CRUISE REPORT

INTERPELACUS 0414

CALIBRATION BETWEEN R/V MIGUEL OLIVER AND R/V THALASSA

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INTRODUCTION

Background

The Spanish acoustic-trawl times series PELACUS started in 1991 when R/V Cornide de Saavedra was rebuilt and a new EK-500 was also purchased. Since that and until 1996 all cruises were carried out on board of this vessel except that of 1995, called IBERSAR, which has been undertook on board R/V Noruega.

In 1997 the series changed from R/V Cornide de Saavedra to the new R/V Thalassa (TH), a French/Spanish research vessel specially conceived for fish surveys. This vessel was used until 2013 when de Spanish authorities decided to move the series to the Spanish vessel Miguel Oliver (MO), built in 2007.

Both vessels , TH and MO have similar technical characteristics, as show in the following table:

	Thalassa	Miguel Oliver
Length	73.65 m	70.00 m
Width	14.90	14.40 m
Engine type	Diesel-electric	Diesel-electric
Engine power	2000 kW	2 x 1000 kW
Propeller	Fixed blades	Fixed blades
Tonnage	2803 GRT	2495 GRT
Propeller rpm at 10 knots	99	130

Table 1.: Main characteristics fro R/V Thalassa (left) and Miguel Oliver (right).

Although the similar features, given the experiences on biomass estimates derived from acoustic-trawl surveys related with fish behaviour, an intercalibration exercise was scheduled for 2014 after the Spanish PELACUS survey.

Objectives

Main objective of this survey was to verify if the times series could have been affected by the change of the research vessel. To do that, the inter-ship variability in some sampler devices (mainly acoustics, CUFES and fishing gears) should be compared with the intra-ship variability in order to give coherence to the time series (i.e. small vessel effect). Accordingly, the following hypothesis should be tested:

> Ho: The characterisation of the pelagic ecosystem by means of an acoustic-trawl survey would give significant differences on account the vessel effect
>
> Ha: The characterisation of the pelagic ecosystem by means of an acoustic-trawl survey is independent from the vessel.

Material and Methods

Survey design consisted in a grid of parallel transects located in two main areas, one close to the Garonne mouth, from 30 to 100 m, and the other close to the slope, from 150 to 1000 (fig. 1). Distance between transects was fixed at only 2.7 nmi in order to allow a parallel prospection without disturbance between vessels. These areas were selected due to expected higher fish species diversity and abundance as compared with the Spanish waters.

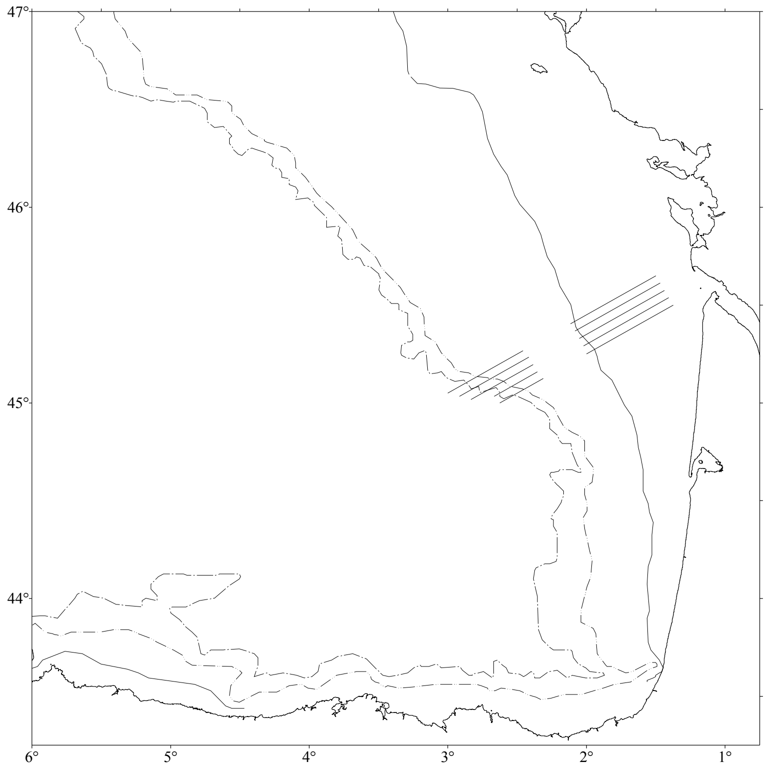


Figure 1.: Selected area for the intercalibration exercise.

Although five tracks have been scheduled, the main idea is to focus only in two of them in order to allow several surveying passes(passages hereafter), on account the low available time. The exercise started in the shallower area from the southernmost tracks; given that the number of detected echotraces was considered relevant, those tracks were steamed repeatedly. In the same way, the survey only focussed in two tracks close to the self-break. Besides, the acoustic prospection has been used to chose the main fishing areas to compare the performance of the fishing gears.

Acoustics

Both vessels used a Simrad EK-60 working at 18-38-120-200 khz; in addition, TH used another transceiver working at 70 kHz. MO was calibrated before the survey during the acoustic survey PELACUS, whilst for TH the results from the calibration done during PELGAS surveys have been used to correct the echograms recorded during this exercise.

Main echosounder setting were similar in both vessels as show in table 2

Transducer power	2000/2000/200/90 W for 18/38/120/200 kHz
Pulse duration	1.024 ms
Ping rate	Maximum, in case of ghost echo-bottom, change to interval starting at 0.30 ms
Range (echograms, files)	200 m in shallower area (i.e. depth<100m); 400 when depth is between 100-200m; and 1000 when depth is>400m

Table 2: Main echosounder settings.

Acoustic tracks were steamed at 10 knot, and ESDU was set at 1 nmi.

Fishing station

Fishing stations were located on account the results obtained during the acoustic prospection. In the same way, several hauls have been done over each area in order to check intra-inter ship variability. Both fishing gears and rigging were different in both vessels. On board TH a 76/70 "grandes mailles", with a vertical opening of about 20 m and around 60 m horizontal one, was used whilst on board MO an adaptation of a pelagic gear with a vertical opening similar to that of the TH but with a less horizontal opening (around 32 m). In the same way, doors were also different (semi-pelagic Vertical V morgère type on board TH and Suberkrüp type -Apollo polyice- in MO. Gear performance was controlled using net sounder. In the former case, a wireless trawl explorer (Marport) was used and in the later a cabled Simrad Sonar 25/20.

CUFES

Although both vessels have an internal pumping system with the intake located at more less the same depth, in TH the sea water goes directly to the CUFES while in MO there is a previous tank of about $1m^3$.

Survey strategy

Acoustics

Once chosen the acoustic tracks, the first leg was steamed in parallel; in the second MO has leaded and in the third, MO has leaded as show in figure 2

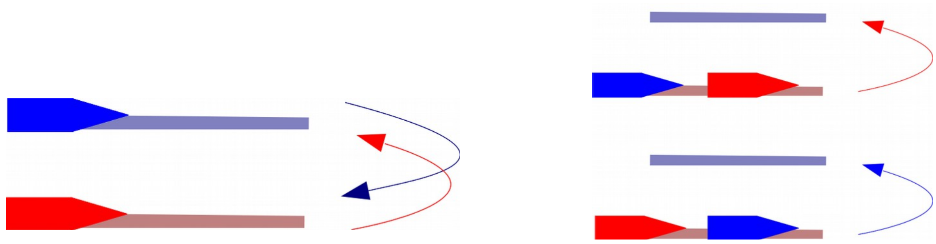


Figure 2.: Schematic representation of the survey strategy during the acoustic prospection

Fishing station

For the fishing station the procedure was similar, some of the hauls were done in parallel whilst in other cases one of the vessels leaded the operation as seen in the following figure.

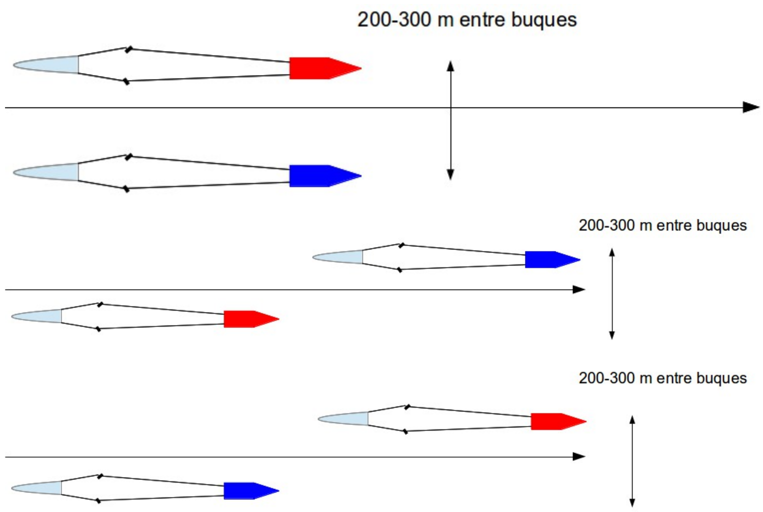


Figure 3: Schematic representation of the survey strategy during the fishing stations

All data were either stored or recorded in order to analyse the performance of each haul. The duration was limited to 30' or 20' minutes depending on the fish availability. Moreover, all trawl hauls were performed close to the sea bottom, thus excluding those mid or upper waters schools.

CUFES

Cufes samples were collected every 3 nmi over the same track used during the acoustic coverage.

Data analysis

Acoustics

Echograms from 18, 38, 120 and 200 kHz were digitally stored for further post-processing analysis using Echoview. Due to the aggregation pattern found in the surveyed area, fish schools were extracted using the following settings:

Sv threshold	-60 dB for all frequencies
Minimum total school length	2 m
Min. total school height	1 m
Min. candidate length	1 m
Min. candidate height	0.5 m
Maximum vertical linking distance	2.5 m
Max. horizontal linking distance	10 m
Distance mode	Vessel log
Main frequency for extraction	120 kHz

Table 3: Main morphological and backscattering energy characteristics used for schools detection

For all school candidates, several of variables were extracted, among them the NASC (s_A, m^2/nmi^2) together with the proportioned region to cell (ESDU, 1 nmi) NASC and the s_V mean and s_V max and geographic position and time. PRC_NASC values were summed for each ESDU and distances were referenced to a single starting point for each transect. Results for 38 and 120 kHz were compared. Besides, the frequency response for each valid school (i.e. those with length and s_V which allows them be properly measured) was calculated as the ratio $s_{A(fi)}/s_{A(38)}$, being f_i the s_A values for 18, 120 and 200 kHz.

No other kind of comparison has been yet performed (i.e. bottom or plankton layers echointegration) as the main objective of this exercise is targeted on fish detection capabilities. Therefore, single data analysis was performed (I.e.correlation index and comparison of probability density functions).

Fishing stations

Results from the fishing stations were compared with the total echointegration values (38 kHz, s_A, m^2/nmi^2). Total catch by species was weighted and subsamples were done for length composition analysis and to estimate the total numbers. Both catch proportion by species and length distribution analysis using Kolmogorov-Smirnov test (KS-T) were done.

CUFES

Numbers of eggs of each identified taxa were converted into number of eggs. Sardine (Sardina pilchardus) and anchovy (Engraulis encrasicolus) eggs were identified under a binocular microscope. Egg concentration for sardine and anchovy were estimated in eggs.m-3 using the filtered volume of the CUFES.

For the comparison, the same station number in the transect for both vessels. As in acoustics, sardine and anchovy egg were cumulated from a common starting point.

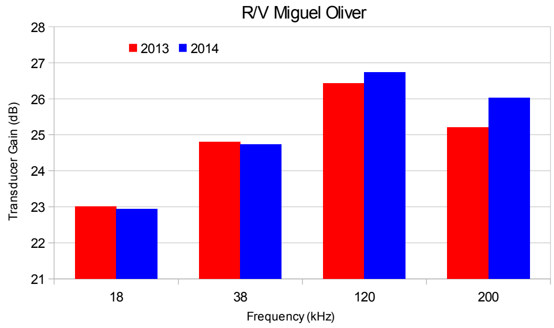
RESULTS

The correction values from the calibration done previously for Miguel Oliver and after for Thalassa are show in the following table:

		Miguel Oliver	Thalassa
18 kHz	Reference target (tungsten carbide)	-42.60 dB	
	Power	2000 W	
	Depth	15.90 m	13.30 m
	Sound Velocity	1504.7 m/s	1494.7 m/s
	Absor. Coef.	2.4 dB/Km	2.5 dB/Km
	Transducer Gain	22.94 dB	22.99 dB
	Sa Correction	-0.80 dB	-0.56 dB
	Beam angles:	10.97 x 10.63 (deg)	10.74 x 10.73 (deg)
	Offset	0.19; 0.31 (deg)	-0.27 ; -0.12 (deg)
	RMS (Beam Polynomial models)	0,55 – 0.51 (dB)	0.32 -0.26 (db)
38 kHz	Reference target (tungsten carbide)	-42.40 dB	
	Power	2000 W	
	Depth	15.73 m	13.30 m
	Absor. Coef.	9.3 dB/Km	9.5 dB/Km
	Sound Velocity	1504.7 m/s	1494.7 m/s
	Transducer Gain	24.73 dB	25.67 dB
	Sa Correction	-0.58 dB	-0.56 dB
	Beam angles:	6.95 x 7.12 (deg)	6.69 x 7.02 (deg)
	Offset	-.05; –0.17 (deg)	-0.6; 0.6 (deg)
	RMS (Beam Polynomial models)	0,20 – 0.18 (dB)	0.33 – 0,24 (dB)
120 kHz	Reference target (tungsten carbide)	-39.50 dB	
	Power	200 W	
	Depth	15.68 m	13.30 m
	Sound Velocity	1504.7 m/s	1494.7 m/s
	Absor. Coef.	41.2 dB/Km	41.1. dB/Km
	Transducer Gain	26.73 dB	26.14 dB
	Sa Correction	-0.37 dB	0.06
	Beam angles:	6.38 x 6.51 (deg)	6.51 x 5.88 (deg)
	Offset	-0.05; –0.01 (deg)	0.03; 0.34 (deg)
	RMS (Beam Polynomial models)	0,52 – 0.44 (dB)	0.35 – 0.27 (dB)
200 kHz	Reference target (tungsten carbide)	-39.05 dB	
	Power	90 W	
	Depth	15.30 m	13.30 m
	Sound Velocity	1504.7 m/s	1494.7 m/s
	Absor. Coef.	59.4 dB/Km	58.8 dB/Km
	Transducer Gain	26.03 dB	26.16 dB
	Sa Correction	-0.27 dB	-0.22 dB
	Beam angles:	6.5 x 6.53 (deg)	6.46 x 6.53 (deg)
	Offset	-0.29; –0.09 (deg)	0.22; 0.37
	RMS (Beam Polynomial models)	0,60 – 0.56 (dB)	0.54 – 0.44 (dB)

Table 4: Calibration output

Results from the calibration are consistent with the previous ones for 18 and 38 kHz, as shown in figure 4



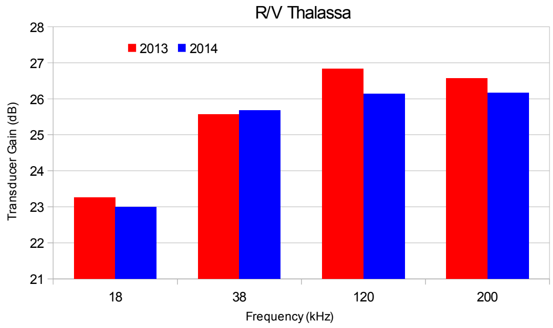


Figure 4: Calibration results (transducer gain) for 2013 and 2014. The later used in this exercise.

In the case of MO, differences for 18 and 38 kHz were 0.07 dB, but for 200 kHz the difference was 0.82 dB (0.30 dB for 120 kHz). On TH the differences were in general higher than those of the MO, being the lowest difference 0.11 dB for 38 kHz and the highest 0.69 dB for 120 kHz. As shown in figure 5 the performance of 38 and 120 kHz for both vessels was contradictory, which made difficult to compare results in a multifrequency approach.

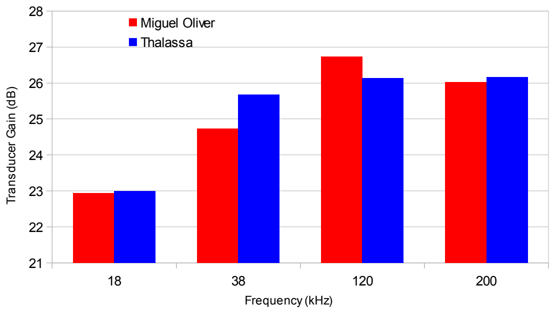


Figure 5: Calibration results (transducer gain) for 2014.

Acoustic

The exercise started on 11th April in the coastal area. Given de abundance of echotraces, only two tracks were steamed in both areas as show in figure 6. The sequence was as follows:

		R/V Thalassa			R/V Miguel Oliver			
Track	Date	Trans.	Time	Dir	Trans.	Time	Dir	Comments
1	11/04	R02	06:13	T Coast	R01	06:10	T Coast	Parallel
2	11/04	R01	08:49	T Slope	R02	08:48	T Slope	Parallel
3	11/04	R01	11:24	T Coast	R01	11:13	T Coast	Same transect, MO leads
4	11/04	R02	14:11	T Slope	R02	13:57	T Slope	Same transect, MO leads
5	11/04	R02	16:31	T Coast	R02	16:46	T Coast	Same transect, TH leads
6	13/04	R09	06:37	T Slope	R10	06:39	T Slope	Parallel
7	13/04	R10	08:27	T Coast	R09	08:23	T Coast	Parallel
8	13/04	R10	11:25	T Slope	R10	11:12	T Slope	Same transect, MO leads
9	13/04	R09	13:17	T Coast	R09	13:04	T Coast	Same transect, MO leads
10	13/04	R09	14:22	T Slope	R09	14:37	T Slope	Same transect, TH leads
11	13/04	R10	16:10	T Coast	R10	16:18	T Coast	Same transect, TH leads

Table 5: Day, transect name, starting time, steaming direction (towards coast or towards slope) for each track

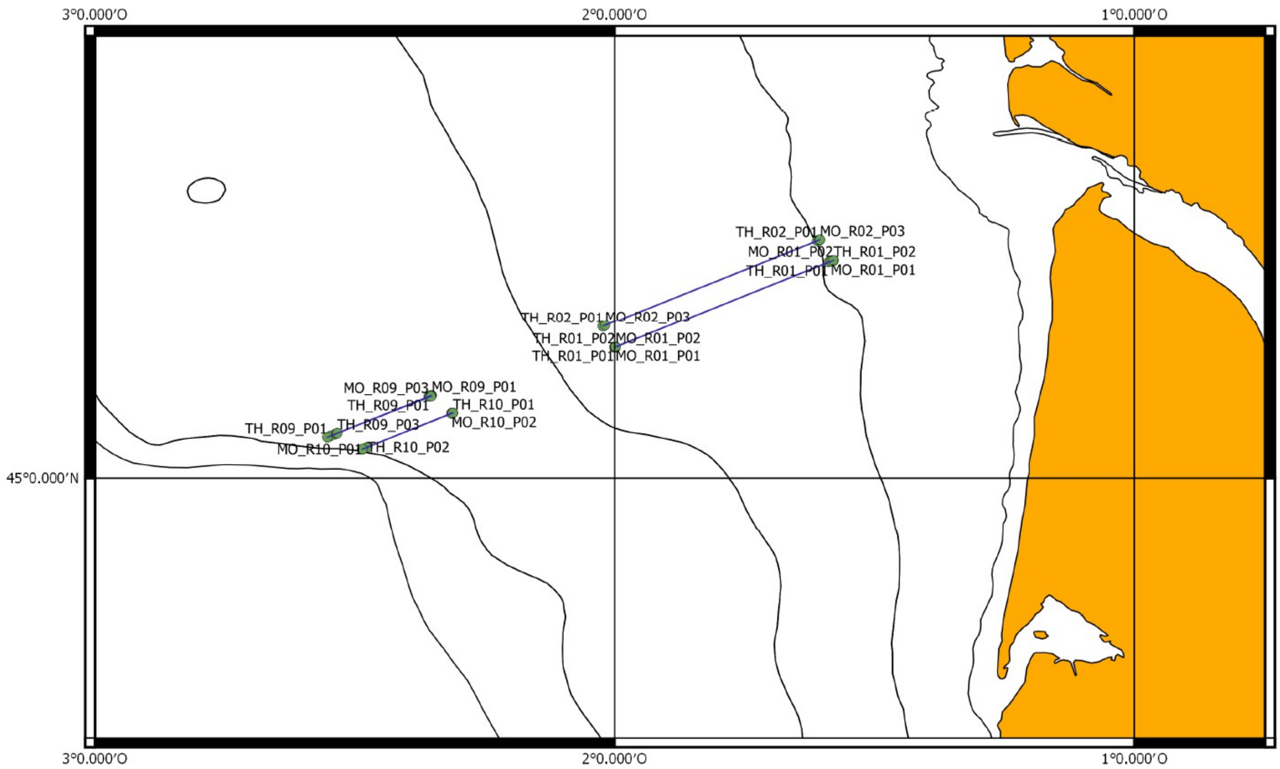


Figure 6: Acoustic track showing the starting and ending point for each passage done by each vessel.

