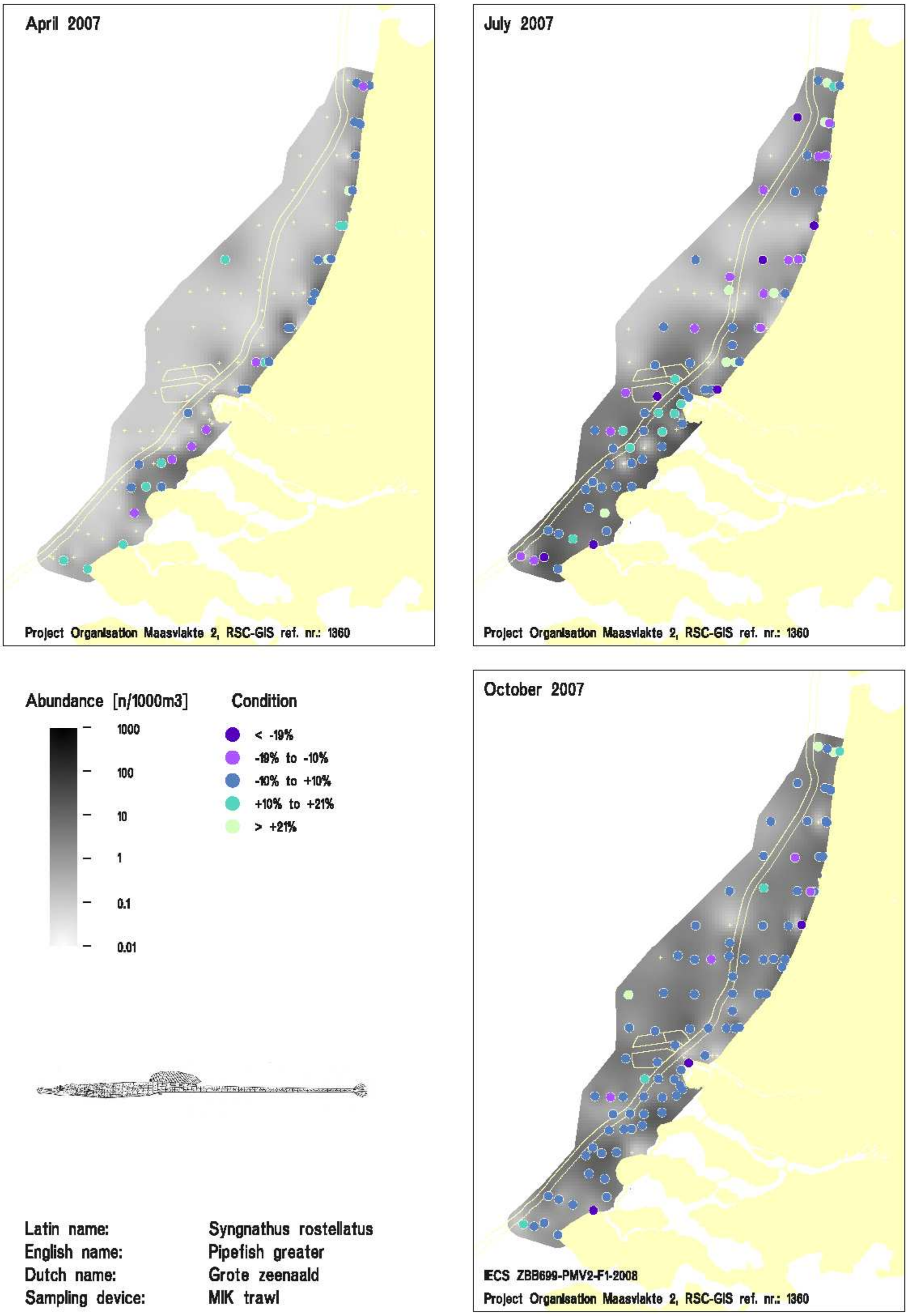

Figure 3.16. ***Syngnathus rostellatus*** **(Pipefish lesser)**

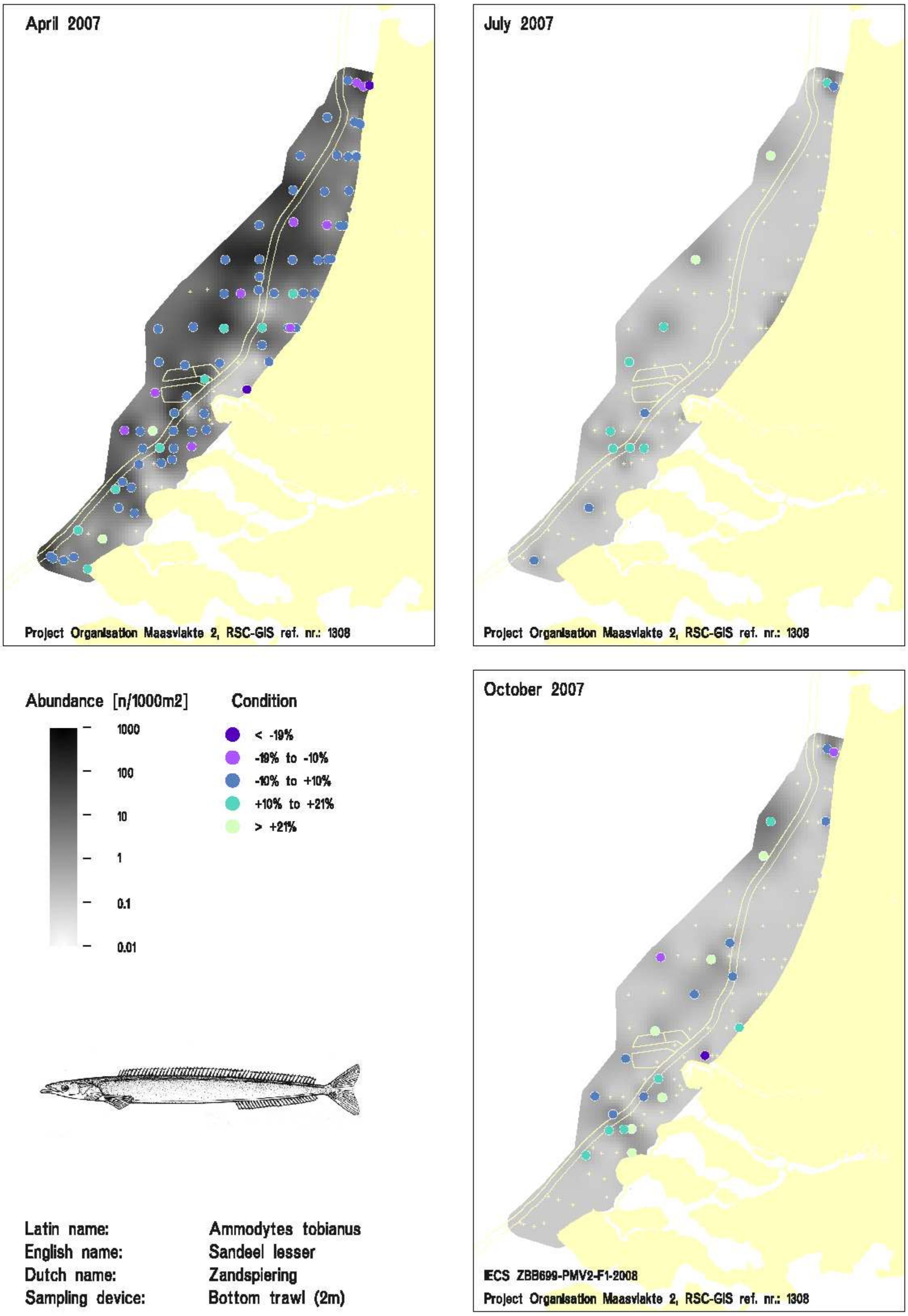

Figure 3.17. ***Ammodytes tobianus*** **(Sandeel lesser)**

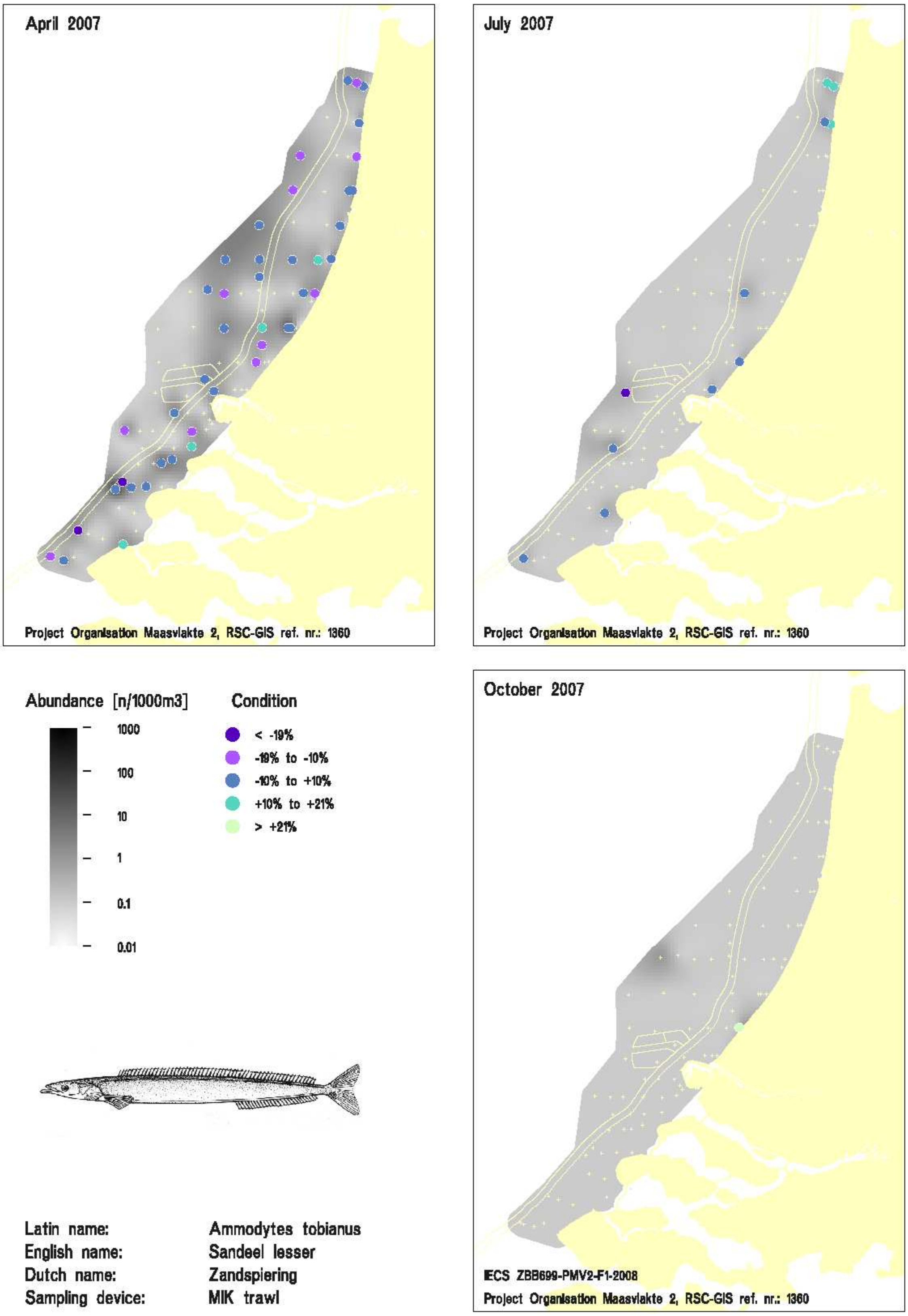

