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Intern rapport
Nummer: 05.003

Cruise report Hydro acoustic survey for blue whiting (*Micromesistius poutassou*) 7 March - 25 March 2005

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Datum: 30 juni 2005

Aantal exemplaren: 5
Aantal pagina's: 35
Aantal tabellen: 3
Aantal figuren: 12
Aantal bijlagen: 9

Inhoudsopgave:

Inhoudsopgave: 2
Samenvatting 3
Summary 3
1. Introduction 4
2. Methods 4
2.1 Scientific Staff 4
2.2 Narrative 4
2.3 Survey design 5
2.4 Calibrations 6
2.5 Acoustic data collection 7
2.6 Biological data 8
2.7 Hydrographical data 8
2.8 Data analysis 8
3. Results 9
3.1 Acoustic data results 9
3.2 Trawl data 12
3.3 Biological data 14
3.4 Intercalibration 15
3.8 CTD data & data acquisition system 16
4. Conclusion & recommendations 17
Acknowledgements 18
Appendix A. Calibration results 19
Appendix B. EK60 settings 21
Appendix C. Age/maturity-length key for blue whiting – All strata 22
Appendix D. NASC frequency distribution by day 24
Appendix E. Species names 26
Appendix F. Length frequency distributions 27
Appendix G. Collection of pipe fish 28
Appendix H. Collection of meso-pelagic fish 31
Appendix I. Zooplankton 33

Samenvatting

Dit is het verslag van de Nederlandse deelname aan de Noord Atlantische akoestische survey voor blauwe wijting. Deze, door ICES gecoördineerde survey wordt jaarlijks uitgevoerd. Naast Nederland nemen Ierland, Denemarken, Faeröer, Rusland, IJsland en Noorwegen deel aan de survey.
Het doel van de survey is het maken van een schatting van de grootte van de Noord Atlantische blauwe wijting populatie. Deze schatting wordt gebruikt als een "tuning index" door ICES om de omvang van de populatie vast te stellen.
Voor de survey wordt gebruik gemaakt van een Simrad 38kHz splitbeam transducer met een EK60 echolood. De toegepaste methode is echo-integratie. Door transecten te varen in het gebied wordt het totale akoestische oppervlak per oppervlakte-eenheid bepaald. Door het uitvoeren van vistrekken wordt de soortsamenstelling bepaald. Van blauwe wijting worden daarnaast biologische monsters genomen om leeftijd en rijpheid te bepalen. Voor deze soort kan aldus een schatting van de populatie, uitgesplitst naar leeftijd en rijpheid, gemaakt worden. Blauwe wijting is overal gevonden in nabijheid van het continentale plat.

Summary

This is the report of the Dutch part of the international North East Atlantic hydro acoustic survey for blue whiting. The survey is coordinated by ICES and has been executed annually. Ireland, Russia, Iceland, Denmark, Faroes and Norway also participate in the survey.
The purpose of the survey is to estimate the blue whiting stock of the North East Atlantic. The ICES uses this estimation is as a "tuning index" to assess the North East Atlantic blue whiting stock.
For this survey a Simrad 38kHz splitbeam transducer was used together with a Simrad EK60 echo sounder. The applied method was echo integration. By sailing transects over the survey area, the total acoustic cross-section can be calculated by surface area sampled. Trawling identified species composition of localized schools. The length composition of each species was determined. Blue whiting was examined on age and fecundity from which a split up stock structure was made. Blue whiting where found throughout the survey area associated with the continental shelf edge.

1. Introduction

The Netherlands Institute for Fisheries Research (RIVO) participates in the international North East Atlantic hydro acoustic survey for blue whiting since 2004. The survey is part of the EU data collection framework. The aim of this survey is to provide an abundance estimate of the whole North East Atlantic blue whiting population as well as to determine the spatial distribution at this time of year. This estimate is used as a tuning index by ICES to determine the size of the population. In this report the results are presented of the survey west of Ireland, carried out by FRV "Tridens".

2. Methods

2.1 Scientific Staff

RIVO staff

1. Sytse Ybema (cruise leader)	(whole survey period)
2. Ronald Bol	(whole survey period)
3. Martien Warmerdam	(whole survey period)

Guest researchers

1. Peter Vingaard Larsen	(DIFRES, Denmark, whole survey period)
2. Rasmus Frydenlund Jensen	(DIFRES, Denmark, whole survey period)

Environmental observer

Kate Bradbury	(Ireland, second part of the cruise)

2.2 Narrative

On Monday 7 March Tridens left the port of Scheveningen at 17.00h and headed towards the Bantry Bay, Ireland. On its way the equipment for the calibration was prepared. Arrival at Bantry Bay was Wednesday at 13.00 Dutch time. In total 4 calibrations were performed, taking 4 hours. All were successful (see paragraph "Calibration").
On Thursday 10 March the survey started at the western end of the 49°15 transect where 2 CTD stations were conducted.
Horsemackerel and mackerel registrations were found on the highest part of the shelf edge (200m depth). Later that day at 49.50N a haul on a small trace revealed blue whiting.
From that moment on, blue whiting was present on all transects, near to the shelf edge at a mean depth of 450m.
The Tridens headed for Galway on 16 March, but due to bad weather conditions it was docked on the 17th. Tridens reached the beginning of the next transect on Saturday 19 March (53.15N 11.5W) at 20.00h in order to arrive at the shelf edge of that transect by daylight.
Due to bad weather conditions it was difficult to fish. Unfortunately, at haul 6, the trawl sonar broke down at 400m making interpretation of the acoustic information of that part of the transect less reliable. A next attempt was unsuccessful because the trawl sonar had not yet been repaired. The next day, the sonar was fixed but did not show the net opening well.
By the beginning of 22 March the Tridens steamed towards the Norwegian research vessel G.O. Sars (56.10N 10.59W) where both vessels surveyed over 40 miles parallel to each other. The survey was ended by a simultaneous trawl haul which brought the Tridens 3 tonnes of blue whiting and the G.O. Sars 150 kilos. A post calibration was planned nearby Ullapool but due to a probably broken cable it was executed without success. The raw acoustic data from the intercalibration was handed over to the pilot in Ullapool who would deliver it to the G.O. Sars next Sunday.
The Tridens headed for home and Arrived in Scheveningen a 09.00 on 27 March.

2.3 Survey design

The survey was carried out from 05 March to 25 March 2005, covering an area west of Ireland from latitude 49.15° to 54.45° North and from longitude 11° West to 15° West (Fig. 2.1). A slightly adapted survey design was applied this time, partly based on the blue whiting distribution seen during the survey. Parallel transects along latitudinal lines were used with spacing between the lines set at 30 nm. Acoustic data from transects running north-south close to the shelf edge (that is parallel to the depth isolines) were excluded from the dataset.

After consultation of with the scientific crew of the R/V G.O. Sars it was decided to compress some transects were no blue whiting was to be expected. Since no fish was observed in areas with water depth below 250m, all transects were cut off at the 200m depth contour. CTD stations were planned in advance but extra stations were added at trawling stations to have all stations equally distributed over the research area.
The actual surveyed cruise track and trawl positions are presented in figure 2.2.

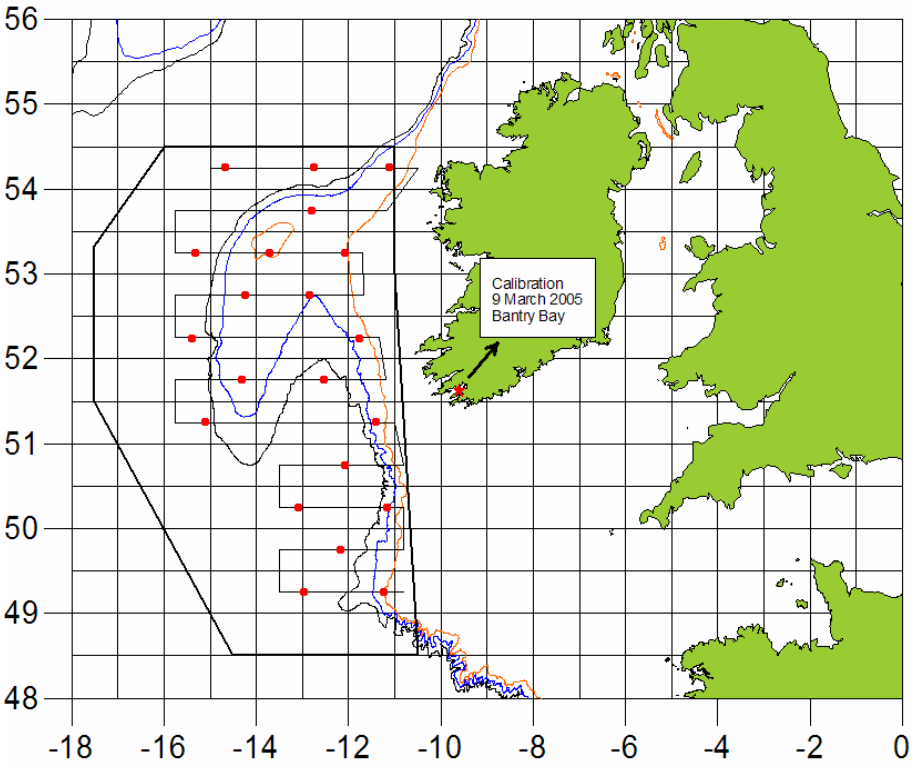


Figure 2.1. Planned cruise tracks and CTD stations. CRD stations are displayed as red dots.

