Working Document presented to the 2013 IBTS Working Group

Inter-calibration experiment between the *R/V Cornide de Saavedra* and the *R/V Miguel Oliver*

F. Velasco
Instituto Español de Oceanografía
Centro Oceanográfico de Santander
P.O. Box 240
39080 Santander, Spain
francisco.velasco@st.ieo.es

1. Introduction

Bottom trawl surveys are one of the most important methods to study commercial fishing stocks, given that they provide information independent from the fishery. The data obtained within the bottom trawl surveys play an important role to calibrate single species assessment models, used as a tool for fisheries management, but also provide crucial information to understand the demersal and benthic faunal assemblages in the area covered. Nowadays bottom trawl surveys with long time series are used in the implementation and application of the European Marine Strategy Framework Directive, being especially important to determine criteria to define Good Environmental Status, and assess the evolution towards the GES achievement for the Marine Environment within the Programme Horizon 2020 as set by the European Union.

Spanish ground-fish survey on the northern Spanish Shelf has been organized and carried out every autumn by the Spanish Institute of Oceanography (IEO) since 1983, being the longest standardized bottom trawl time-series in Spanish waters. The survey has been performed annually but in 1987 on board the *R/V Cornide de Saavedra*, with standard protocols as defined by the IBTSWG, being the IEO and the SPNGFS one of the IBTS surveys on its western and southern areas since the mid-90s. Besides this survey provides abundant data for the PPC, and in the XXI Century has being co-financed by the EU within the DCF.

Nevertheless the vessel was built in 1972, and although it was refurbished in 1990, her equipment has become out of date and maintenance is increasingly more expensive. With views to substitute the *R/V Cornide de Saavedra* (CDS) by the new and modern *R/V Miguel Oliver* (MOL), an inter-calibration experiment with 60 paired hauls, covering the whole western area of the SPNGFS: namely Galician IXaN and VIIIcW ICES subdivisions. The aim of the present working document is to present the results of this calibration and prospects for the SPNGFS time series.

2. Material and methods

The inter-calibration plan was to perform two complete geographical sectors of the SPNGFS trawling with both vessels in parallel tows, (Figure 1) namely sectors Miño-Finisterre and Finisterre-Estaca, thus covering all depths strata of the survey (Figure 2). The gear used in both vessels was the standard Baca 44/60 m, with 200 m sweeps. All hauls were carried out during daylight at 3 knots and lasted 30 minutes except those deeper than 500 m that lasted 45 minutes following survey protocols. Vessels distance during the pair trawls was maintained at a distance of ca. 400 m, and boards were changed between hauls to avoid possible effects in trawling.

Following recommendations for inter-calibrations in ICES (2006) together with the change of vessel, the standard wooden doors used in SPNGFS survey were replaced by new polyvalent oval Thyborøn doors weighing 330 kg, since the traditional wooden doors are not built anymore and are more difficult to control and adjust during the fishing operations. Previous trials were carried out only with the MOL, to adjust the vessel-doors-gear to obtain the net geometry vertical and horizontal opening usually obtained during SPNGFS time series, that is to say vertical opening 2.2 ± 0.1 m and 18.1 ± 1.7 horizontal opening. During the intercalibration experiment gears were monitored in both vessels, but with different systems, since the CDS used ScanMar monitoring system, while MOL has mounted SIMRAD ITI system. Besides doors distances were not logged in the CDS since the wooden doors do not have sensor holders. This difference in values logged forced to use the trigonometric conversion (1) between doors spread and wings opening to compare gear performance in both vessels.

$$W = {D \times N}/{D + S}, \qquad (1)$$

being W the wing opening, D door spread, N the net length and S the sweeps length. Equation from what deriving wings opening from door spread is obvious. Differences in gear performed were compared with non parametric Mann-Whiney tests, since the number of paired hauls in each stratum were less than 20, and parametric test were not advisable. Data processing was done on board using CAMP 11 software while station tracking and vessel data capturing was done using PescaWin.2012 version.

Catch processing and sorting were done in both vessels following the IBTS manual procedures (ICES, 2010). Species were sorted to species level in the case of fish, crustaceans, molluscs and other species, each species catch was weighed and a representative sample of the catch was counted and length distribution sampled in the case of fish and crustaceans. While catch sorting and length distributions were done following the same protocols in both vessels, biological sampling, otoliths collection, CTDs and sediment sampling were only performed on the CDS. This vessel carried out the standard Data Collection Framework annual IBTS survey, while on board the MOL catch and performed the samplings were only done to obtain the necessary information to compare catches in biomass and number, and length distributions by sex.

Abundance index used was mean stratified catch per 30 minutes haul; these indices are independent for every stratum and are equivalent to the expected yield in each stratum. (2) mean stratified biomass and (3) Stratified Variance:

$$\overline{Y}_{st} = \frac{1}{A}\sum A_h \overline{Y}_h \qquad (2)$$

$$S^2_{(\overline{Y}_{st})} = \frac{1}{A^2}\sum \frac{A_h^2 S_h^2}{n_h}, \qquad (3)$$

being A total area; A_h stratum h area; Y_h mean catch by haul in stratum h, n_h number of hauls in stratum h and S_h^2 variance in stratum h. (Cochran, 1971; Grosslein and Laurec, 1982).

To compare catches between both vessels the logarithm of the catch differences between both vessels using the quotient, that for equal catches would be 0 (log(1)=0), therefore the nil hypothesis would be:

$$H_0 : \sum \log\left({Yst_{\mathrm{CDS}}}/{Yst_{\mathrm{MOL}}} \right) = 0$$

That is tested for significance through parametric and non-parametric tests (Mann-Whitney test in most of the cases since samples are not representative to perform parametric tests).

Regarding the length distributions, the mean length and shape of the parametric stratified length distributions per depth in each vessel and depth strata were compared, besides GLM logistic curves are fitted to compare selection pattern in each vessel for the main species.

Differences in catch compositions and sampling of faunal assemblages are assessed using PCA, following the approach adopted on the IPROST project (Mahe et al. 2001), and also hierarchical cluster analysis of the catch-matrices in biomass and number per species and haul in each vessel.

PCA were applied to the matrix shown below:

Station / Species Vessel	Sp1.CDS	Sp1.MOL	Sp2.CDS	Sp2.MOL	Sp3.CDS	….
Haul 1	Catch wght or nbr					
Haul 2						
Haul 3						
…						
Haul 60						

These data matrices were re-scaled to reduce the effect of large catches of some species standardizing species (columns) by their mean catch, and then hauls (rows) are standardized by dividing by their standard deviation.

All calculations and plots were done using R (R Development Core Team, 2013).

3. Results

During the inter-calibration survey a total of 59 valid hauls were performed with both vessels, while one haul was invalid for the MOL, and it was not possible to repeat later since changing the gear and repairing damages on the wire required extra time that could not be lost to maintain the planned schedule, besides the nil haul was on the deepest strata that is not considered on standard stratification and therefore neither on the standard stratified abundance indices.

3.1. Gear performance

Figure 3 present the results of gear comparisons while Table 2 present the results of probabilities of the Mann-Whitney test of those comparisons, as mentioned above the change of gear on the MOL, posed an extra problem because it added an extra factor to the comparison (number of paired trawls ranged between 19 and 4 hauls), since significant differences (considered as significantly different when $p<0.1$) in gear performance within the same strata only were found for wings and door spread in depth strata C between the MOL3C and CDS1C (CDS1C: 19.89 m, MOL3C: 21.83), while differences between CDS1C and MOL2C (20.05 m) were not significant. Differences in stratum D were also significant ($p=0.075$) for wings and door spread Differences between both initial gears (CDS1 and MOL2), given that gear 3 was not used on stratum D, in any case only 4 hauls were performed and important differences in depth between both vessels occurred in one of the hauls that was on the edge of the shelf slope, with one of the vessels working around 616 m and the other at 558 m depth.

3.2. Catch comparisons

Figure 4 shows the differences in total catches between both vessels in all hauls. Catches were very similar on the first part of the survey before the gear change forced after the fast on haul 43. Within this first part there is a clear outlier on haul 39, the deep haul mentioned in the previous section, with an important catch of *Deania calcea* (387 kg) on MOL trawling deeper than 600 m that did not appear on CDS trawling ca. 550 m, excluding this haul mean total catches were very similar (CDS: 158.2 kg, MOL: 160.8 kg, $p_{t.test}= 0.94$). After the gear change catches were larger on the CDS in 15 of the 17 hauls performed (Mean total catches: CDS: 175.4 kg, MOL: 122.0 kg, $p= 0.32$).

Figure 5 shows the same type of result but comparing catches per species of main fish species (commercial and abundant species), in general results are the same as for total catches, with similar catches in both vessels except in the case of lesser argentine (*Argentina sphyraena*) and blue whiting (*Micromessistius poutassou*), with larger catches on CDS, and thick back sole (*Microchirus variegatus*) that had larger catches on MOL. Besides clear differences after the change of gear are evident on catches of dragonet (*Callionymus lyra*) and gurnard (*Eutrigla gurnardus*) with larger catches on MOL than on CDS after the gear change, or in hake or blue whiting with the opposite differences. These results suggest that the second gear used on MOL was catching more benthic fauna and less demersal-pelagic species.