Figure 3.18. ***Ammodytes tobianus*** **(Sandeel lesser)**

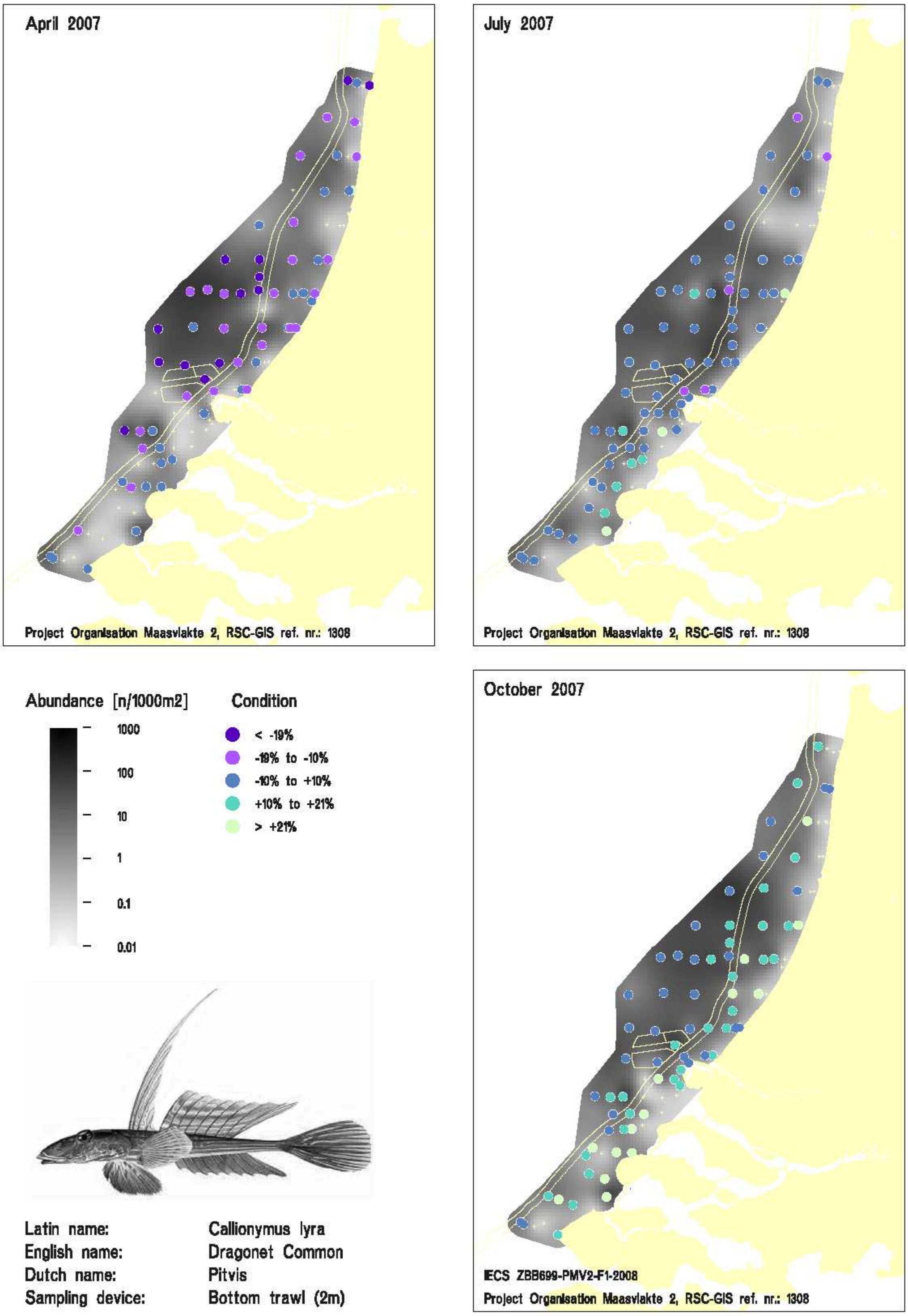

Figure 3.19. ***Callionymus lyra*** **(Dragonet Common)**

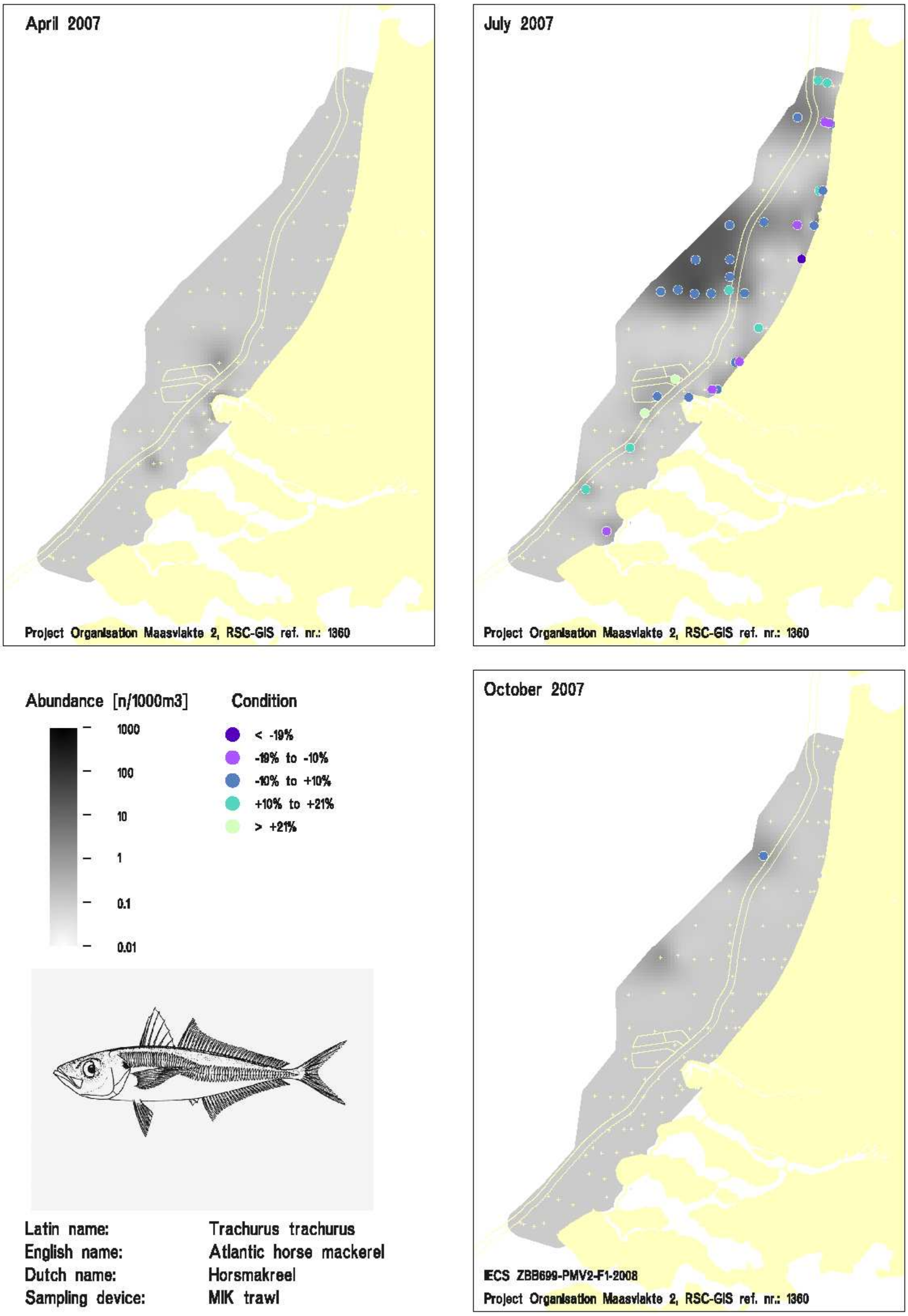

Figure 3.20. *Trachurus trachurus* (Atlantic horse mackerel)