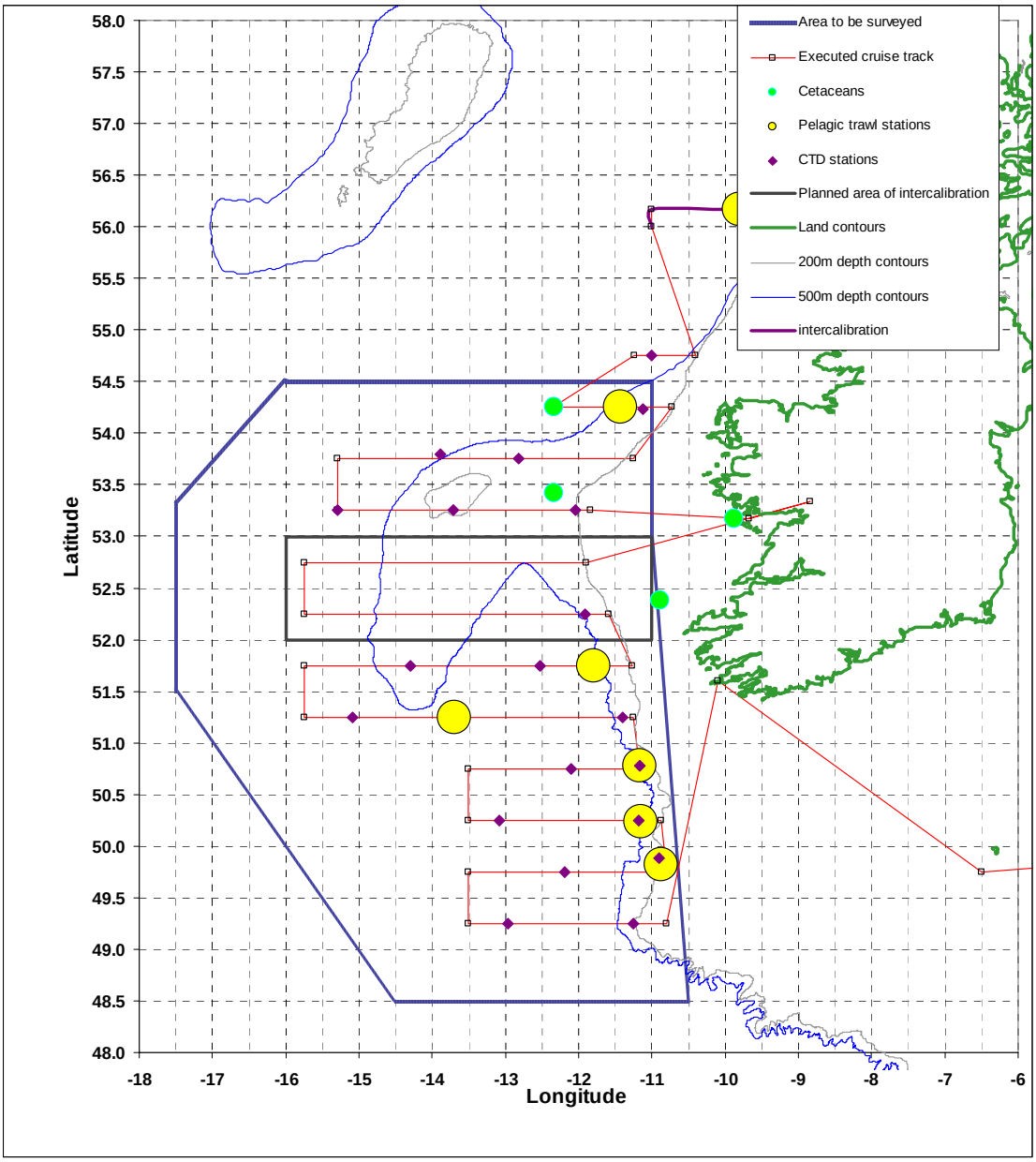


Figure 2.2. Executed cruise track, CTD stations and trawl hauls during the BWHTS 2005.

2.4 Calibrations

Four calibrations were executed successfully:

1. 38 kHz in the towed body: 45min, good results.
2. 38 kHz in the towed body (second calibration): 20min, good results.
3. spare 38 kHz in the towed body: 30min, good results.
4. 38 kHz hull mounted: 120min, good results.

Calibration nr 2. was used for this survey. The results are listed in Appendix A.

An inter-ship calibration was conducted together with the Norwegian R/V “G.O. Sars”. Both ships sailed 40 nautical miles side by side (at a distance of 200m), north of the Porcupine Bank at N 56º 10’ and W 10º 00’ without interfering each others acoustic equipment (Fig. 2.3).

After synchronizing the vessel logs, acoustic densities of blue whiting were then compared for each nautical mile. The weather conditions were rather good, but the wind speed increased rapidly to a near gale from the south. A blue whiting layer was clearly visible throughout the calibration and at a trawl haul was made at a point where the signals were at its strongest. CTD values down to a depth of 500m were compared at the end of the haul.

Following settings were used:

Ship-to-ship distance:	200m
Speed:	10 knots
Pulse duration:	1ms
Stored depth range:	750m
Calibration exercise distance:	40 nautical miles
Comparable CTD depth range:	500m
Fishing duration:	30 minutes

Figure 2.3. Sailing side by side during an intercalibration with the G.O. Sars.

After the intercalibration with the FRV G.O. Sars, a post-survey calibration was performed without success. Problems with the cable are believed to be the cause of signal strength problems. The acoustic image looked very blurry and the bottom detection was not strong enough. A bad weather forecast (gale from the south) made it not worthwhile to redo this calibration.

2.5 Acoustic data collection

A Simrad 38 kHz split beam transducer was operated in a towed body (type “Shark”) 6-7 m under the water surface. The settings of the EK60 are listed in appendix B. Acoustic data were collected with a Simrad EK60 scientific echo sounder. The data were logged with Sonardata Echoview software. The EK60 received the vessel speed from the ship’s GPS. A maximum ping rate was used. The data were logged in 1 nautical mile intervals.
A vessel speed of 11 knots was used on one engine without disturbing the acoustic image. Two engines proved to be unfavourable for data collection.
Low threshold images of entire transects were stored for further qualitative analysis.

2.6 Biological data

The acoustic recordings were verified by fishing with a 5600 mesh pelagic trawl with 20 mm meshes in the cod-end. Fishing was carried out when there was doubt about the species composition of recordings observed on the echo sounder and to obtain biological samples of blue whiting. In general, after it was decided to make a tow with a pelagic trawl, the vessel turned and fished back on its track line.
Fish samples were divided into species by weight. Length measurements were taken to the 1.0 cm below for all species. For blue whiting length representative samples were taken for maturity, age (otolith extraction) and weight.
The effort made by both Danish assistants resulted in more detailed examination of pipefish. In some cases, specimens of non-target species were frozen for species determination in the lab.

2.7 Hydrographical data

Hydrographical data have been collected in 21 CTD stations, (Figure 2.1). In addition, some environmental variables were continuously measured by the ships own “Data acquisition system” (DAS). The continuous measuring sensors had not been calibrated.

2.8 Data analysis

The acoustic values (NASC’s) from each log interval were assigned to the following categories: “blue whiting”, “mesopelagics”, “mackerel” and “zooplankton.
Hydro acoustic – biological and hydrographic data are being stored in the PGNAPES format. Further analysis of the international data will take place in Bergen, Norway, 20 to 22 April 2005.

3. Results

3.1 Acoustic data results

All echoes were recorded with a threshold of -80dB up to a depth of 600 meters below the transducer. All assigned NASC values were distributed as shown in figure 3.1.1.

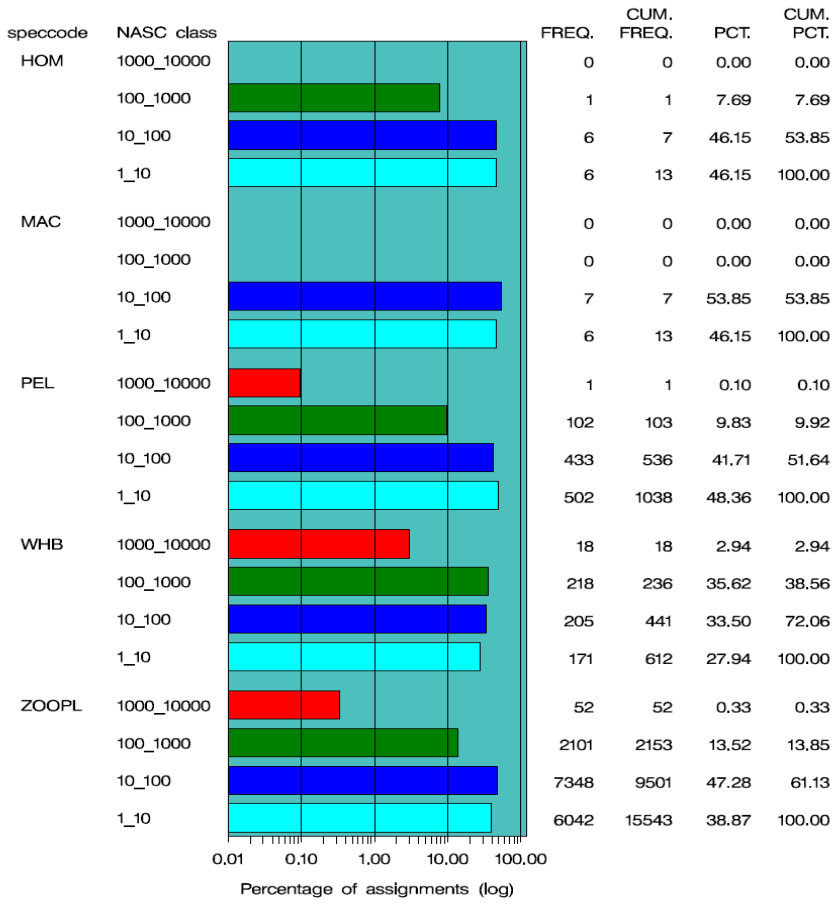


Figure 3.1.1. NASC frequency distribution. NASC values are grouped in logarithmic classes. HOM=horse mackerel, MAC=mackerel, PEL=meso-pelagics, WHB=blue whiting, ZOOPL=zooplankton. Units used are nautical cells (50m height and 1 nauticale mile wide).

The acoustic response of blue whiting was very low but their presence was evident. Further north around the Porcupine bank, schools became more dense and were no longer associated with the bottom (Fig. 3.1.2).

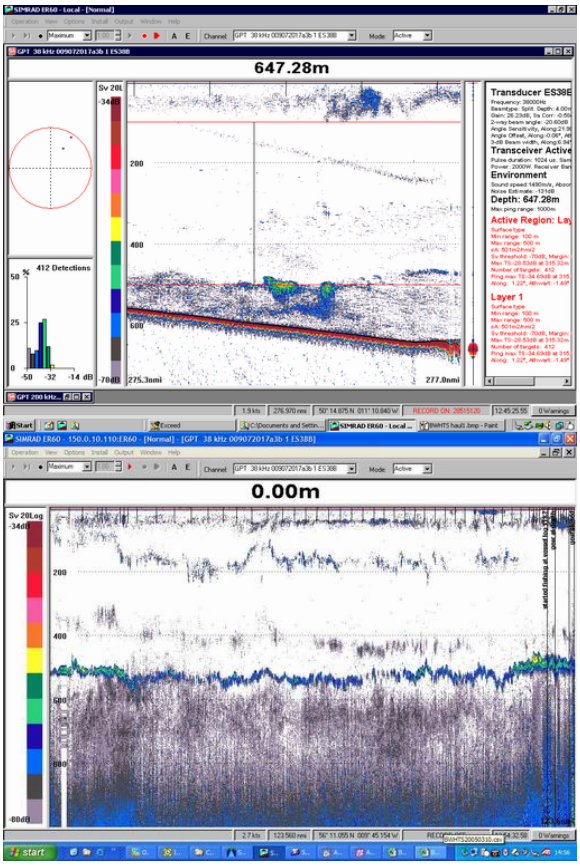


Figure 3.1.2 Echogram showing an example of small schools of blue whiting (green/yellow pattern) along the shelf edge in the south of the survey area (left panel) and large schools detected further away from the shelf edge (right panel). Recorded at respectively 50º14'N – 11º10'W at 11 March and 56º11'N –9º45'W at 22 March 2005.

Horizontal and vertical distribution patterns

Overall, the strongest signals of blue whiting were observed at depths of 400-500m, sometimes extending to around 300m depth (or even shallower) on the slope areas (Fig. 3.1.3 and 3.1.4). In the northern part of the survey area, schools were found further off the slope area.