These results are clearer on Figure 6 that summarizes the biomass catch comparisons results for the representative species caught on both vessels during the inter-calibration. In this figure *A. sphyraena*, the anemone *Calliactis parasitica*, the pandalid *Chlorotocus crassicornis* and the blackmouth dogfish *Galeus melastomus* presented larger catches in CDS than in MOL, while the dragonet, thick back sole, the curled octopus *Eledone cirrhosa*, and most species of sepiolids shown larger catches on MOL than on CDS. Besides also black belly angler (*Lophius budegassa*) had this same pattern but this species appeared only in six hauls with few large individuals, so this difference can be considered negligible, especially when monkfish (*L. piscatorius*) catches were similar on both vessels.

These results indicate that MOL, with the polyvalent doors, catches more benthic species than CDS, this later, on the other hand, samples better demersal species less close to the ground that are upper on the water column, nevertheless this behaviour seems to be incremented after the gear change on MOL.

3.3. Commercial species catch comparisons

Figures 7 to 9 (Figure 7-Figure 9) compare the catches in number and weight terms per depth strata of three of the main commercial species that use SPNGFS abundance indices on their assessment, namely hake, four-spot megrim and blue whiting. Hake catches per haul are shown in number (Figure 7 top panel) since catches in weight do not reflect the abundance of recruits, one of the main goals of SPNGFS. On the map a larger variability on VIIIc Division (stratum FE) than on IXa, and especially remarkable are the differences on the northern part close to A Coruña, with larger catches on CDS, that occurred after the gear change. Nevertheless in spite of these differences, the boxplots (Figure 7 bottom panel) show that splitting results per depth strata the differences are less appreciable in general with the exception of the deepest strata (>500 m) where catches are clearly larger on MOL, but it should be borne in mind that in this strata hake is usually larger and as shown by the smaller differences in number than in weight, and the catch of few large individuals is an event with high randomness.

Figure 8 presents four-spot megrim catches in each vessel per haul (top panel), and differences per depth strata (bottom panel), in the case of four-spot megrim results are remarkably similar.

Figure 9 shows the same results for blue whiting. Geographically (top panel) few big catches in either vessel bring the attention, as usually occurs with this species that appears in large shoals that can easily be captured in one vessel and missed on a vessel trawling within 400 meters. Nevertheless when observing the comparisons per strata (bottom panel), even with a higher variability (large inter-quartile range) that reflect the patchiness of the shoals, the medians are similar in most of the strata.

Other important commercial species as megrim, Norway lobster or anglers were not present on the catches to perform these comparisons though some conclusions can be drawn from length distributions or from the faunal assemblages.

3.4. Length distributions

Figure 10 to Figure 12 present area stratified length distributions of hake (per strata, Figure 10), four-spot megrim, blue whiting and scaldfish (Figure 11), and finally horse mackerel, lesser argentine, and monkfish on Figure 12. Most of the length distributions show the same peaks and distribution shapes. In the case of hake main differences are found on depth strata C (200-500 m, right panel on Figure 10) where the smaller individuals are less abundant in MOL than on CDS, though in both cases the mode is 13 cm, and mean close to 14 cm.

Four spot megrim shows a remarkable similar shape with peaks-modes marked at 7, 14 and 21 cm, on both vessels, though the smallest peak is more conspicuous on CDS than on MOL which had more individuals on the large peak (19-22 cm), but the overall image is analogous. Same results were found for blue whiting and scaldfish, with similar shapes and peaks on their length distributions (Figure 11)

Figure 12 presents a set of species with more overall differences between their length distributions. Horse mackerel (right panels) shows the same peak of small individuals with 7-8 cm, but more abundant on MOL, while CDS showed a group of large individuals (28-29 cm and 34-36 cm) whose abundance was halved on MOL catches. Lesser argentine is one of the species with more remarkable differences with catches that were a third larger on MOL than on CDS, however again the same peaks are evident on the length distribution, with two modes, namely 7-9 cm and 13-14 cm. Finally monkfish on Figure 12 right panel, in spite of its large length range (12-100 cm) also showed remarkably similar peaks on both vessels with a group of recruits 17-23 cm, another group 32-50 cm, and then the rest of the length distribution with some sparse large individuals.

Finally Figure 13 presents the comparisons of the selection curves in each vessel/gear using the stratified length catch for the whole sampling area on the species discussed above except monkfish whose large length range and scarcity prevents the use of this model. On all the species selection curves on both vessels present very similar shapes with almost identical curves on hake, blue whiting and lesser argentine, in this case in spite of the difference in abundance stated above, the logistic model selection pattern is almost equal.

3.5. Faunal fish assemblages sampling analysis

The PCA analysis of the matrix in numbers, using only the fish species, shows very similar ordination of the species on both vessels, with MOL and CDS species placed closely (Figure 14). A hierarchical cluster with the same matrix offers the same results (Figure 15), and identifying the 4 clusters, the most differentiated species is black mouth dogfish, that appears on both vessels concentrated on the deeper hauls. Then a second cluster is formed by silvery pout (*Gadiculus argenteus*), piper gurnard (*Trigla lyra*) and redfish (*Helicolenus dactilopterus*). A third group clusters other 7 species, that are always grouped together in both vessels. And finally on the fourth group, 12 species are clustered with only few species that are not clustered together by vessel, namely lesser spotted dogfish (*Scyliorhinus canicula*), bib (*Trisopterus luscus*), lesser argentine and spiny gurnard (*Lepidotrigla dieuzeidei*).

Similar results are obtained with weight data (Figure 16 and Figure 17) that include also the abundant cephalopods species, that are also grouped together in most of the cases with the exception of curled octopus (*E. cirrhosa*) that on MOL is split from the rest of a larger cluster that contains conger eel, silvery pout, four spot megrim and the flying squid together with curled octopus on CDS.

4. Conclusions

- Analysis of faunal assemblages done with both vessels, *Miguel Oliver* and *Cornide de Saavedra*, render similar image, and comparable results could be derived from these analysis.
- *Miguel Oliver*, with polyvalent doors seems to be more efficient in catching a few species closely related to the ground (e.g. cuttlefish species, or some flatfish species as thickback sole), while *Cornide de Saavedra* samples slightly better some more swimming species (e.g. argentine or some pandalids). These differences were reduced; however trials to compensate these effects will be done if possible in 2013 before next SPNGFS.
- Length distributions of abundant species show similar modes for recruitment, even in different depths (e.g. hake), or for more sparsely distributed species (e.g. monkfish).
- Main species assessed with this survey (hake, megrims and monkfish) do not present significant differences.
- Given that deriving inter-calibration factors for all the whole species set, the plan is to continue SPNGFS time series with the R/V *Miguel Oliver* and the new polyvalent doors, though special attention will be paid to test and verify the continuity of the time series.

5. Acknowledgments

It is necessary to thank R/V *Cornide de Saavedra* and R/V *Miguel Oliver* crews and the scientific teams in both vessels that made possible the inter-calibration survey. María Soto Ruiz also collaborated in the faunal assemblage analysis, besides her active participation on the survey. Thanks are also due to Antonio Punzón, who was the scientists on charge on the *Cornide de Saavedra*, and Crisanto Devesa and Manuel Riobo masters and skippers of *Miguel Oliver* and *Cornide de Saavedra* respectively.

6. References

Cochran, W. G. 1977. Sampling techniques (3rd ed.). New York: John Wiley & Sons.

Grosslein, M.D. and Laurec, A. 1982. Bottom trawl survey design, operation and analysis. CECAF/ECAF Series 81/22: 22 pp.

ICES. 2005. Report of the Study Group on Survey Trawl Standardisation (SGSTS), 16–18 April 2005, Rome, Italy. ICES CM 2005/B:02. 67 pp.

ICES. 2006. Report of the Study Group on Survey Trawl Standardisation (SGSTS), 1–2 April 2006, Izmir, Turkey. ICES CM 2006/FTC:05. 67 pp.

ICES, 2010. Manual for the International Bottom Trawl Surveys in the Western and Southern Areas Revision III Agreed during the meeting of the International Bottom Trawl Survey Working Group 22–26 March 2010, Lisbon. Addendum 2: ICES CM 2010/SSGESST:06. 58 pp.

Mahé, J.C.; Bellail, R.; Newton, A. Officer, R.; Reid, D.; Stokes, D. and Zuur, A. 2001. Final report of the IPROST project

R Development Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

7. Tables

Table 1.- Number of paired hauls carried out in the intercalibration experiment by depth strata and sector.