Coastal area

Most of the schools detected by both vessels were smaller, with mean area of about 10 m^2, but with a skewed distribution (median around 4 m^2), with almost no differences between vessels nor among passages.

Comparison among passages in the coastal area is shown in the following figures

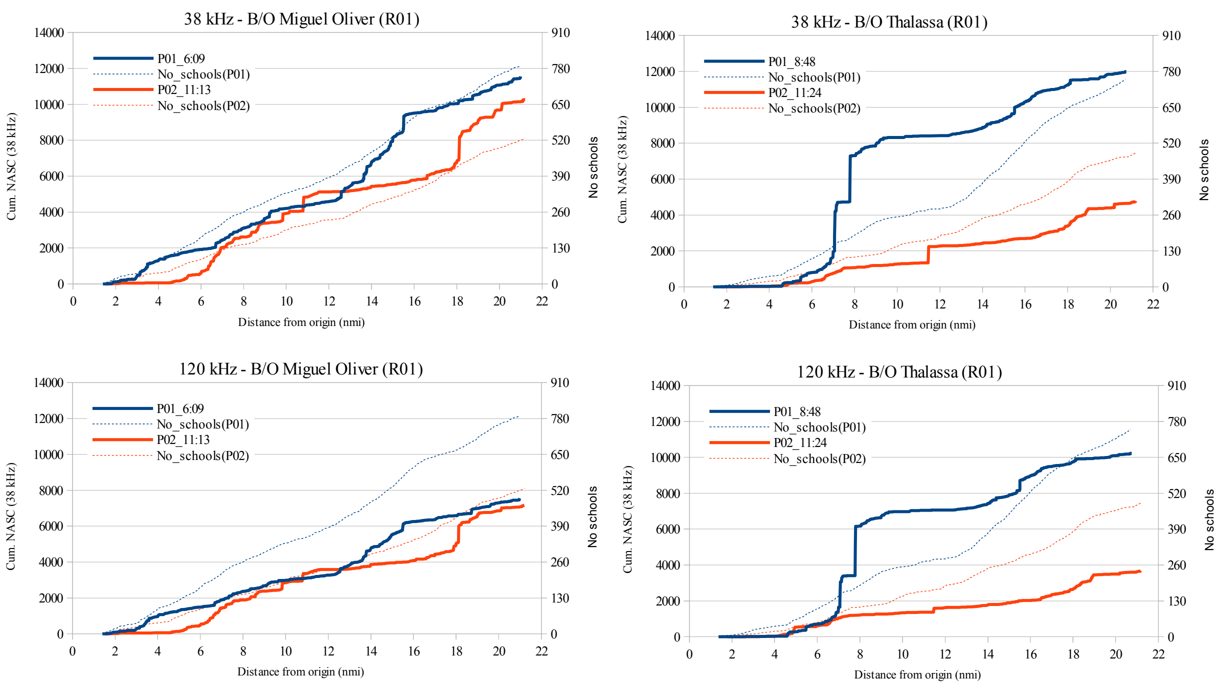


Figure 6: Cumulated NASC values and number of schools along transect (distance from the origin) for each passage done to transect number 1 for each vessel at 38 and 120 kHz.

The two passages to the first transect done by the MO gave similar results. In the case of TH the occurrence of a thick school explain the big differences between passages. On the other hand, the number of schools has changed from the first to the second passage (788 to 527 in the case of MO and 752 to 486 in the case of TH), but it seems that in the case of MO, this change did not affect the total cumulated NASC.

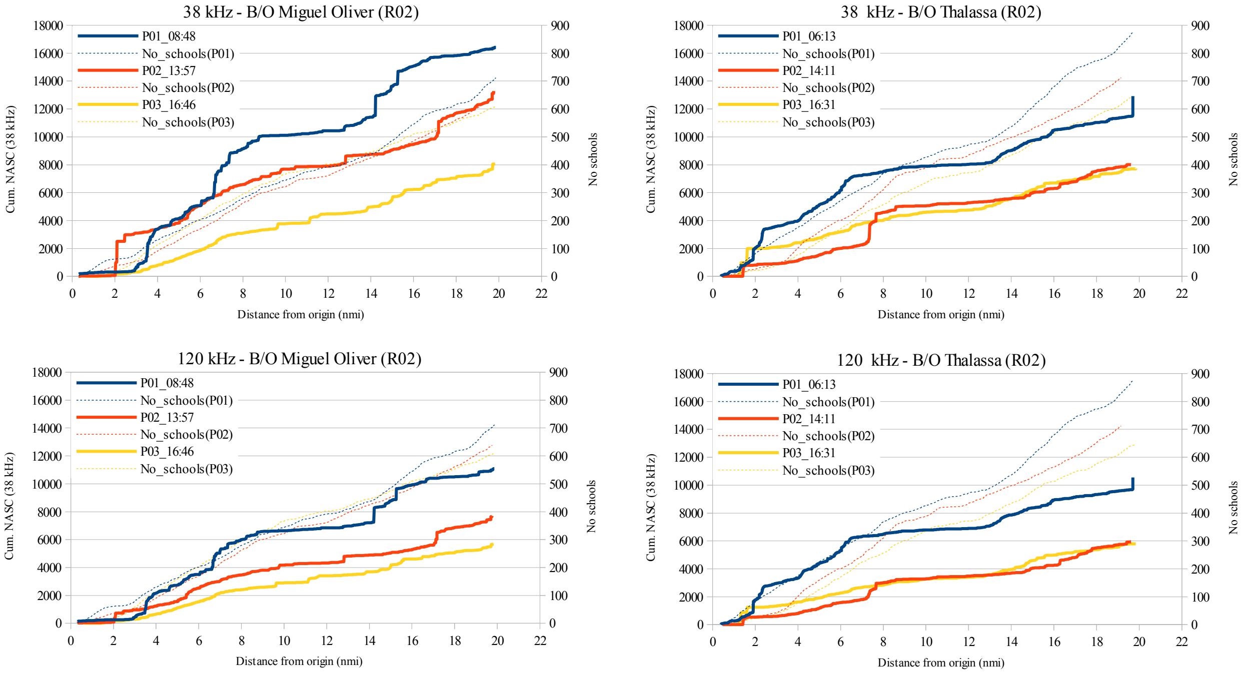


Figure 7: Cumulated NASC values and number of schools along transect (distance from the origin) for each passage done to transect number 2 for each vessel at 38 and 120 kHz.

The second transect was surveyed three times and, as in the case of the first transect, the number of schools detected decreased along passes (712, 638 and 609 for R/V MO and 876, 729, 646 for TH). This decrease has been also accomplished with a decrease in the cumulated NASC, being more evident for MO.

Comparison between passages is shown in figures 8-12. First passage, with both vessels steaming in parallel, gave similar results in cumulated NASC values, although distribution along track was different. Main differences occurred at 120 kHz, although cumulated integrated values were lower. Median frequency response (FR, 120/38) was 0.86 for MO and 0.93 for TH, which explains the differences obtained between both frequencies.

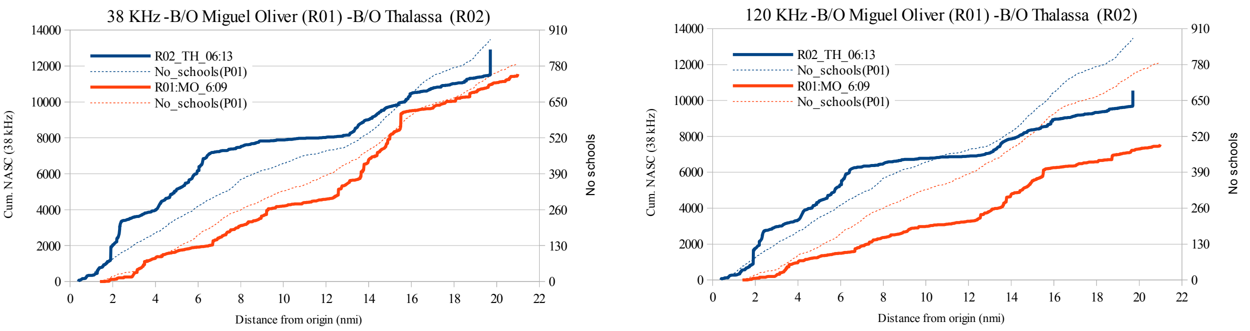


Figure 8: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the first parallel navigation. Left panel, results from 38 kHz and right panel results from 120 kHz.

In the second passage both vessels steamed again in parallel from the coast to offshore. At 38 kHz frequency, MO has cumulated higher NASC values but at 120 kHz values were similar.

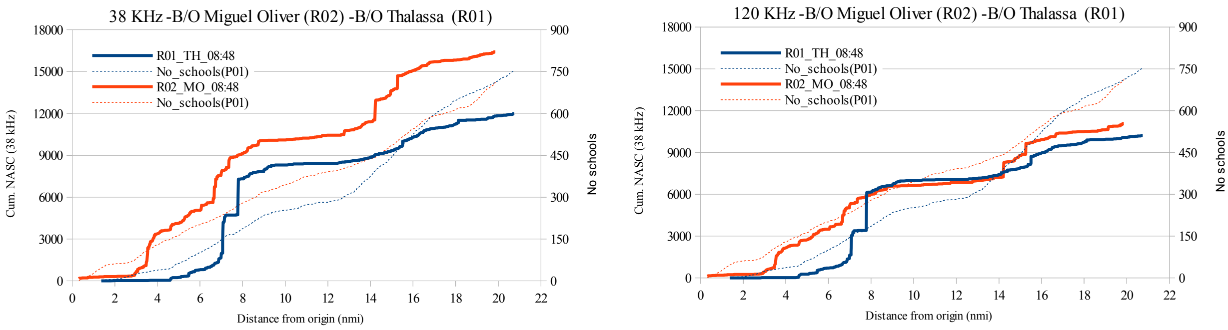


Figure 9: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the second parallel navigation. Left panel, results from 38 kHz and right panel results from 120 kHz.

In the third passage, both vessels steamed the same transect (R01) being leaded by MO. Both, the number of schools and cumulated NASC values were higher for this vessel.

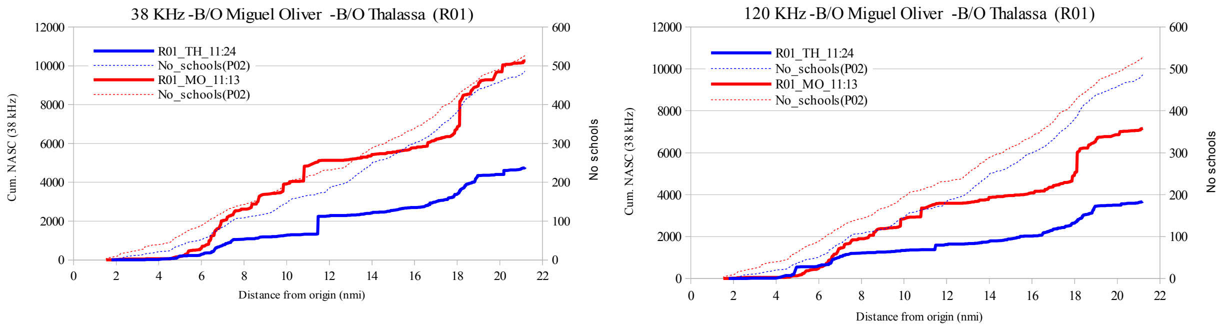


Figure 10: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the third passage leaded by MO. Left panel, results from 38 kHz and right panel results from 120 kHz.

The forth, was also leaded by MO and in this case, TH has found more schools, but cumulated NASC was higher in MO

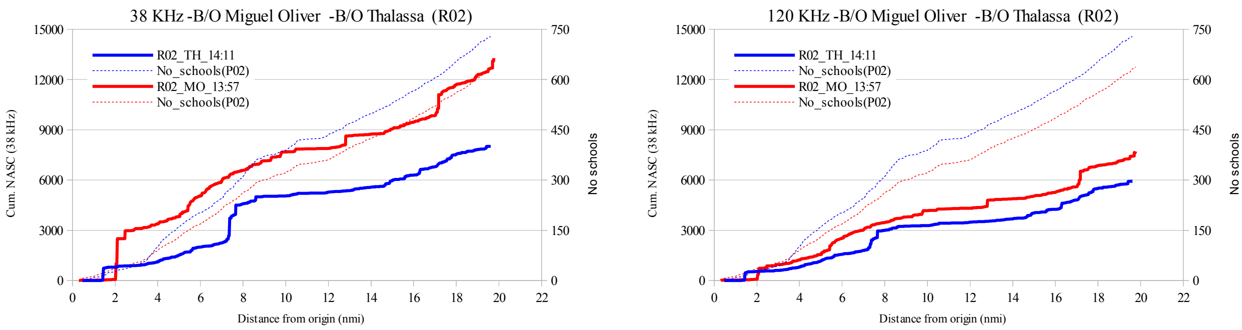


Figure 11: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the forth passage leaded by MO. Left panel, results from 38 kHz and right panel results from 120 kHz.

Finally fifth passage was leaded by TH and in this case both number schools and NASC were similar in both vessels

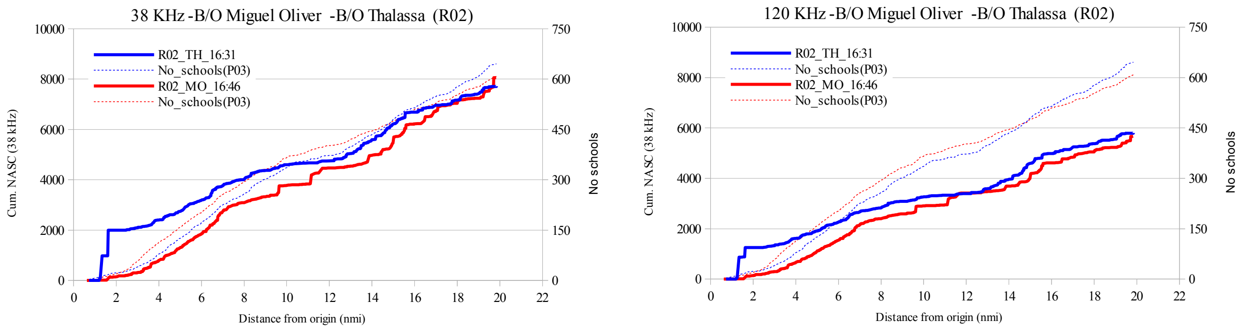


Figure 12: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the fifth passage leaded by TH. Left panel, results from 38 kHz and right panel results from 120 kHz.

Shelf break area

Echotraces were more variable both in terms of size and backscattering energy. Besides, the length of the tracks was smaller (8-10 nmi) as compared with those of the coastal area due to the self-break. The two tracks were steamed three times by each vessel. Figures 13 and 14 show the different passages to each transect done by each vessel.

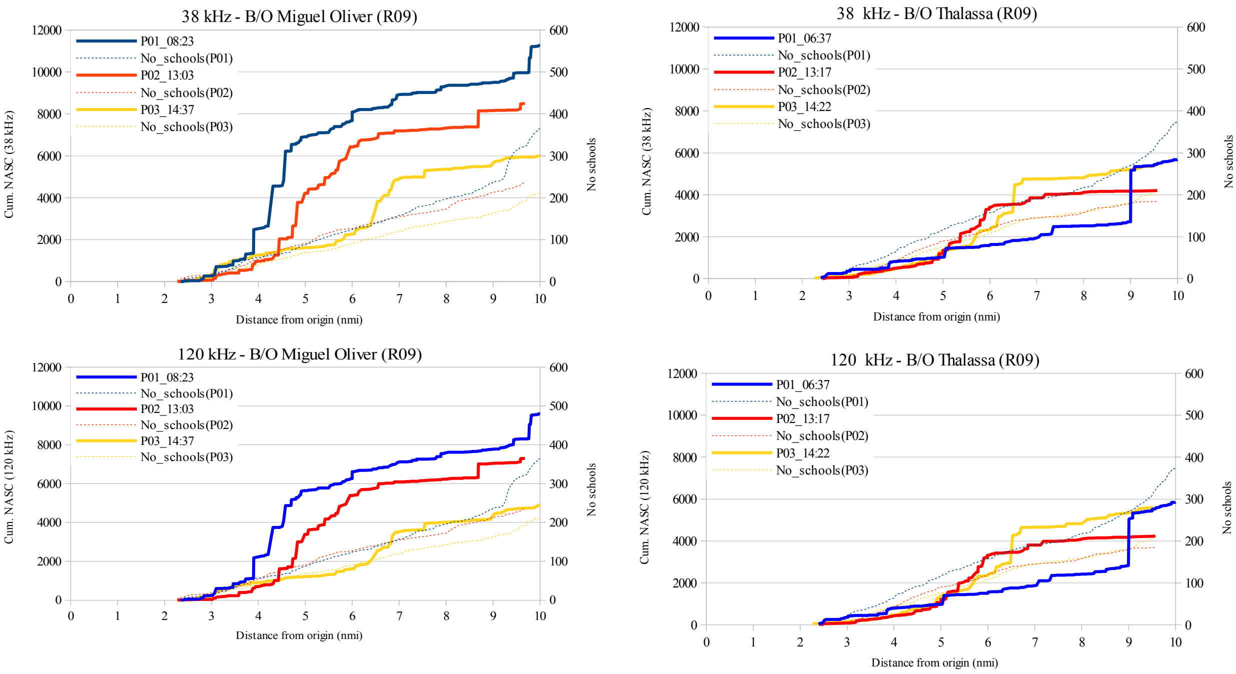


Figure 13: Cumulated NASC values and number of schools along transect (distance from the origin) for each passage done to transect number 9 for each vessel at 38 and 120 kHz.