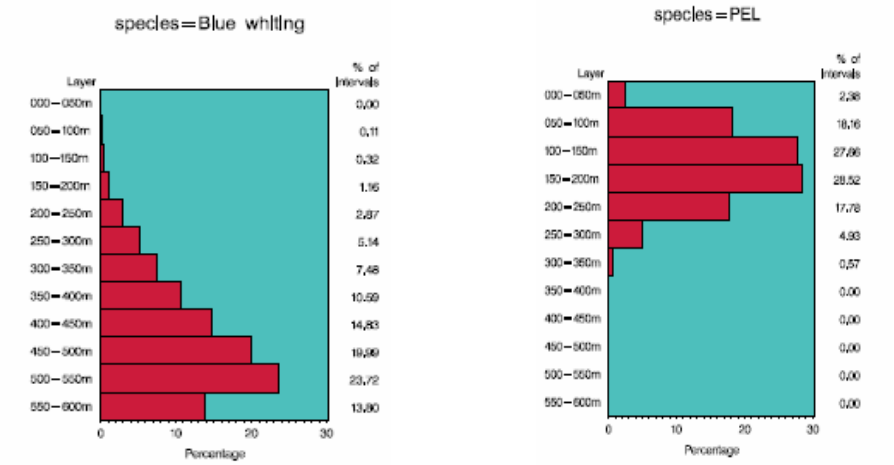


Figure 3.1.3. Vertical distribution pattern of echo's assigned to blue whiting and meso pelagic fish. The red bars show the percentage of intervals in which a species was assigned. PEL= meso-pelagics

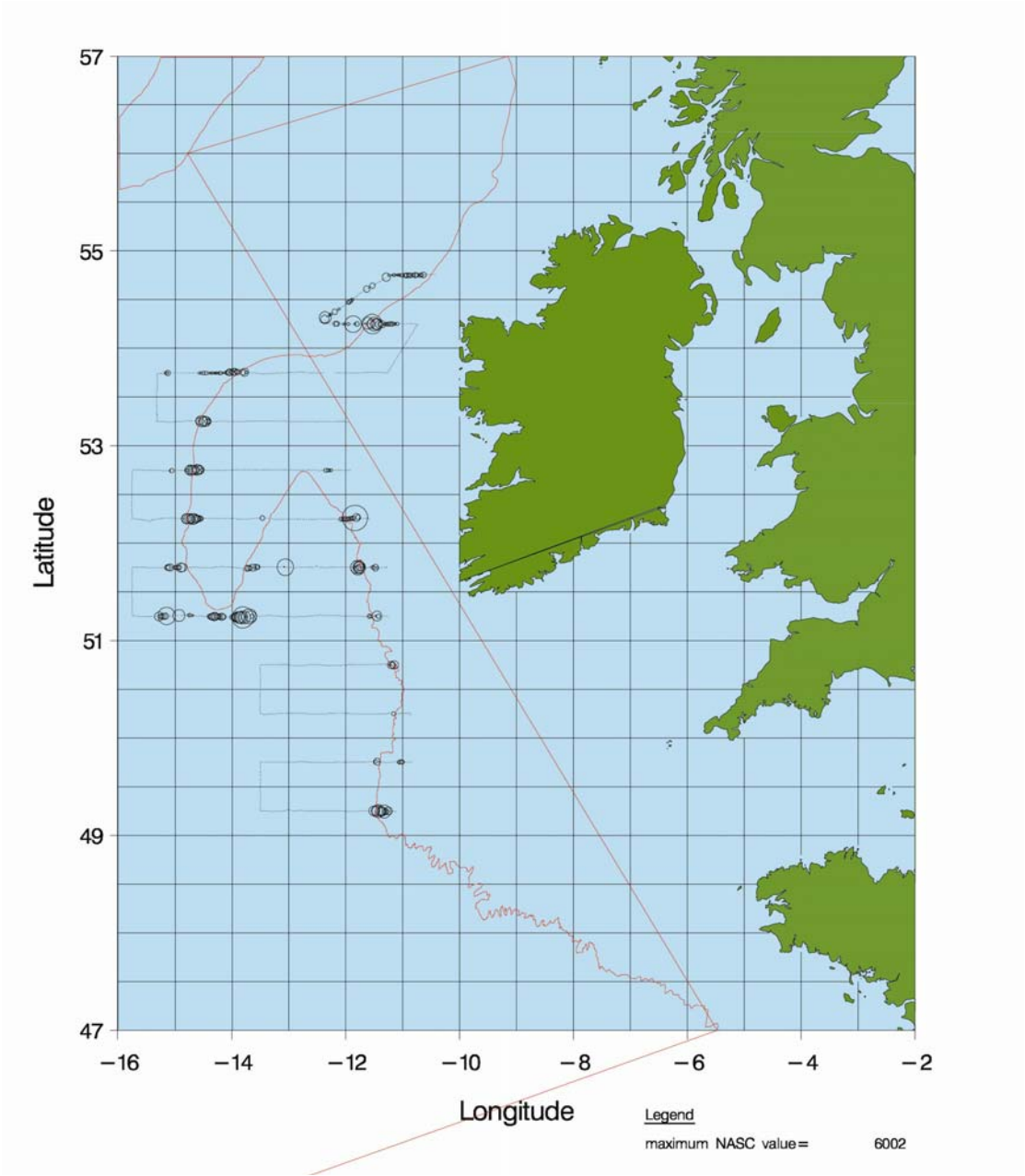


*Figure 3.1.4. Post plot showing the distribution of **total blue whiting** NASC values (on a proportional square root scale relative to the largest value of 6002) obtained during the March 2005 North East Atlantic blue whiting hydro acoustic survey on FRV "Tridens". The red line indicates the 500m depth contour.*

3.2 Trawl data

In all, 8 trawl hauls were conducted (Table 3.2.1). Blue whiting was found in 6 hauls. From every haul containing blue whiting, 50 specimens were taken randomly for measurements of length, weight, sex, maturity and age (otoliths). From all 8 hauls, only 2 were taken in the higher regions of the shelf edge. The first trawl haul consisted mainly of horse mackerel and mackerel but the following hauls were all strongly dominated by blue whiting as shown in table 3.2.2. Blue whiting found along the shelf edge appeared to be smaller in length than specimens from the deeper zones as shown in figure 3.2.3.

Table 3.2.1. Details of the trawl hauls taken during the March 2005 North East Atlantic hydro acoustic survey, FRV "Tridens". *In haul 6 the net sonar broke down during the haul.

Sample	Valid	haul	ICES rect	date	Time GMT	position	haul duration (min)	Depth (m)	Gear depth (m)	Wind direction (degrees)	Wind force (m/s)
5400001	Y	1	28D9	11/03/2005	00:09	49.49N-10.52W	30	180	170	90	3
5400002	Y	2	29D8	11/03/2005	00:16	50.14N-11.09W	40	670	500	359	2
5400003	Y	3	30D8	12/03/2005	00:18	50.45N-11.07W	30	262	250	45	4
5400004	Y	4	31D6	13/03/2005	00:08	51.15N-13.42W	45	750	412	359	2
5400005	Y	5	32D8	14/03/2005	00:10	51.45N-11.45W	120	510	452	150	12
5400006*	N	6	36D6	20/03/2005	00:16	53.45N-13.59W	65	800	n.a.	120	12
5400007	Y	7	31D8	21/03/2005	00:11	51.14N-11.26W	65	475	380	150	4
5400008	Y	8	41E0	22/03/2005	00:13	56.10N-09.47W	65	1640	450	135	5

	5400001	5400002	5400003	5400004	5400005	5400006	5400007	5400008
Alfonsino		0.176						
Blackfish		0.96						0.754
Blue whiting	**0.032**	**1027**	**1683**	**485**	**923**		**1065.43**	**2042**
Deal-fish				1.8				
Eledone cirrhosa		0.024		0.269			0.394	
Greater argentine		0.022			2.035		0.332	
Snake pipefish		0.032	0.026	0.108	0.078		0.013	0.005
Hachetfish		0.735		0.028			0.148	0.056
Hake	6		22.42					
Horse mackerel	3562		0.875		0.18			
Mackerel	984.505	0.715	16		2.06			
Notoscopelus kroeyeri		2.15	0.101	1.26	2.2		0.97	0.06
Palaemon serratus		0.002						
Pearl side				0.004				

Table 3.2.2 Trawl catches during the March 2005 North East Atlantic hydro acoustic survey, FRV "Tridens" in kg. Scientific and English species names are listed in appendix E.

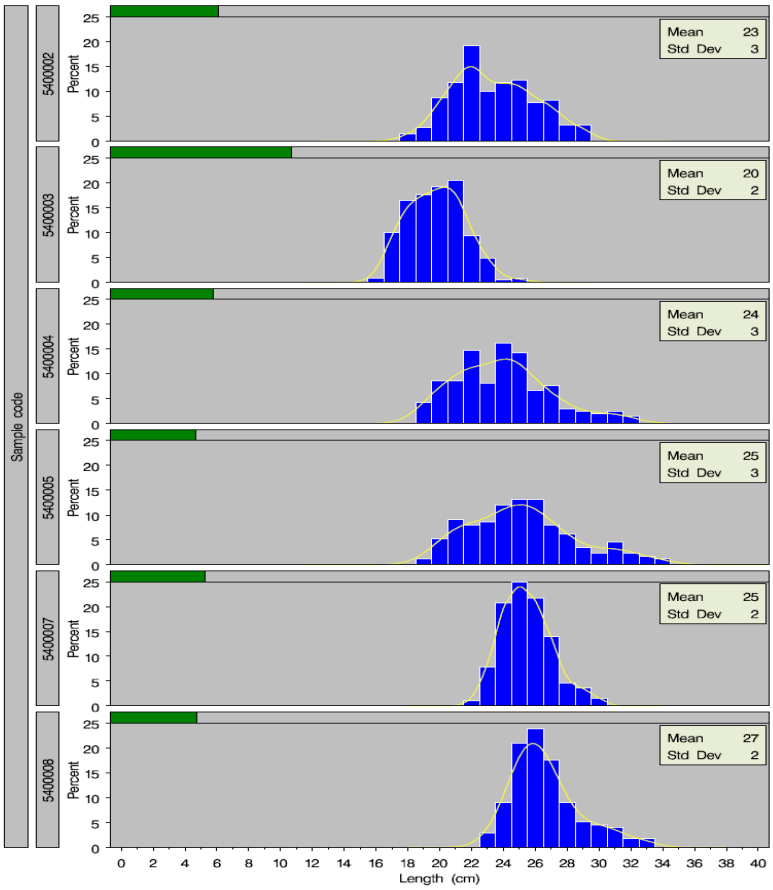


Figure 3.2.1. Length frequency distributions of blue whiting. Smoothing is obtained by normal kernel density estimates. The green bars indicate the relative amount of samples used.

3.3 Biological data

In total 300 biological samples were collected and used for length, age and maturity keys (Appendix C). An overview of these samples is shown below (Table 3.3.1).

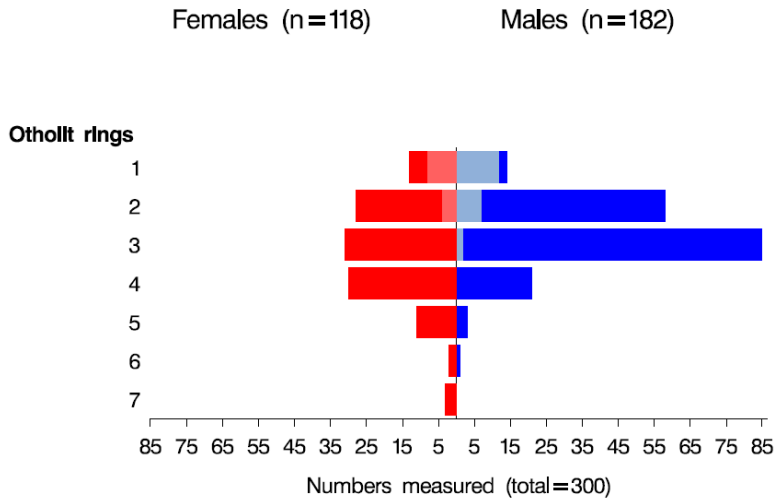


Figure 3.3.1 Overview of collected biological samples of blue whiting by haul during the March 2005 North East Atlantic hydro acoustic survey, FRV "Tridens". The light shaded colours respresent juveniles.

Overall, most of the blue whiting were mature 3 year olds (40%). By the age of 3 years almost all blue whiting is mature (Fig. 3.3.2).