Sector/ Strata		**Miño Finisterre**	**Finisterre Estaca**	**Total**
Strata Hauls	70-120 m	**4**	**4**	**8**
	121-200 m	**10**	**17**	**27**
	201-500 m	**5**	**15**	**20**
Total strata		**19**	**36**	**55**
Extra hauls	<70 m	**-**	**-**	
	>500 m	**2**	**2 (1 nul)**	**4**
Total		**21**	**38**	**59**

Table 2.- Probabilities of Mann Whitney test on the differences in vertical and wings opening between the vessels and gears (the three gears had the same design, but last one from a different manufacturer) used per depth strata. In bold: significant differences (<0.1). Only relevant comparisons (same strata in both vessels-gears) are presented

Differences in vertical opening p(Mann-Whitney test)						
	CDS1A	CDS1B	MOL2B	CDS1C	MOL2C	CDS1D
MOL2A	1					
MOL2B		1				
MOL3B		0.507	1			
MOL2C				1		
MOL3C				0.565	1	
MOL2D						1
Differences in wings spread: p(Mann-Whitney test)						
	CDS1A	CDS1B	MOL2B	CDS1C	MOL2C	CDS1D
MOL2A	0.461					
MOL2B		0.128				
MOL3B		1	1			
MOL2C				1		
MOL3C				**0.095**	0.128	
MOL2D						**0.075**
Differences in door spread: p(Mann-Whitney test)						
	CDS1A	CDS1B	MOL2B	CDS1C	MOL2C	CDS1D
MOL2A	0.465					
MOL2B		0.180				
MOL3B		1	1			
MOL2C				1		
MOL3C				**0.068**	**0.094**	
MOL2D						**0.075**

Keys used:
Vessels: CDS: *Cornide de Saavedra*, MOL: *Miguel Oliver*
Gears: 1 to 3, 1 only in CDS, 2 & 3 in MOL
Depth strata: A: 70-120 m, B: 120-200 m, C: 200-500 m, D: >500 m

8. Figures

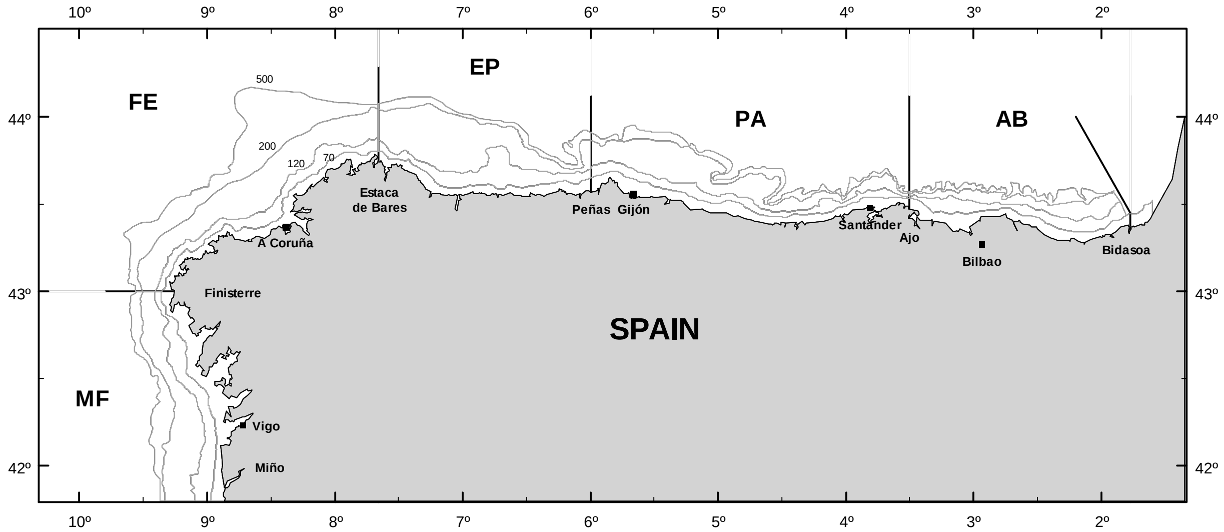

Figure 1.- Stratification used in SP-NGFS IBTS survey. Depth strata were a) shallower 70-120 m, b) 121 – 200 m and c) 201 – 500 m. Additional hauls are performed every years in grounds shallower and deeper than 70 and 500 m respectively. Only MF and FE sectors were covered during the intercalibration

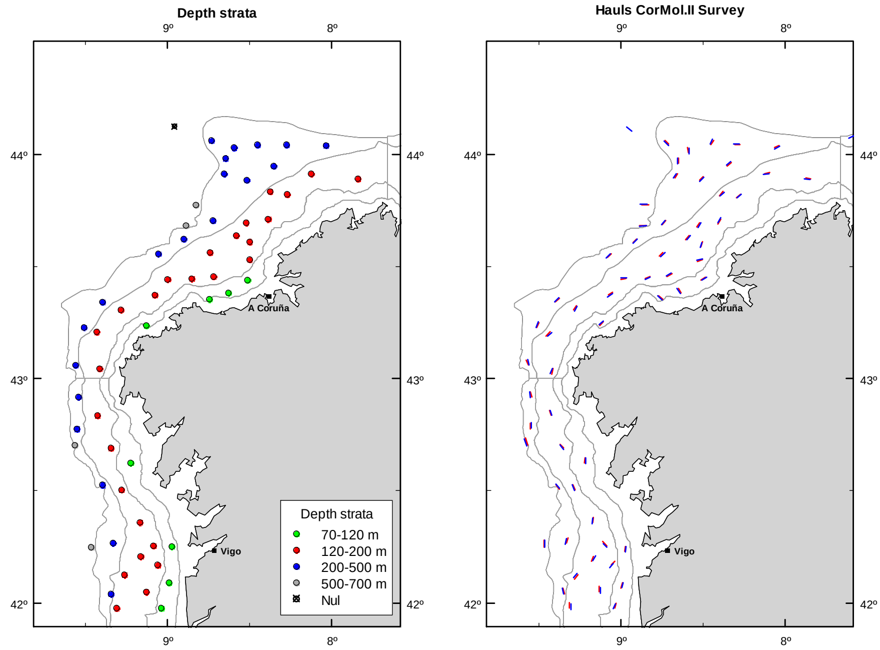

Figure 2. Paired hauls per depth strata done during the inter-calibration experiment between R/V Cornide de Saavedra and R/V Miguel Oliver

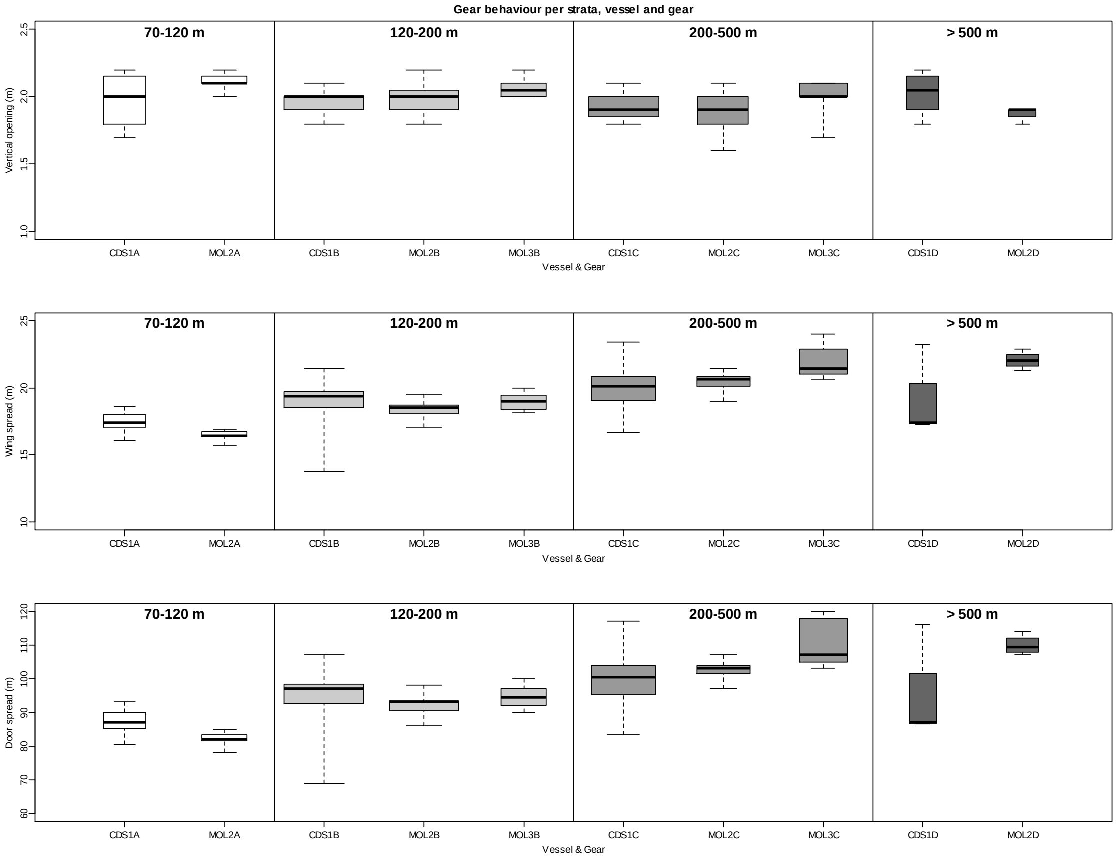

Figure 3. Variation of vertical opening, wings and door spread per haul along the hauls carried out in the inter-calibration survey