In transect 9, as in the previous ones, cumulated NASC values recorded by MO decreased along passages, but for TH these values were more similar, although lower than those of MO.

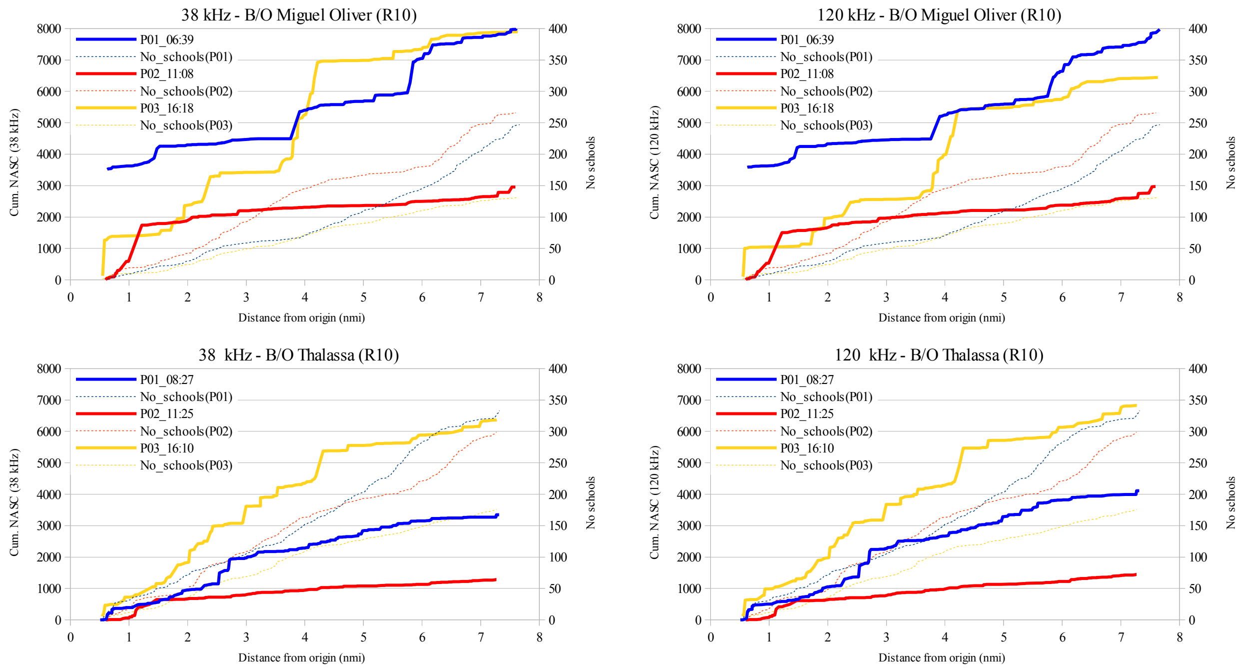


Figure 14: Cumulated NASC values and number of schools along transect (distance from the origin) for each passage done to transect number 10 for each vessel at 38 and 120 kHz.

In transect 10 differences in NASC among passages were significant. In the second passage, both vessels accounted for the lowest cumulated NASC, but the number of schools during this passage was higher and similar to those encountered during the first passage, although the cumulated NASC was higher. Direct comparison are shown in figures 15-20

First passage was characterised by the occurrence of thick schools; MO has been found one at the beginning of the track while in TH this occurred almost at the end. This thick school achieved 43% of the total cumulated energy in MO and 42% for TH. On the other hand the number of schools encountered by TH was higher thant those found by MO, although the later accounted higher cumulated NASC

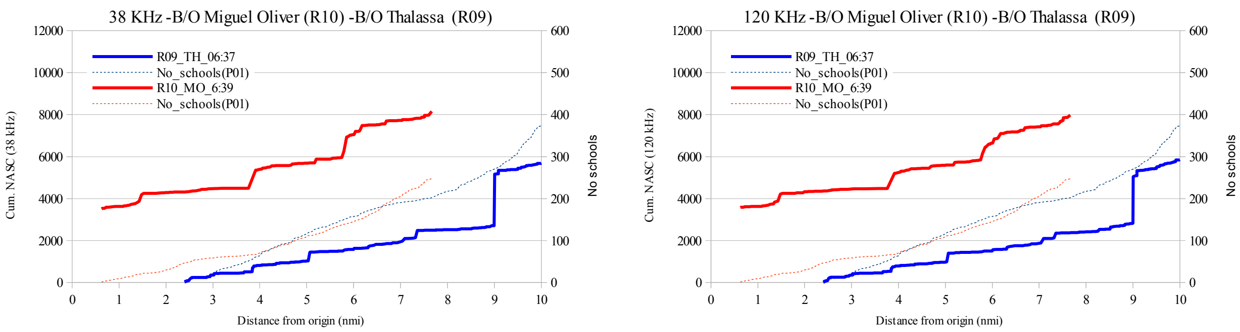


Figure 15: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the first passage, vessels steaming in parallel. Left panel, results from 38 kHz and right panel results from 120 kHz.

During the second passage, MO has found more schools and achieved, as in the previous passage, higher cumulated NASC for both frequencies.

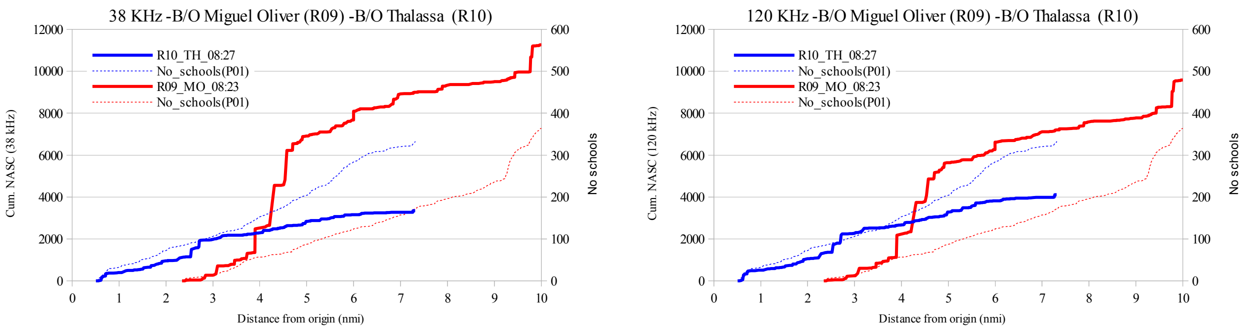


Figure 16: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the second passage, vessels steaming in parallel. Left panel, results from 38 kHz and right panel results from 120 kHz.

The following two passages were leaded by MO. The third done on track number 10, where both vessels showed more or less the same shape in cumulated NASC and schools, although MO, as occurred during the first passage, has found a thicker school which accounted for the 39% of the total cumulated NASC.

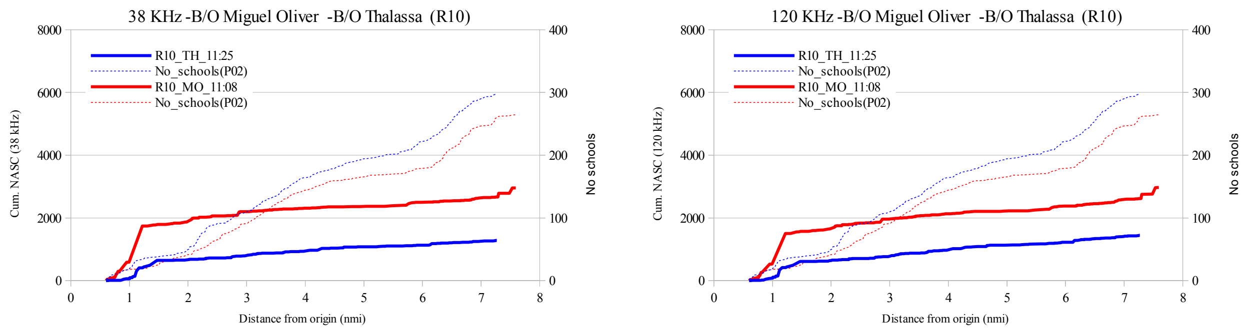


Figure 17: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the third passage, MO leading. Left panel, results from 38 kHz and right panel results from 120 kHz.

In the forth passage, main differences between the two vessels were found in the middle of the transect. In this area both vessels found more or less the same number of schools but those accounted by MO had more backscattering energy (figure 18).

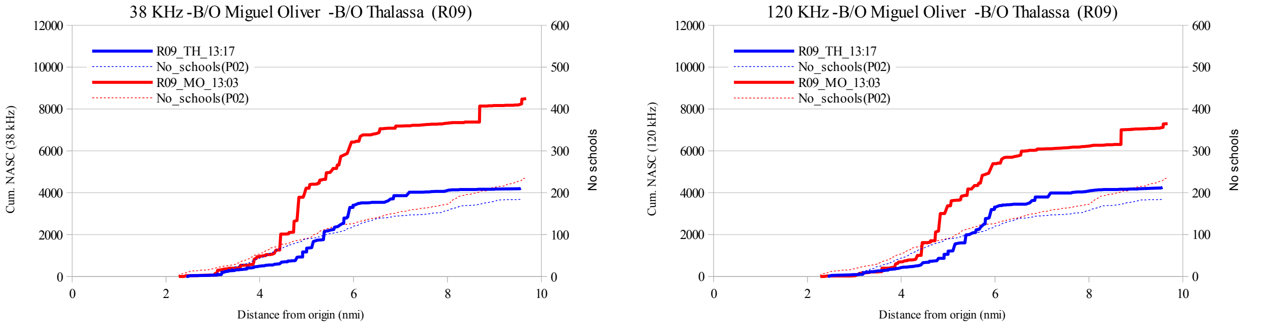


Figure 18: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the forth passage, MO leading. Left panel, results from 38 kHz and right panel results from 120 kHz.

Besides the school occurrence was slightly different from one vessel to the other. While MO has found schools throughout the whole water column, most of the schools for TH were located close to the sea bottom. Indeed, it seemed that some of the schools seen by TH were diving, as shown in figure 19, which may explain the lower backscattering energy due to the change in the tilt angle.

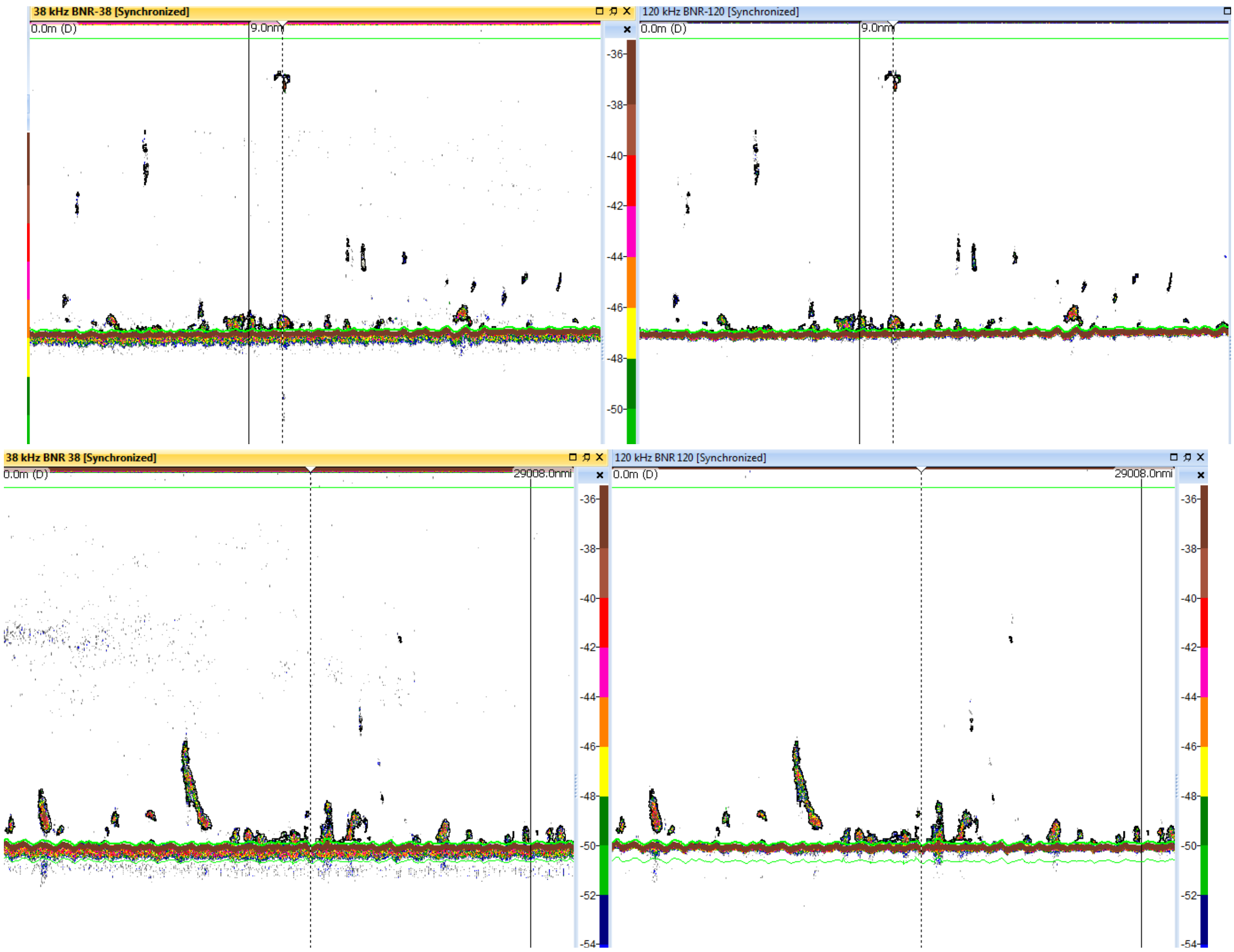


Figure 19: 38 (left)and 120 kHz (right) ecograms for MO (above) and TH (below) showing the school occurrence during the vessels passage.

The fifth passage was done over the track R09 just at the end of the forth one done also over the same track, but leaded by TH. In this case, both vessels gave similar results at 38 kHz but higher for TH at 120 kHz (figure 20). The school occurrence was slightly different, with those accounting for

MO located more close to the sea bottom, as shown in figure 21

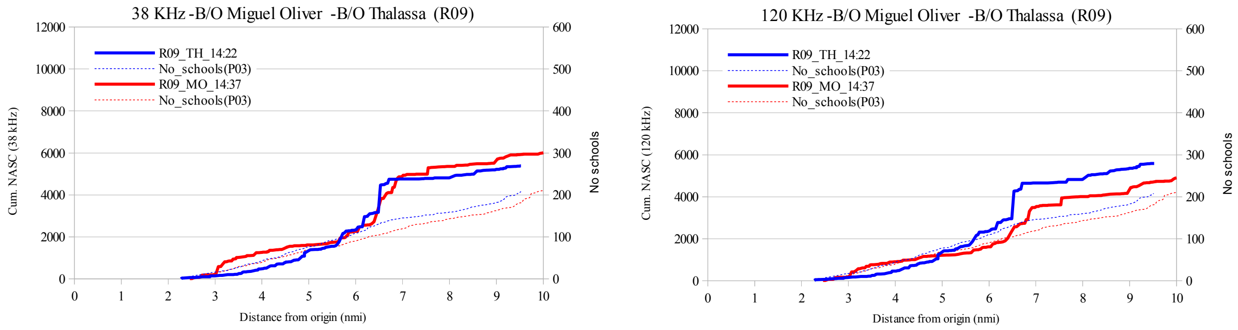


Figure 20: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the fifth passage, TH leading. Left panel, results from 38 kHz and right panel results from 120 kHz.

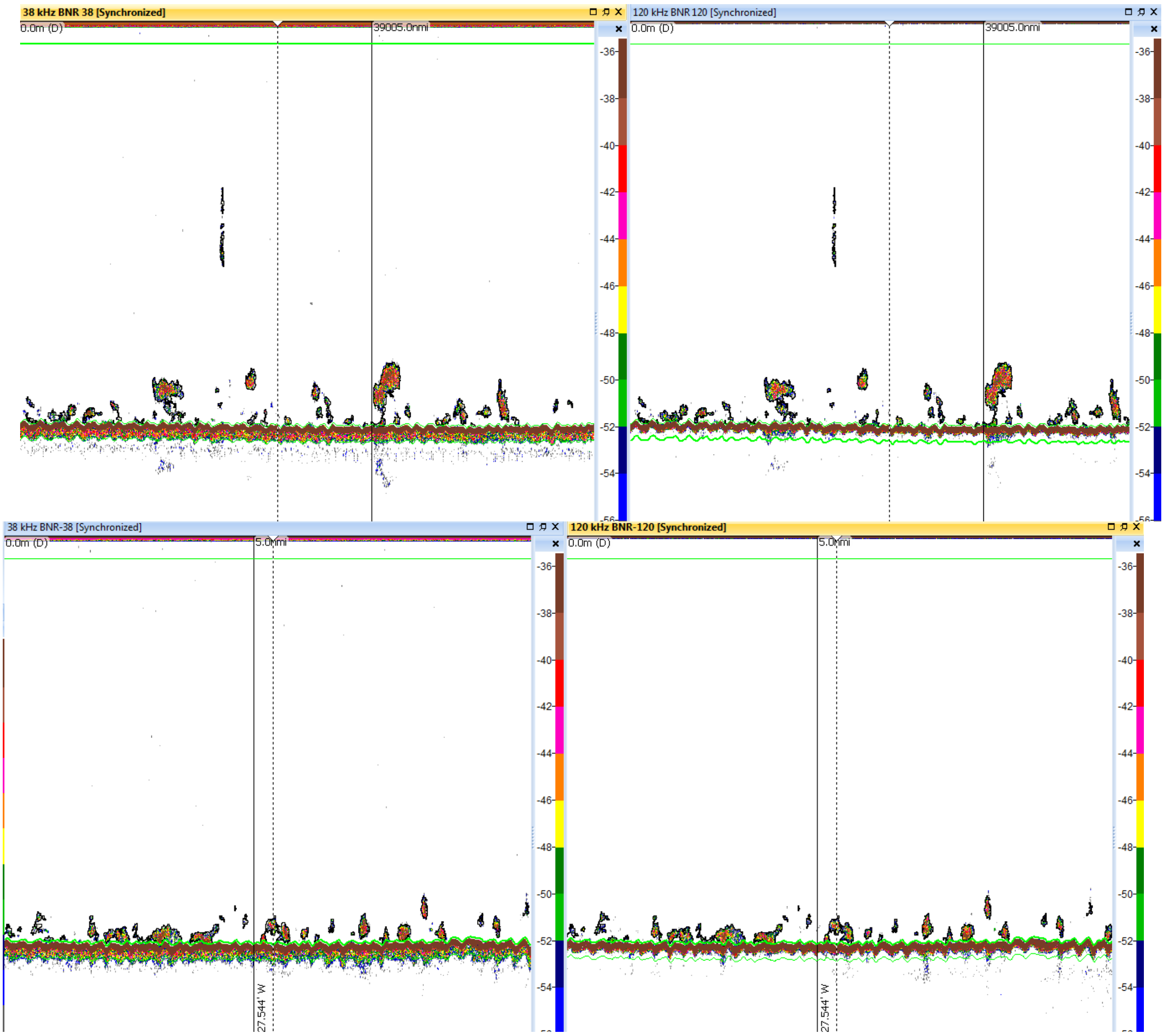


Figure 21: 38 (left)and 120 kHz (right) ecograms for TH (above) and MO (below) showing the school occurrence during the vessels passage.