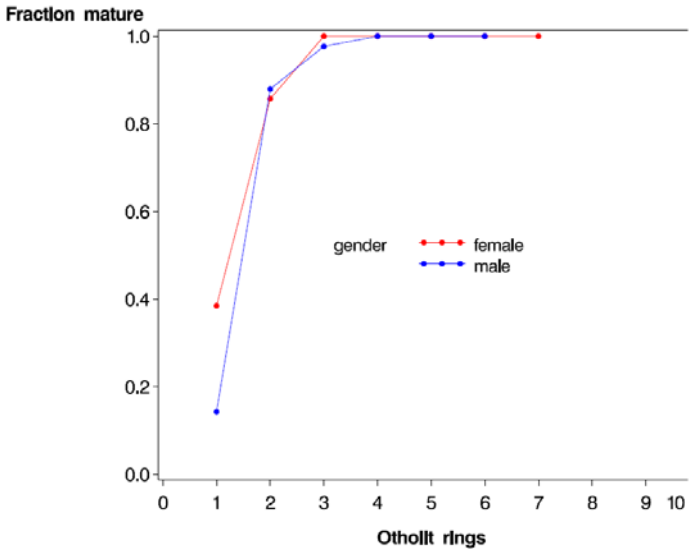


Figure 3.3.2. Maturity related to otholit rings.

Condition
An overall length-weight relationship log(W)=intercept + slope*(log(L) observed during this survey was compared to the relationship used at RIVO institute.

intercept_RIVO	intercept_BWHTS	slope_RIVO	slope_BWHTS
-2.657577319	-2.704145289	3.3892	3.266478528

Growth
Growth of blue whiting is represented by the following "Von Bertalanffy growth curve:
length=L(t) = L_{inf} (1 - exp[-K(t-to)]),
Where L(t)= length at age 't' in cm, T=age in years, K=constant

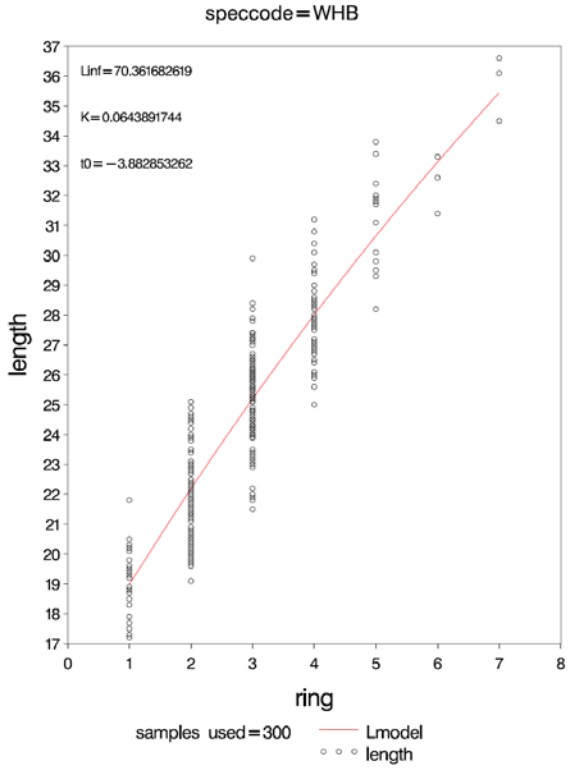


Figure 3.3.3 Von Bertalanffy growth curve.

3.4 Intercalibration

The intercalibration with the G.O. Sars was performed successfully, but there was a discrepancy in acoustic values and age reading.

- The acoustic signals observed by the Tridens were on average 5 times lower than the signals observed by the G.O. Sars, but the acoustic densities showed a very similar pattern. Having a closer look at the raw data, revealed the possibility of a non-continuous damage. Some quadrants in the splitbeam transducer may not have worked properly. This pattern, based on the appearance pattern of the TS values in the transverse section of the beam, could be seen throughout the data files from 19 March onwards when the Tridens restarted the survey after a break in Galway. A NASC frequency distribution, plotted by day, is shown in appendix D to indicate changes in assigned values of zooplankton. Zooplankton is believed to be more evenly distributed over the survey area. Both observations, mentioned here indicate a change in hardware behaviour from 19 March on.

- The results of a simultaneous trawl haul showed a difference in otholit age readings of approximately 1 year. This issue has been discussed at the post-survey meeting in Bergen in April 2005.
- CTD results have yet to be compared.
- Both vessels towed to the same direction at a distance of about half nautical mile apart. Tridens towed at depth of 450 m for 30 minutes and caught 3000 kg of blue whiting. G. O. Sars towed for 20 minutes at depths of 450-500 metres and caught 150 kg of blue whiting (first cod-end towed for 10 min: 70 kg; second cod-end towed for 10 min: 80 kg). More information on data comparison can be found in the cruise report of R/V G.O. Sars.

3.8 CTD data & data acquisition system

CTD measurements showed a highly homogenous water mass in temperature. The CTD probe experienced some minor damage which resulted in blank data points at lower depth during some measurements.

On board of the Tridens, several environmental variables are continuously measured such as water and air temperature, air pressure, wind speed and direction and more. Most of the used sensors have not been calibrated properly but nevertheless, the results of these measurements can give a more complete image of the surrounding environment in which the fish research has taken place. The water temperature at the surface has been plotted as an example to show the movement of the relative warm “North East Atlantic Drift” along the Porcupine Bank (Fig. 3.8.1).

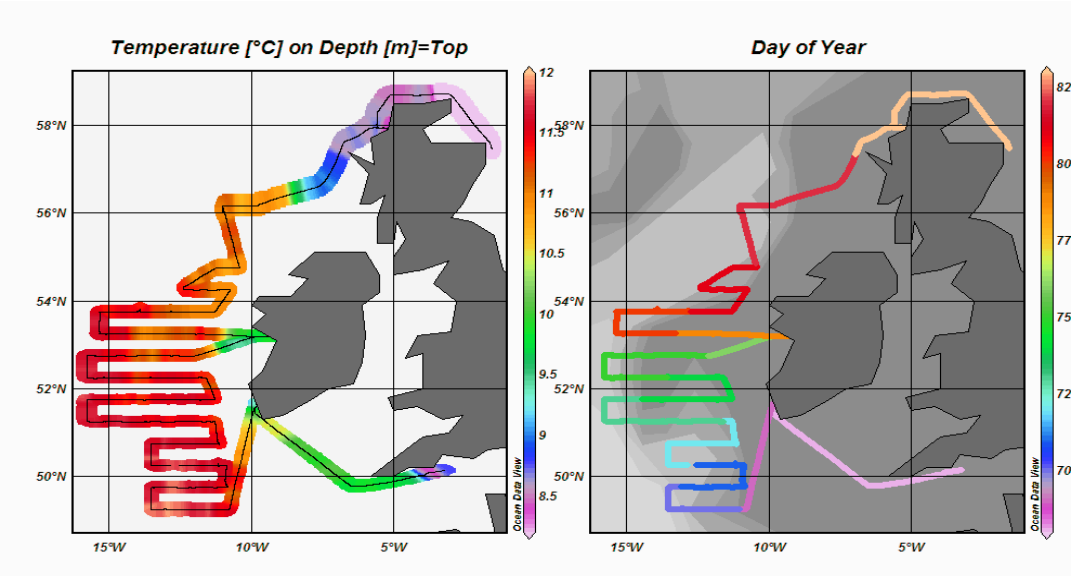


Figure 3.8.1. Surface temperature collected with the data acquisition system during the March 2005 North East Atlantic hydro acoustic survey for blue whiting, FRV “Tridens”. The days of the year have been plotted aside to indicate the time span.

4. Conclusion & recommendations

The survey was successfully completed. All calibrations had good results and all planned transects were covered. Due to relative good weather conditions more CTD samples could be taken.
The survey had a strong international character which was good for the moral. In contradiction to 2004, Tridens found blue whiting all the way down to 49ºN. In the southern part of the survey area, blue whiting was found only on the slope of the shelf. A similar pattern was found in 2004 but not as evident as this year.

Improvements compared to 2004:

- Towing and lifting construction of the towed body has been improved. It is now possible to change cables while surveying.
- A spare transducer was available and calibrated successfully.
- The ships LAN network was used intensively and made it easy to share data quickly.
- This cruise had a strong international character due to better communications with both the Dutch fishing fleet as the R/V G.O. Sars. Some minor adaptations of the cruise design have been made as a result of this communication.
- For the first time, surface temperature was measured continuously. CTD data has not been analysed completely, but primarily results show a highly homogenous water mass for temperature. Therefore, temperature measurement at the surface gives a good indication of the temperature in deep water layers.

Recommendations for 2006:

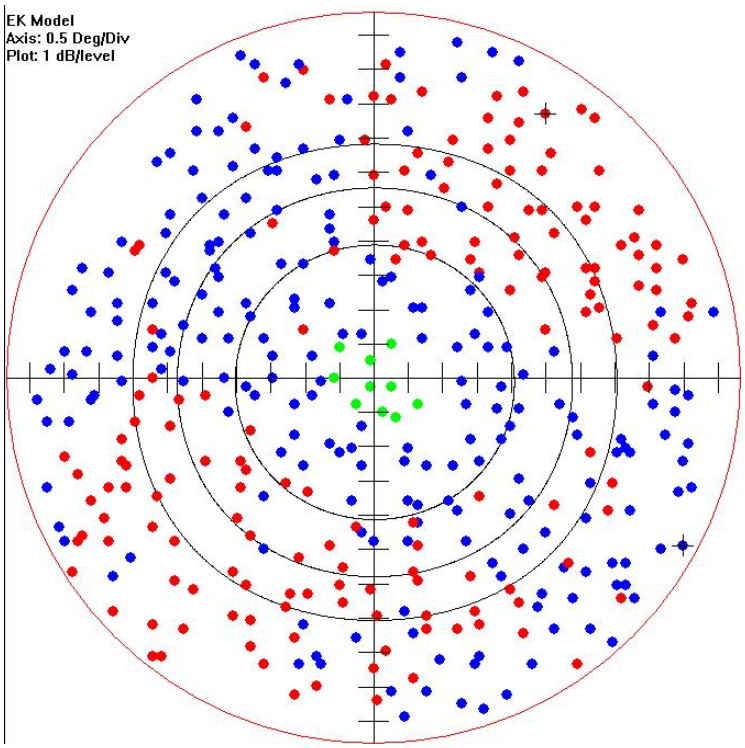
- Without the extra effort of assistants and the help of our Danish colleagues, this survey could not have been executed. This survey requires a fully skilled research team.
- Raw data was recorded down to a depth of 500m which proved to be not sufficient. Next year the standard depth will be set to 750m.
- Age determination was different from the method used onboard the R/V G.O. Sars. RIVO age readers have attended a workshop for age reading in Hirtshals in June 2005.
- All cable connections will be checked frequently during high and low tension.
- Bring both 5600 and 4300 mesh size nets.
- Maximum cruise speed is set to 10.5 knts to avoid cable damage.