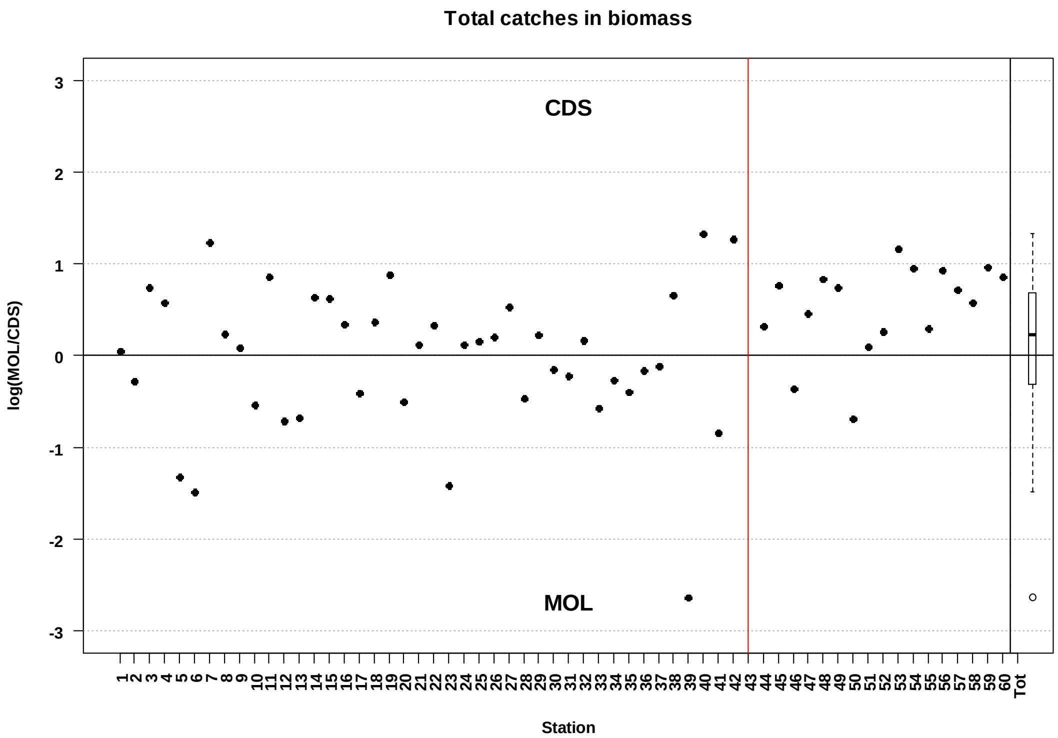

Figure 4. Differences in catches per haul between both vessels in logarithm scale. Data are shown as log(catch MOL/catch CDS). Positive catches, above 0, were larger on CDS, while negative ones were larger on MOL. The red line marks the invalid haul 43 with no catches on MOL. Boxplot shows variability along the survey

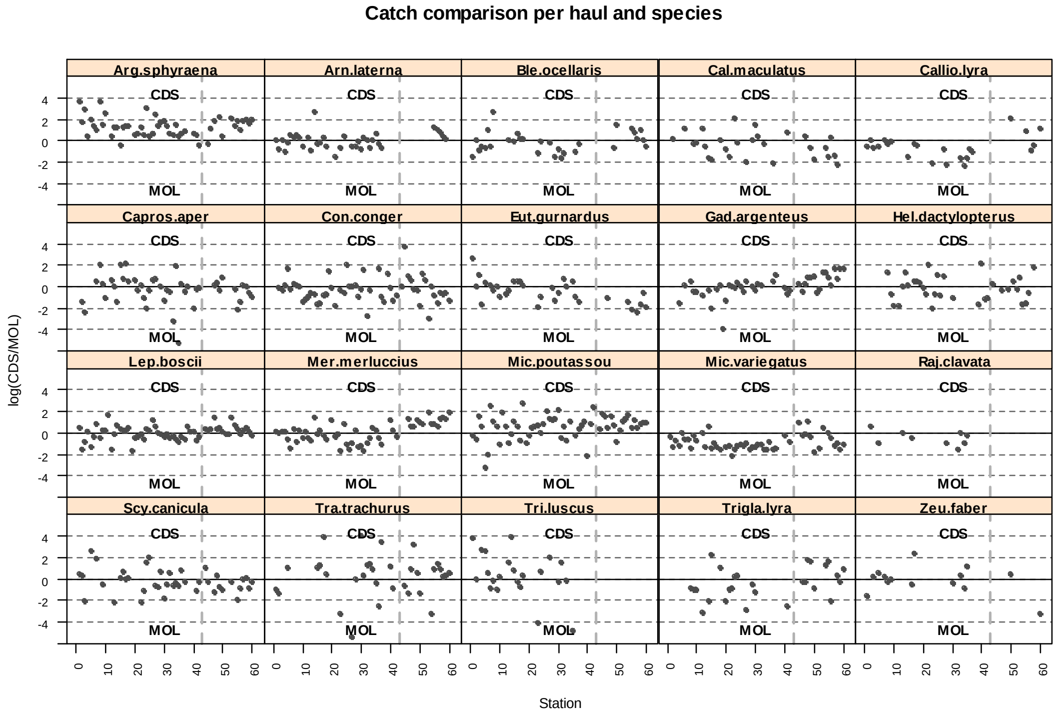

Figure 5. Differences in catches per main commercial and abundant fish species and haul between both vessels in logarithm scale. Data are shown as log(catch MOL/catch CDS). Positive catches, above 0, were larger on CDS, while negative ones were larger on MOL. The red line marks the invalid haul 43 with no catches on MOL

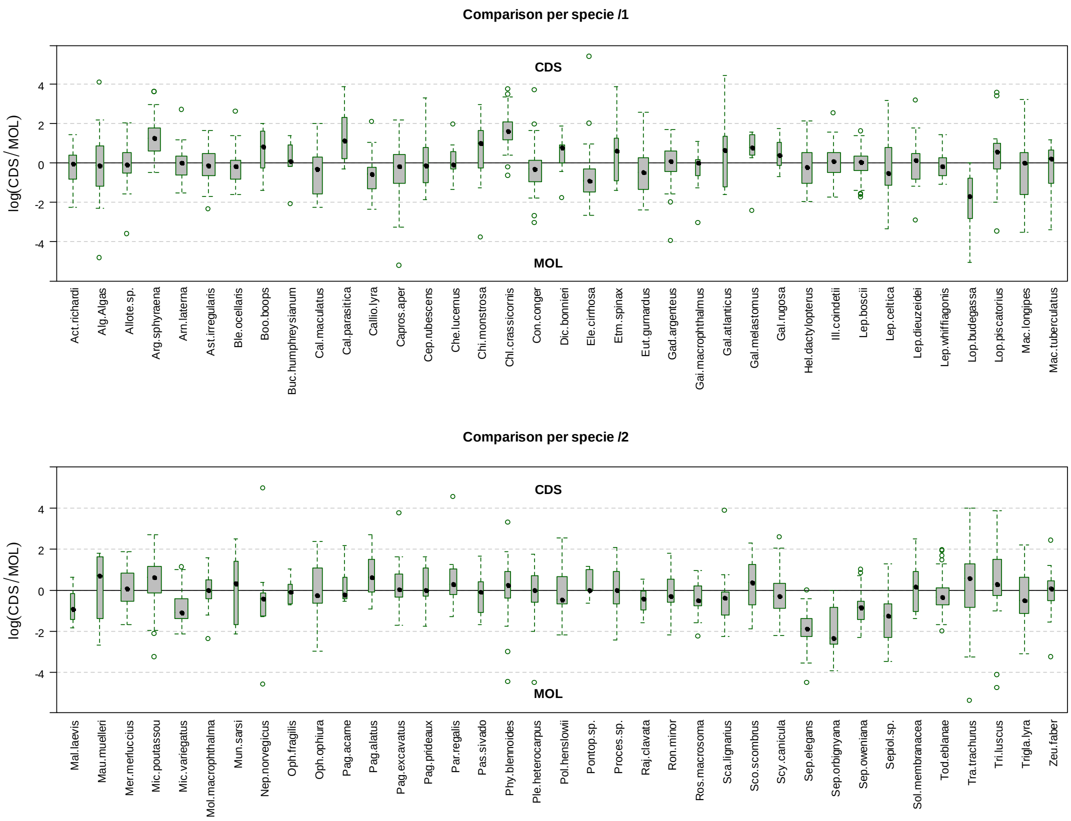

Figure 6. Differences in catches per species and haul between both vessels in logarithm scale. Data are shown as log(catch MOL/catch CDS). Positive catches, above 0, were larger on CDS, while negative ones were larger on MOL. Boxes represent the variability along the total survey, and box width is proportional to the number of hauls with presence of the species on both vessels. When the box does not intersect the 0-axis, significant differences in the catches between vessels were found.