Finally in the sixth passage done over track number 10 and leaded by TH, this vessel has recorded more schools but at 38 kHz cumulated NASC was higher in MO

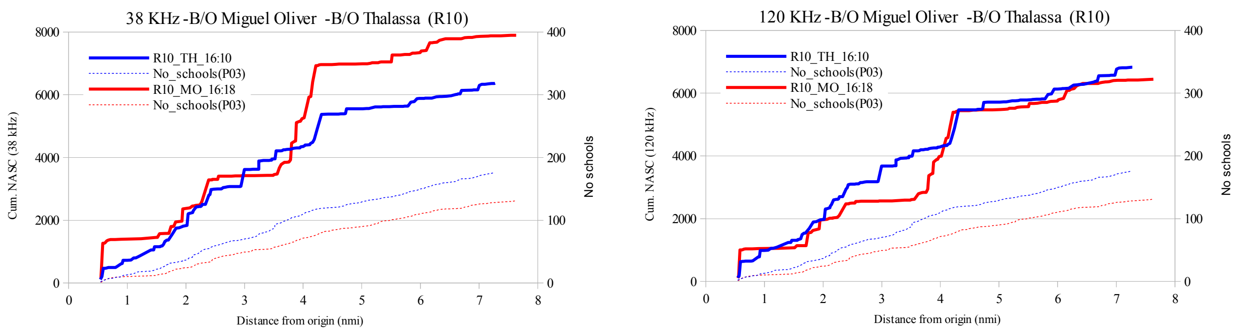


Figure 22: Comparison of cumulated NASC values and number of schools along transect (distance from the origin) from the sixth passage, TH leading. Left panel, results from 38 kHz and right panel results from 120 kHz.

Relative Cumulated frecuency analysis

Given the similarity in the number of schools found for both vessels but with higher cumulated NASC values achieved by MO, it seems that this vessel would have be found thicker schools in terms of backscattering energy than TH. In order to verify this, relative cumulated frequency distributions for each passage was calculated as follows:

$$F_{NASC} = \sum_{i \leqslant n} f_i$$

being: $$f_i = NASC_i / \sum_{n} NASC_i$$

in addition, the relative cumulative frequency distribution number of schools per passage and vessels was calculated in the same way. Both frequency distributions were plotted and shown in figures 23 and 24.

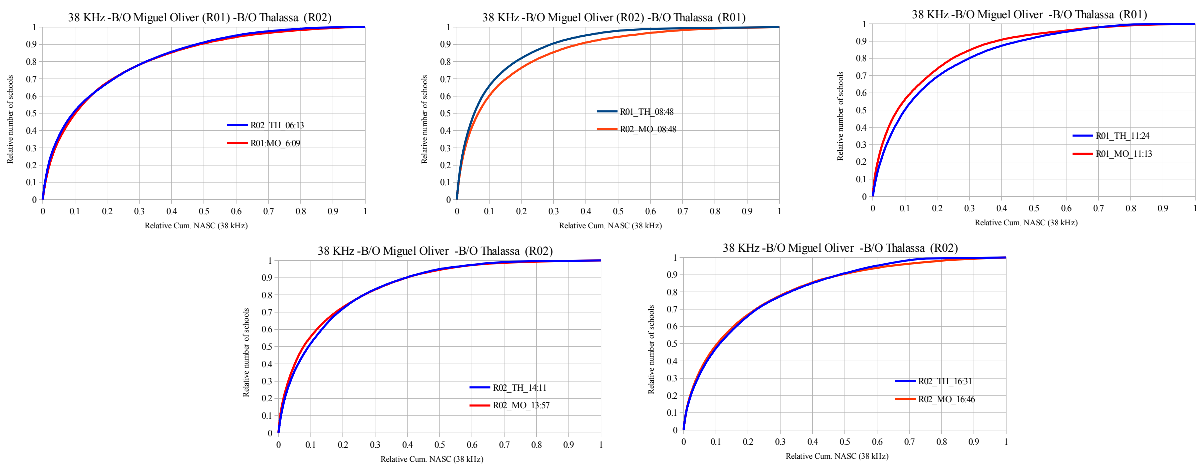


Figure 23: Relative cumulated frequency distribution of schools (Y-axis) and NASC (X-axis) for the five passage done in the coastal area. Red line Miguel Oliver; blue one Thalassa

Cumulated frequency distribution plots were similar for both vessels, meaning that the schools were similar in terms of relative backscattering energy. Nevertheless, in passages two and three there was a slight discrepancy between vessels. In the second one, the 10 % of the schools in TH accounted for the 70% of the total cumulated NASC whilst for MO this contribution was 62%. In the same way, in the third passage the 10 % of the schools in MO accounted again for the 62% of the total cumulated NASC, but for TH this contribution was 54%.

In the shelf-break area, discrepancies were higher as can be observed in figure 24. Only passages one and five gave similar relative cumulated NASC; in the rest, distributions were more skewed in MO.

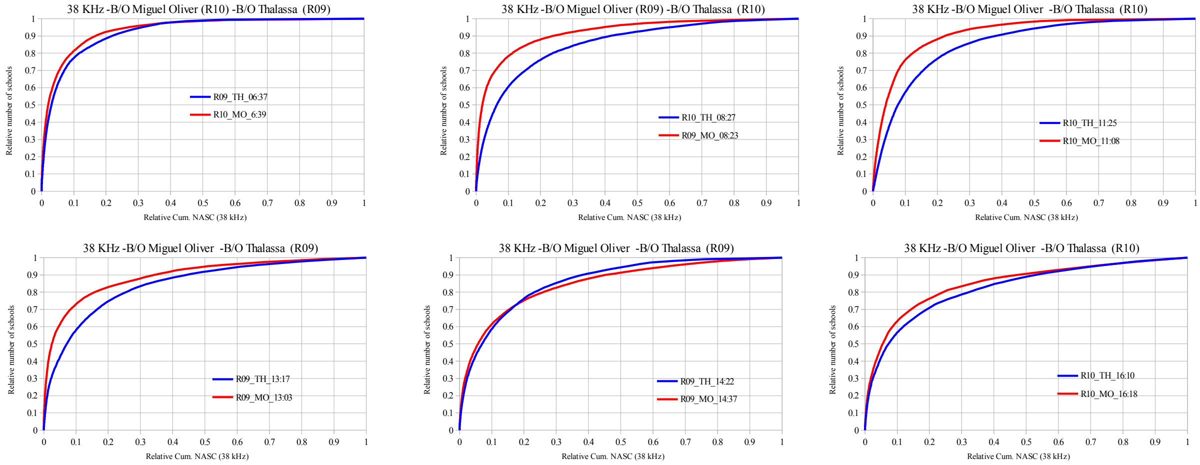


Figure 24: Relative cumulated frequency distribution of schools (Y-axis) and NASC (X-axis) for the five passage done in the shelf break area. Red line Miguel Oliver; blue one Thalassa

In such circumstances, the more skewed distribution, the higher contribution of few schools to the cumulated frequency distribution, which haven't been accounted at the same level by the other vessel.

When MO leaded, this vessel got, in general, higher cumulated values; besides when TH leaded the cumulated values were similar to those obtained by MO although lower than those obtained when MO leaded or even when this vessel covered these tracks in parallel. Given also that MO got more passages with more skewed distributions, it seems that MO would be found more thicker schools than those encountered by TH.

Fishing stations

A total of 15 fishing stations were done over the surveyed area. Main characteristics are shown in table 6. MO has changed the fishing gear during the fishing station number 10. Besides this vessel has changed the settings according to depth. During the first trawl haul, done in shallower water a fence for extra buoyancy has been put in each upper wing together with 400 kG weight in each lower wing which had a longitude of 100 m. For the rest of the hauls no fence has been used; instead, during the last haul, done also in shallower waters, the wings were reduced to 50 m.

Three comparison were done in waters < 60m, six between 60 to 90 m and other six in waters deeper than 125 m, as shown in figure 25. These three depth strata were retained for analysis purposes.

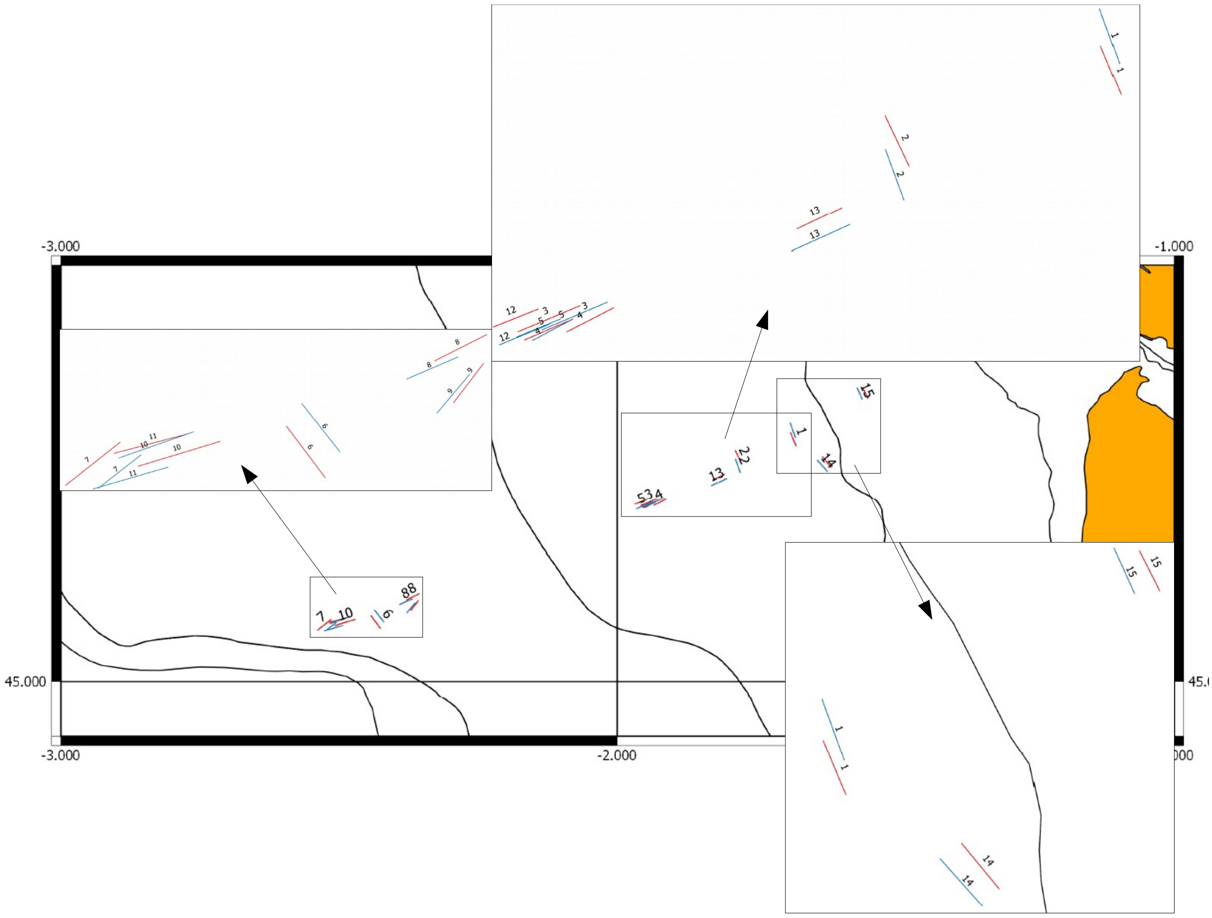


Figure 25: Location of the fishing station. In blue hauls performed by R/V Thalassa and in red those performed by R/V Miguel Oliver

11 hauls were done in parallel whilst in the other 4 one vessel leaded the haul. Hauls number 3, 4, 5 and 12 were done in almost the same area in order to check inter/intraship variability. In the same way, hauls 8 and 9 and 7, 10 and 11 were as well done over the same area.

				R/V MIGUEL OLIVER									R/V THALASSA											
				Start		End									Start		End							
No	Day	Time	Dep.	Latitude	Longitude	Time	Dep.	Latitude	Longitude	Dis.	Sp.	NASC	Time	Dep.	Latitude	Longitude	Time	Dep.	Latitude	Longitude	Dis.	Sp.	NASC	Remarks
1	12	07:42	53	45º25.50 N	1º40.72 W	08:02	55	45º26.86 N	1º41.28 W	1.40	4.35	2659.06	06:55	55	45º26.39 N	1º48.77 W	07:31	58	45º27.91 N	1º41.32 W	1.56	4.58	2570.69	Parallel
2	12	09:07	65	45º29.80 N	1º47.21 W	09:27	63	45º23.58 N	1º46.58 W	1.46	4.27	2239.14	09:14	67	45º23.99 N	1º47.21 W	09:35	67	45º22.58 N	1º46.71 W	1.44	4.23	1056.34	Parallel
3	12	12:11	84	45º18.98 N	1º57.31 W	12:31	83	45º19.68 N	1º55.64 W	1.42	4.06	1098.35	12:15	85	45º19.01 N	1º56.69 W	12:50	81	45º19.08 N	1º54.09 W	1.50	4.45	1118.49	Parallel
4	12	14:34	81	45º19.59 N	1º54.80 W	14:49	85	48º18.96 N	1º56.02 W	1.14	4.37	221.75	14:32	84	45º19.37 N	1º55.74 W	15:01	88	45º18.71 N	1º57.00 W	0.92	4.42	932.39	TH Leads
5	12	16:27	83	45º18.73 N	1º57.18 W	16:42	83	45º19.31 N	1º55.87 W	1.11	4.15	420.03	16:31	84	45º18.82 N	1º57.38 W	17:01	83	45º19.92 N	1º55.87 W	0.99	3.94	249.04	MO Leads
6	14	07:07	125	45º05.80 N	2º25.56 W	07:27	125	45º07.10 N	2º26.55 W	1.49	4.31	2772.69	07:09	125	45º06.43 N	2º25.15 W	07:44	125	45º07.75 N	2º26.21 W	1.42	4.24	221.10	Parallel
7	14	09:02	125	45º05.59 N	2º32.26 W	09:22	125	45º06.69 N	2º30.88 W	1.53	4.39	446.06	09:05	128	45º05.49 N	2º31.45 W	09:41	128	45º06.58 N	2º30.84 W	1.18	4.34	319.42	Parallel
8	14	13:13	126	45º09.48 N	2º21.39 W	13:28	127	45º08.82 N	2º22.71 W	1.18	4.32	7092.16	13:14	128	45º08.86 N	2º22.25 W	13:43	129	45º08.35 N	2º23.45 W	1.10	3.95	2669.81	TH Leads
9	14	15:58	128	45º08.69 N	2º21.49 W	16:13	127	45º07.74 N	2º22.22 W	1.17	4.36	1404.57	16:04	129	45º06.46 N	2º21.82 W	16:20	127	45º07.44 N	2º22.67 W	1.19	4.70	1001.94	MO leads
10	15	06:51	126	45º06.72 N	2º28.31 W	07:12	126	45º26.08 N	2º30.41 W	1.65	4.49	118.66	06:50	127	45º06.97 N	2º28.97 W	07:25	127	45º06.29 N	2º30.93 W	1.54	4.64	310.64	Parallel
11	15	08:39	126	45º06.91 N	2º29.13 W	08:59	125	45º06.39 N	2º31.09 W	1.47	4.39	238.63	08:43	126	45º06.65 N	2º29.59 W	09:03	128	45º05.53 N	2º31.51 W	1.49	4.50	1156.29	Parallel
12	15	12:45	84	45º19.58 N	1º56.85 W	13:00	84	45º19.09 N	1º58.06 W	1.01	3.91	1384.76	12:45	85	45º19.11 N	1º56.66 W	13:15	88	45º18.60 N	1º57.91 W	1.13	4.02	637.21	Parallel
13	15	16:42	73	45º22.38 N	1º48.44 W	16:57	75	45º21.80 N	1º49.66 W	1.05	4.15	881.68	16:44	75	45º21.81 N	1º48.44 W	17:14	79	45º21.18 N	1º49.85 W	1.35	4.73	560.08	Parallel
14	16	06:13	52	45º23.18 N	1º36.94 W	06:33	52	45º24.31 N	1º37.86 W	1.29	3.85	4598.70	06:12	54	45º22.69 N	1º37.31 W	06:46	55	45º23.92 N	1º38.39 W	1.37	4.30	1194.21	Parallel
15	16	08:37	43	45º31.60 N	1º33.43 W	08:52	42	45º30.62	1º32.94 W	1.05	4.02	4281.37	08:37	44	45º31.64 N	1º34.61 W	09:08	44	45º30.54 N	1º33.56 W	1.19	4.38	4708.23	Parallel

Table 10. Main characteristics of the fishing stations, including Number (No); Day (Day); Starting time for effective fishing (i.e. trawl close to the sea bottom, Time); Depth in meters (Dep.); Latitude; Longitude; Ending time for fishing operation (ie hauling, Time); Depth in meters (Dep.); Latitude; Longitude; Trawling distances in nautical miles (Dist); Mean towing speed expressed in knots (Sp.); Backscattering echointegrated energy (NASC) for both vessels and also main remarks

Towing speed was slightly higher in TH, although differences were not significant (t-test, p=0.1124) as shown in figure 26. In both cases, the mean towing speed was higher than 4.2 knots.

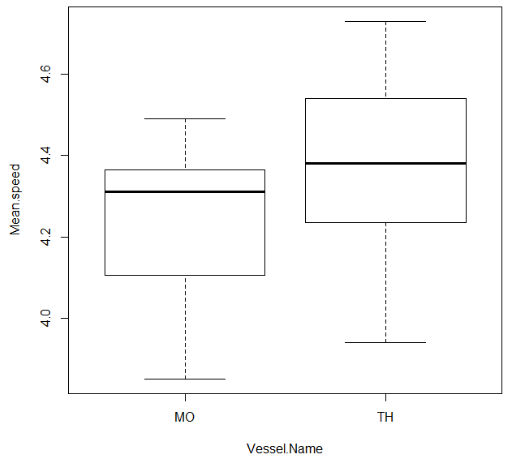


Figure 26: Box-plot showing the towing speed for each vessel

Fish proportion analysis

The special footrope used in the MO gear, a kind of rockhopper with small dishes which allows it to have a permanent contact with the sea bottom while preserving the net, makes the demersal species be more available to this vessel. Accordingly the faunistic list obtained by MO was longer (table 11). It includes almost the same species caught by the TH (this vessel also caught ten Trigla lyra in a single haul)

Miguel Oliver			Thalassa		
Specie	No hauls	No	Specie	No hauls	No
Chelidonichthys cuculus	1	1			
Engraulis encrasicolus	9	244442	*Engraulis encrasicolus*	9	384276
Illex coindetii	1	na	*Illex coindetii*	1	na
Merluccius merluccius	13	380	*Merluccius merluccius*	8	89
Petromyzon marinus	1	1			
Pollachius pollachius	3	6			
Raja spp	1	4			
Sardina pilchardus	8	20211	*Sardina pilchardus*	7	24247
Scomber colias	12	452	*Scomber colias*	9	331
Scomber scombrus	14	18270	*Scomber scombrus*	13	15973
Sprattus sprattus	9	21203	*Sprattus sprattus*	9	24787
Trachinus draco	2	3			
Trachurus trachurus	15	53815	*Trachurus trachurus*	9	15024
			Trigla lyra	1	10
Trisopterus luscus	1	1			
Trisopterus minutus	1	23			
Zeus faber	3	3			

Table 11. Faunistic list obtained in PELACUS0414-INTERCALIBRATION by both vessels, including the number of hauls with presence and total specimen caught.