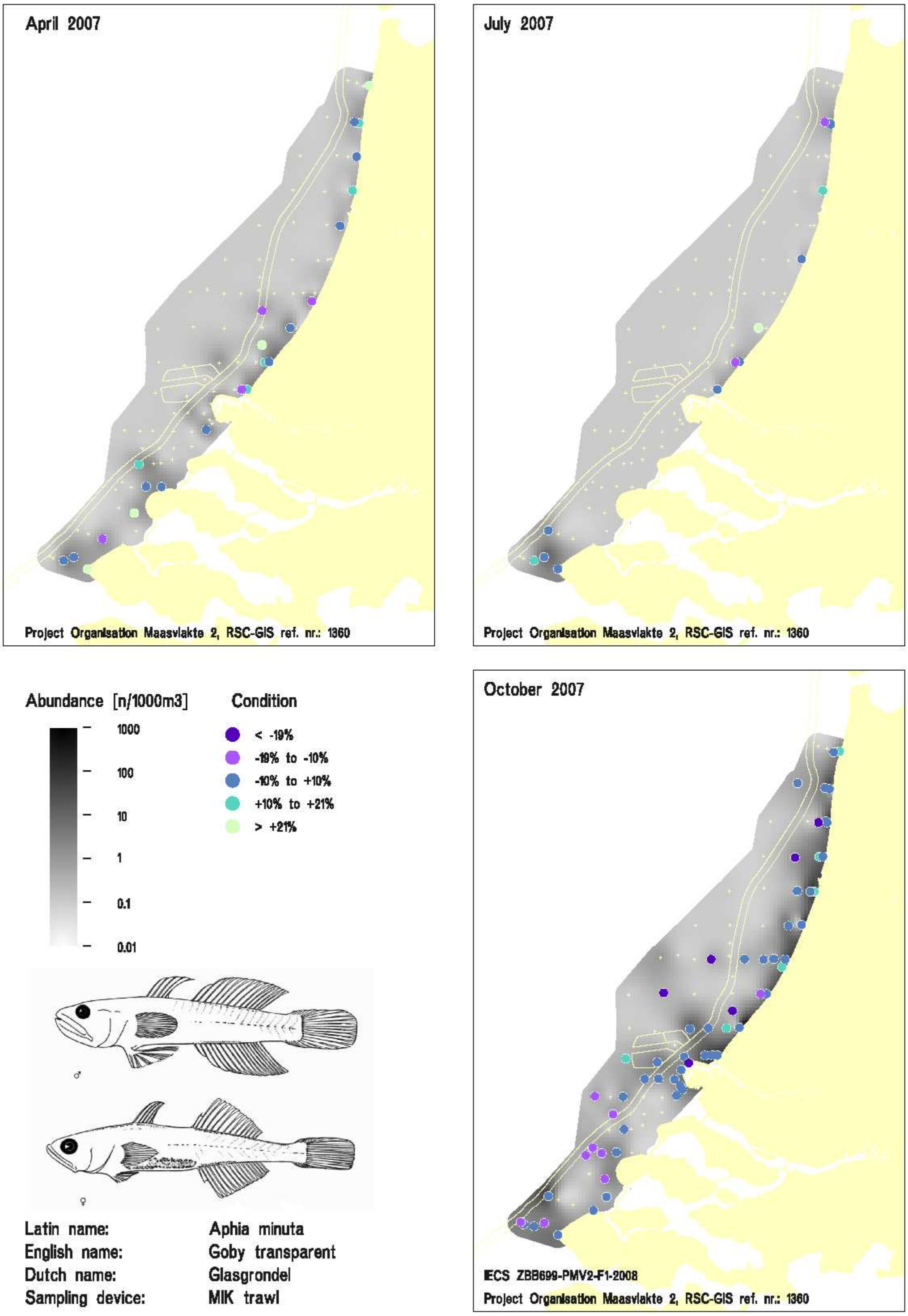

Figure 3.21. ***Aphia minuta*** **(Goby transparent)**

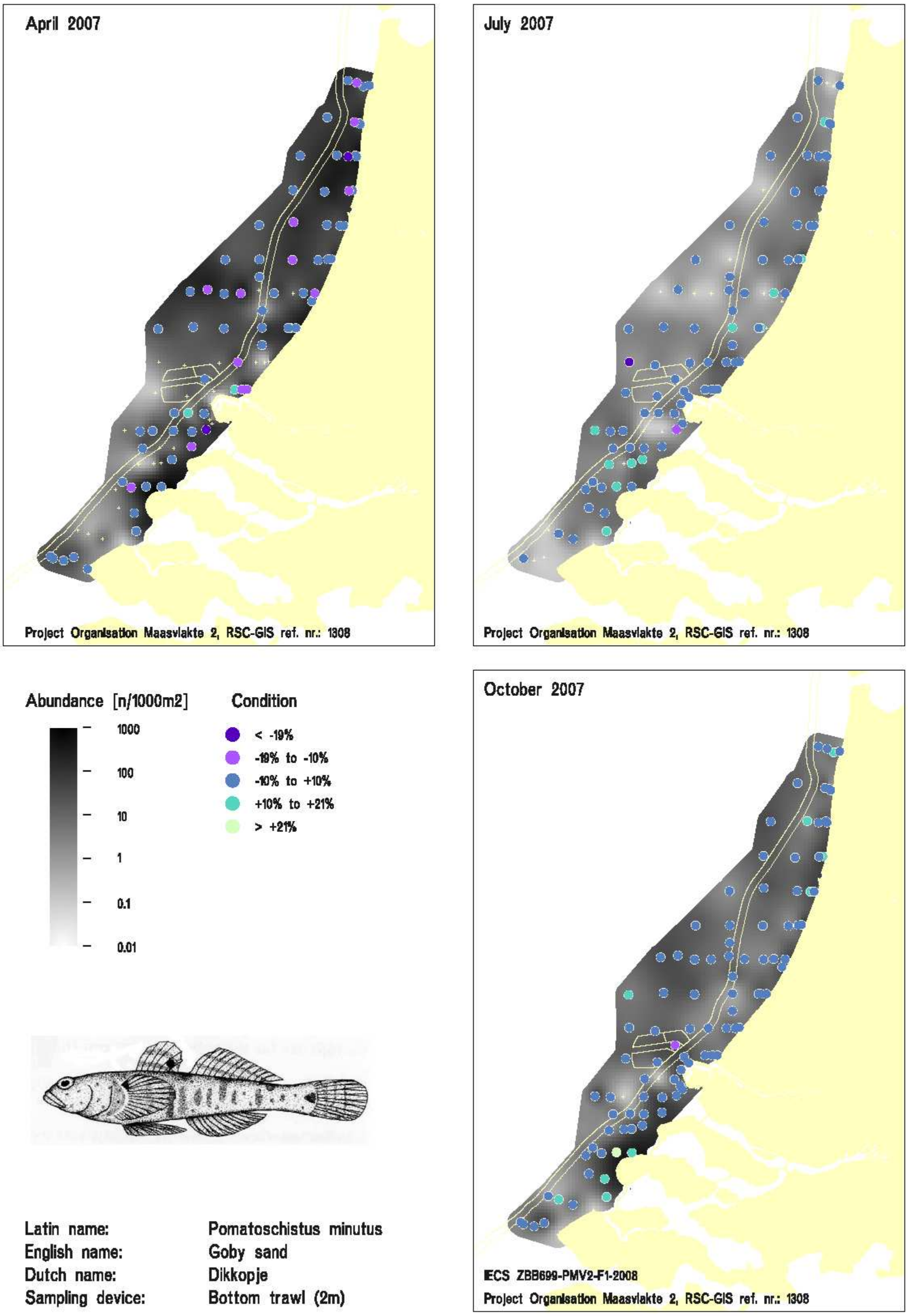

Figure 3.22. ***Pomatoschistus minutus*** **(Goby sand)**

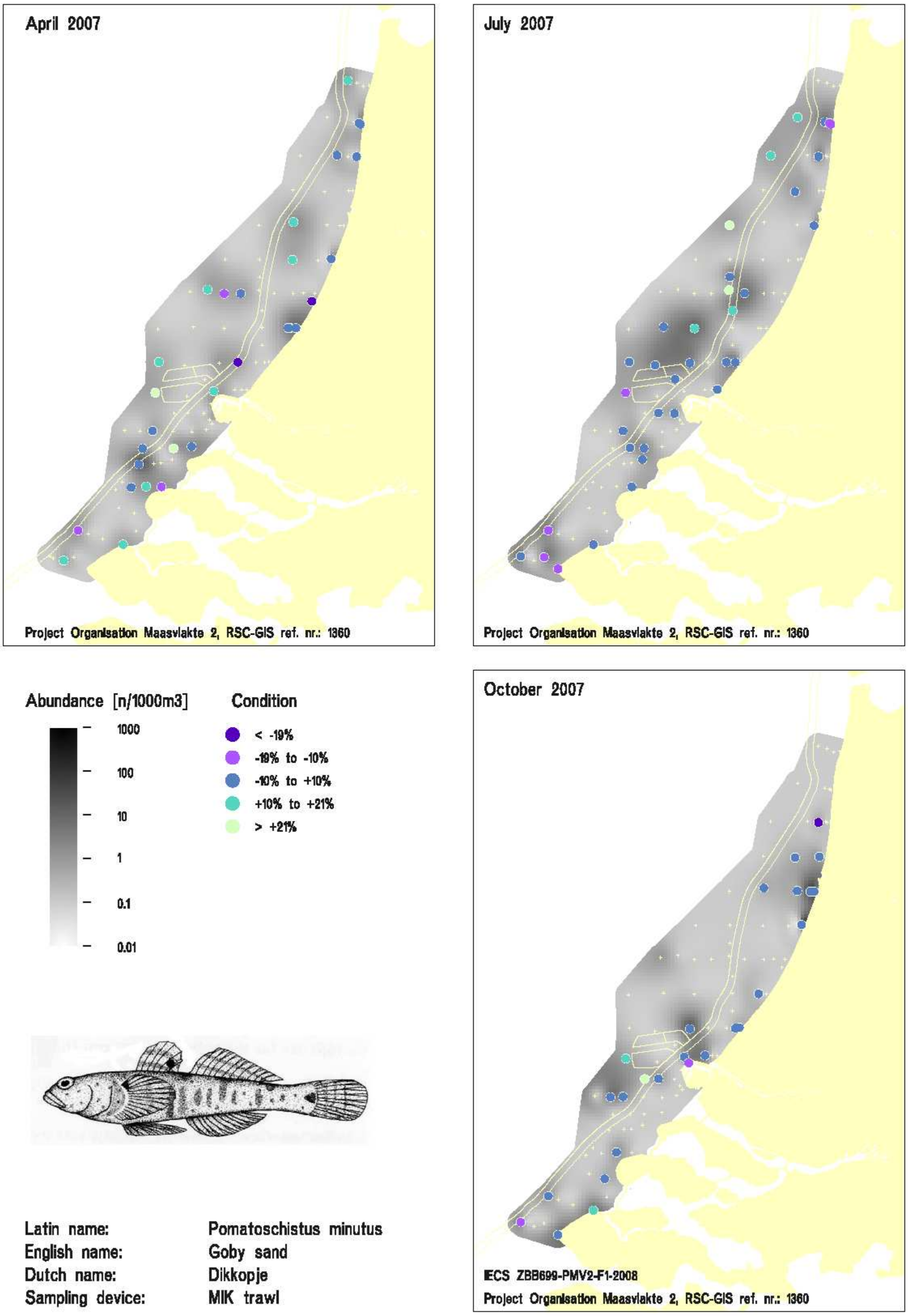

Figure 3.23. ***Pomatoschistus minutus*** **(Goby sand)**

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5. APPENDICES

Appendix 1. Cruise log and station array

Entries for the pelagic and demersal surveys with area and volume of water sampled by the beam and MIK trawl respectively. SEQ, unique sailing sequence code; STA, sampling station; UTC, Coordinated Universal Time.