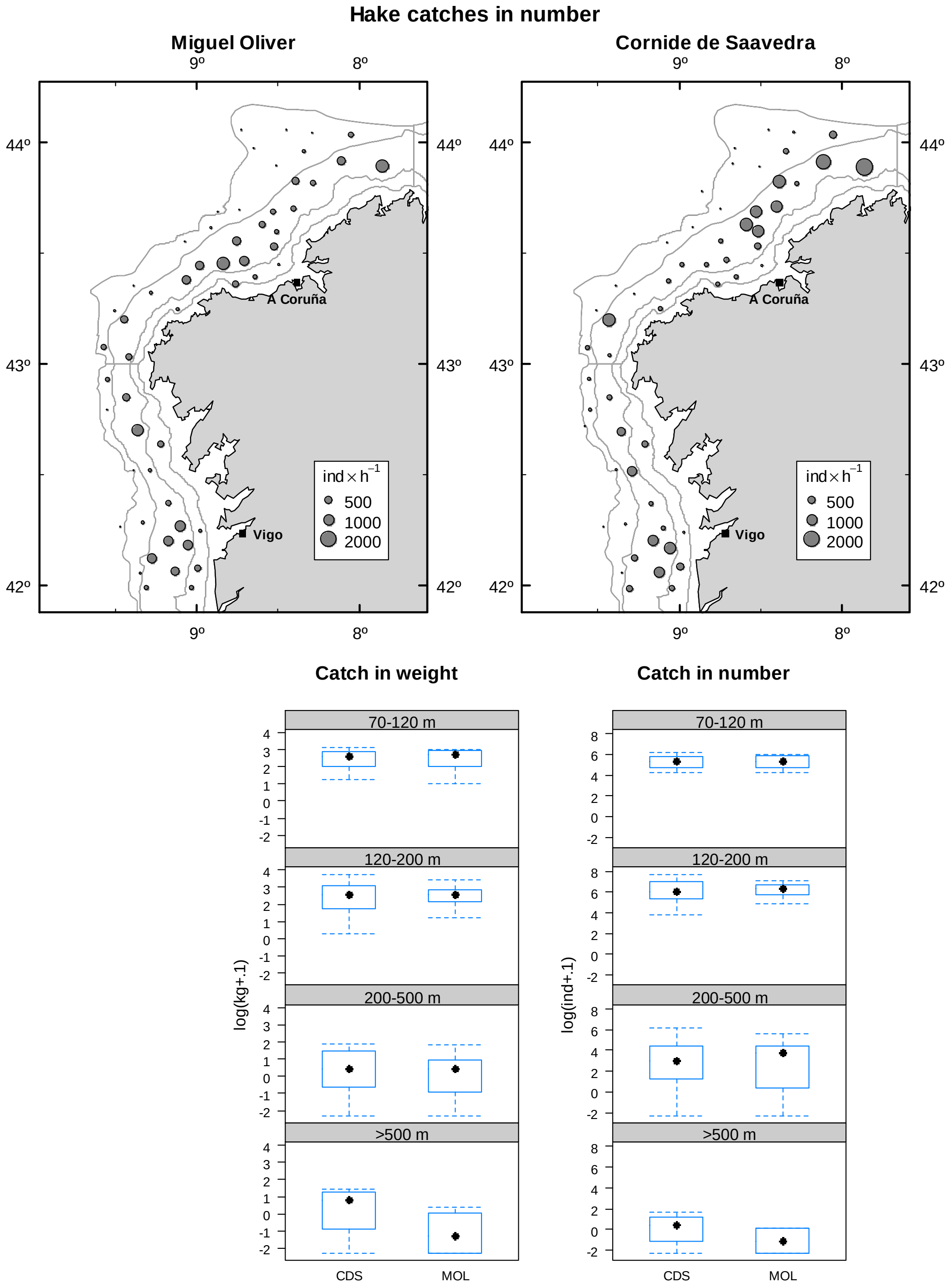

Figure 7. Top panel: map of hake catches in number in both vessels. Bottom panel: boxplots showing differences in hake catches per strata in weight and number (logarithm scale)

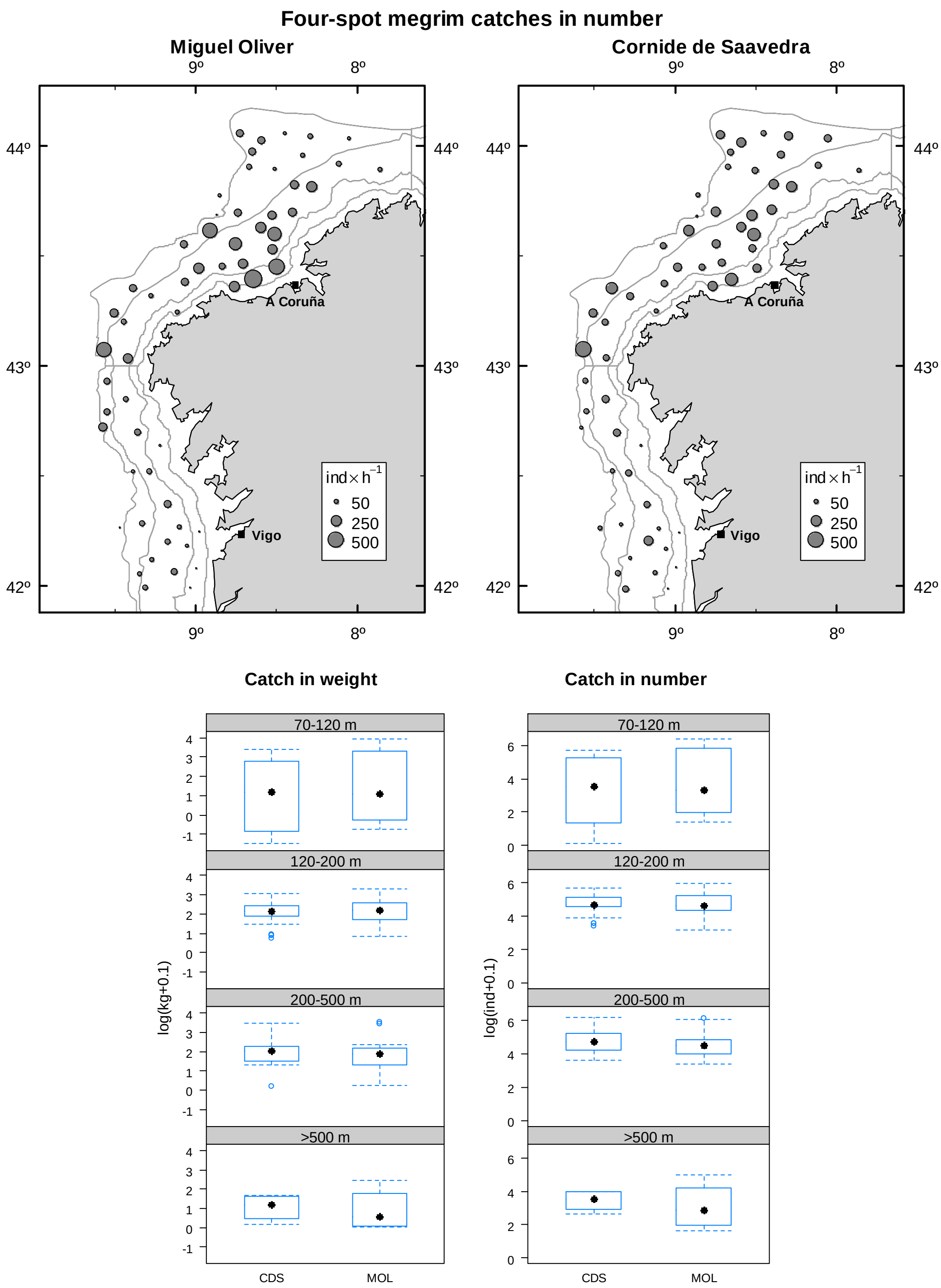

Figure 8. Top panel: map of four spot megrim (*L. boscii*) catches in number in both vessels. Bottom panel: boxplots showing differences in hake catches per strata in weight and number (logarithm scale)