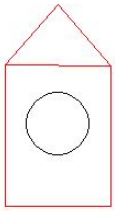
Acknowledgements

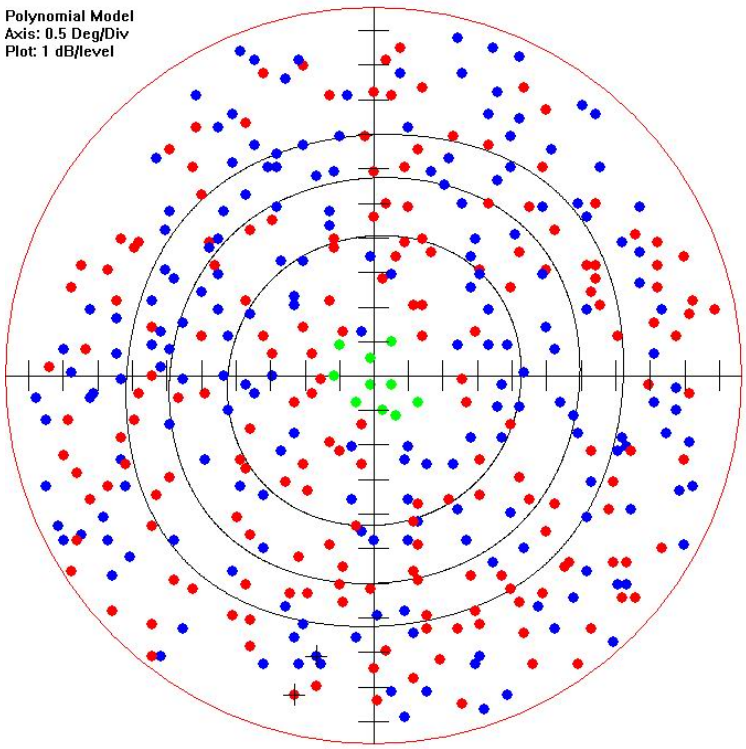
The main technician in acoustic work was absent this year, but thanks to the extra effort made by RIVO assistant Bol, most technical issues of the towed body were handled with success.
Partly due to the enthusiasm of RIVO assistant Warmerdam a high priority has been given to both analysis and display data from the “Data AquisitionSystem” on board the Tridens.

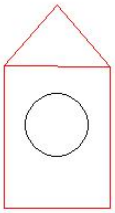
Appendix A. Calibration results

Calibration Version 2.1.0.11
#
Date: 3/9/2005
#
Comments:
Blauwe wijtingsurvey Bantry baai. Ping rate 1ms. Poging 2
#
Reference Target:
TS -33.60 dB Min. Distance 10.00 m
TS Deviation 4.0 dB Max. Distance 14.00 m
#
Transducer: ES38B Serial No. 30501
Frequency 38000 Hz Beamtype Split
Gain 26.50 dB Two Way Beam Angle -20.6 dB
Athw. Angle Sens. 21.90 Along. Angle Sens. 21.90
Athw. Beam Angle 7.10 deg Along. Beam Angle 7.10 deg
Athw. Offset Angle 0.00 deg Along. Offset Angle 0.00 deg
SaCorrection 0.00 dB Depth 4.00 m
#
Transceiver: GPT 38 kHz 009072017a3b 1 ES38B
Pulse Duration 1.024 ms Sample Interval 0.191 m
Power 2000 W Receiver Bandwidth 2.43 kHz
#
Sounder Type:
EK60 Version 2.1.1
#
TS Detection:
Min. Value -50.0 dB Min. Spacing 100 %
Max. Beam Comp. 6.0 dB Min. Echolength 80 %
Max. Phase Dev. 8.0 Max. Echolength 180 %
#
Environment:
Absorption Coeff. 10.0 dB/km Sound Velocity 1489.7 m/s
#
Beam Model results:
Transducer Gain = 26.23 dB SaCorrection = -0.58 dB
Athw. Beam Angle = 7.04 deg Along. Beam Angle = 6.94 deg
Athw. Offset Angle = 0.01 deg Along. Offset Angle=-0.06 deg
#
Data deviation from beam model:
RMS = 0.15 dB
Max = 0.51 dB No. = 156 Athw. = 2.5 deg Along = 3.9 deg
Min = -0.55 dB No. = 326 Athw. = 4.5 deg Along = -2.4 deg
#
Data deviation from polynomial model:
RMS = 0.10 dB
Max = 0.41 dB No. = 199 Athw. = -1.2 deg Along = -4.6 deg
Min = -0.62 dB No. = 203 Athw. = -0.8 deg Along = -4.0 deg


EK Model
Axis: 0.5 Deg/Div
Plot: 1 dB/level




Polynomial Model
Axis: 0.5 Deg/Div
Plot: 1 dB/level



Appendix B. EK60 settings

Transceiver menu	
Absorption coefficient	9.6 dB/km
SA correction	-0.58 dB
Pulse length	1.024 ms
Bandwidth	2.43 kHz
Max Power	2000 W
Two-way beam angle	-20.6 dB
3 dB Beam width	7.10 dg
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	10.00 m
Transducer gain	26.50 dB
Calibration factor for NASC's	-
Log/Navigation Menu	
Speed, position, vessel log	Serial from ship's GPS
Operation Menu	
Ping interval (s)	maximum
Display/Printer Menu	
TVG	20 log R
Integration line	N/A
TS colour min.	-50 dB
Sv colour min.	-70 dB

Appendix C. Age/maturity-length key for blue whiting – All strata

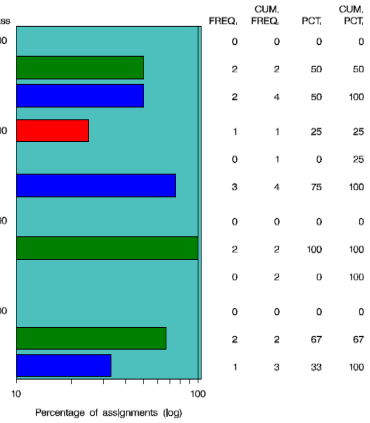
length	1imm	1mat	2imm	2mat	3imm	3mat	4imm	4mat	5imm	5mat	6imm	6mat	7imm	7mat
17.2	1													
17.3	1													
17.5	1													
17.7	1													
17.9	1													
18.3	2													
18.5	2													
18.7	1													
18.8	3													
18.9	1													
19.1			1											
19.2		1												
19.3	1													
19.4	1													
19.5	1													
19.6		1	1											
19.7			1											
19.8	1			1										
19.9			3											
20			1											
20.1	1			2										
20.2		1		1										
20.3		3	1	1										
20.4				1										
20.5		1		1										
20.6				1										
20.7			2											
20.8				2										
20.9				2										
21.1				2										
21.2				3										
21.3				2										
21.4				2										
21.5				3	1									
21.6				1										
21.7				1										
21.8	1			4		1								
21.9				2		1								
22				1		1								
22.1				3										
22.2				3		1								
22.3				1										
22.4				6										
22.5			1	2										
22.7				1										
22.8				5										
22.9				1		1								
23				2		1								
23.1				1		1								
23.2						1								
23.3					1									
23.4				1		1								
23.5				1		1								
23.8				2										
23.9				4		3								
24				1		2								
24.1						2								
24.2				1		3								
24.3						2								
24.4				1		1								
24.5				1		6								
24.6				1		2								
24.7				1		3								
24.8						3								
24.9				2		2								
25								1						

length	1imm	1mat	2imm	2mat	3imm	3mat	4imm	4mat	5imm	5mat	6imm	6mat	7imm	7mat
25.1				1		2								
25.2						6								
25.3						5								
25.4						3								
25.5						5								
25.6						4		2						
25.7						1								
25.8						5								
25.9						5		2						
26						3		1						
26.1						4		2						
26.2						6								
26.3						1								
26.4						2		1						
26.5						5		3						
26.6						2								
26.7						2		2						
26.8								1						
26.9								1						
27						1		3						
27.1						1		2						
27.2						2		2						
27.3						1								
27.4						2								
27.5								2						
27.6								1						
27.7								4						
27.8						1		2						
27.9						2		1						
28								1						
28.2						2		1		1				
28.3								1						
28.4						1		1						
28.5								2						
28.6								1						
28.8								1						
29								2						
29.3										1				
29.4								2						
29.5								1		1				
29.7								1						
29.8										1				
29.9						1								
30.1								1		2				
30.4								1						
30.8								1						
31.1										1				
31.2								1						
31.4												1		
31.7										1				
31.8										1				
31.9										1				
32										1				
32.4										1				
32.6												1		
33.3												1		
33.4										1				
33.8										1				
34.5														1
36.1														1
36.6														1

Appendix D. NASC frequency distribution by day

speccode = HOM

day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	100_1000	0	0	0	0
	10_100	2	2	50	50
	1_10	2	4	50	100
11	100_1000	1	1	25	25
	10_100	0	1	0	25
	1_10	3	4	75	100
14	100_1000	0	0	0	0
	10_100	2	2	100	100
	1_10	0	2	0	100
21	100_1000	0	0	0	0
	10_100	2	2	67	67
	1_10	1	3	33	100

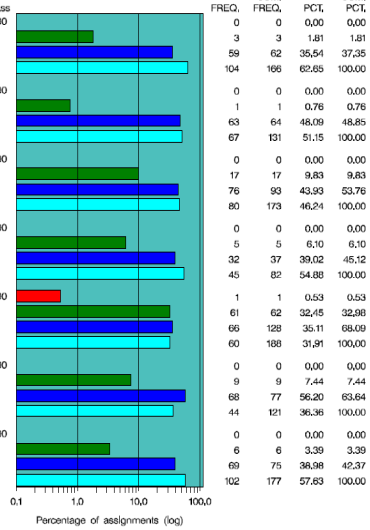


speccode = MAC

day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	10_100	2	2	50	50
	1_10	2	4	50	100
11	10_100	1	1	25	25
	1_10	3	4	75	100
14	10_100	2	2	100	100
	1_10	0	2	0	100
21	10_100	2	2	67	67
	1_10	1	3	33	100

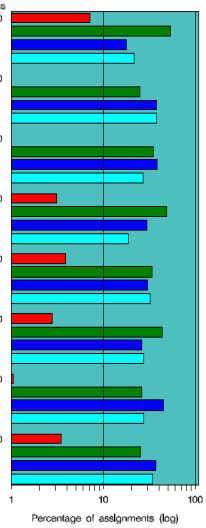
speccode = PEL

day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	1000_10000	0	0	0,00	0,00
	100_1000	3	3	1,81	1,81
	10_100	59	62	35,54	37,35
	1_10	104	166	62,65	100,00
12	1000_10000	0	0	0,00	0,00
	100_1000	1	1	0,76	0,76
	10_100	63	64	48,09	48,85
	1_10	67	131	51,15	100,00
13	1000_10000	0	0	0,00	0,00
	100_1000	17	17	9,83	9,83
	10_100	76	93	43,93	53,76
	1_10	80	173	46,24	100,00
14	1000_10000	0	0	0,00	0,00
	100_1000	5	5	6,10	6,10
	10_100	32	37	39,02	45,12
	1_10	45	82	54,88	100,00
15	1000_10000	1	1	0,53	0,53
	100_1000	61	62	32,45	32,98
	10_100	66	128	35,11	68,09
	1_10	60	188	31,91	100,00
20	1000_10000	0	0	0,00	0,00
	100_1000	9	9	7,44	7,44
	10_100	68	77	56,20	63,64
	1_10	44	121	36,36	100,00
21	1000_10000	0	0	0,00	0,00
	100_1000	6	6	3,39	3,39
	10_100	69	75	38,98	42,37
	1_10	102	177	57,63	100,00