1. Anchovy and sprat were present in the same hauls, although, given the higher sweep area of the TH trawl gear, which doubled that of the MO, and the special aggregation pattern of these fish species, TH has caught a 57.2% more of anchovy and a 16.9% more of sprat.

Besides, she has also caught a 20% more of sardine. In the same way, as expected, horse mackerel and hake were present in more hauls (40 %) and also the number of specimen caught was higher in MO (72 % and 77% respectively). MO has caught horse mackerel in all hauls. For *Scomber*, MO catches were higher both in number of hauls with presence and in the overall number (7% and 13 % respectively higher for mackerel and 25% and 27% for chub mackerel).

Species composition by depth strata (<60; 60-90; and >120 m) are shown in figure 27.a-c

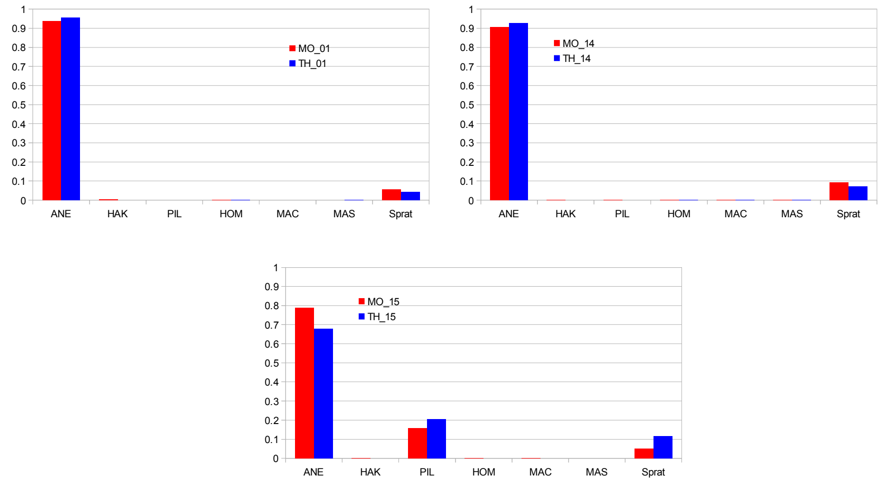


Figure 27a: Species composition (%) in number in the hauls performed in coastal areas (depth < 60 m)

School occurrence and aggregation pattern were similar to both vessels, although during the fishing station number 14 the amount of backscattering integrated by TH was lower than that of MO. Also, the school distribution found by TH during the 15th trawl was slightly different from that found by MO; in the former, some schools occurred in mid waters, in layers upper than those saw by MO; besides (figure 28), there were some thick schools close to the bottom which would have been more accessible to MO due to its foot-rope.

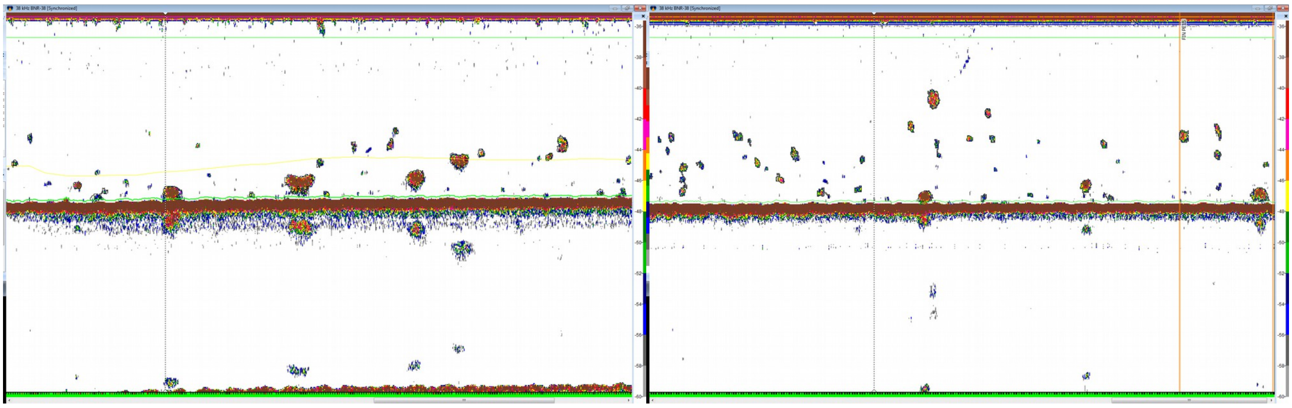


Figure 28: Echogram (38 kHz) obtained during the fishing station number 15. Left, MO; right, TH.

In strata 60-90 (figure 27b), catches were similar. Nevertheless, significant differences were found in fishing station 4, where TH leaded. In this case, TH caught a 20% more anchovy than MO and this vessel clearly caught less anchovy than its average proportion in this area (73%). In this case, the total backscattering energy integrated by MO was much lower than that from TH (222 to 932 NASC) but also the number of schools as shown in figure 29.

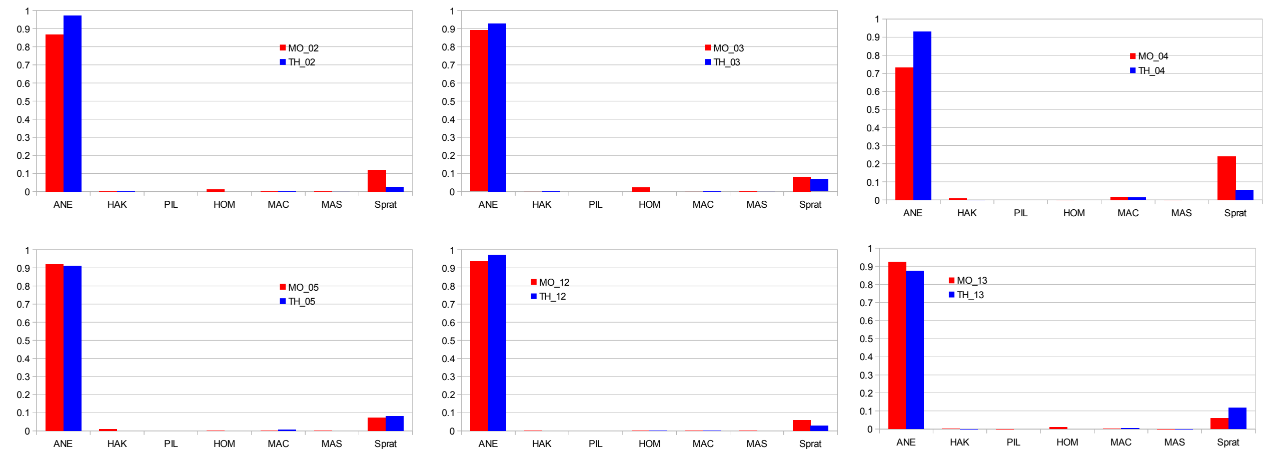


Figure 27b: Species composition (%) in the hauls performed in middle waters (depth between 60-90 m)

The differences when TH leaded were not seen when MO leaded, although in this case TH got less backscattering energy integrated than MO.

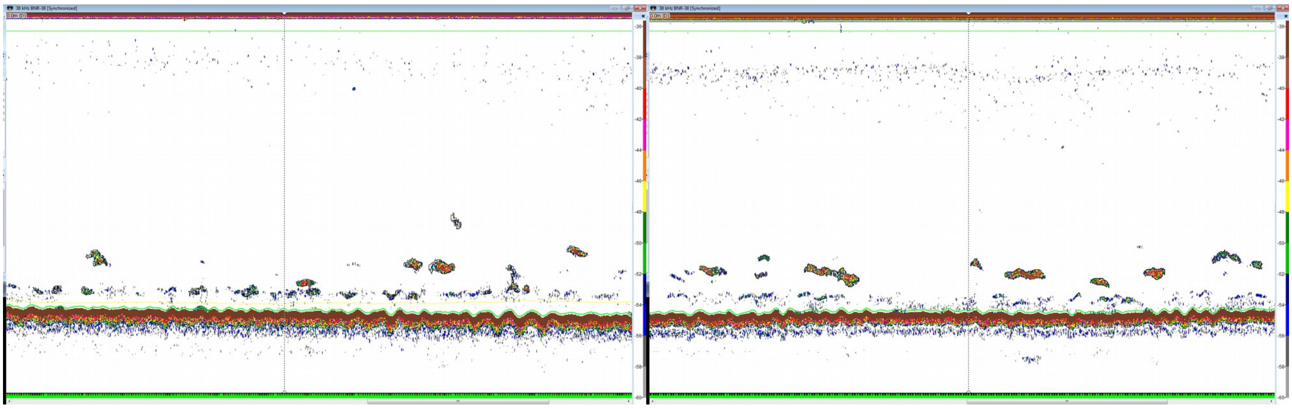


Figure 29: Echogram (38 kHz) obtained during the fishing station number 4. Left, MO; right, TH.

Finally in deeper waters (depth >125 m), the presence of occasionally sardine schools, made difficult to extract conclusions.

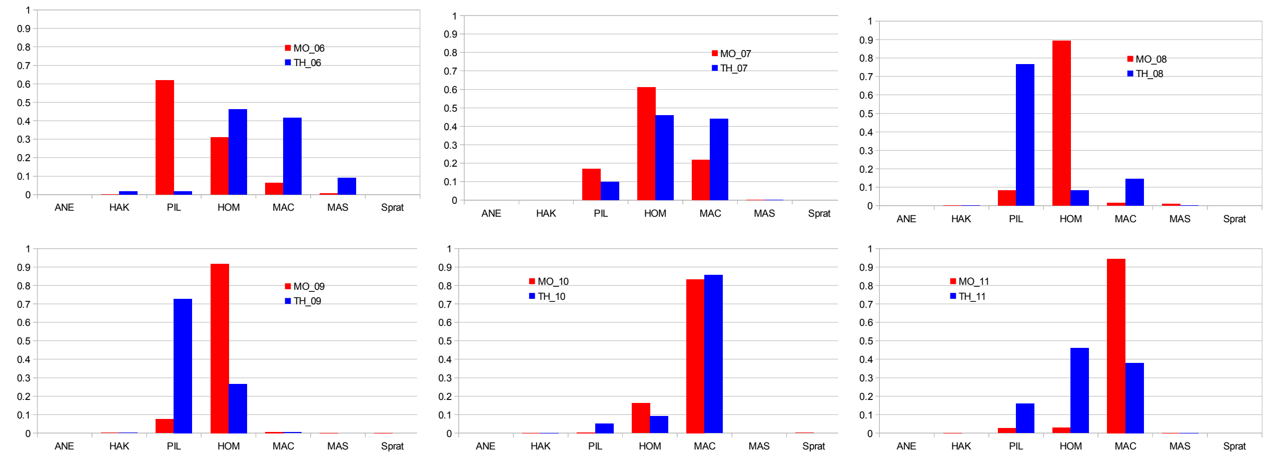


Figure 27c: Species composition (%) in the hauls performed in deeper waters (depth >125 m)

Fishing stations 6 and 7 although parallel, got contradictory results, accounting the presence or not of sardine schools. In fishing stations 8 and 9, the former leaded by TH and the second by MO, and also very close each other, each vessel got consistent results but very different from the other. In both cases, MO accounted for more backscattering integrated energy (7092 to 2670 for the first and 1405 to 1002 for the second). In fishing station 8, MO has found only a big school, probably horse mackerel, and three very compact ones in upper layers, out of the fishing area, while TH accounted for a wider variety of echotraces, all of them close to the sea bottom, as shown in figure 30.

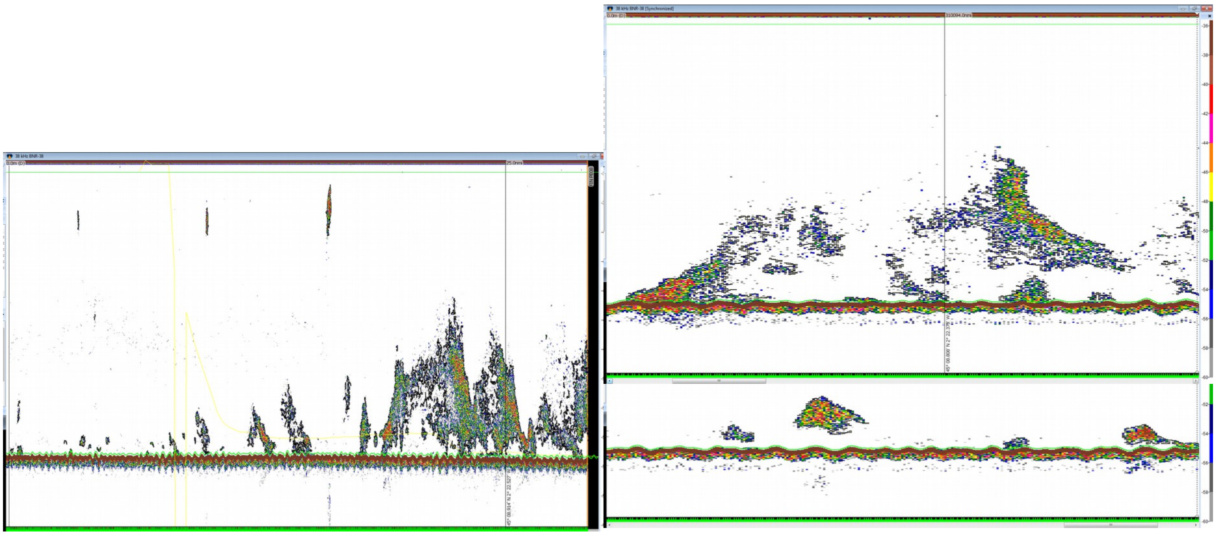


Figure 30: Echogram (38 kHz) obtained during the fishing station number 8. Left, MO; right, TH, showing two different areas of the fishing track.

In the same way in fishing station 9, some of the schools detected by MO were located in middle waters, out of the trawling path, as shown in figure 31.

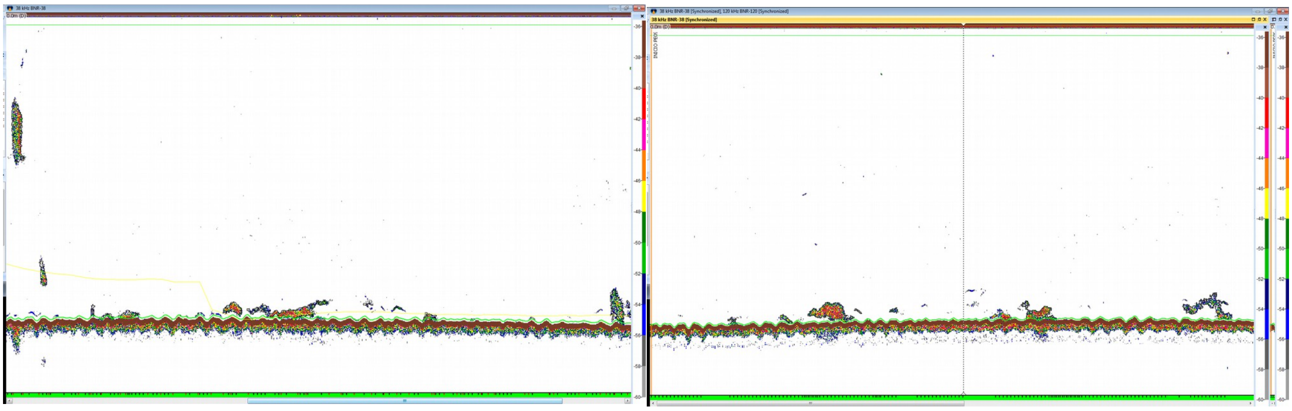


Figure 31: Echogram (38 kHz) obtained during the fishing station number 9. Left, MO; right, TH.

Fishing stations 10 and 11 were undertook simultaneously and almost in the same area. 19 echotraces found for both vessels had similar frequency response to that expected for a mackerel school (45% of them for MO and 42% of them for TH). They occurred in isolated, well defined schools, as shown in figure 32.

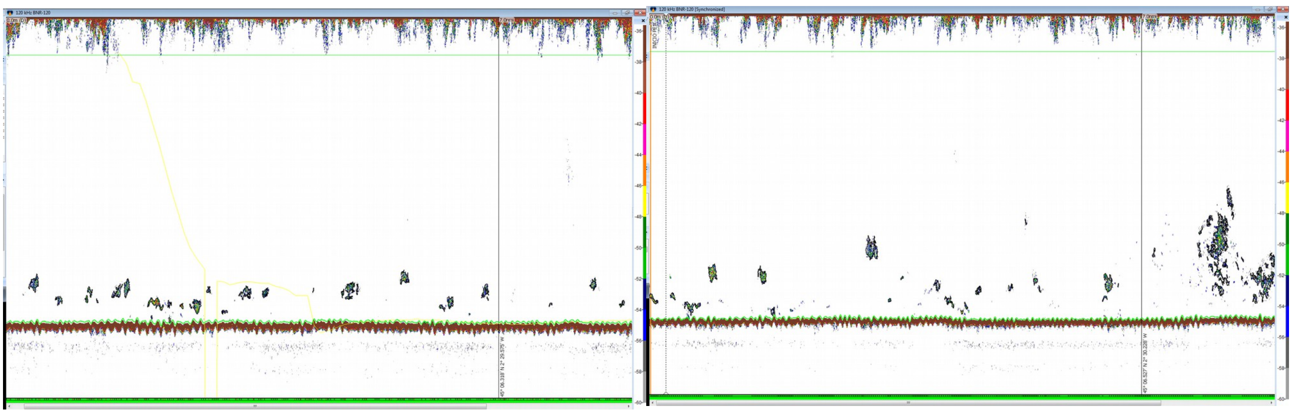


Figure 32: Echogram (38 kHz) obtained during the fishing station number 10. Left, MO; right, TH.

80% of the total catch in number corresponded to mackerel, although the fishing gear used by MO haven't performed properly[1]. In fishing station 11, 52% (11 of 21) schools recorded by MO had a frequency response similar to that of mackerel; contrary, only a 3% (3 of 88) of the schools recorded by TH gave a similar frequency response to that of mackerel and hence, the important differences in species composition found in this fishing station. It is very difficult to elucidate whether this change in both frequency response and species composition obtained during the two consecutive trawl hauls done by TH were due to change in the behaviour induced by the vessel or by a very local change in the pelagic community.

In any case it seems that the accessibility to the pelagic community yielded similar results for both gear, although that of the MO seems to achieve a better representation of those pelagic fish with a more demersal behaviour such as horse mackerel.

Fish length distribution analysis

This analysis has been done in the similar way as the previous one, i.e. by strata and comparing in pairs those representative length distributions (number >30 individuals) obtained by both vessels in the same fishing station.