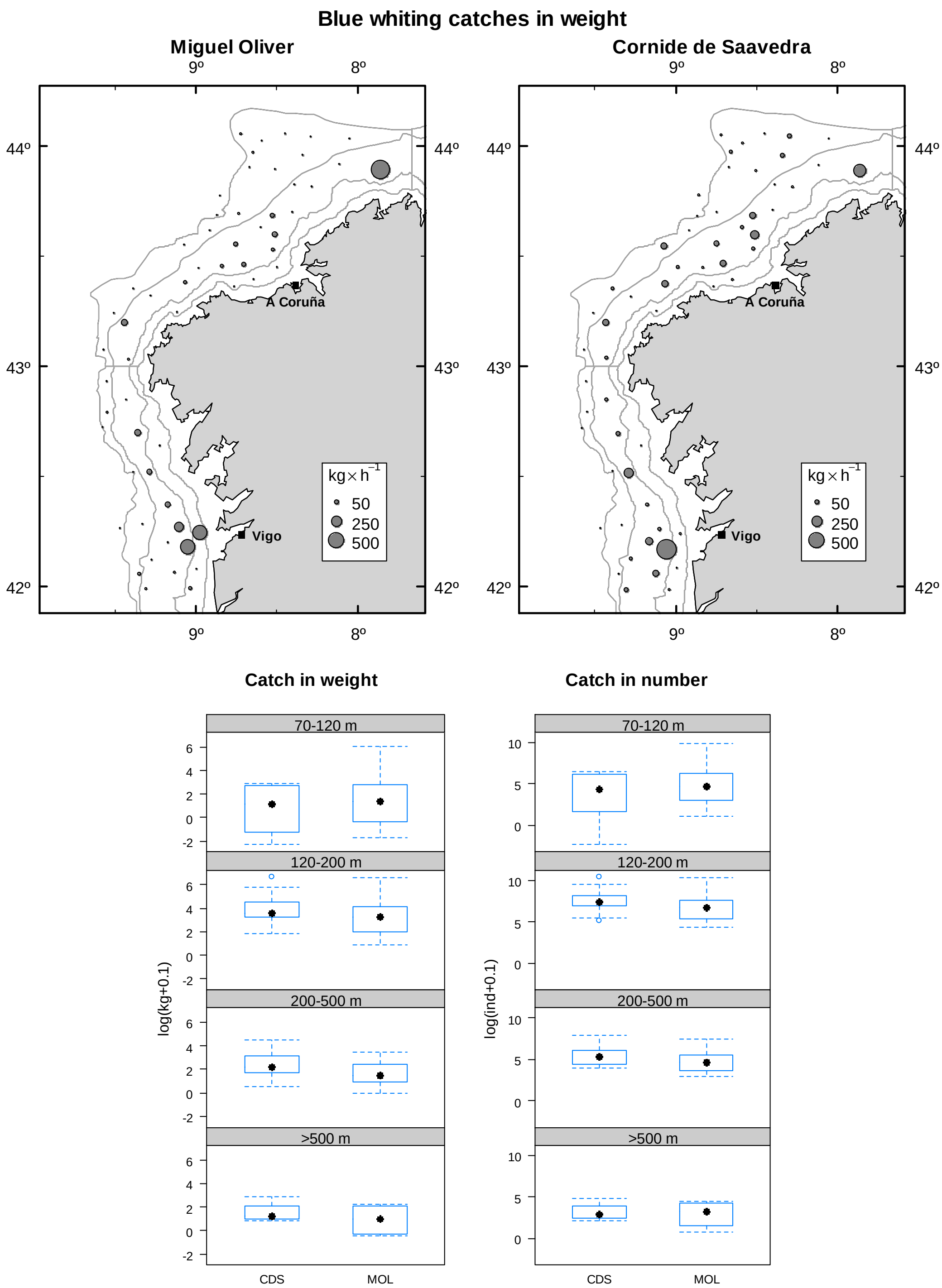

Figure 9. Top panel: map of blue whiting catches in number in both vessels. Bottom panel: boxplots showing differences in hake catches per strata in weight and number (logarithm scale)

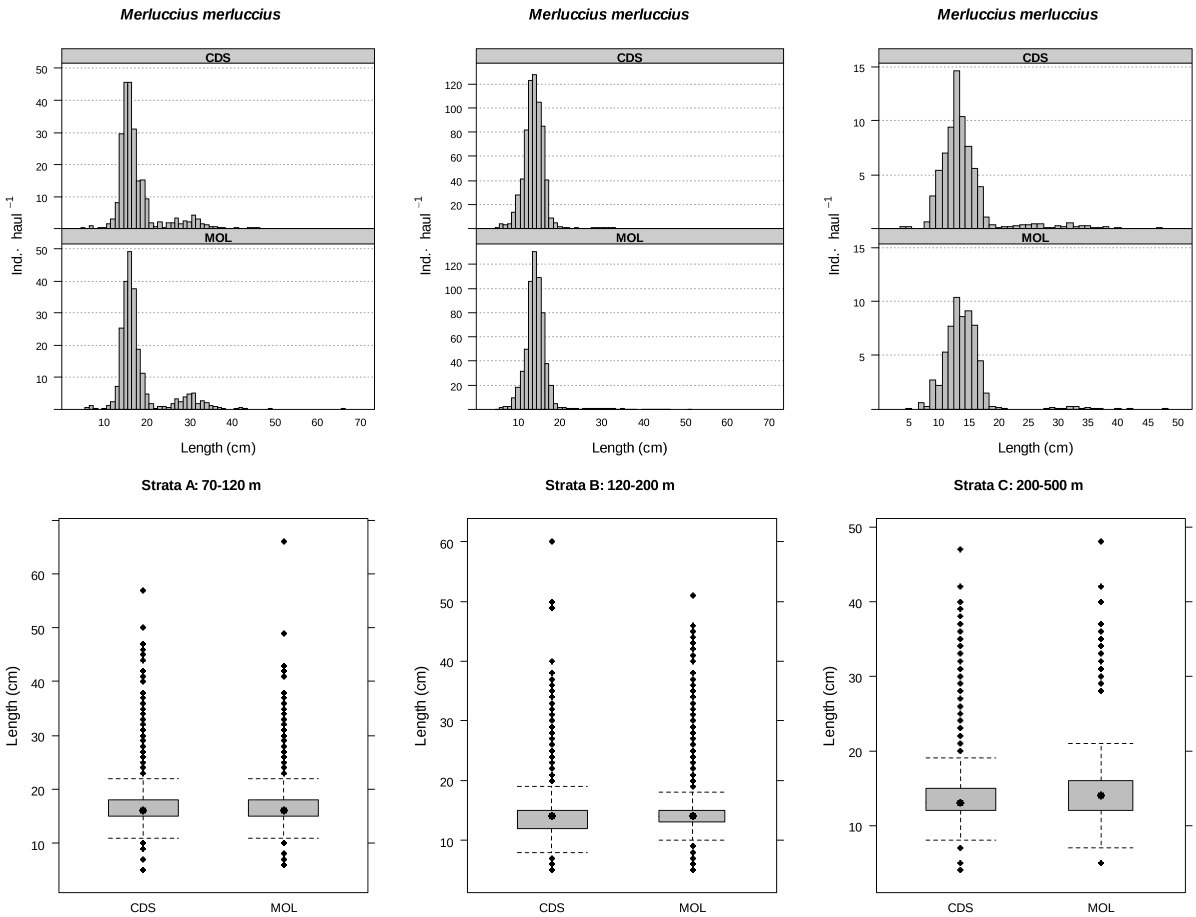

Figure 10. Top panel: hake stratified length distributions per strata. Bottom panel: boxplots showing the variability of hake stratified length distribution per strata. CDS: R/V *Cornide de Saavedra,* MOL: R/V *Miguel Oliver*

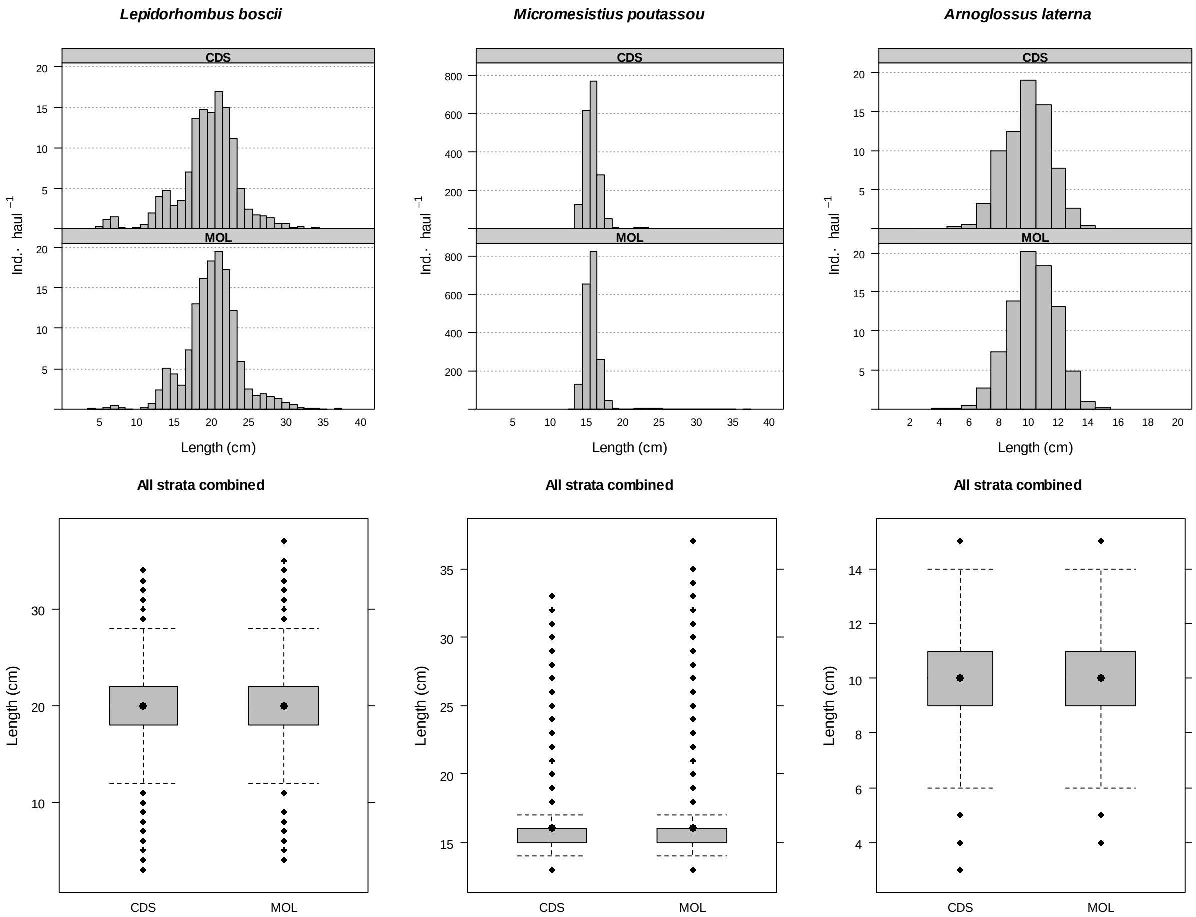

Figure 11. Top panel: stratified length distributions of *L. boscii* (left), *M. poutassou* (center) and *A. laterna* (right). Bottom panel: boxplots showing the variability of the same species stratified length distribution. CDS: R/V *Cornide de Saavedra*, MOL: R/V *Miguel Oliver*