Table a. April Cruise

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area $1000m^2$	Vol. $1000m^3$
1	1	11/04/07	20:46	20	2.02	52.803977	004.583515	2.00	1.86
2	2	11/04/07	21:45	10	0.97	52.800777	004.606275	0.96	2.85
3	3	11/04/07	22:36	10	1.82	52.790257	004.643873	1.01	-
3b	3	11/04/07	23:00	10	-	52.793898	004.629995	-	1.64
4	4	11/04/07	23:28	8	3.01	52.785015	004.662665	2.60	1.43
5	5	12/04/07	2:02	8	2.48	52.518458	004.581362	2.14	2.18
6	6	12/04/07	2:32	11	2.34	52.516541	004.563234	1.87	2.87
7	7b	12/04/07	3:22	17	2.10	52.518876	004.458934	1.94	2.66
8	8	12/04/07	4:20	19	1.51	52.519686	004.321899	1.87	2.97
9	9	12/04/07	20:35	26	2.49	52.261393	003.869288	2.15	-
9b	9	12/04/07	21:02	25	-	52.255234	003.877633	-	1.99
10	10	12/04/07	21:48	23	1.99	52.264188	003.950853	1.47	1.56
11	11	12/04/07	22:48	22	2.58	52.254632	004.091834	1.91	1.59
12	12	12/04/07	23:46	18	3.11	52.252252	004.244785	2.30	1.69
13	13	13/04/07	0:34	18	2.66	52.252605	004.362982	2.14	1.84
14	14	13/04/07	1:02	6	2.41	52.250863	004.415196	2.08	2.60
15	15	13/04/07	3:30	5	1.98	51.999623	004.110235	1.84	1.82
16	16	13/04/07	3:54	8	1.67	52.001754	004.091243	1.23	2.22
17	17	13/04/07	4:25	12	2.21	52.001827	004.060694	1.77	1.33
18	18	13/04/07	4:56	18	2.53	51.998799	003.973827	2.03	2.18
19	19	13/04/07	20:09	16	1.17	51.984930	003.856245	0.94	1.71
20	20	13/04/07	21:08	24	2.29	51.996744	003.721597	1.84	2.05
21	21	13/04/07	22:26	25	2.54	51.897195	003.596643	2.20	1.79
22	22	13/04/07	23:19	19	2.15	51.851934	003.667193	2.12	2.01
23	23	13/04/07	23:52	18	2.50	51.850748	003.734616	2.31	1.68
24	24	14/04/07	0:20	13	3.09	51.849030	003.794176	2.48	1.84
25	25	14/04/07	0:55	7	1.98	51.851957	003.871250	2.07	1.82
26	39	14/04/07	1:34	7	1.85	51.894272	003.942307	1.71	1.57
27	40	14/04/07	2:10	11	2.18	51.892936	003.874187	1.61	1.94
28	41	14/04/07	2:38	11	2.13	51.896583	003.795093	1.84	2.17
29	28	14/04/07	20:16	12	1.71	51.536782	003.430688	1.37	2.15
30	29	14/04/07	21:03	8	2.12	51.566310	003.373770	1.70	2.09
31	30	14/04/07	21:36	9	2.63	51.556800	003.331582	2.27	1.54
32	31	14/04/07	22:14	14	2.25	51.564996	003.286681	1.94	3.27
33	32	14/04/07	22:40	18	1.51	51.570934	003.276067	1.50	2.92
34	33	15/04/07	0:40	11	2.39	51.763220	003.577239	2.36	2.05
35	34	15/04/07	1:07	7	2.39	51.748704	003.616465	1.92	2.08
36	35	15/04/07	1:39	8	2.36	51.750331	003.680735	1.75	1.67
37	36	15/04/07	2:08	8	2.67	51.749204	003.744906	1.65	1.70
38	42	15/04/07	4:02	22	2.79	51.896396	003.709865	2.07	2.07
39	43	15/04/07	4:38	21	2.73	51.895750	003.654137	2.19	2.07
40	44	15/04/07	20:50	21	2.29	52.077396	003.737698	1.70	2.94

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area $1000m^2$	Vol. $1000m^3$
41	45	15/04/07	21:42	20	2.07	52.073577	003.850014	1.53	2.38
42	46	15/04/07	22:48	21	1.77	52.072902	004.000010	1.42	1.25
43	47	15/04/07	23:51	20	1.81	52.074824	004.076507	1.78	1.85
44	48	16/04/07	0:30	14	2.68	52.074943	004.155889	1.98	1.93
45	49	16/04/07	0:55	11	4.05	52.074202	004.194328	2.75	2.05
46	50	16/04/07	1:18	7	3.58	52.075435	004.211721	2.87	1.88
47	51	16/04/07	1:53	18	2.66	52.118489	004.182590	1.81	2.33
48	52	16/04/07	2:40	22	3.72	52.210341	004.183175	2.98	2.38
49	53	16/04/07	3:15	18	3.71	52.263950	004.168882	2.98	2.23
50	54	16/04/07	4:09	17	3.25	52.250551	004.319379	2.81	2.50
51	55	16/04/07	4:49	8	2.50	52.250201	004.411029	2.01	2.25
52	56	16/04/07	20:18	8	2.12	52.339672	004.481228	1.70	1.91
53	57	16/04/07	20:48	12	3.22	52.339210	004.466688	2.58	1.90
54	58	16/04/07	21:19	18	1.56	52.337175	004.426216	1.25	2.15
55	59	16/04/07	22:04	18	1.81	52.341761	004.322310	1.45	2.27
56	60	16/04/07	22:42	18	2.31	52.342832	004.172608	1.85	2.60
57	61	16/04/07	23:22	20	2.59	52.342821	004.026436	2.08	2.02
58	62	17/04/07	2:02	8	2.77	52.609179	004.601575	2.22	1.70
59	63	17/04/07	2:28	13	1.42	52.609988	004.595433	1.22	2.68
60	64	17/04/07	2:55	16	1.95	52.607436	004.562403	1.68	2.65
61	65b	17/04/07	3:22	18	1.81	52.612075	004.517059	1.45	2.56
62	66b	17/04/07	4:00	21	2.66	52.613413	004.354886	2.14	1.49
63	67	17/04/07	4:33	17	4.64	52.713900	004.476465	3.72	1.56
64	68	17/04/07	20:04	15	2.87	52.698652	004.596831	2.31	1.14
65	69	17/04/07	20:32	12	1.55	52.694500	004.614360	1.15	1.16
66	70	17/04/07	20:53	6	4.33	52.691230	004.620910	2.67	0.99
67	71	17/04/07	22:51	20	2.81	52.432027	004.174908	1.91	0.90
68	72	17/04/07	23:32	19	2.24	52.430621	004.323970	1.94	1.30
69	73	18/04/07	0:12	13	1.93	52.429616	004.468517	1.19	1.26
70	74	18/04/07	0:39	11	3.10	52.426712	004.524520	2.10	1.14
71	75	18/04/07	0:57	6	2.67	52.426492	004.537710	1.65	1.12
72	76	18/04/07	3:08	22	2.61	52.298396	004.173817	1.61	1.49
73	77	18/04/07	3:56	21	2.88	52.254457	004.022771	1.78	1.90
74	78	18/04/07	5:14	21	2.67	52.162547	003.737412	2.30	1.57
75	80b	18/04/07	20:12	7	3.35	51.913322	003.967988	2.07	1.13
76	81	18/04/07	20:43	13	2.76	51.938850	003.927615	1.88	1.39
77	82	18/04/07	21:16	16	4.61	51.942745	003.862312	3.13	1.14
78	83	18/04/07	21:41	16	2.38	51.942419	003.798968	1.61	0.99
79	84b	18/04/07	22:44	7	4.20	51.818319	003.784767	2.59	1.20
80	85	18/04/07	23:05	8	3.01	51.811438	003.743432	2.23	1.22
81	86	18/04/07	23:36	17	4.28	51.808796	003.649514	3.17	1.33
82	87	19/04/07	1:12	15	3.79	51.636836	003.390515	2.57	1.21
83	88	19/04/07	1:35	12	4.63	51.626800	003.437376	2.86	1.15
84	89	19/04/07	1:57	10	4.25	51.614587	003.495072	2.62	1.14
85	90	19/04/07	2:23	23	6.88	51.601791	003.580596	3.82	1.31
86	91	19/04/07	3:02	8	2.39	51.634170	003.635616	2.07	1.68
87	92	19/04/07	3:59	8	2.54	51.681035	003.628510	1.72	1.39
88	93	19/04/07	4:29	11	4.46	51.695000	003.561384	2.76	1.20
89	94	19/04/07	4:57	10	3.88	51.742640	003.549496	2.63	1.18
90	79	19/04/07	19:55	22	3.06	52.028519	003.932301	2.65	1.49
91	95	19/04/07	21:14	24	2.67	52.168085	003.888615	1.98	1.16
92	96	19/04/07	22:09	22	1.63	52.164190	004.018422	1.20	1.57
93	97	19/04/07	23:10	18	1.99	52.162746	004.184571	1.35	1.30