Figure 33a-f shows the pairs obtained for the main pelagic species (anchovy, sardine, sprat, horse mackerel, chub mackerel and mackerel) in the coastal area (depth < 60 m)

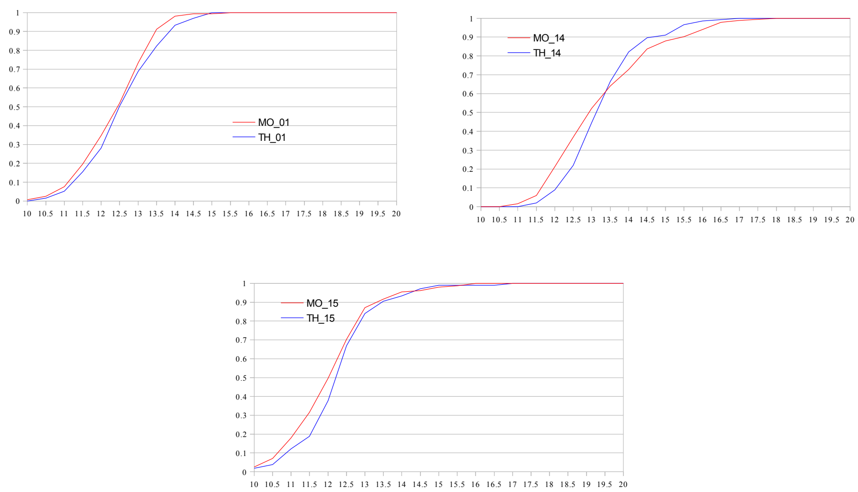
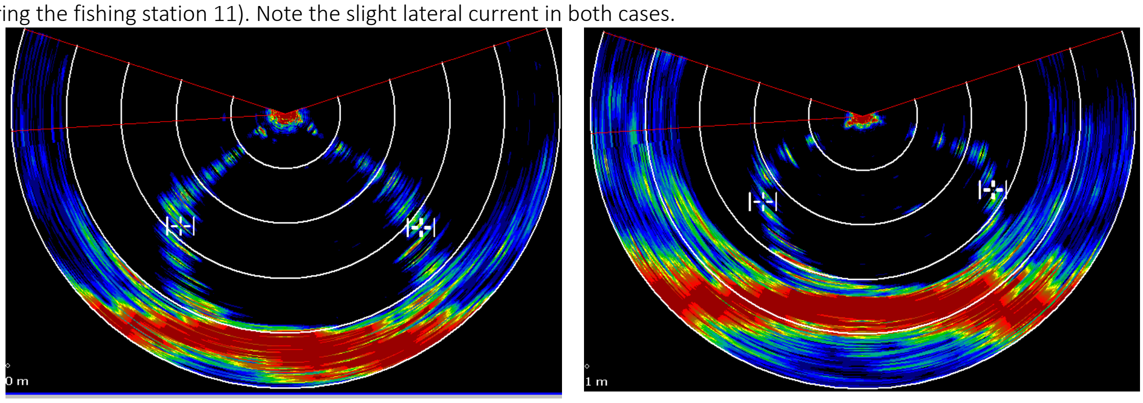


Figure 33a: Anchovy cumulated length distributions obtained in coastal area

1 This haul was performed using a brand new gear which should be similar to the previous. Either because a problem in headline of in the first great meshes, the doors haven't worked properly, with only a distance between them of about 45 m instead 70 m which is the standard working at that depth. Besides headline was maintained by the netsonar cable as shown in the following figure giving an overture of 15.23 m in the horizontal plane and a V shape with a vertical opening of 15.70 m (left panel captured during the fishing station 10) when the normal is around 26-30 in the horizontal and 19-20 in the vertical (right panel, captured during the fishing station 11). Note the slight lateral current in both cases.



In coastal waters, anchovy had a mean length of about 12.8 cm (fishing station 1 and 15) and 13.7 in fishing station 14. Besides there were no significant differences between pairs (k-s test). Both vessels obtained the same length distribution (figure 33 a).

Sardine was only caught in fishing station 15 and, as in the case of anchovy, there were no significant differences in length distribution (mean length 13.3 cm) (figure 33 b)

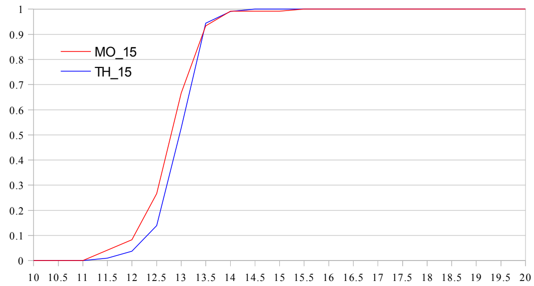


Figure 33b: Sardine cumulated length distribution obtained in coastal area.

Sprat in coastal waters had a mean length of 10 cm and as in the case of anchovy, no significant differences were found in length distributions as shown in figure 33c

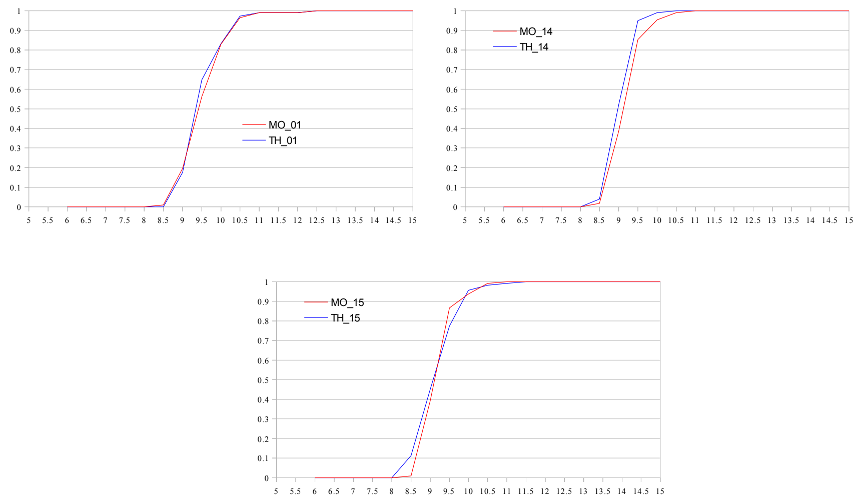


Figure 33c: Sprat cumulated length distributions obtained in coastal area.

The only comparison pair for mackerel was the fishing station 15 and again there were no significant differences in length distribution

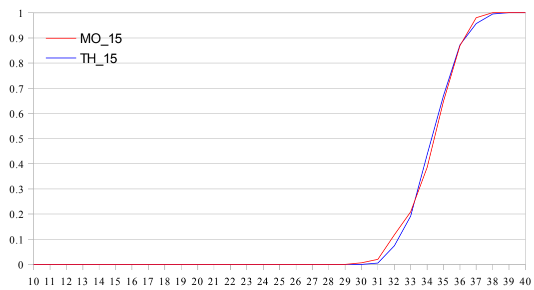


Figure 33d: Mackerel cumulated length distribution obtained in coastal area.

No comparison for chub mackerel nor for horse mackerel was available in coastal waters as only MO got enough specimen for both species.

In the second strata (60-90 m depth) mean length of anchovy ranged from 13.7 to 16 cm.

Significant differences were found between fishing stations 2, 4 and 13 while those distributions obtained in fishing stations 3, 5 and 12 were similar (figure 34a). Differences occurred in fishing station 4 might have been due to the different aggregation pattern found during the hauls.

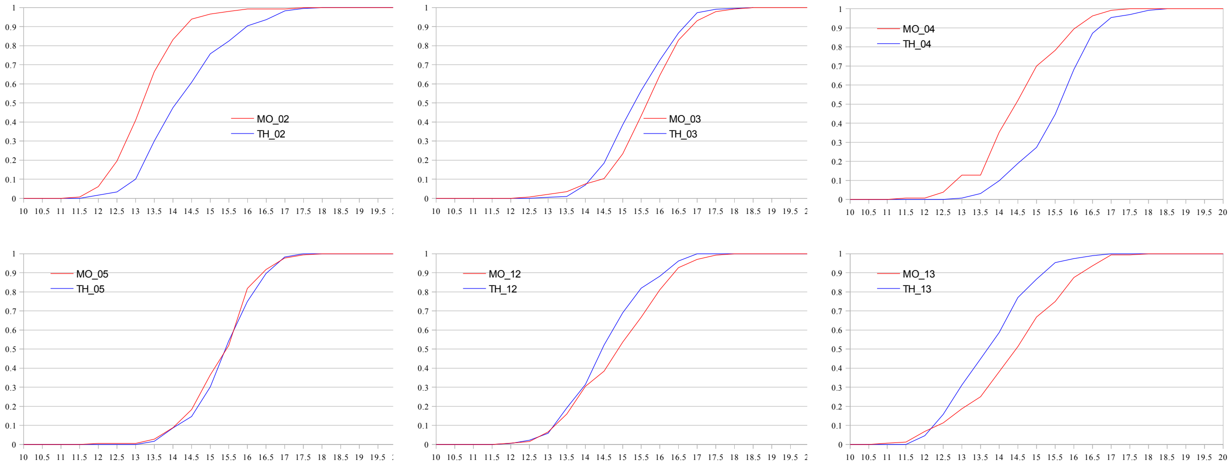


Figure 34a: Anchovy cumulated length distributions obtained in middle waters (60-90 m depth).

Given that there is not a clear pattern and most of the samples got similar length distribution, both vessels and gears obtained similar stock length structure, thus a good representation of the population.

For sprat, although mean length were similar, lengths distributions showed significant difference in most of the cases (fishing stations 3, 4, 12 and 13) as shown in figure 34b

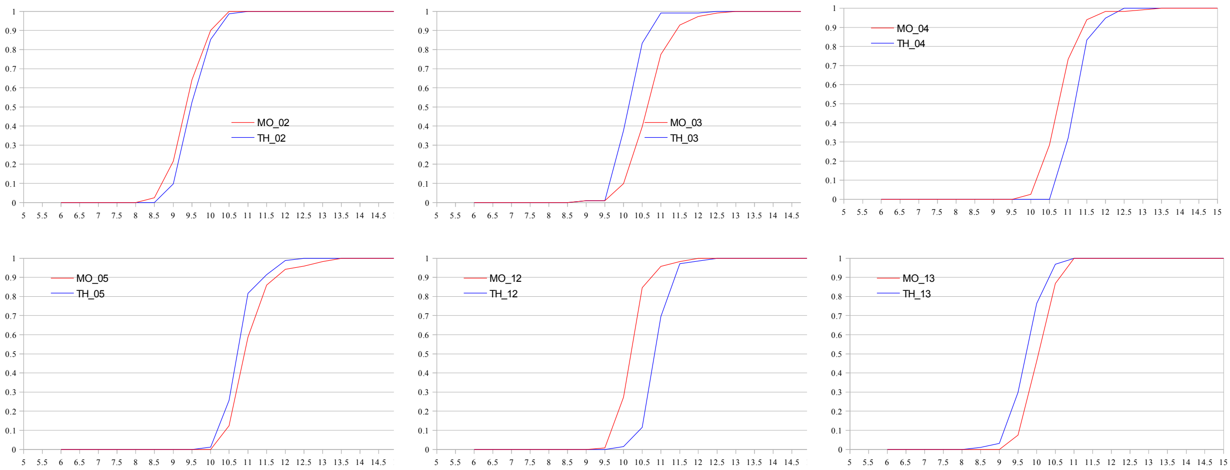


Figure 34b: Sprat cumulated length distributions obtained in middle waters (60-90 m depth).

Slight changes in the mode of only 0.5 cm and mean length resulted, given the short length distribution (length ranged between 8.5 and 13.5 cm), in significant differences.

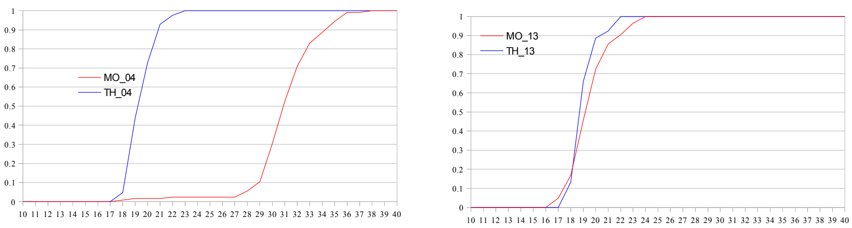


Figure 34c: Mackerel cumulated length distributions obtained in middle waters (60-90 m depth).

For mackerel only two comparison were available. In fishing station 4, length distribution obtained by MO was bimodal, with most of the specimen located in the second mode (i.e. higher than 28 cm) while TH had only one mode at 19 cm. On the contrary length distributions were similar in fishing station 13.

In deeper waters no anchovy nor sprat were caught. Comparison were available for sardine, horse mackerel, mackerel and chub mackerel.

Sardine was present in all haul but the low numbers obtained by MO in fishing station 10 (the one in which MO used the alternate fishing gear) did not allow to make any comparison. Only in fishing station 6 length distributions showed significant differences. Ranges were identical, but the sample obtained by TH (mean length 22.88 cm) had much more larger specimen than that obtained by MO (mean length 22.12 cm)

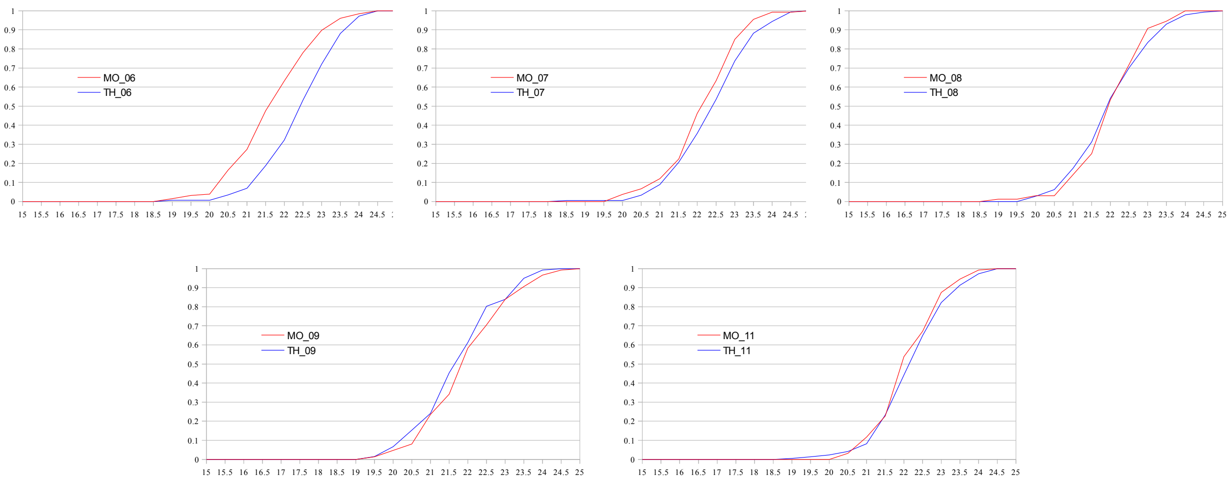


Figure 35a: Sardine cumulated length distributions obtained in deeper waters (> 125 m depth).

As it was previously said, horse mackerel was more accessible to the MO trawl. This species generally occurred in a bimodal length distribution, with first mode located at 12.5-13 cm and the second one at 16-17.5 cm. The differences in the strength of each of this mode resulted in significant differences in length distributions as shown in figure 35b. This differences were found between pairs of the fishing stations 9, 10 and 11 but there were no differences between those distributions obtained in fishing stations 6, 7 and 8.

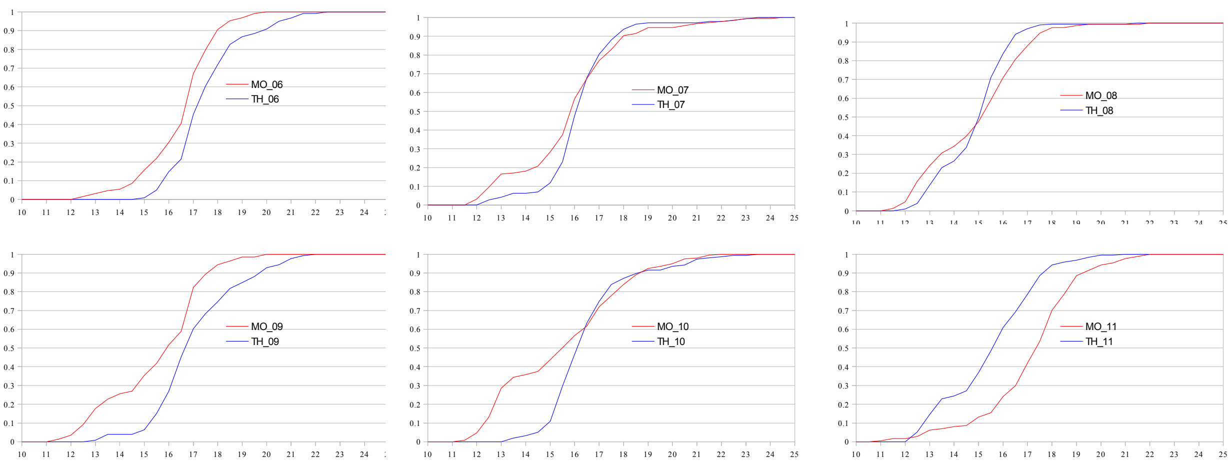


Figure 35b: Horse mackerel cumulated length distributions obtained in deeper waters (> 125 m depth).

In mackerel different modes have been obtained. In some of the pairs of comparison these modes were different which resulted in significant differences in length distributions. (figure 35c)

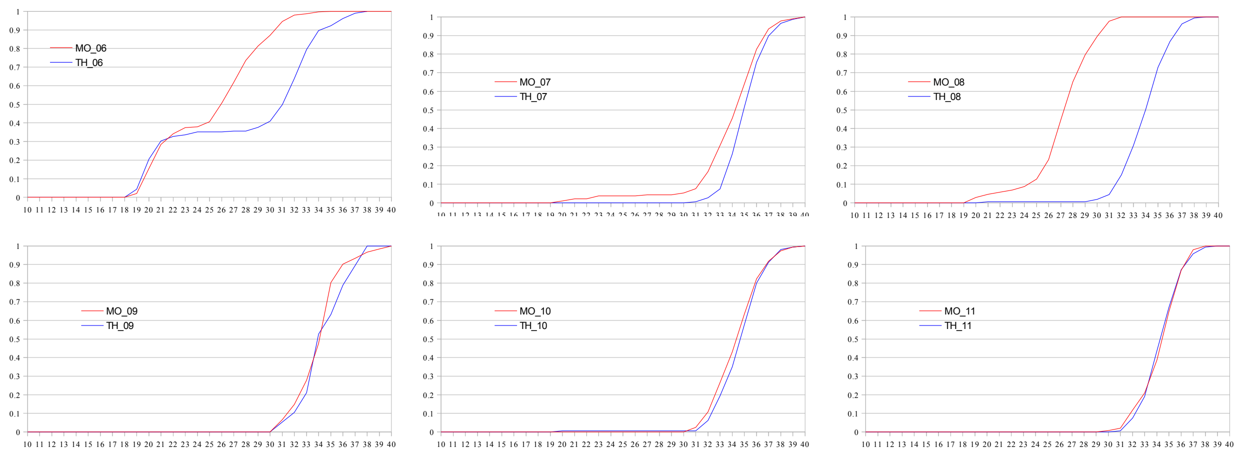


Figure 35c: Mackerel cumulated length distributions obtained in deeper waters (> 125 m depth).

Instead, length distributions obtained in fishing stations 9, 10 and 11 were similar, thus without significant differences. In fishing station 7, although both modes and distributions seemed very close, the differences were also significant.