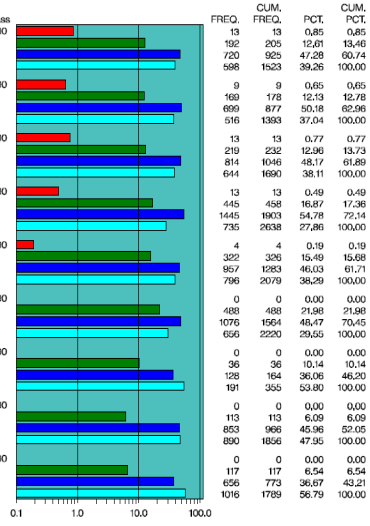
speccode = WHB

day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	1000_10000	2	2	7.14	7.14
	100_1000	15	17	53.57	60.71
	10_100	5	22	17.86	78.57
	1_10	6	28	21.43	100.00
11	1000_10000	0	0	0.00	0.00
	100_1000	4	4	25.00	25.00
	10_100	6	10	37.50	62.50
	1_10	6	16	37.50	100.00
12	1000_10000	0	0	0.00	0.00
	100_1000	9	9	34.62	34.62
	10_100	10	19	38.46	73.08
	1_10	7	26	26.92	100.00
13	1000_10000	4	4	3.13	3.13
	100_1000	62	66	48.44	51.56
	10_100	38	104	29.69	81.25
	1_10	24	128	18.75	100.00
14	1000_10000	4	4	3.88	3.88
	100_1000	35	39	33.98	37.86
	10_100	31	70	30.10	67.96
	1_10	33	103	32.04	100.00
15	1000_10000	2	2	2.74	2.74
	100_1000	32	34	43.84	46.58
	10_100	19	53	26.03	72.60
	1_10	20	73	27.40	100.00
20	1000_10000	1	1	1.05	1.05
	100_1000	25	26	26.32	27.37
	10_100	43	69	45.26	72.63
	1_10	26	95	27.37	100.00
21	1000_10000	5	5	3.50	3.50
	100_1000	36	41	25.17	28.67
	10_100	53	94	37.06	65.73
	1_10	49	143	34.27	100.00

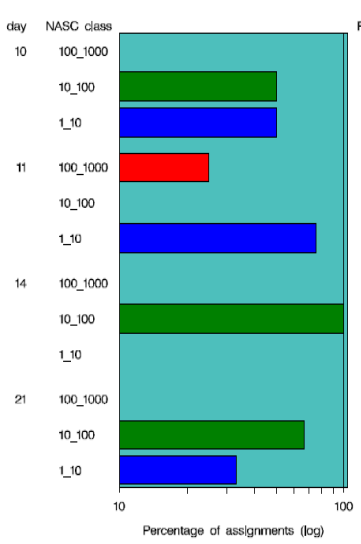


speccode = ZOOPL

day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	1000_10000	13	13	0,85	0,85
	100_1000	192	205	12,61	13,46
	10_100	720	925	47,28	60,74
	1_10	598	1523	39,26	100,00
11	1000_10000	9	9	0,65	0,65
	100_1000	169	178	12,13	12,78
	10_100	699	877	50,18	62,96
	1_10	516	1393	37,04	100,00
12	1000_10000	13	13	0,77	0,77
	100_1000	219	232	12,96	13,73
	10_100	814	1046	48,17	61,89
	1_10	644	1690	38,11	100,00
13	1000_10000	13	13	0,49	0,49
	100_1000	445	458	16,87	17,36
	10_100	1445	1903	54,78	72,14
	1_10	735	2638	27,86	100,00
14	1000_10000	4	4	0,19	0,19
	100_1000	322	326	15,49	15,68
	10_100	957	1283	46,03	61,71
	1_10	796	2079	38,29	100,00
15	1000_10000	0	0	0,00	0,00
	100_1000	488	488	21,98	21,98
	10_100	1076	1564	48,47	70,45
	1_10	656	2220	29,55	100,00
19	1000_10000	0	0	0,00	0,00
	100_1000	36	36	10,14	10,14
	10_100	128	164	36,06	46,20
	1_10	191	355	53,80	100,00
20	1000_10000	0	0	0,00	0,00
	100_1000	113	113	6,09	6,09
	10_100	853	966	45,96	52,05
	1_10	890	1856	47,95	100,00
21	1000_10000	0	0	0,00	0,00
	100_1000	117	117	6,54	6,54
	10_100	656	773	36,67	43,21
	1_10	1016	1789	56,79	100,00

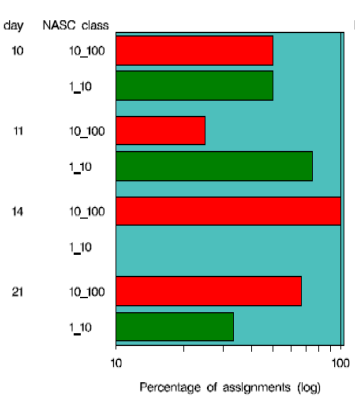


speccode = HOM



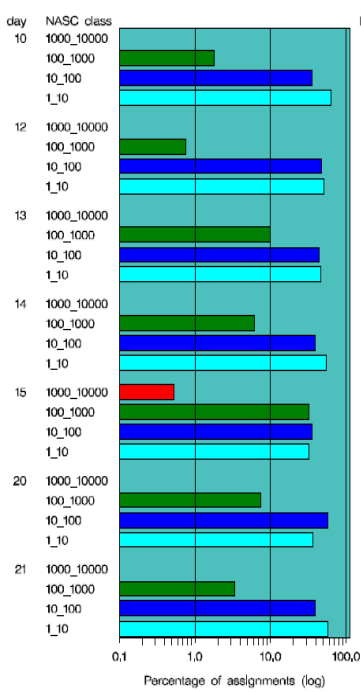
day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	100_1000	0	0	0	0
	10_100	2	2	50	50
	1_10	2	4	50	100
11	100_1000	1	1	25	25
	10_100	0	1	0	25
	1_10	3	4	75	100
14	100_1000	0	0	0	0
	10_100	2	2	100	100
	1_10	0	2	0	100
21	100_1000	0	0	0	0
	10_100	2	2	67	67
	1_10	1	3	33	100

speccode = MAC



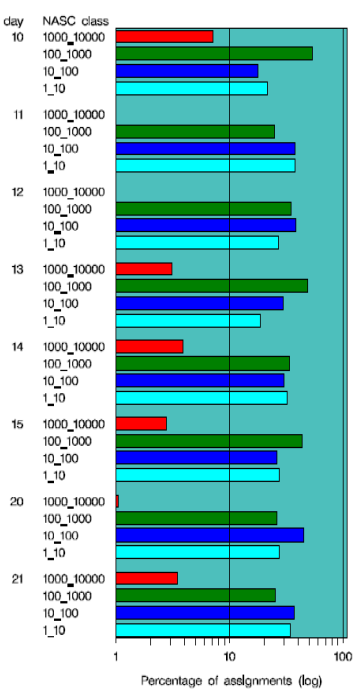
day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	10_100	2	2	50	50
	1_10	2	4	50	100
11	10_100	1	1	25	25
	1_10	3	4	75	100
14	10_100	2	2	100	100
	1_10	0	2	0	100
21	10_100	2	2	67	67
	1_10	1	3	33	100

speccode = PEL



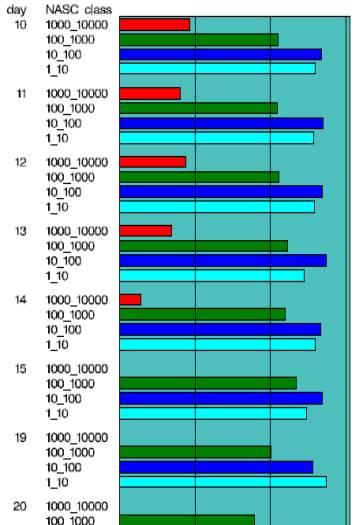
day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	1000_10000	0	0	0,00	0,00
	100_1000	3	3	1.81	1.81
	10_100	59	62	35,54	37,35
	1_10	104	166	62.65	100.00
12	1000_10000	0	0	0.00	0.00
	100_1000	1	1	0.76	0.76
	10_100	63	64	48.09	48.85
	1_10	67	131	51.15	100.00
13	1000_10000	0	0	0,00	0,00
	100_1000	17	17	9,83	9,83
	10_100	76	93	43,93	53,76
	1_10	80	173	46,24	100,00
14	1000_10000	0	0	0,00	0,00
	100_1000	5	5	6,10	6,10
	10_100	32	37	39,02	45,12
	1_10	45	82	54,88	100,00
15	1000_10000	1	1	0.53	0.53
	100_1000	61	62	32,45	32,98
	10_100	66	128	35.11	68.09
	1_10	60	188	31,91	100,00
20	1000_10000	0	0	0,00	0,00
	100_1000	9	9	7,44	7,44
	10_100	68	77	56,20	63,64
	1_10	44	121	36,36	100,00
21	1000_10000	0	0	0.00	0.00
	100_1000	6	6	3.39	3.39
	10_100	69	75	38,98	42,37
	1_10	102	177	57.63	100.00

speccode = WHB



day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	1000_10000	2	2	7.14	7.14
	100_1000	15	17	53.57	60.71
	10_100	5	22	17.86	78.57
	1_10	6	28	21.43	100.00
11	1000_10000	0	0	0.00	0.00
	100_1000	4	4	25.00	25.00
	10_100	6	10	37.50	62.50
	1_10	6	16	37.50	100.00
12	1000_10000	0	0	0.00	0.00
	100_1000	9	9	34.62	34.62
	10_100	10	19	38.46	73.08
	1_10	7	26	26.92	100.00
13	1000_10000	4	4	3.13	3.13
	100_1000	62	66	48.44	51.56
	10_100	38	104	29.69	81.25
	1_10	24	128	18.75	100.00
14	1000_10000	4	4	3.88	3.88
	100_1000	35	39	33.98	37.86
	10_100	31	70	30.10	67.96
	1_10	33	103	32.04	100.00
15	1000_10000	2	2	2.74	2.74
	100_1000	32	34	43.84	46.58
	10_100	19	53	26.03	72.60
	1_10	20	73	27.40	100.00
20	1000_10000	1	1	1.05	1.05
	100_1000	25	26	26.32	27.37
	10_100	43	69	45.26	72.63
	1_10	26	95	27.37	100.00
21	1000_10000	5	5	3.50	3.50
	100_1000	36	41	25.17	28.67
	10_100	53	94	37.06	65.73
	1_10	49	143	34.27	100.00