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area $1000m^2$	Vol. $1000m^3$
94	98	19/04/07	23:50	13	1.07	52.162048	004.279975	0.79	1.14
95	99	20:04:07	0:11	9	1.93	52.159479	004.309589	1.31	1.03
96	100	20:04:07	0:31	7	1.95	52.160318	004.326244	1.32	1.26

Table b. July Cruise

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area $1000m^2$	Vol. $1000m^3$
1	1	30/06/07	21:45	18	4.49	52.809292	004.563238	3.19	2.38
2	2	30/06/07	22:18	9	1.75	52.800458	004.609250	1.78	2.55
3	3	30/06/07	22:49	9	3.47	52.788892	004.633533	3.37	2.59
4	4	30/06/07	23:20	9	1.78	52.794742	004.661333	1.70	3.15
5	70	01/07/07	0:28	7	3.05	52.694100	004.620925	2.78	2.64
6	69	01/07/07	0:53	11	1.72	52.693458	004.614458	1.78	3.30
7	68	01/07/07	1:18	14	2.51	52.699233	004.594233	2.59	3.44
8	67	01/07/07	2:03	15	1.78	52.709933	004.476250	2.00	3.55
9	61	01/07/07	21:38	20	1.54	52.342667	004.027017	1.85	3.37
10	60	01/07/07	22:48	18	1.58	52.342483	004.171883	1.78	2.89
11	76	01/07/07	23:30	18	2.57	52.294517	004.176192	2.85	2.85
12	12	02/07/07	0:14	15	1.84	52.251458	004.248417	2.07	2.61
13	53	02/07/07	0:56	18	2.61	52.261508	004.168417	2.70	2.91
14	11	02/07/07	1:39	20	2.33	52.254050	004.093542	2.48	2.79
15	77	02/07/07	2:30	22	2.23	52.254775	004.022192	2.48	3.00
16	10	02/07/07	3:16	22	2.90	52.266375	003.947158	-	2.69
17	9	02/07/07	4:02	22	2.84	52.256108	003.873508	1.93	2.49
18	10	02/07/07	4:44	22	3.75	52.265425	003.963783	3.70	-
19	47	03/07/07	21:22	20	2.22	52.070492	004.072708	2.30	3.31
20	48	03/07/07	22:12	14	1.77	52.073156	004.151633	1.89	3.80
21	49	03/07/07	22:40	11	2.05	52.071275	004.189883	1.96	3.30
22	50	03/07/07	23:02	9	1.91	52.074525	004.208850	1.89	3.65
23	15	03/07/07	23:58	7	3.20	52.000304	004.109450	2.96	2.93
24	16	04/07/07	0:22	9	2.80	52.002542	004.089108	2.33	2.50
25	17	04/07/07	0:47	13	2.84	52.002075	004.056958	2.89	3.68
26	18	04/07/07	1:31	16	2.64	51.998875	003.969075	2.82	3.71
27	71	08/07/07	22:24	23	2.47	52.432541	004.179313	2.59	3.41
28	72	08/07/07	23:14	18	3.55	52.457058	004.326285	2.85	3.01
29	73	09/07/07	0:00	13	3.46	52.430075	004.471300	2.78	2.66
30	74	09/07/07	0:28	11	2.76	52.426333	004.521133	2.56	2.87
31	75	09/07/07	0:50	7	1.77	52.427033	004.538767	1.56	2.32
32	56	09/07/07	1:45	6	1.04	52.338227	004.480467	0.85	2.72
33	57	09/07/07	2:09	12	2.32	52.338608	004.468767	2.07	3.13
34	58	09/07/07	2:40	16	2.78	52.341375	004.427950	2.44	2.82
35	59	09/07/07	3:25	14	2.72	52.337631	004.311614	2.82	3.66
36*	27b	09/07/07	14:32	16	-	51.978992	003.984817	3.59	-
37*	26b	09/07/07	14:59	14	-	51.964475	003.960108	3.37	3.52
38*	27b	09/07/07	20:45	16	-	51.983400	003.990367	-	3.67
39	27b	09/07/07	21:21	16	4.13	51.983758	003.990975	4.07	3.86
40	26b	09/07/07	22:02	14	2.78	51.964442	003.957417	3.00	3.35
41	25	09/07/07	23:28	7	1.85	51.852992	003.872725	1.85	3.73
42	24	10/07/07	0:05	11	1.75	51.850825	003.799008	1.78	3.16
43	23	10/07/07	0:38	18	1.94	51.851353	003.739900	2.33	3.96
44	22	10/07/07	1:17	16	2.01	51.851933	003.665800	2.30	3.42

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area $1000m^2$	Vol. $1000m^3$
45	86	10/07/07	1:55	17	1.94	51.809631	003.652625	2.04	3.33
46	85	10/07/07	2:38	7	2.11	51.811767	003.744075	2.19	3.65
47	84b	10/07/07	3:10	6	2.36	51.821517	003.791708	2.22	3.87
48	91	10/07/07	21:10	9	3.50	51.633117	003.637967	3.30	3.15
49	90	10/07/07	22:04	25	1.25	51.591900	003.577542	1.44	4.33
50	89	10/07/07	22:50	9	2.30	51.614525	003.488708	2.48	3.75
51	88	10/07/07	23:20	10	1.92	51.628367	003.432508	1.78	3.31
52	87	10/07/07	23:55	18	1.10	51.637417	003.388725	1.56	5.25
53	32	11/07/07	1:05	19	1.90	51.570225	003.273242	1.96	3.56
54	31	11/07/07	1:30	13	1.91	51.565546	003.285934	2.15	4.28
55	30	11/07/07	2:04	9	1.60	51.559266	003.328812	1.78	3.86
56	29	11/07/07	2:47	8	1.50	51.566364	003.372479	1.56	3.10
57	28	11/07/07	4:00	12	4.00	51.532633	003.429408	3.33	2.75
58	92	11/07/07	21:17	8	2.10	51.681450	003.626858	2.04	3.41
59	93	11/07/07	21:58	10	1.66	51.693512	003.567150	1.67	3.86
60	94	11/07/07	22:36	10	2.93	51.738775	003.549800	2.89	3.46
61	33	11/07/07	23:03	10	3.35	51.764742	003.581217	3.67	3.68
62	34	11/07/07	23:33	9	2.14	51.748467	003.617283	2.15	3.36
63	35	12/07/07	0:01	10	2.75	51.750508	003.681583	2.59	3.17
64	36	12/07/07	0:33	10	1.96	51.749358	003.743183	1.67	2.93
65	83	12/07/07	2:56	15	-	51.941642	003.804375	2.59	3.83
66	19	12/07/07	3:36	20	-	51.987200	003.858575	2.82	3.17
67	79	12/07/07	4:15	23	-	52.031267	003.934500	2.74	4.13
68	51	12/07/07	21:00	16	2.58	52.116150	004.177017	2.70	3.22
69	97	12/07/07	21:47	18	2.16	52.161617	004.180775	2.04	2.77
70	52	12/07/07	22:30	20	2.26	52.207967	004.183917	2.44	3.32
71	54	12/07/07	23:26	16	3.28	52.252125	004.318908	3.04	2.95
72	13	12/07/07	23:59	16	3.40	52.253033	004.363533	2.78	2.74
73	55b	13/07/07	0:32	10	4.54	52.253850	004.406050	3.30	2.41
76	99	13/07/07	2:35	15	3.90	52.165247	004.288325	3.37	3.11
77	98	13/07/07	3:25	11	3.21	52.161142	004.311950	3.37	3.53
78	21	13/07/07	21:17	20	1.98	51.900450	003.585258	2.30	3.55
79	43	13/07/07	21:52	22	1.91	51.894025	003.650450	1.89	3.34
80	42	13/07/07	22:24	22	2.01	51.896850	003.709817	2.07	3.48
81	41	13/07/07	23:08	10	2.99	51.896317	003.798633	3.00	3.37
82	40	13/07/07	23:44	11	2.40	51.893283	003.877317	2.37	2.82
83	39b	14/07/07	0:11	9	2.85	51.900267	003.933050	2.59	2.79
84	80c	14/07/07	0:33	8	2.86	51.913558	003.958767	2.74	3.09
85	81	14/07/07	1:04	15	3.34	51.941550	003.929417	2.89	2.88
86	82	14/07/07	1:45	19	2.01	51.942650	003.860633	2.07	2.63
87	20	14/07/07	2:48	23	2.83	51.994700	003.724450	3.15	3.87
88	46	14/07/07	22:27	21	3.12	52.073000	003.993483	2.89	4.69
89	45	14/07/07	23:19	21	2.98	52.075058	003.844775	3.22	1.92
90	44	15/07/07	0:02	23	3.02	52.076317	003.737642	2.89	3.03
91	78	15/07/07	1:02	23	3.28	52.163517	003.734300	3.19	2.73
93	95	15/07/07	2:02	23	2.47	52.168117	003.893017	2.48	2.72
94	96	15/07/07	2:47	21	3.13	52.164083	004.020150	3.82	3.09
95	8	15/07/07	21:09	18	1.65	52.522408	004.324525	1.78	3.71
96	7b	15/07/07	22:00	11	2.75	52.513592	004.460225	2.63	2.49
97	6	15/07/07	22:47	10	3.02	52.516575	004.567000	3.07	2.42
98	5	15/07/07	23:18	8	2.04	52.520142	004.580825	2.52	2.94
99	62	16/07/07	0:17	8	1.90	52.607708	004.600433	2.11	3.51
100	63	16/07/07	0:43	11	3.07	52.606567	004.595083	2.70	2.34

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area 1000m^2	Vol. 1000m^3
101	64	16/07/07	1:07	14	2.36	52.608042	004.563100	2.15	2.26
102	65b	16/07/07	1:33	15	2.47	52.611650	004.513533	2.67	2.35
103	66b	16/07/07	2:45	16	2.40	52.611592	004.359548	2.52	1.79