For purposes of comparison only fishing station 6 got enough chub mackerel to perform the k-s test. In this case differences were not significant, as shown in figure 35d.

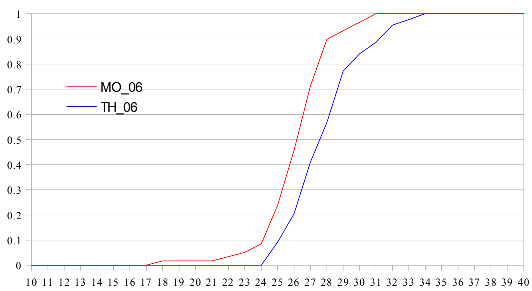


Figure 35c: Mackerel cumulated length distributions obtained in deeper waters (> 125 m depth).

Intraship comparison was also done accounting the distance among fishing station. Pair comparison, when available were stablished as follows:

Strata	Pair comparison
Coastal	FST02-FST13
	FST01-FST14
Middle	FST03-FST04
	FST05-FST12
Deeper	FST08-FST09
	FST10-FST11

Coastal comparisons and one of the middle strata were done using fishing station performed in different day. The other made in the middle strata, the time between stations was lower than 2 hours.

For anchovy in coastal waters, although inter-ship comparison got not significant differences, the gap between days made differences be significant, as shown in figure 36a. The elapsed time between the first and the second haul explains such differences

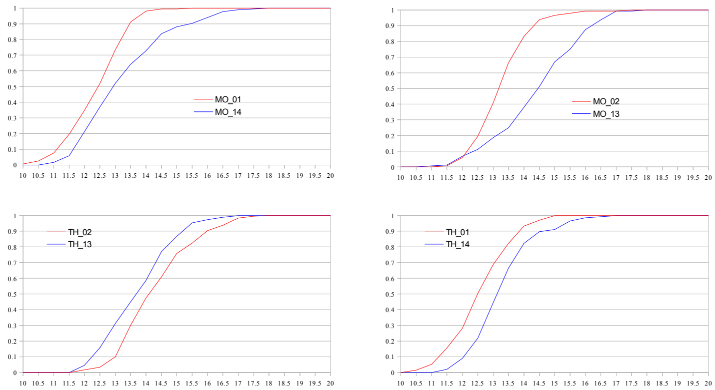


Figure 36a: Anchovy cumulated length distributions obtained in coastal waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH.

In middle waters, the comparison between the hauls performed the same day (3 and 4) gave significant differences for MO although the comparison between 4 and 5 gave no such differences, nor between fishing stations 5 and 12. On the contrary, those performed by TH gave similar length distribution except fishing station 12.

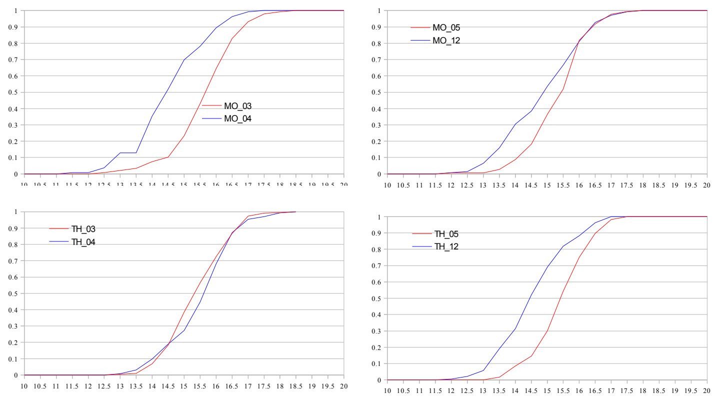


Figure 36b: Anchovy cumulated length distributions obtained in middle waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH

Intra-ship comparison for sprat are shown in figure 37a-b. In coastal waters, as seen for anchovy, there were significant differences between pair comparison except for the comparison between fishing station 2 and 13 done by TH.

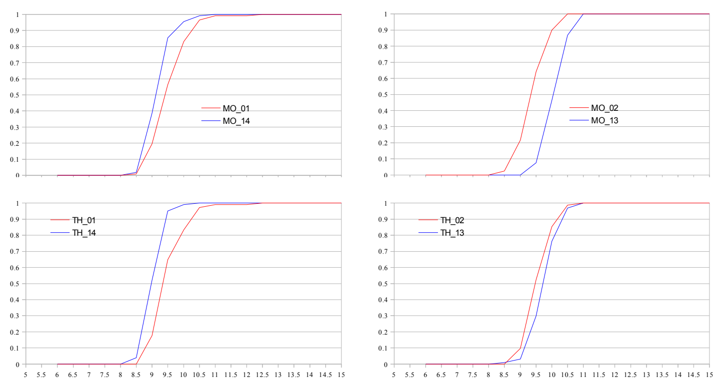


Figure 37a: Sprat cumulated length distributions obtained in coastal waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH.

In middle waters, all comparison for TH gave significant differences except that between fishing station 5 and 12. For MO, fishing stations 3, 4 and 5 had similar length distribution while fishing station 12 was different

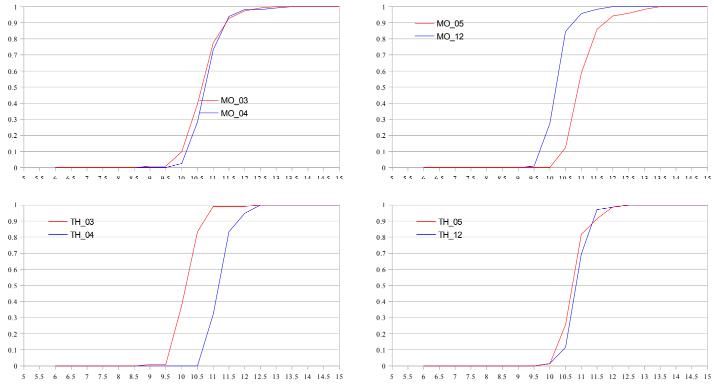


Figure 37b: Sprat cumulated length distributions obtained in middle waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH.

For sardine only samples from deeper waters were available and no differences has been found between fishing stations, as shown in figure 38.

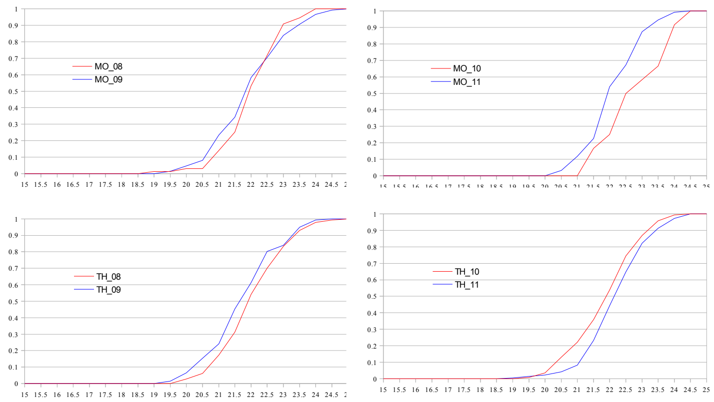


Figure 38: Sardine cumulated length distributions obtained in deeper waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH.

For horse mackerel, as for sardine, only comparison were available in deeper waters, but in this case, differences were significant except that between fishing stations 8 and 9 for MO.

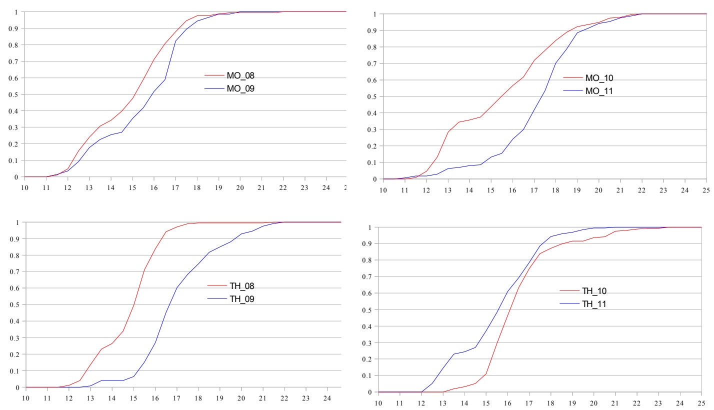


Figure 39: Horse mackerel cumulated length distributions obtained in deeper waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH.

For mackerel intra-ship pair comparison were available only in middle water for MO between fishing stations 3 and 4. Comparison in deeper waters were done between 10 and 11 for both vessels and between 8 and 9 only for MO.

Differences were significant for mackerel length distributions obtained by MO in middle waters. Two different modes were caught in each fishing haul. While the distribution peaked at around 19 cm in fishing station 3 (which was similar to that obtained by TH in fishing station 4), that of fishing station 4 had the mode at 31 cm (figure 40a)

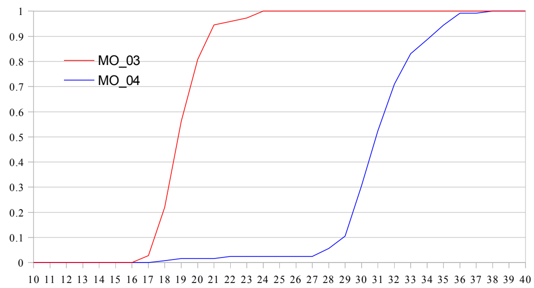


Figure 40a: Mackerel cumulated length distributions obtained fo MO in middle waters.

Again in deeper waters differences between length distribution obtained in fishing stations 8 and 9 by MO had significant differences. In this case the length distribution in fishing station 8 had a mode in 27.5 cm and that of the fishing station 9 in 35 cm. This mode was similar to those obtained by both vessels in fishing stations 10 and 11 which had no significant differences between them.

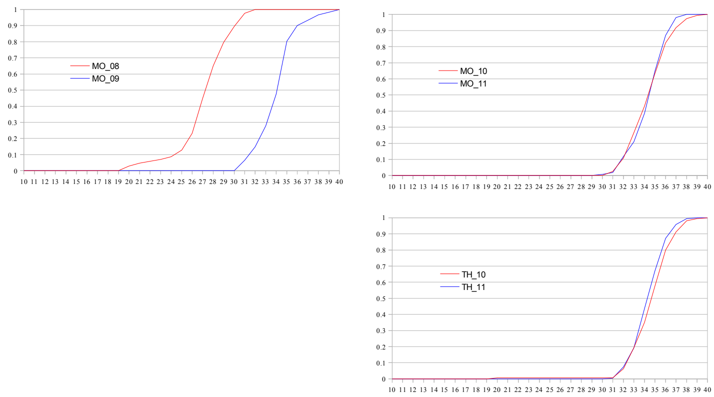


Figure 40b: Mackerel cumulated length distributions obtained in deeper waters. Top panels comparison between fishing station performed by MO; bottom panel comparison between those performed by TH..

CUFES

A total of 89 CUFES valid stations (47 in R/V Thalassa and 42 in R/V Miguel Oliver) were used for intercalibration purposes (figure 41). Samples were taken during the first and second passages to each transect.

Sardine and anchovy egg concentrations obtained during the intercalibration are shown in figure 42a-b. Sardine egg concentrations during INTERPELACUS were much higher than anchovy ones. The former were mainly located near the self-break while the second in shallower waters. As it was already mentioned, the first passage to each transect was done in parallel while during the second MO has leaded. The elapsed time between passages was higher than 2 hours (see table 5 for further details).

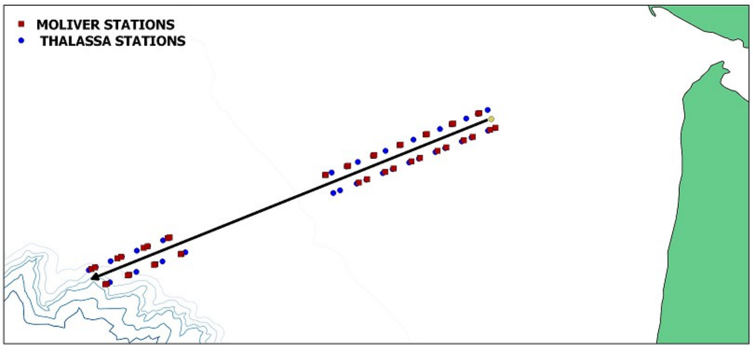


Figure 41: Location of the CUFES stations for each vessel.

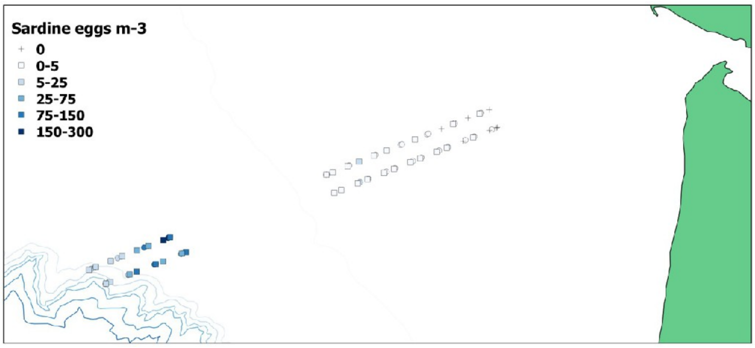


Figure 42a: Sardine egg concentration (no of egg m^{-3}) obtained from the CUFES stations (all passages) by MO (circles) and TH (square). Colours grade is proportional to concentration.

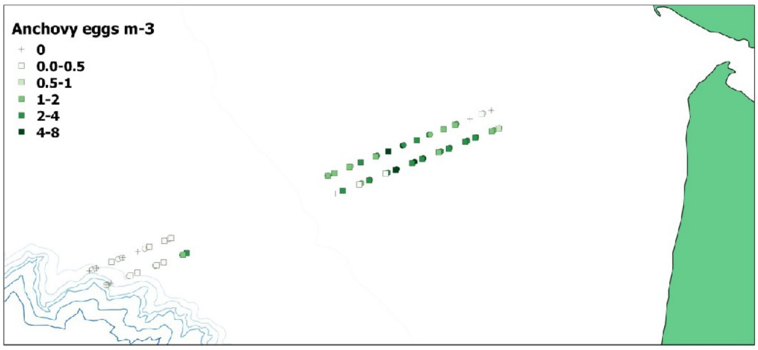


Figure 42b: Anchovy egg concentration (no of egg m^{-3}) obtained from the CUFES stations (all passages) by MO (circles) and TH (square). Colours grade is proportional to concentration.

Inter-ship analysis

Although the samples were not taken exactly at the same position, for sardine there was a high correlation for sardine egg concentration between pair of stations located at roughly the same position, (figure 43). On the contrary, for anchovy the correlation was too low

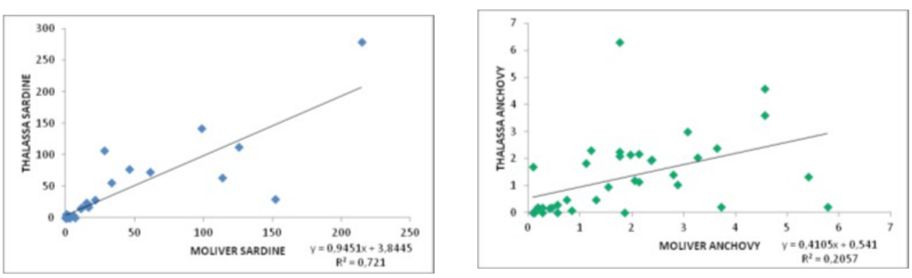


Figure 43: Egg concentration relationship between pairs of samples obtained at roughly the same position for both vessels. Left panel, sardine; right panel, anchovy

As in the case of the backscattering energy, egg concentration was cumulated from a common starting point, but in this case, the origin was the same for both transects, thus giving a single probability density function for each specie. Besides, due to the skewness of the data, these were transformed in logarithmic scale (ln(x+1)). As it was already said, there was a depth trend for both species; for sardine the trend was positive while for anchovy this was negative. For both species cumulated egg concentration could be adjusted to a simple regression model, linear for sardine and exponential for anchovy. In both cases models were significant, explaining most of the variability (R^2 >0.983). Besides,comparison between the models obtained for each specie and vessel did not shown differences as shown in figure 44 .

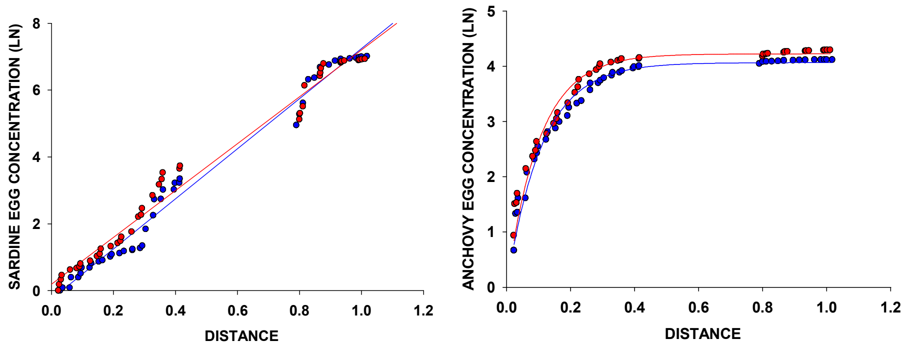


Figure 44: Fitted models and cumulated egg concentration for each specie and vessel. Left panel, sardine; right panel anchovy. In red data from MO; in blue data from TH

Intra-ship analysis

For each vessel, although sardine and anchovy egg abundance was correlated, differences between passages were noticeable. For TH, only in transects R09 and R10 for anchovy and R10 for sardine, differences were lower than a 15%; for MO, only R01 for both species such differences were lower than 15%. Moreover, in TH and for sardine, only in transect R10 these differences were lower than a 50%; in the case of MO most of the differences between passages were lower than 50% except for transect R02. In the case of anchovy, due the low number of eggs which would be also related with the lack of spawning activity, all differences for both vessels were below 50% except in R01 for TH. (figure 45).

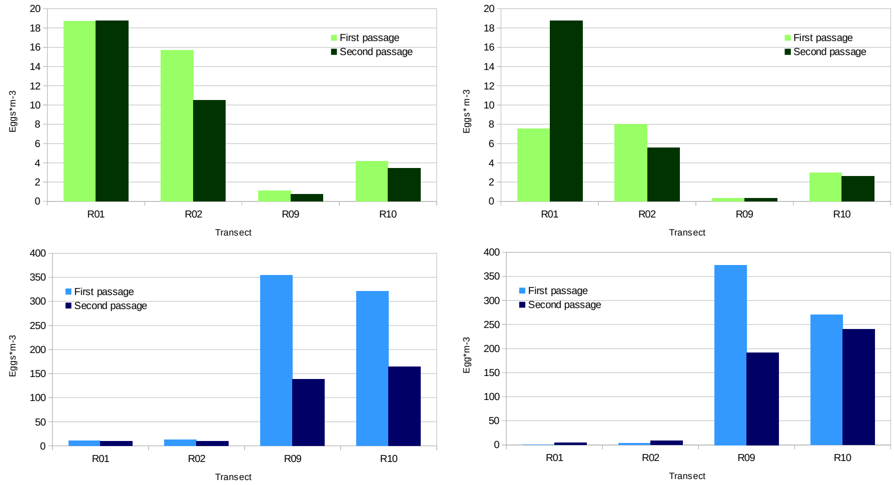


Figure 45: Egg abundance (no egg/m^3) for anchovy (green colours) and sardine (blue colours) from the CUFES stations. Lefts panels samples from MO; right panel samples from TH.