speccode = ZOOPL

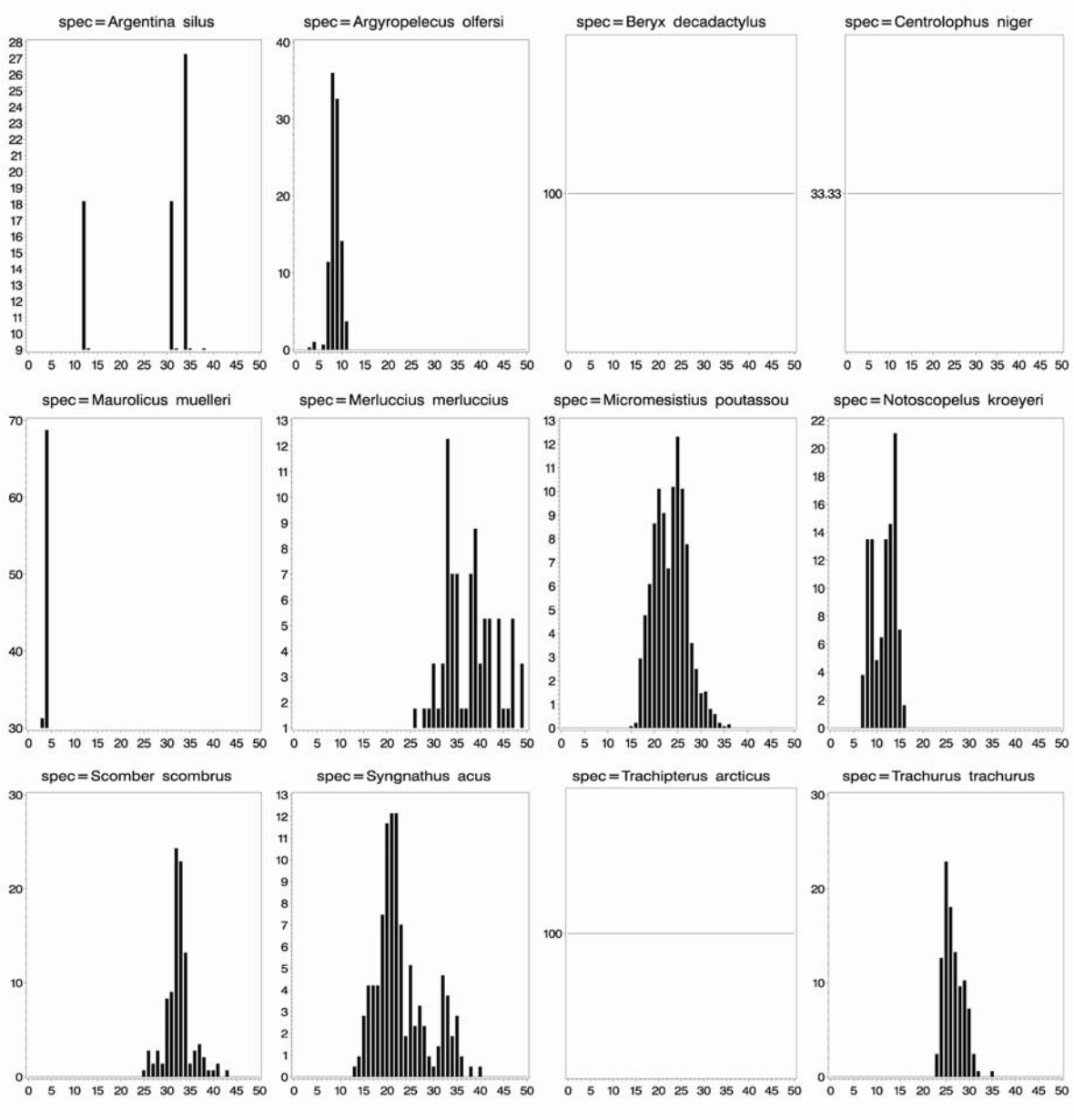


day	NASC class	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
10	1000_10000	13	13	0,85	0,85
	100_1000	192	205	12,61	13,46
	10_100	720	925	47.28	60.74
	1_10	598	1523	39.26	100.00
11	1000_10000	9	9	0,65	0,65
	100_1000	169	178	12.13	12.78
	10_100	699	877	50.18	62.96
	1_10	516	1393	37.04	100.00
12	1000_10000	13	13	0.77	0.77
	100_1000	219	232	12.96	13.73
	10_100	814	1046	48.17	61.89
	1_10	644	1690	38.11	100.00
13	1000_10000	13	13	0.49	0.49
	100_1000	445	458	16.87	17.36
	10_100	1445	1903	54.78	72.14
	1_10	735	2638	27.86	100.00
14	1000_10000	4	4	0.19	0.19
	100_1000	322	326	15.49	15.68
	10_100	957	1283	46.03	61.71
	1_10	796	2079	38.29	100.00
15	1000_10000	0	0	0.00	0.00
	100_1000	488	488	21.98	21.98
	10_100	1076	1564	48.47	70.45
	1_10	656	2220	29.55	100.00
19	1000_10000	0	0	0.00	0.00
	100_1000	36	36	10.14	10.14
	10_100	128	164	36.06	46.20
	1_10	191	355	53.80	100.00
20	1000_10000	0	0	0,00	0,00
	100_1000	113	113	6.09	6.09

Appendix E. Species names

Scientific name	English name
Argentina silus	Greater argentine
Argyropelecus olfersi	Hachetfish
Beryx decadactylus	Alfonsino
Centrolophus niger	Blackfish
Maurolicus muelleri	Pearl side
Merluccius merluccius	Hake
Micromesistius poutassou	Blue whiting
Notoscopelus kroeyeri	Lancet fish
Scomber scombrus	Mackerel
Entelurus *aequoreus*	Snake pipefish
Trachipterus arcticus	Deal-fish
Trachurus trachurus	Horse mackerel

Appendix F. Length frequency distributions



Syngnatathus acus should be : Entelurus aequoreus

Appendix G. Collection of pipe fish

Preservation:
All specimens of pipefish which were caught during the survey were collected. Some specimens were trapped in the net and were not examined. In total 214 pipefish from 6 hauls were frozen or preserved on formaline for a more thorough determination in the lab. When available, a sample of 25 specimens was weighted and frozen. The remainder per haul was stored on formaline.

Determination:
All specimens of pipefish have been recorded as Entelurus *aequoreus* but determination was thought to be inconclusive. The specimens may belong to another species (i.e. Syngnathus *spec*.).

Both Clofnam and a guide called "The fishes of the British Isles and North-West Europe" from Wheeler (1969) were used for determination.
Fig. 3.5.1 shows the shape of the head.The lengths of snout compared to the length of the head was recorded. The dorsal fin rays (42) were counted. It was impossible to distinguish body rings which is an important issue in both keys.

Figure 3.5.1 Close up image of pipefish which was caught in nearly all hauls during the March 2005 North East Atlantic hydro acoustic survey for blue whiting, FRV "Tridens".

Fertility:

Just 3 of all 214 specimens were carrying eggs from which just one had embryos, which were clearly visible (Fig. 3.5.2). It could well be that the eggs of other specimens had fallen off.

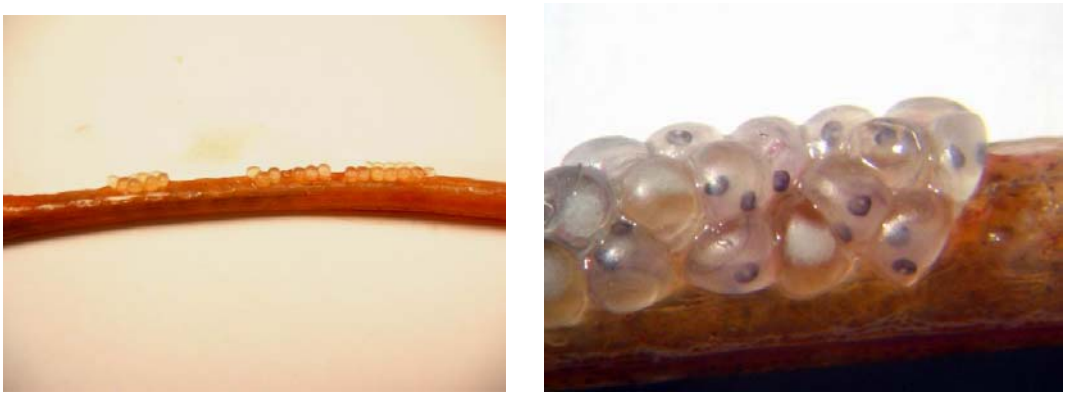


Figure 3.5.2. Eggs, some with visible embryos, carried around by 3 of the 214 pipefish caught during the March 2005 North East Atlantic hydro acoustic survey for blue whiting, FRV "Tridens".

Length frequency distributions:

In total 214 pipefish were collected and used for further analysis (Fig. 3.5.3 and 3.5.4).

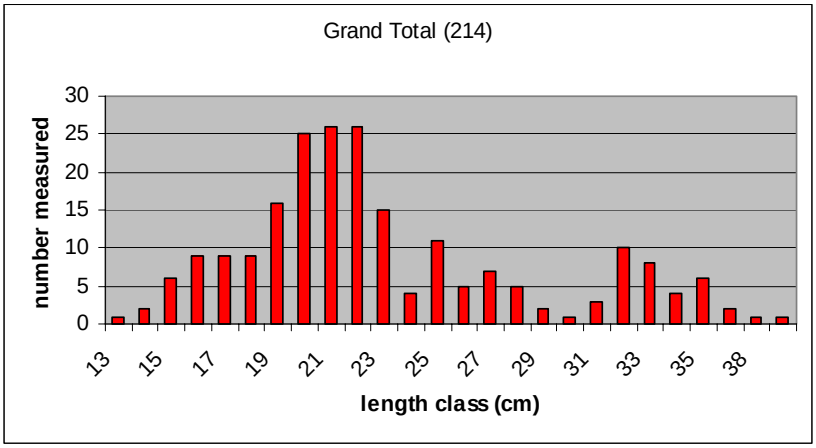


Figure 3.5.3. Overall length frequency distribution of pipefish during the March 2005 North East Atlantic hydro acoustic survey for blue whiting, FRV "Tridens".

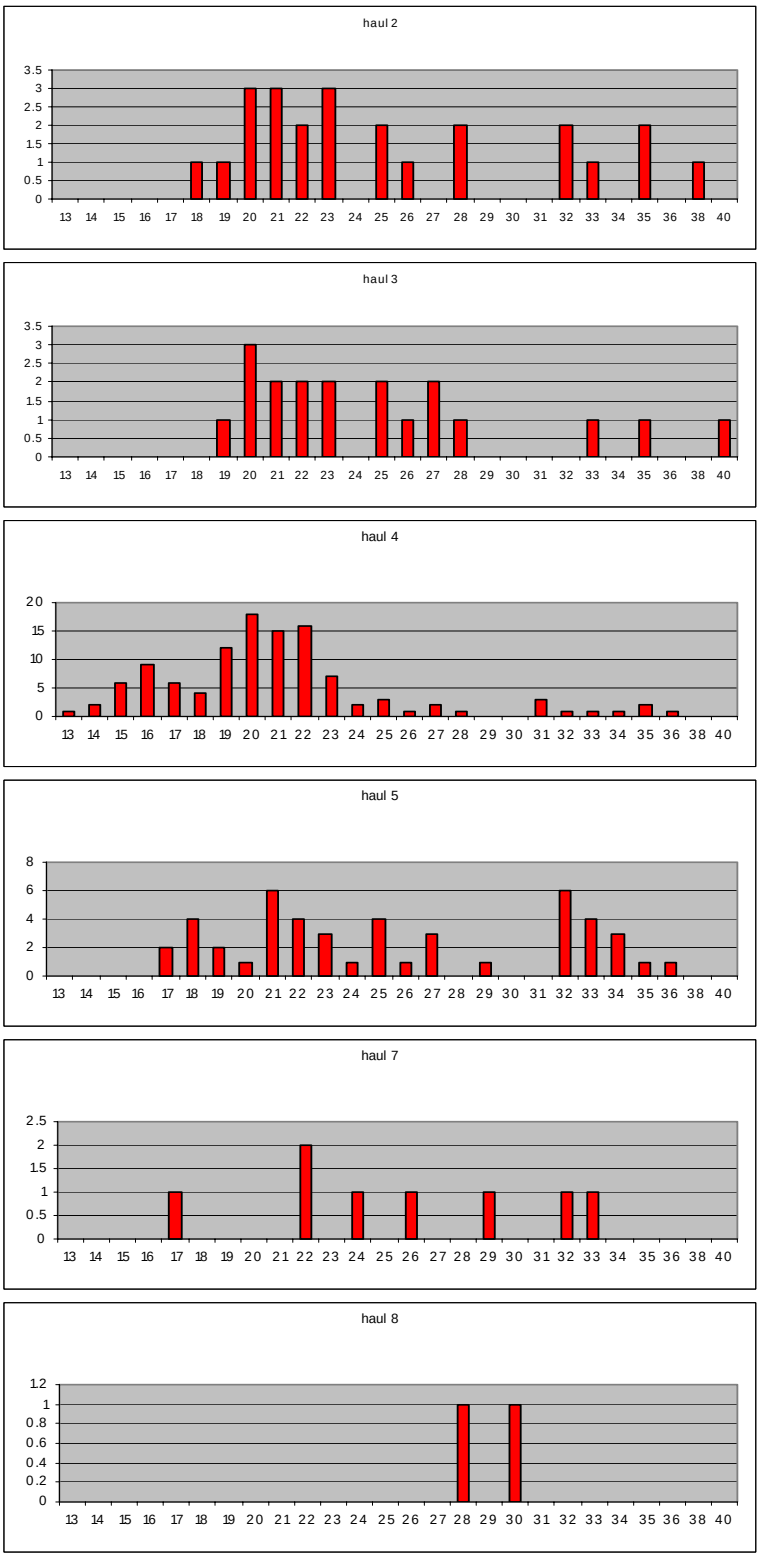


Figure 3.5.4 Length distribution of pipefish by haul during the March 2005 North East Atlantic hydro acoustic survey for blue whiting, FRV "Tridens".