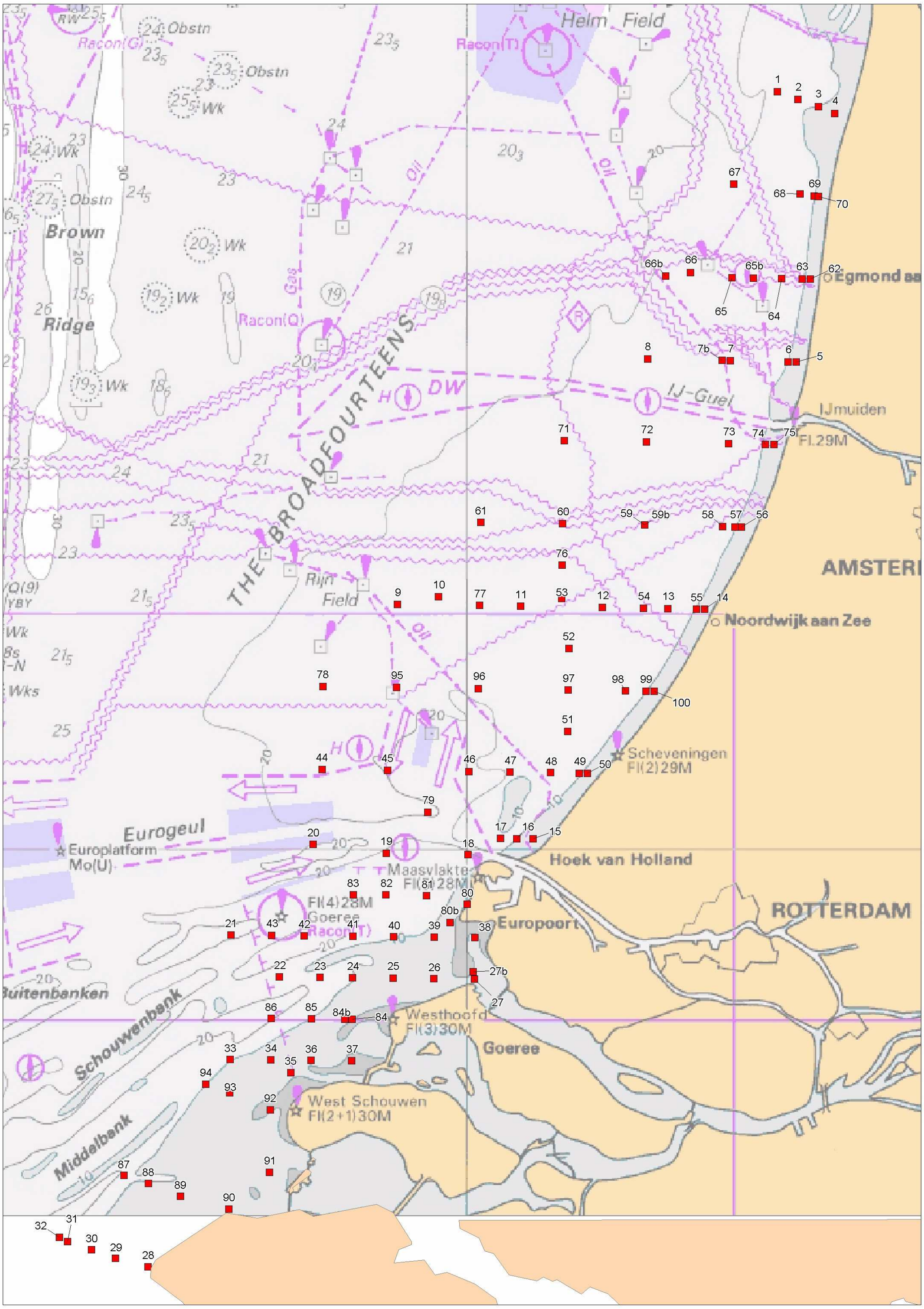
Table c. October Cruise

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area 1000m^2	Vol. 1000m^3
1	1	22/10/07	18:42	19	2.7	52.808296	004.563331	2.52	3.02
2	2	22/10/07	19:17	8	2.6	52.800034	004.610769	2.44	3.00
3	3	22/10/07	19:39	9	2.3	52.793808	004.632020	2.41	3.17
4	4	22/10/07	20:09	7	3.3	52.799334	004.664404	3.44	3.03
5	70	22/10/07	21:21	7	2.6	52.689860	004.618273	2.26	2.55
6	69	22/10/07	21:49	11	1.9	52.696007	004.614902	2.00	3.28
7	68	22/10/07	22:32	15	2.6	52.695650	004.593722	2.59	3.19
8	67	22/10/07	23:24	16	3.3	52.711533	004.479477	3.44	3.59
9	65b	23/10/07	0:38	18	1.3	52.611763	004.517626	1.41	3.47
10	64	23/10/07	1:17	16	2.7	52.607413	004.566768	2.63	2.96
11	63	23/10/07	1:46	10	3.6	52.613442	004.596286	3.33	2.89
12	62	23/10/07	2:25	11	2.4	52.604418	004.600208	2.41	3.43
13	51	23/10/07	18:30	17	3.0	52.119007	004.180072	2.78	4.20
14	97	23/10/07	19:18	15	2.6	52.165442	004.178051	2.44	5.03
15	96	23/10/07	21:05	18	2.1	52.160100	004.017657	1.93	3.68
16	95	23/10/07	21:55	23	3.5	52.167055	003.879982	3.22	4.45
17	78	23/10/07	22:46	26	2.8	52.163944	003.741101	2.63	3.57
18	44	24/10/07	0:01	29	2.1	52.077003	003.742448	1.93	4.37
19	45	24/10/07	1:12	25	2.0	52.053756	003.852617	1.85	4.26
20	46	24/10/07	2:29	23	2.8	52.070590	003.998360	2.63	3.21
21	47	24/10/07	3:21	21	2.4	52.075590	004.077165	2.22	3.76
22	48	24/10/07	4:23	14	3.0	52.070633	004.152000	2.74	3.32
23	49	24/10/07	5:05	10	3.4	52.071171	004.189352	3.11	3.45
24	50	24/10/07	5:50	8	4.3	52.070966	004.204752	3.96	3.65
25	32	24/10/07	18:47	16	3.9	51.565593	003.271080	3.89	3.20
26	31	24/10/07	19:32	12	4.1	51.560025	003.283508	4.04	3.40
27	30	24/10/07	20:14	8	2.0	51.557445	003.329559	2.22	4.31
28	29	24/10/07	20:53	8	2.4	51.566747	003.370715	2.33	2.92
29	28	24/10/07	21:30	13	3.9	51.536733	003.430990	3.33	2.64
30	87	24/10/07	22:49	13	3.1	51.636560	003.393015	3.30	3.53
31	88	24/10/07	23:28	13	3.5	51.628730	003.431386	2.19	3.20
32	89	24/10/07	23:59	12	3.5	51.612431	003.498159	3.70	3.11
33	90	25/10/07	0:35	30	5.8	51.602823	003.583099	3.59	2.91
34	91	25/10/07	1:19	8	2.3	51.634149	003.635374	2.22	3.50
35	92	25/10/07	2:23	8	2.8	51.681425	003.631611	1.74	3.27
36	93	25/10/07	2:55	10	4.1	51.696952	003.559121	3.78	3.54
37	94	25/10/07	3:32	10	4.6	51.749560	003.549945	4.30	3.41
38	33	25/10/07	4:03	11	2.3	51.762144	003.580598	2.15	3.34
39	34	25/10/07	4:33	7	2.0	51.748624	003.616165	1.89	3.82
40	35	25/10/07	5:08	9	3.4	51.751134	003.677483	2.07	4.11
41	36	25/10/07	5:52	9	1.6	51.749146	003.746084	1.37	2.99
42	98	25/10/07	18:15	13	1.8	52.160935	004.286145	1.93	3.05
43	99	25/10/07	18:42	10	2.2	52.158803	004.306305	1.93	3.14
44	100	25/10/07	19:25	7	2.1	52.160881	004.325248	2.04	3.29

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area 1000m²	Vol. 1000m³
45	14	25/10/07	20:56	6	2.8	52.209888	004.375710	2.59	3.65
46	55	25/10/07	21:22	7.5	3.8	52.247636	004.409584	3.48	3.29
47	13	25/10/07	21:53	11	3.2	52.251353	004.354590	3.15	2.80
48	54	25/10/07	22:20	16	3.0	52.250616	004.312111	3.67	4.07
49	12	25/10/07	22:59	16	3.3	52.256114	004.211953	3.30	3.33
50	11	25/10/07	23:51	22	2.6	52.252911	004.091499	2.78	3.68
51	77	26/10/07	0:26	24	2.5	52.252869	004.018676	2.59	3.39
52	10	26/10/07	1:25	21	2.2	52.265767	003.945482	2.33	4.59
53	9	26/10/07	2:15	21	3.3	52.264813	003.885691	3.70	2.94
54	61	26/10/07	3:27	21	1.9	52.344031	004.030323	2.30	3.48
55	60	26/10/07	4:30	18.5	2.7	52.341875	004.179997	3.04	3.47
56	76	26/10/07	5:18	19	2.3	52.296172	004.170418	2.22	3.39
57	53	26/10/07	5:54	20	2.1	52.260260	004.169554	1.96	2.57
58	52	26/10/07	6:34	17	2.4	52.205455	004.182483	2.48	2.91
59	19	26/10/07	18:10	18	2.4	51.985837	003.854991	2.82	3.74
60	20	26/10/07	19:02	20	2.6	51.997507	003.721208	2.89	3.67
61	21	26/10/07	20:12	19	2.1	51.897245	003.588975	2.30	4.41
62	22	26/10/07	20:57	13	3.2	51.847652	003.666173	3.19	3.12
63	86	26/10/07	21:29	17	4.4	51.807244	003.646627	2.74	2.94
64	37b	26/10/07	22:15	13	2.4	51.810974	003.712638	2.37	3.84
65	85	26/10/07	22:41	8	2.4	51.811915	003.746556	2.41	4.16
66	84b	26/10/07	23:11	6	2.3	51.821887	003.795437	2.22	3.52
67	23	26/10/07	23:51	12	2.4	51.853453	003.741828	2.67	3.56
68	24	27/10/07	0:24	9	2.6	51.850242	003.800513	2.59	3.13
69	25	27/10/07	1:00	8	3.2	51.856988	003.879191	3.37	3.35
70	56	29/10/07	20:19	8	2.2	52.342412	004.483693	2.00	2.74
71	57	29/10/07	20:53	12	2.8	52.340099	004.468661	2.63	2.96
72	58	29/10/07	21:26	17	2.8	52.335008	004.423197	2.56	3.18
73	59	29/10/07	22:17	18	3.7	52.340321	004.313379	3.41	3.63
74	71	29/10/07	23:41	23	1.5	52.431998	004.172813	1.41	3.68
75	72	30/10/07	0:45	18	1.9	52.428485	004.319863	1.78	3.62
76	73	30/10/07	1:38	14	2.6	52.428786	004.459827	2.70	3.77
77	74	30/10/07	2:13	13	2.5	52.426890	004.523310	2.33	3.22
78	75	30/10/07	2:37	7	2.1	52.426731	004.539518	1.96	2.95
79	5	30/10/07	3:44	7	2.2	52.516413	004.577982	2.19	2.87
80	6	30/10/07	4:16	10	2.5	52.520603	004.563600	2.48	3.70
81	7	30/10/07	5:08	18	2.4	52.518062	004.459854	2.26	3.21
82	8	30/10/07	6:13	21	2.8	52.526079	004.325527	2.78	3.03
83	66b	30/10/07	7:08	19	1.5	52.612922	004.359402	1.59	3.76
84	79	30/10/07	19:08	19	1.8	52.031197	003.933847	2.11	4.53
85	82	30/10/07	20:18	19	2.5	51.941699	003.860323	2.67	4.61
86	83	30/10/07	21:10	15	2.0	51.942913	003.804528	2.15	-
87	83	30/10/07	21:30	15	-	51.941110	003.798751	-	4.00
88	43	30/10/07	22:24	24	2.1	51.896700	003.664114	2.07	3.15
89	42	30/10/07	23:02	23	1.0	51.895973	003.709875	1.22	4.09
90	41	30/10/07	23:54	12	1.5	51.894970	003.797067	1.37	3.37
91	40	31/10/07	0:38	13	3.0	51.892807	003.877606	2.63	4.18
92	39b	31/10/07	1:14	9	2.1	51.899324	003.935356	2.59	4.73
93	80c	31/10/07	1:43	9	2.3	51.913922	003.957754	2.11	3.69
94	38b	31/10/07	2:04	10	2.3	51.923998	003.952191	2.15	3.57
95	81	31/10/07	2:29	13	2.7	51.940683	003.929280	2.48	3.78
96	26b	31/10/07	3:10	15	2.8	51.965564	003.958900	2.56	3.95
97	27b	31/10/07	3:42	16	2.1	51.981970	003.989235	2.11	3.47