On the other hand, the magnitude of the change in sardine egg abundance from the first to the second passage in the slope area occurred in both vessels suggests a high hydrodynamic activity conditions.

CONCLUSIONS

The performance of two modern halieuthic-oriented research vessels has been tested by comparison of the results obtained in three samples devices (echosounders, fishing gears and CUFES), which are the more important ones when an acoustic-trawl survey is carried out. The results in terms of biomass estimates, population structure and distribution area as well as spawning activity are heavily influenced by either the performance of such sampling devices and the effect of the vessel on the fish behaviour.

While for echosounders the performance could be corrected during the calibration process, the ability for finding fish is more vessel-dependent (i.e. fish can be accessible but the availability to a specific vessel depends, among other factors, on the fish response to the radiated vessel noise). In the same way, CUFES installation would be the same but the availability to fish egg will depend on the position of the pump intake and also on the hull design and its impact on the hydrodynamic (the later has also impact on the performance of the transducers due to the generation of air bubbles). Fishing gears together with the problems of availability which depends on both vessel and gear characteristics, would present an additional source of uncertainty derived from the catchability. All these impacts should be measured in order to estimate de precision and the accuracy of the estimates. However, these sources of error are sometimes difficult to measured nor, those remain fixed along time and space, as they could change according to time, oceanographic and meteorological conditions, geographical position, fish condition, population structure, fish behaviour (aggregation and distribution patterns) and also interactions among different fish species and their relative abundance.

In spite of that, intercalibration exercises between vessels are needed in order to know the relative performance which allows data from different vessels be combined.

The intercalibration between R/V Thalassa and R/V Miguel Oliver has been made in a small area and only during the light hours of four days and a half of effective work. It is, therefore, complicate to extract conclusions for a large scale survey such us PELACUS time series.

Acoustic performance

P Córdoba (2014) has analysed the noise level accounted for the transducers in passive mode. R/V Thalassa showed a more stable spectra along increasing propeller rpm and only the noise increased at 18 kHz when the propeller turns at more than 40 rpm (4 knots). On the other hand at 200 kHz R/V Miguel Oliver has at noise level of around 15 dB higher than Thalassa. These differences would be related with the different propeller regime for the same speed, which increases for a given speed the cavitation in R/V Miguel Oliver.

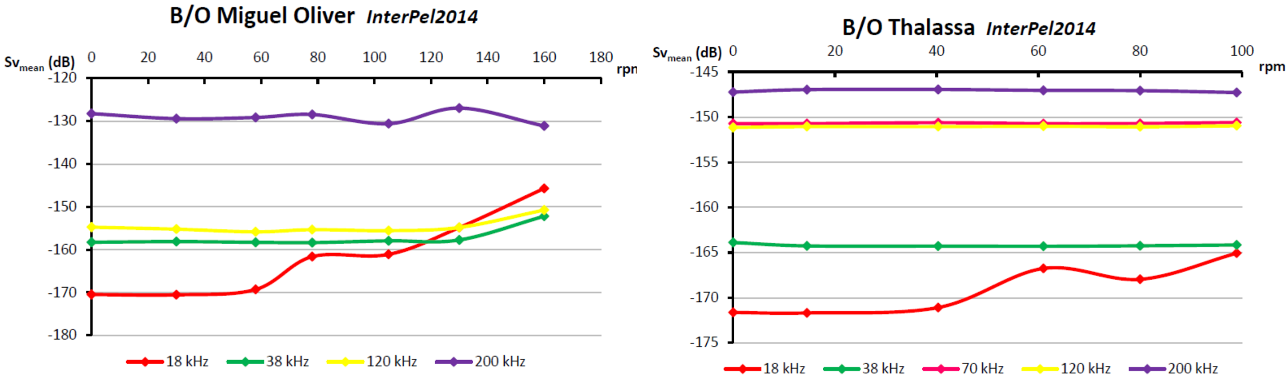


Figure 46: Noise measurements in passive mode (mode: integrated values -S_V- close to the sea surface at different rpm regimes) extracted from Cordoba (2014). Note that the Y axis are in different scale.

Contradictory, this high level of cavitation would not result in a higher fish avoidance. For a given comparison, it seems that at 38 kHz R/V Miguel Oliver consistently integrated more backscattering energy than R/V Thalassa which could be related with a higher fish avoidance or more presumably with a higher diving response to R/V Thalassa. This kind of response changes the tilt angle and TS becomes lower than expected, which in turn results in an underestimation of the fish abundance. This contradictory response has been already observed in other ship comparisons. Fish reactions cannot be explained only by considering noise spectra but also sound pressure fields and particle acceleration. This later feature would explain the results obtained.

In any case the repercussion on a large scale survey of such differences are still matter of concern. Ideally ship performance should be compared in a broader survey targeted on the same species as the reference survey time series.

Fishing gear performance

The different fishing gear would not result in significant differences between catch composition and length structure as the intra-ship variability was similar to the inter-ship one. However it should be mention that the higher accessibility to horse mackerel and hake shown by the Miguel Oliver might result in lower proportion in NASC allocation accounting the proportion found at the fishing station for the rest of the fish species. This fact can be shown in figure 47 where the comparison in species proportion derived from the Nakken and Dommasness method for multi-specific situations and the proportion in number obtained in each trawl haul. Because horse mackerel and hake has higher TS, the more proportion of these fish species in the catches, the lower NASC allocation for mackerel, sardine, sprat and anchovy among other species.

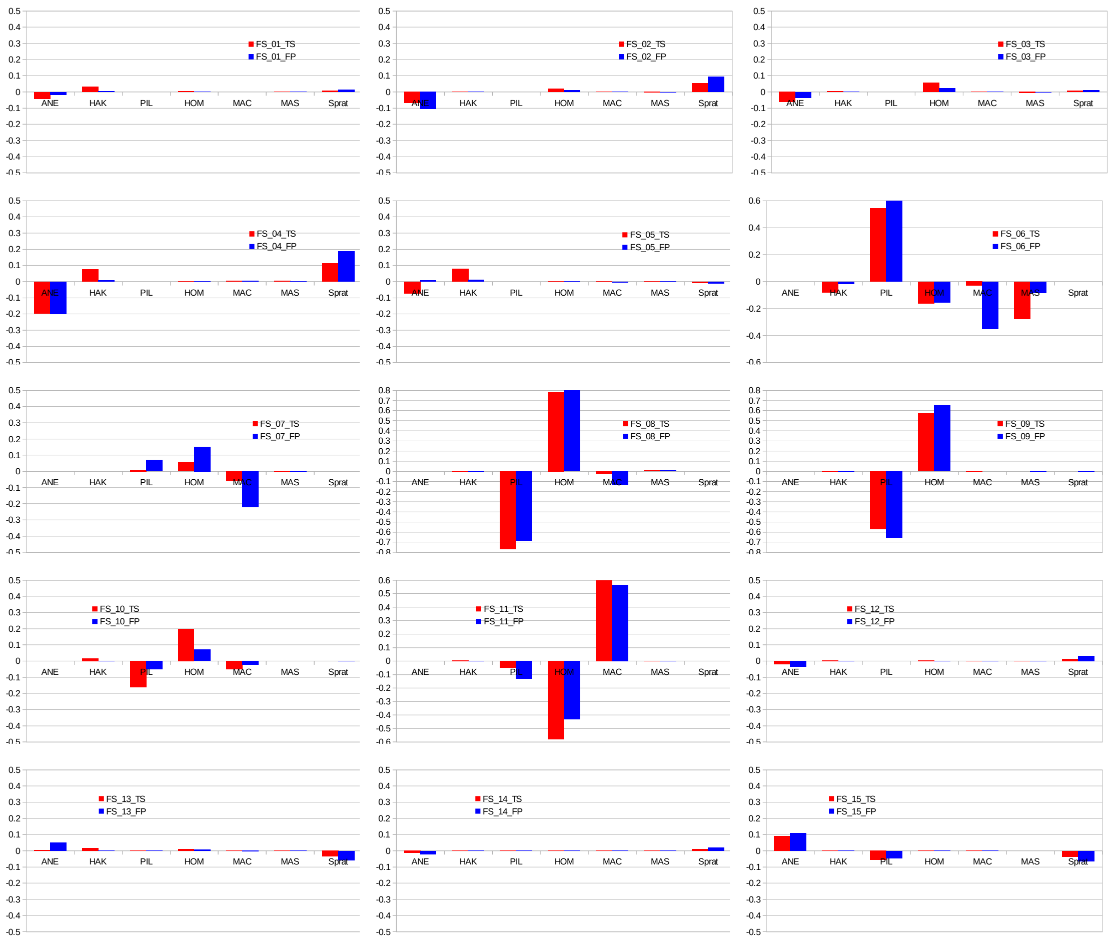


Figure 46: Differences in fish species proportions in pairs of fishing stations obtained using the Nakken and Dommanes method (red colours) and from the fish number caught (blue colour)

In the studied area differences between the fish species proportion obtained using the Nakken and Dommasnes method and that obtained as number per species divided the total catch in number got value higher than 0.1 in the pairs of comparison P06 (mackerel and chub mackerel); P07 (mackerel); P08 (mackerel); P10 (sardine and horse mackerel); and P11 (horse mackerel). Only those species would result affected by the higher availability of the R/V Miguel Oliver fishing year to horse mackerel and hake.

Nevertheless, as it was already stated in the previous section, the impact of this differences should be checked in a large scale survey.

CUFES performance

For CUFES it seems that intra-ship variability is of the same order as the inter-ship one, although the surveys would be undertaken outside the main anchovy spawning period. Nevertheless as during PELACUS only sardine eggs are found through all the surveyed area, both vessels seems to achieve the same performance.

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The INTERPELACUS 0314 survey took place after PELACUS, a 33 days survey. Our colleagues Joan Miquel (who was the responsible on board R/V Thalassa), Pilar Córdoba, Dolors Oñate, Rosendo Otero, Isabel González and Ana Antolínez went from Santander to Brest by car once PELACUS has ended. We wish to thank them together with the crew of the R/V Thalassa for the intensive coordination work done during the survey. In the same way we wish to thank to our colleagues Charo Navarro, Clara Dueñas, Javier Delgado, Isabel Loureiro and Sara Abalo and also the crew of the Miguel Oliver. Without the enthusiasm and hard effort of these people, the survey would be not possible.

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CONSULTED BIBLIOGRAPHY

Blaxter, J. H. S., Gray, J. A. B. and Denton, E. J. 1981. Sound and startle responses in herring shoals. J. mar. boil. Ass. U. K. 61, 851-869.

Bethke, E. Arrhenius, F., Cardinale, M., and Håkanssson, N. 1999. Comparison of the selectivity of three pelagic sampling trawls in a hydroacoustic survey. Fisheries Research, 44, 15-23.

Bodholt, H. 1990. Fish density derived from echo-integration and in-situ target strength measurements. ICES C.M. 1990/B:11, 15 pp.

Carrera P. (1997). PELACUS 0397. Informe de campaña. Instituto Español de Oceanografía (mimeo)

Checkley, D., Ortner, P., Settle, L., Cummings, S. 1997. A continuous underway fish egg sampler. Fisheries Oceanography, 6(2) : 58-73

Cordoba P. (2014). Informe de la prueba de ruídos. Campaña PELACUS INTERCALIBRACIÓN 0414 (mimeo)

De Robertis, A., and Higginbottom, I. 2007. A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise. – ICES Journal of Marine Science, 64: 1282–1291.

De Robertis, A., Hjellvik, V., Williamson, N. J., and Wilson, C. D. 2008. Silent ships do not always encounter more fish: comparison of acoustic backscatter recorded by a noise-reduced and a conventional research vessel. ICES Journal of Marine Science, 65:623–635.

De Robertis, A., and Wilson, C. D. 2010. Silent ships sometimes do encounter more fish. Part II: concurrent echosounder observations from a free-drifting buoy and vessels. ICES Journal of Marine Science, 67: 996–1003.

De Robertis, A., and Wilson, C. D. 2011. Silent ships do not always encounter more fish (revisited): comparison of acoustic backscatter from walleye pollock recorded by a noise-reduced and a conventional research vessel in the eastern Bering Sea. ICES Journal of Marine Science, 68: 2229–2239.

De Robertis, A., Wilson, C. D., Williamson, N. J., Guttormsen, M. A., and Stienessen, S. 2010. Silent ships sometimes do encounter more fish. Part I: vessel comparisons during winter pollock spawning surveys. ICES Journal of Marine Science, 67: 985–995.

De Robertis, A. and Handegard, N. O. 2012. Fish avoidance of research vessels and the efficacy of noise-reduced vessels: a review. ICES Journal of Marine Science 12pp

De Robertis, A., Wilson, C. D., Furnish, S. R., and Dahl, P. H. 2013. Underwater radiated noise measurements of a noise-reduced fisheries research vessel. ICES Journal of Marine Science, 70: 480–484.

Diner,N., Weill, A., Coail, J. Y., and Coudeville, J. M. 1989. INES-MOVIES: a new acoustic data acquisition and processing system. ICES CM 1989/B:45. 11pp

Domenici, P., Blagburn, J. M., and Bacon, J.P. 2011. Animal escapology II: escape trajectory case studies. The Journal of Experimental Biology 214, 2474-2494

Enger, P. S., Karlsen, H. K., Knudsen, F. R. and Sand, O. 1993. Detection and reaction of fish to infrasound. ICES mar. Sci. Symp., 196:108-112.

Fernandes, P., Brierley, A. S., Simmonds, E. J., Millard, N. W., McPhail, S. D., Armstrong, F., Stevenson, P., and Squires, M. 2000. Fish do not avoid surveys vessels. Nature vol. 404. 35-36.

Fréon, P. and and Misund, O. A. 1999. Dynamics of Pelagic Fish Distribution and Behaviour: Effects on Fisheries and Stock Assessment. Fishing News Books, Oxford.

Gerlotto, F., Castillo, J., Saavedra, A., Barbieri, M. A., Espejo, M., and Cotel, P. 2004. Three-dimensional structure and avoidance behaviour of anchovy and common sardine schools in central southern Chile. ICES Journal of Marine Science, 61: 1120-1126.

Handegard, N. O., and Tjøstheim, D. 2005. When fish meet a trawling vessel: examining the behaviour of gadoids using a free-floating buoy and acoustic split-beam tracking. Canadian Journal of Fisheries and Aquatic Sciences, 62: 2409–2422.

Hjellvik, V., Handegard, N. O., and Ona, E. 2008. Correcting for vessel avoidance in acoustic-abundance estimates for herring. ICES Journal of Marine Science, 65: 1036–1045.

Horne, J. K. 2000. Acoustic approaches to remote species identification: a review. Fisheries Oceanography,):4,356-371

ICES 1995. Underwater noise of research vessels. Review and recommendations. ICES cooperative research report. Copenhagen [ICES COOP. RES. REP.], 1995, no. 209, 61 pp

Kloser, R., Ryan, T., Sakov, P., Williams, A. and Koslow, J. A. 2002. Species identification in deep water using multiple acoustic frequencies. Canadian Journal of Fisheries and Aquatic Science, 59:1065-1077.

Kieser, R., Mulligan, T. J., Williamson, N. J., and Nelson, M. O. 1987. Intercalibration of two echo integration systems based on acoustic backscattering measurements. Canadian Journal of Fisheries and Aquatic Sciences, 44: 562–572.

Machias, A. and Tsimenides, N. Anatomical and physiological factors affecting the swim-bladder cross-section of the sardine Sardina pilchardus. Canadian Journal of Fisheries and Aquatic Science, 53:280-287.

Maravelias C., Reid, D. G., Simmonds, E. J. and Haralabous, J. 1996. Spatial analysis and mapping of acoustic survey data in the presence of high local variability: geostatistical application to North Sea Herring (Clupea harengus) Canadian Journal of Fisheries and Aquatic Science 53(7): 1497-1505.

Maravelias, C. and Reid, D. G. 1997. Identifying the effects of oceanographic features and zooplankton on prespawning herring abundance using generalized additive models. Mar. Ecol. Prog. Ser. Vol. 147: 1-9.

Misund, O. A., Ovedal, J.T., and Hafsteinsson, M. T. 1996. Reactions of herring schools to the sound field of a survey vessel. Aquatic Living Resources, 9: 5–11.

Mitson, R. B. Underwater noise radiated by research vessels. 1993. ICES marine Science Symposia. 196: 147-152.

Mitson, R. B., and Knudsen, H. P. 2003. Causes and effects of underwater noise on fish abundance estimation. Aquatic Living Resources 16: 255-263

Nakken O. &Dommasnes A., 1977. Acoustic estimates of the Barents Sea capelin stock 1971–1976. ICES CM, 1977/H:35

Ona, E. and Godø, O. R. 1990. Fish reaction to trawling noise: the significant for trawl sampling.

Ona, E., Godø, O. R., Handegard, N. O., Hjellvik, V., Patel, R., and Pedersen, G. 2007. Silent research vessels are not quiet. Journal of the Acoustical Society of America, 121: 145–150

Olsen, K. 1971. Influence of vessel noise on behaviour of herring. In Modern fishing gear of the world. 3: 291-294. Ed. by H. Kristjonsson. Fishing New Books Ltd. For FAO.

Olsen, K. 1979. Observed avoidance behaviour in herring in relation to passage of an echo survey vessel. ICES CM 1979/B:18 21pp.

Olsen, K., Angell, J. and Løvik, A. 1982. Quantitative estimation of the influence of fish behaviour on acoustically determined fish abundance. FAO Fish. Rep., 300: 139-149.

Peeke, H.V.S., and Peeke, S. C.1973. Habituation in fish with special reference to intraespecific aggressive behaviour. In: Peeke H. V.S., Herz, M. J. (Eds.) Habituation Behavioural Studies, Vol, 1. Academic Press, New York.

Petitgas. P. 1993. Geostatistics for fish stock assessments: a review and an acoustic application. ICES Journal of Marine Science, 50: 285-298.

Popper, A. N., Plachta, D. T. T., Mann, D. A., and Higgs, D. 2004. Response of clupeid fish to ultrasound: a review. ICES Journal of Marine Science, 61: 1057-1061.

Rieucau G, Boswell KM, De Robertis A, Macaulay GJ, Handegard NO (2014) Experimental evidence of threat-sensitive collective avoidance responses in a large wild-caught herring school. PLoS ONE 9(1): e86726. doi:10.1371/journal.pone.0086726

Sand, O., Karlsen, H. E., and Knudsen, F. R. 2008. Comment on “Silent research vessels are not quiet”. Journal of the Acoustical Society of America, 123: 1831–1833

Santiago, J. S. and Carbó, R. Estudio acústico del B. I. O. Hespérides. Rep. Inst. de Acústica, Madrid, 1991

Simmonds E. J. and MacLennan, D. 2005. Survey design in Fisheries Acoustics. Theory and practice. 2nd edition. Blackwell Science.

Skaret, G., Axelsen, B. E., Nøttestad, L., Ferno¨, A., and Johannessen, A. 2005. The behaviour of spawning herring in relation to a survey vessel. ICES Journal of Marine Science, 62: 1061-1064.

Soule, M., Hampton, I. and Barange, M. 1996. Potential improvements to current methods of recognizing single targets with a split-beam echo-sounder. ICES Journal of Marine Science, 53: 237-243.

Watkins, J. L., and Brierley, A. S. 1996. A post-processing technique to remove background noise from echo-ingegration data. ICES Journal of Marine Science, 53: 339-344.