Appendix H. Collection of meso-pelagic fish

All specimens which were rarely found in the trawl hauls were frozen for determination. Suitable photo equipment is needed for revealing the characteristics of these fish when they are still fresh. Especially fish from the deep are very difficult to handle as their soft skin falls of easily. Important characteristics will therefore not be available for determination: photophore cells; the light producing organs which are embedded in their skin. Length frequency distributions of all species caught are shown in appendix F.
Some examples of less common fish are shown below (Fig. 3.6.1).

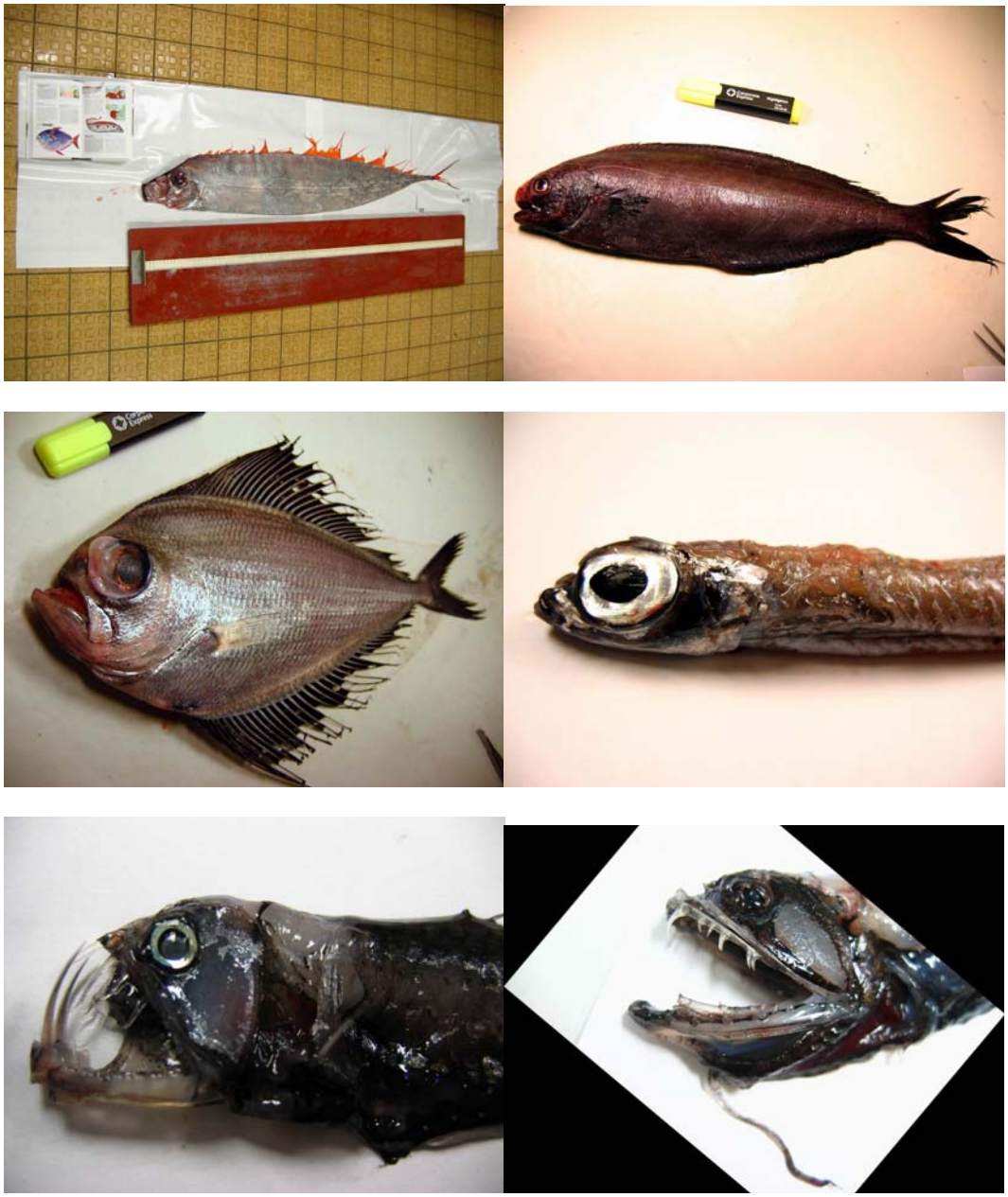


Figure 3.6.1. Some of the less common species caught during the March 2005 North East Atlantic hydro acoustic survey for blue whiting, FRV "Tridens".

Most of the NASC's assigned to meso-pelagic species were distributed off the shelf slope (Fig. 3.6.2)

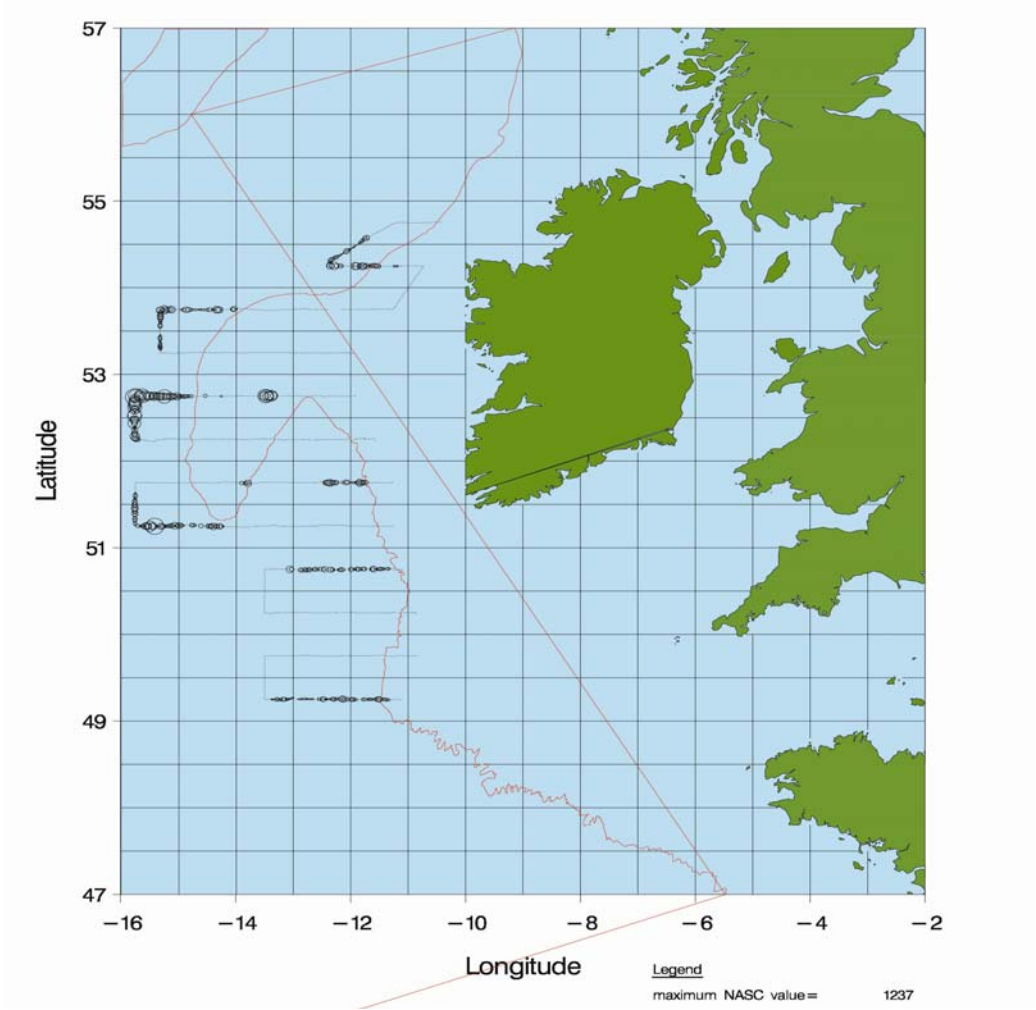


Figure 3.6.2 Post plot showing the distribution of total ***meso-pelagics*** *NASC values (on a proportional square root scale relative to the largest value of 1237) obtained* during

the March 2005 North East Atlantic blue whiting hydro acoustic survey on FRV "Tridens". The red line indicates the 500m depth contour. The straight line depth contours are falsely drawn.

Appendix I. Zooplankton

Long interval images revealed movement of, what is probably zooplankton during dusk (moving up) and dawn (moving down) as shown in figure 3.7.1. From 06.00 GMT acoustic signals started to move downwards.

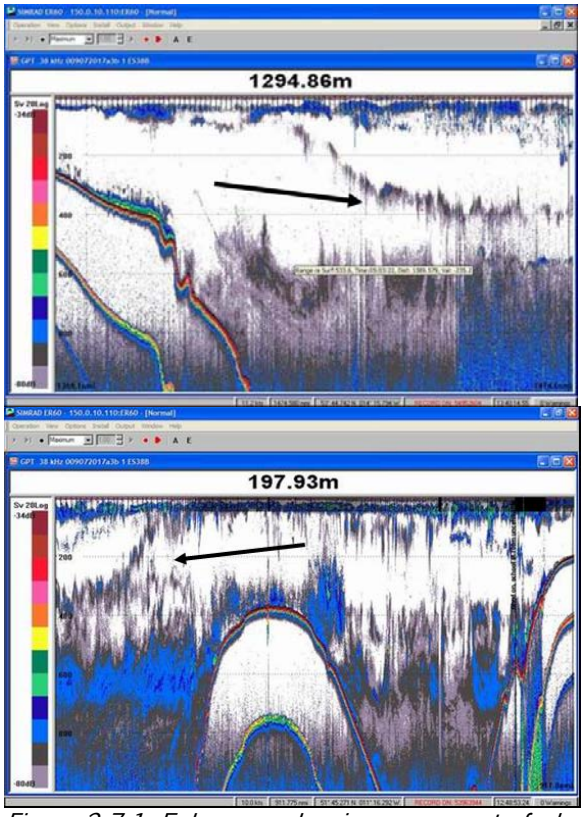


Figure 3.7.1. Echogram showing movement of what is believed to be zooplankton during dawn (left panel) and dusk (right panel). Recorded at respectively 53º44 and 51º45 5transects.