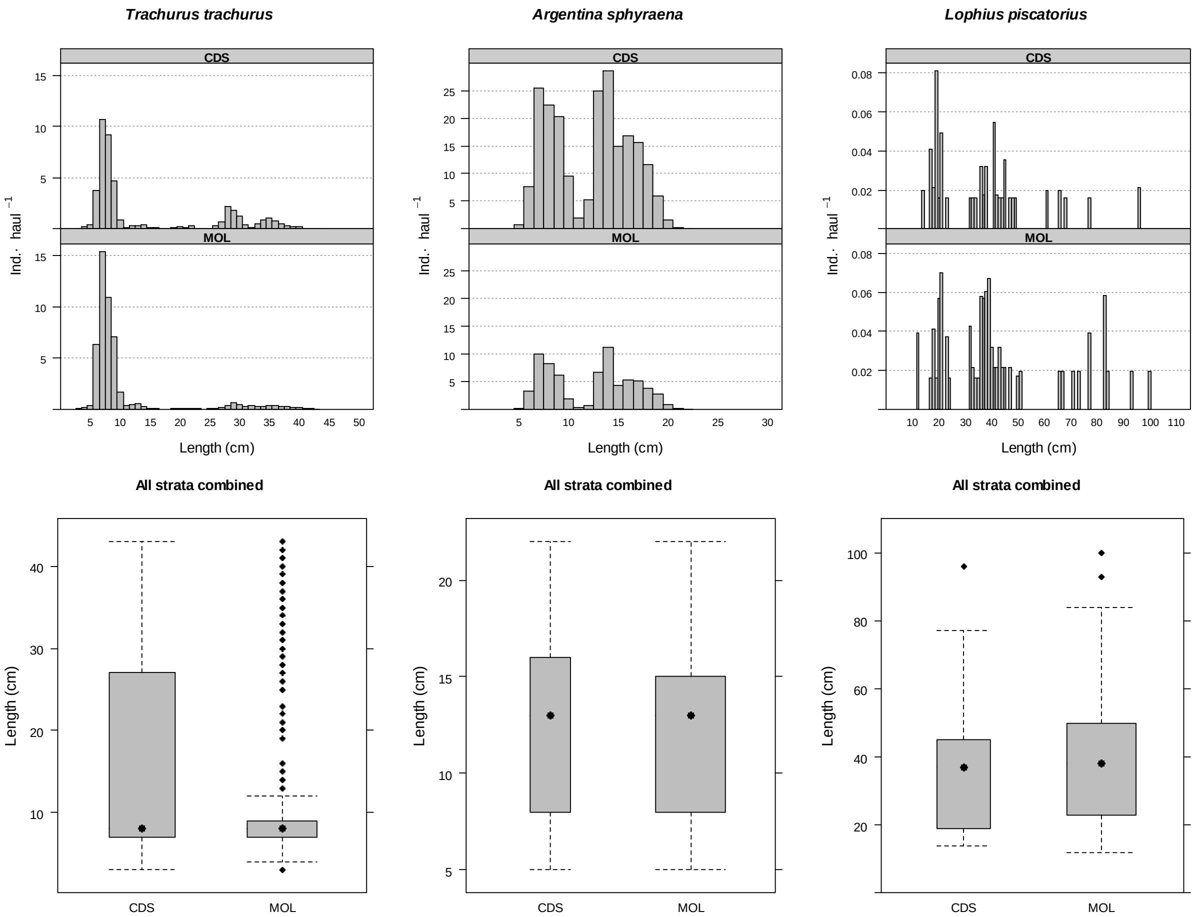

Figure 12. Top panel: stratified length distributions of horse mackerel (left), argentine (centre) and monkfish (right). Bottom panel: boxplots showing the variability of the same species stratified length distribution, width of the boxes is proportional to the number of fishes. CDS: R/V *Cornide de Saavedra*, MOL: R/V *Miguel Oliver*

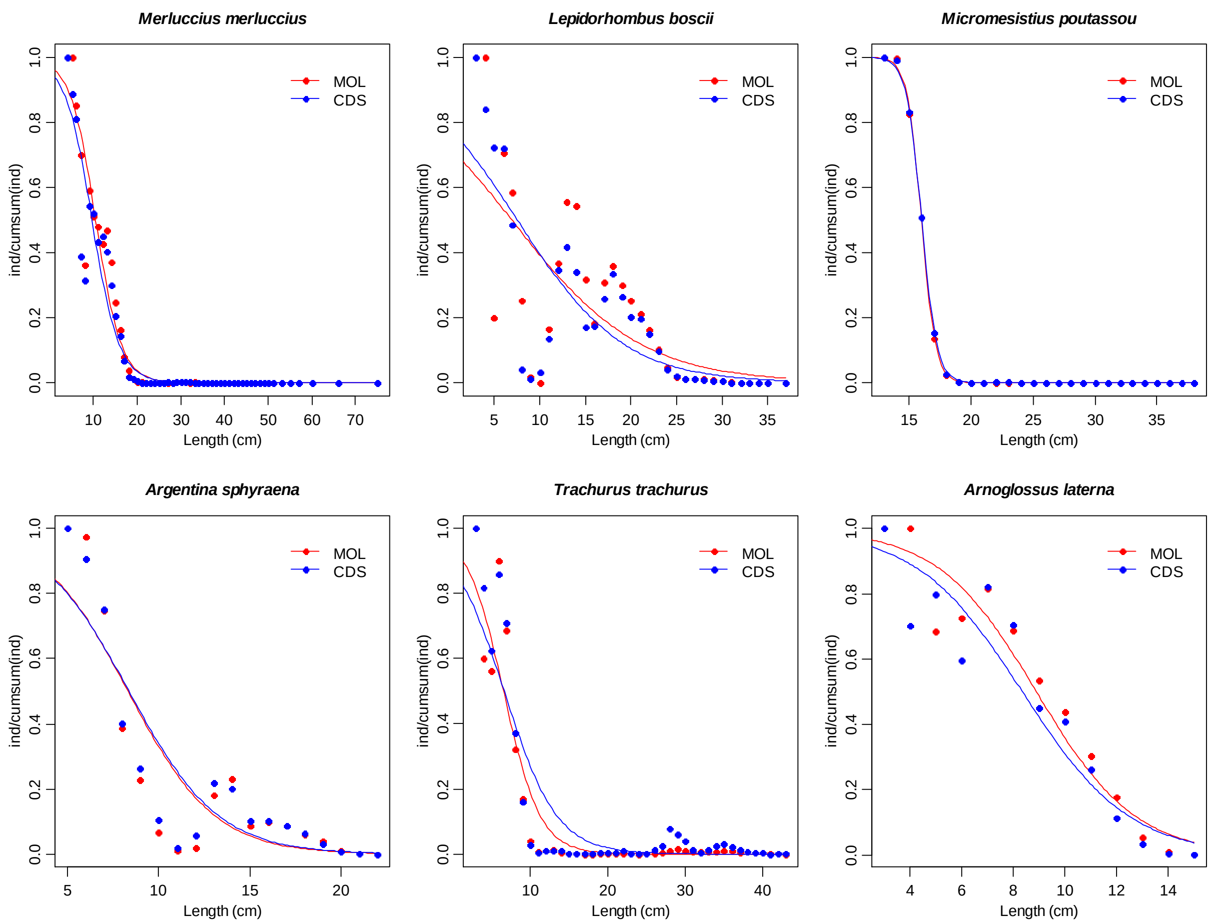

Figure 13. Selection per length in each vessel catch for hake, four spot megrim, blue whiting, lesser argentine, horse mackerel and scaldfish, including GLMs fitted to the selection curves in each vessel. CDS: R/V *Cornide de Saavedra*, MOL: R/V *Miguel Oliver*