SEQ	STA	Date	Time UTC	Depth m	Speed Knots	Mid-trawl Position-WGS 84 Lat. (N)	Lon. (E)	Area $1000m^2$	Vol. $1000m^3$
98	18	31/10/07	4:09	17	2.6	51.998426	003.971204	2.70	3.95
99	17	31/10/07	4:57	14	3.2	52.001903	004.063318	2.93	3.28
100	16	31/10/07	5:16	11	3.2	52.001472	004.092033	3.11	3.41
101	15	31/10/07	5:45	8	3.3	52.005461	004.117211	3.07	3.19

Figure a. Map of the sampling area showing the position of the sampling stations. The stations labels correspond to the coding used in the April cruise.



Appendix 2. MIK calibration

Weights were rigged to the bridle to make the plankton trawl sink to the approximate test depth. To verify the sample depth, an automated data logger CTD device was mounted on one of the three bridle lines. Dummy runs with the fully rigged MIK sampler were conducted at the start of each cruise to determine the relationship between warp length, tow line angle, and sampling depth (Fig. b).

The CTD was permanently rigged to the sampler from the second half of the April cruise and provided continuous water quality records (temperature, salinity, pH and dissolved oxygen) during regular tows.

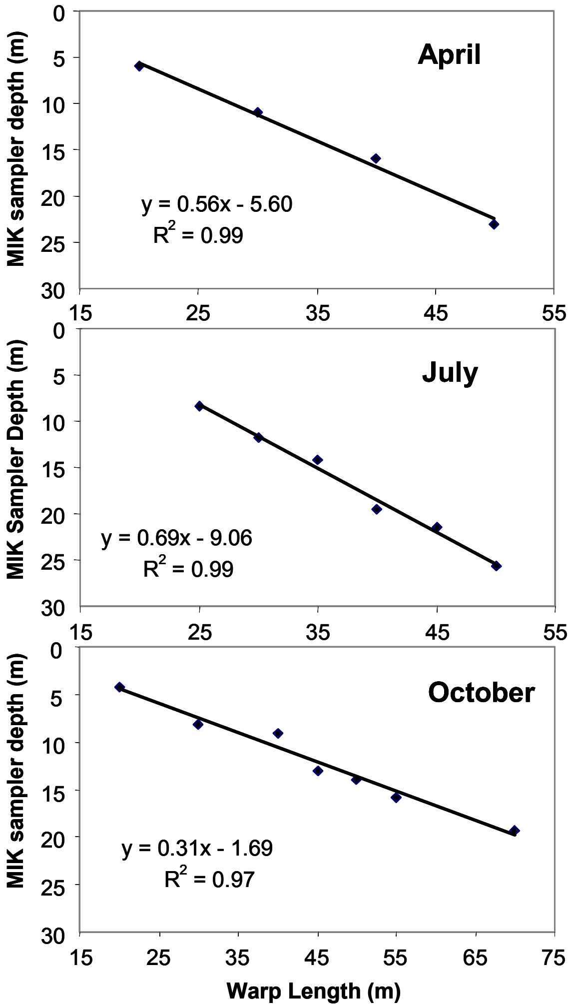


Figure b. Sampling depth calibration exercises for each of the three cruises. The regression parameters used to estimate sampling depth are given with the regression coefficients.

After inspection, the depth records from the second half of the April cruise showed an unexpectedly large variability (ca. ±3-4m) compared to the MIK calibration runs that were accurate within one m. To attain additional precision on the MIK sampling depth while still sampling at a fixed 2 knots (relative to the ground) further tests were run to find a correction for changes in true towing speed across the water caused by tidal currents. The test consisted of parallel tows run in opposite directions to the tidal current at the standard two knots (speed relative to ground) (Fig. c). The tests showed distinct shifts in sampler depth and warp angle (i.e. angle of the towing line respect to the water surface).

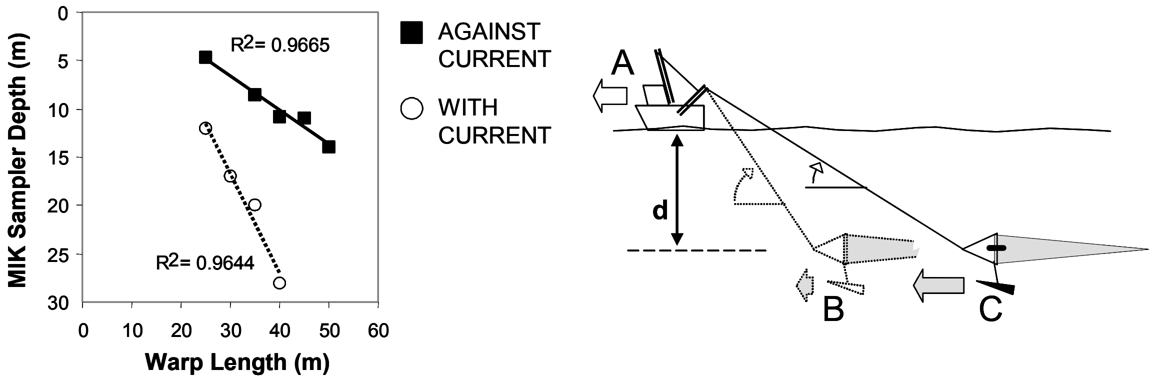


Fig c. Effect of current speed on sampling depth. Left. result of dummy runs. Right. Diagram showing the relationship between warp length and angle under two tidal conditions A, speed relative to ground; B, forward motion of the sampler towing in the same direction of the current and C, towing in the opposite direction; d, sampling depth.

To account for differences in warp angle we used independent sliding scales depending on the warp length visible above the water surface that is a rough estimate of the warp angle. The refinement of the method effectively reduced the depth shifts during the July and October cruises (Figure d). The overall deviation from the intended deployment depth was approximately 1±3m (mean ± standard deviation) above the target depth.

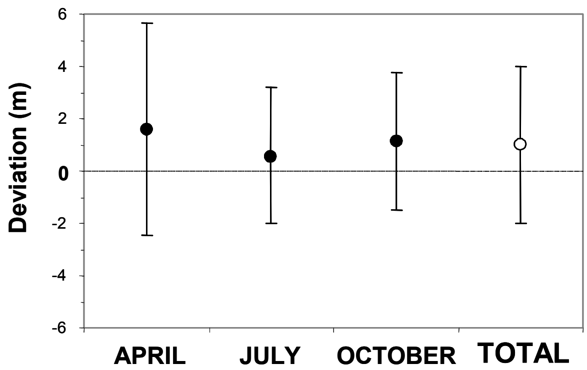


Figure d. Average deviations from target depth. The error bars represent standard deviations. The dotted line represents the target depth.

In addition to the test conducted to estimate the sampling depth, the calibration of the flow meter was validated. The calibration was conducted by towing the MIK sampler (cod end untied) for a fixed distance and comparing the registered counts in the flowmeter dial with the known towed distance. In practice this was achieved by lowering the fully assembled gear to a predetermined depth. After retrieving the sampler the flow meter reading was translated into a distance estimate according with manufacturer specifications (Figure e). The MIK deployment depth was almost perfectly correlated with the calculated distance with the flowmeter.

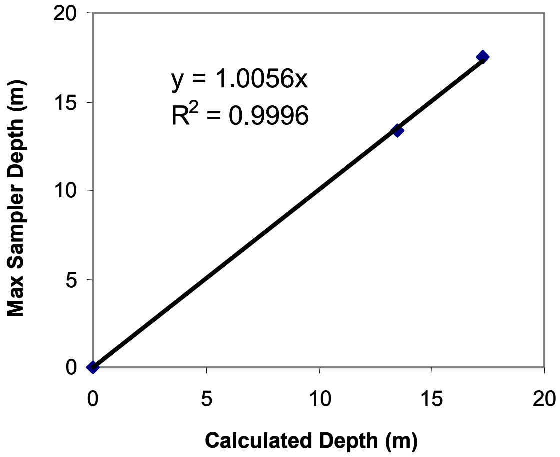


Figure e. Flowmeter calibration check.