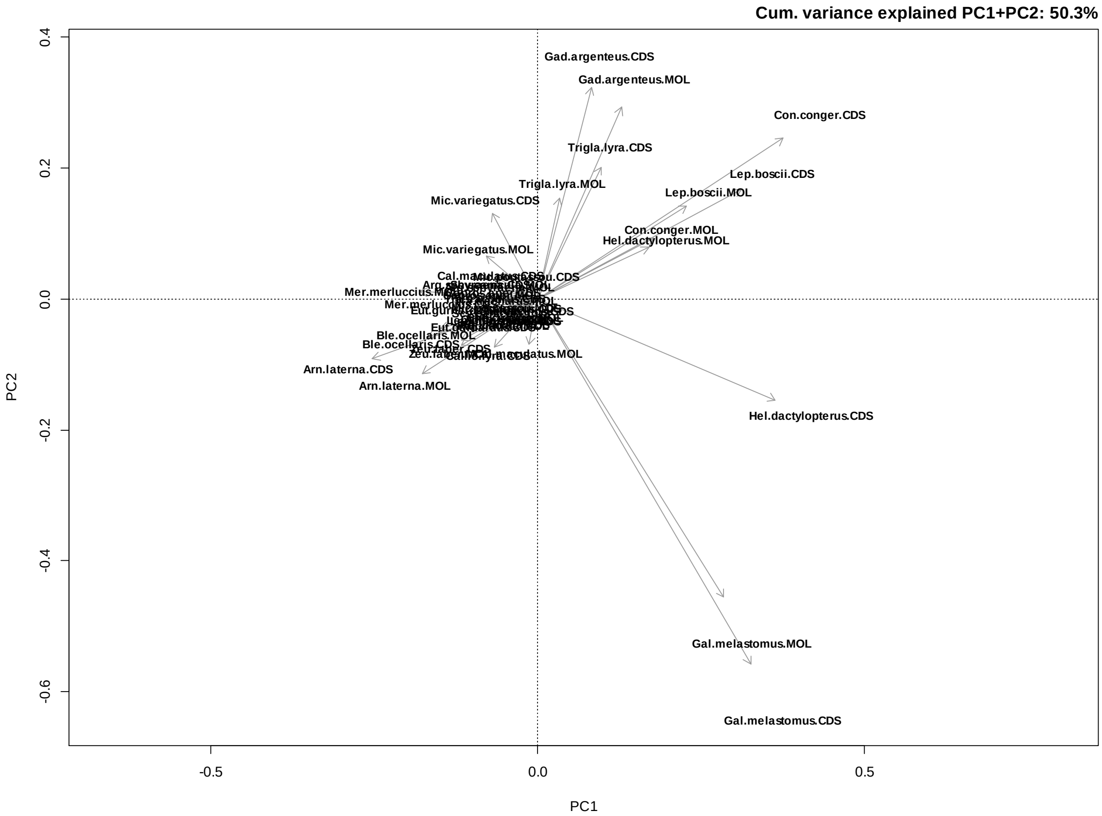

Figure 14. Biplot of the PCA analysis of the fish catches in number per vessel

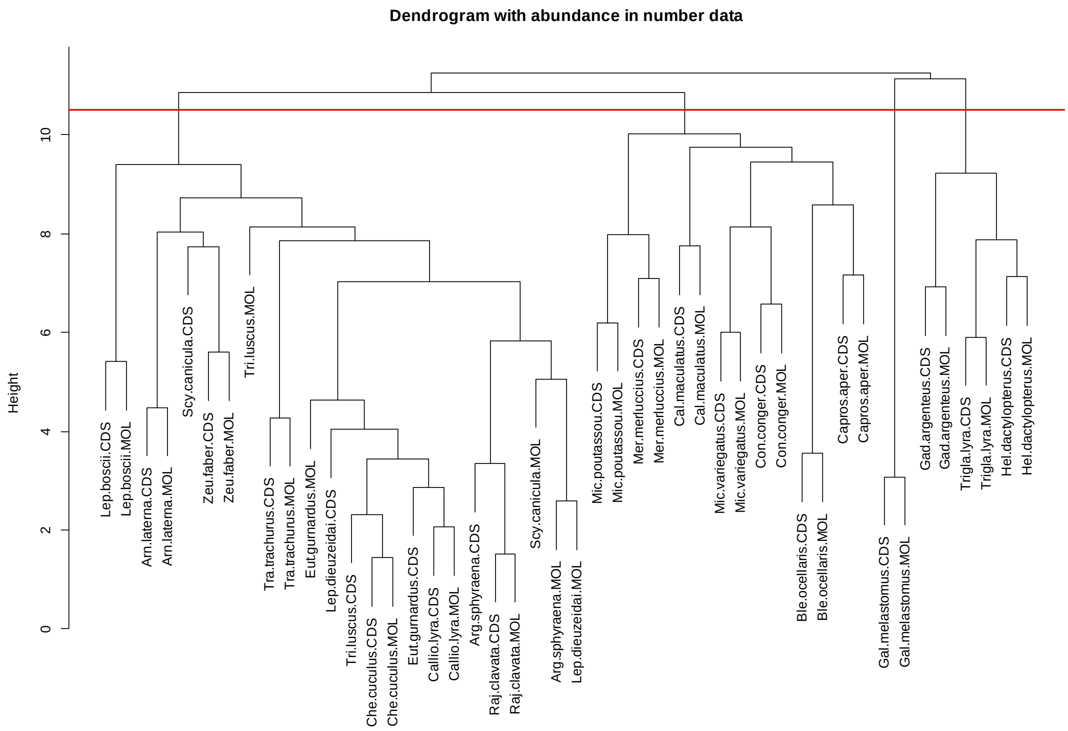

Figure 15. Hierarchical cluster analysis of fish catches in number per vessel

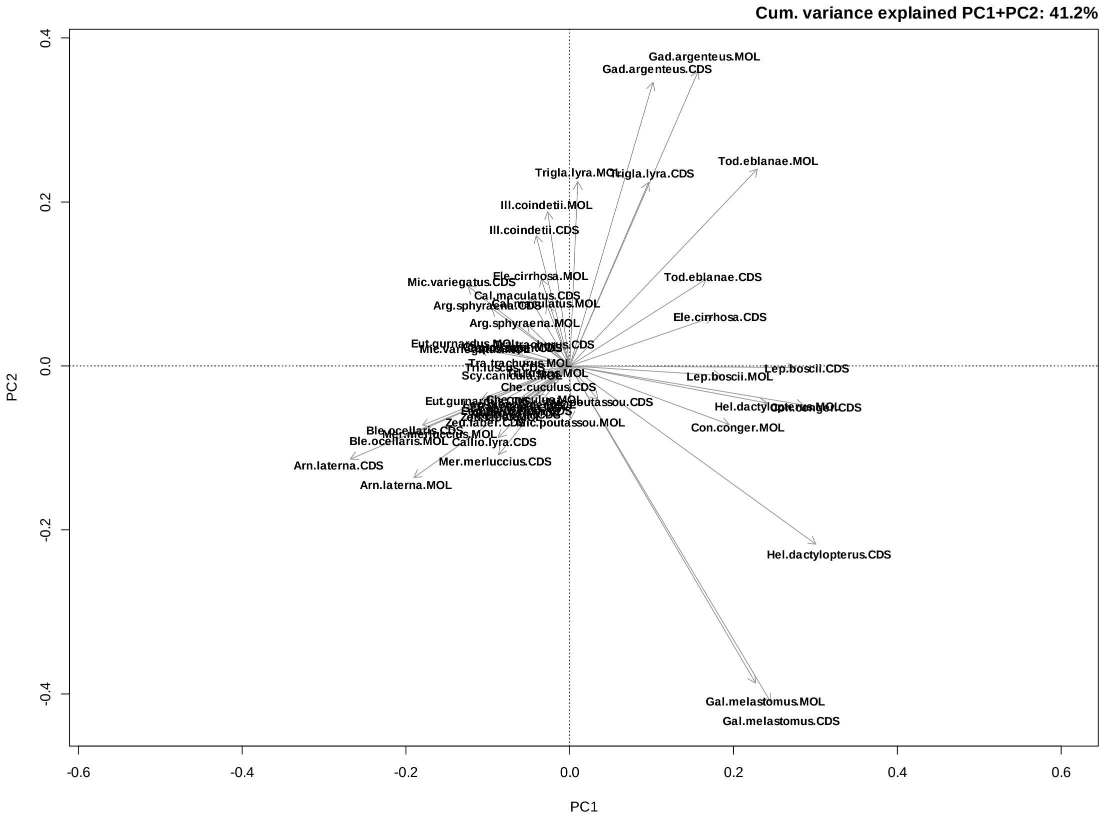

Figure 16. Biplot of the PCA analysis of fish and cephalopod catches in biomass per vessel

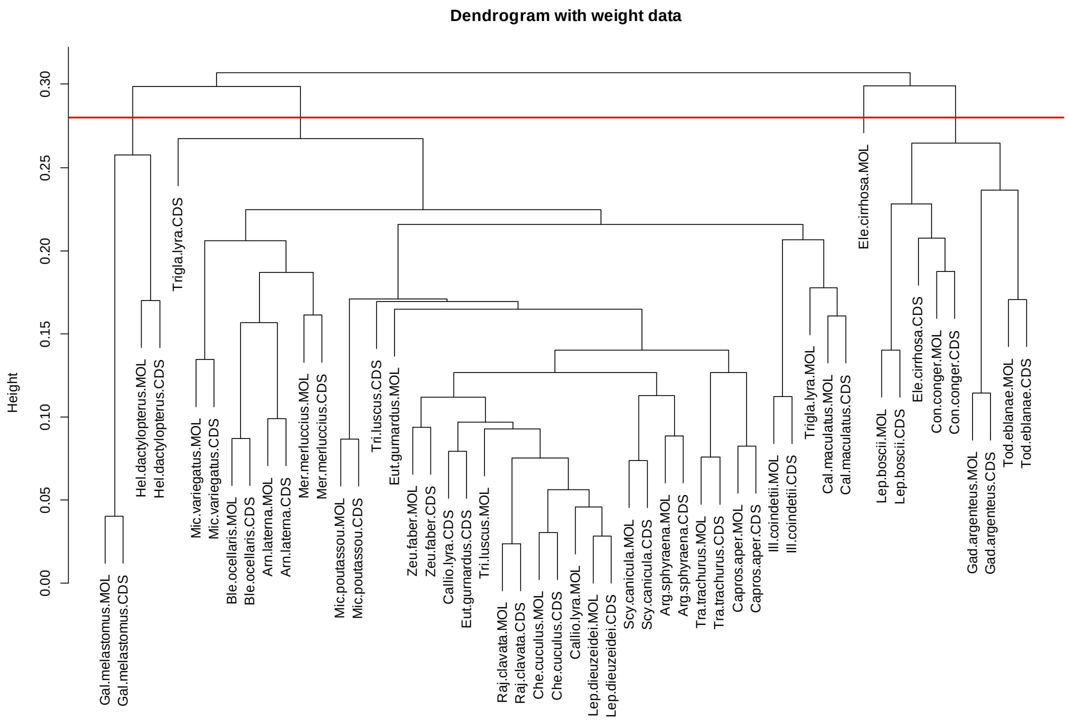

Figure 17. Hierarchical cluster analysis of fish and cephalopod catches in biomass per vessel