Appendix 3. Fish assemblages

Similarity percent (SIMPER) analysis was used to identify the fish assemblages for each *a priori* defined group (cruises or depth bands) for the demersal and pelagic surveys. The analysis was followed by pair-wise tests to identify the species driving the dissimilarities between groups. For example in Table d (demersal survey-by-cruise), *B luteum* and *C lyra* have a significant contribution to the April assemblage however, they are not highlighted in the pair-wise tests. The interpretation is that these two species were also important for the July and October assemblage and hence are not responsible for the dissimilarity between cruise-assemblages. In contrast *P minutus* is driving the dissimilarity (more notably in July that in October).

Table d. SIMPER analysis output by cruise for the demersal survey. The species are listed by decreasing contribution to the named group assemblage. Only the main discriminant species (those explaining 90% of the group similarity) are listed. The average similarity of each assemblage is given in the tables. The summary pair-wise table shows those species contributing to the overall 50% dissimilarity between the named group and each one of the contrast group. Species explaining more than 10% of the dissimilarity are coded with a double symbol (i.e. ++). (†) average abundance; (*) percentage contribution. 'ns' identifies those contrasts where the ANOSIM analysis failed to detect significant differences between groups.

April group			Pairwise dissimilarity test	
Average similarity: 58.51			Contrast group	
Species	Av.Abund†	%Contrib.*	July	October
Pomatoschistus minutus	83.32	28.34	++	+
Limanda limanda	47.78	13.74	+	+
Ammodytes tobianus	49.52	13.24	+	++
Buglossidium luteum	36.95	11.02		
Callionymus lyra	29.88	7.67		
Syngnathus rostellatus	31.14	7.13		+
Arnoglossus laterna	22.18	4.87		+
Pleuronectes platessa	20.97	3.92	+	+
Agonus cataphractus	15.55	2.52		+

July Group				
Average similarity: 60.41			Contrast group	
Species	Av.Abund	%Contrib.	April	October
Buglossidium luteum	48.07	15.73		
Limanda limanda	61.79	13.91	+	+
Trisopterus luscus	56.02	12.41	+	++
Pleuronectes platessa	56.01	11.86	+	+
Merlangius merlangus	48.84	10.29	+	+
Callionymus lyra	38.53	8.8		
Pomatoschistus minutus	37.41	6.95	++	++
Solea solea	36.28	6.29		+
Arnoglossus laterna	16.19	3.72		
Liparis montagui	24.86	3.37		

October Group

Average similarity: 61.18			Contrast group	
Species	Av.Abund	%Contrib.	April	July
Pomatoschistus minutus	69.56	22.83	+	++
Limanda limanda	65.31	17.73	+	+
Buglossidium luteum	43.72	12.99		
Callionymus lyra	35.88	9.4		
Arnoglossus laterna	35.3	8.6	+	
Pleuronectes platessa	37.73	8.02	+	+
Agonus cataphractus	32.64	6.15		
Merlangius merlangus	25.26	3.9		+
Solea solea	21.72	3.09		+

Table e. SIMPER analysis output by by depth band for the demersal survey. Table organization and symbols are explained in Table d.

0-5m Group

Average similarity: 49.83			Pairwise dissimilarity test Contrast group				
Species	Av.Abund	%Contrib.		5-10	10-15	15-20	20-25
Pomatoschistus minutus	71.95	32.24		ns	+	+	+
Limanda limanda	41.5	10.83		ns	+	+	+
Trisopterus luscus	33.41	10.8		ns			
Pleuronectes platessa	34.08	7.77		ns	+	+	
Syngnathus rostellatus	27.62	6.93		ns			
Solea solea	29.03	6.38		ns	+		
Merlangius merlangus	23.9	5.24		ns	+		
Liparis montagui	19.88	4.33		ns			
Agonus cataphractus	18.27	3.17		ns			+
Ammodytes tobianus	12.81	2.88		ns			

5-10m Group

Average similarity: 58.02			Contrast group				
Species	Av.Abund	%Contrib.	0-5		10-15	15-20	20-25
Pomatoschistus minutus	76.41	27.7	ns		+	+	+
Pleuronectes platessa	50.15	13.98	ns		+	+	
Limanda limanda	51.04	13.54	ns		+	+	+
Trisopterus luscus	31.56	7.43	ns				
Syngnathus rostellatus	25.66	6.73	ns				
Solea solea	27.66	5.73	ns		+		
Merlangius merlangus	27.72	5.61	ns				
Agonus cataphractus	19.46	3.72	ns		+		+
Ammodytes tobianus	16.06	3.37	ns				
Liparis montagui	19.93	3.23	ns				

10-15m Group

Average similarity: 57.58

Species	Av.Abund	%Contrib.	Contrast group 0-5	5-10		15-20	20-25
Limanda limanda	67.3	17.97	+	+		+	ns
Pomatoschistus minutus	58.78	16.56	+	+		+	ns
Pleuronectes platessa	43.69	10.11	+	+		+	ns
Trisopterus luscus	35.39	7.9				+	ns
Merlangius merlangus	35.16	7.82	+				ns
Buglossidium luteum	41.81	7.39	+	+		++	ns
Arnoglossus laterna	28.74	6.44					ns
Callionymus lyra	30.3	5.47	+	+		+	ns
Agonus cataphractus	28.64	5.36		+			ns
Solea solea	24.67	4	+	+			ns
Ammodytes tobianus	21.31	3.85					ns

15-20m Group

Average similarity: 66.48

Species	Av.Abund	%Contrib.	Contrast group 0-5	5-10	10-15		20-25
Buglossidium luteum	85.88	24.51	++	++	++		ns
Limanda limanda	65.86	16.17	+	+	+		ns
Callionymus lyra	59.32	14.6	+	++	+		ns
Pomatoschistus minutus	54.24	13.05	+	+	+		ns
Arnoglossus laterna	36.66	8.24	+	+			ns
Pleuronectes platessa	30.49	5.23	+	+	+		ns
Ammodytes tobianus	24.21	5.23					ns
Agonus cataphractus	24.73	3.8					ns

20-25m Group

Average similarity: 69.29

Species	Av.Abund	%Contrib.	Contrast group 0-5	5-10	10-15	15-20	
Buglossidium luteum	95.45	23.63	++	++	ns	ns	
Callionymus lyra	75	16.56	++	++	ns	ns	
Limanda limanda	75.42	16.49	+	+	ns	ns	
Pomatoschistus minutus	50.38	9.44	+	+	ns	ns	
Agonus cataphractus	49.24	7.18	+	+	ns	ns	
Arnoglossus laterna	39.25	7.13	+		ns	ns	
Pleuronectes platessa	35.4	5.36		+	ns	ns	
Trisopterus luscus	31.37	4.65			ns	ns	

Table f. SIMPER analysis output by cruise for the pelagic survey. Table organization and symbols are explained in Table d.

April Group	Pairwise dissimilarity test
Average similarity: 28.03	Contrast group

Species	Av.Abund	%Contrib.	July	October
Merlangius merlangus	0.53	39.34	++	++
Syngnathus rostellatus	0.44	20.13	++	++
Ammodytes tobianus	0.37	18.09		
Pomatoschistus minutus	0.29	8.03	++	
Aphia minuta	0.26	7.34		++

July Group

Average similarity: 37.48

Species	Av.Abund	%Contrib.	Contrast group April	 October
Syngnathus rostellatus	1.28	56.55	++	++
Sprattus sprattus	0.95	19.58	++	++
Trachururs trachurus	0.37	11.8	++	++
Pomatoschistus minutus	0.33	6.36	++	++

October Group

Average similarity: 46.12

Species	Av.Abund	%Contrib.	Contrast group April	 July
Syngnathus rostellatus	1.21	73.07	++	
Aphia minuta	1.04	18.91	++	++

Table g. SIMPER analysis output by depth band for the pelagic survey. Table organization and symbols are explained in Table d.

0-5m Group

Average similarity: 40.64

Pairwise dissimilarity test

Species	Av.Abund	%Contrib.	Contrast group 5-10	 10-15	 15-20	 20-25
Syngnathus rostellatus	1.36	51.05	ns	++	++	ns
Aphia minuta	0.95	20.15	ns	++	++	ns
Sprattus sprattus	0.95	14.01	ns	++	++	ns
Clupea harengus	0.67	7.64	ns			ns

05-10m Group

Average similarity: 40.56

Species	Av.Abund	%Contrib.	Contrast group 0-5	 10-15	 15-20	 20-25
Syngnathus rostellatus	1.38	58.08	ns	ns	++	ns
Sprattus sprattus	0.87	16.91	ns	ns	++	ns
Aphia minuta	0.73	12.16	ns	ns	++	ns
Clupea harengus	0.43	5.84	ns	ns		ns

10-15m Group

Average similarity: 35.53

Species	Av.Abund	%Contrib.	Contrast group 0-5	 5-10	 15-20	 20-25
Syngnathus rostellatus	0.92	60.12	++	ns	++	ns
Aphia minuta	0.35	14.2	++	ns	++	ns

Sprattus sprattus	0.54	11.43	++	ns		++	ns
Pomatoschistus minutus	0.31	5.76		ns		++	ns

15-20m Group

Average similarity: 35.74			Contrast group				
Species	Av.Abund	%Contrib.	0-5	5-10	10-15		20-25
Syngnathus rostellatus	0.54	54.33	++	++	++		ns
Merlangius merlangus	0.32	19.05					ns
Trachururs trachurus	0.29	9.1					ns
Pomatoschistus minutus	0.25	6.65	++		++		ns
Ammodytes tobianus	0.11	6.23					ns

20-25m Group

Average similarity: 44.07			Contrast group			
Species	Av.Abund	%Contrib.	0-5	5-10	10-15	15-20
Syngnathus rostellatus	0.97	62.87	ns	ns	ns	ns
Merlangius merlangus	0.26	14.19	ns	ns	ns	ns
Pomatoschistus minutus	0.62	13.16	ns	ns	ns	ns