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Direct assessment of small pelagic fish by the PELGAS14 acoustic survey

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1. MATERIAL AND METHOD

1.1. PELGAS survey on board Thalassa

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area covered from Gibraltar to Brest with the same protocol regarding sampling strategy. Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

In the spirit of the ecosystemic approach, the pelagic ecosystem is characterised at each trophic level. To achieve this and to assess an optimum horizontal and vertical description of the area, two types of actions are combined :

1) Continuous acquisition of acoustic data from six different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler)
2) discrete sampling at stations (by pelagic trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelling have been also used before and during the survey to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans and birds (from board) carried out in order to characterise the higher level predators of the pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2013). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al,2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).

- acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo-sounders between the surface and 8 m depth.

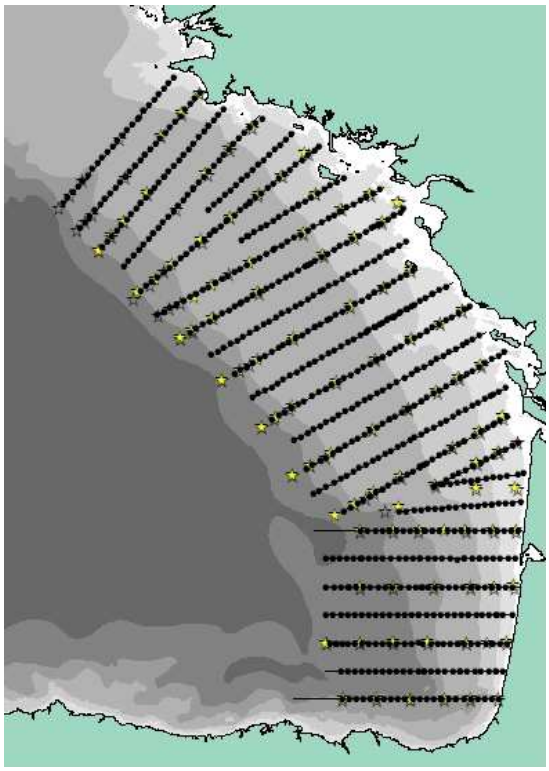


Fig. 1.1.1 - Transects prospected during PELGAS14 by Thalassa.

Three different echo-sounders were used during the survey :

In 2014, as in previous surveys (since 2009), three modes of acoustic observations were used :

- 6 split beam vertical echo-sounders (EK60), 6 frequencies, 18, 38, 70, 120, 200 and 333 kHz
- 1 horizontal echo-sounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echo-sounder (32 x 2°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during the whole survey. Nevertheless, only echoes stored on the vertical echo-sounder were used for abundance index calculation.

Energies and samples provided by all sounders were simultaneously visualised and stored using the MOVIES+ and MOVIES3D software and stored at the same standard HAC format.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage in the Douarnenez bay, in the West of Brittany, in good meteorological conditions at the end of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 6230 nautical miles from which 2011 nautical miles on one way transect were used for assessment. A total of 28 352 fishes were measured (including 9038 anchovies and 8129 sardines) and 2458 otoliths were collected for age determination (1197 of anchovy and 1261 of sardine).

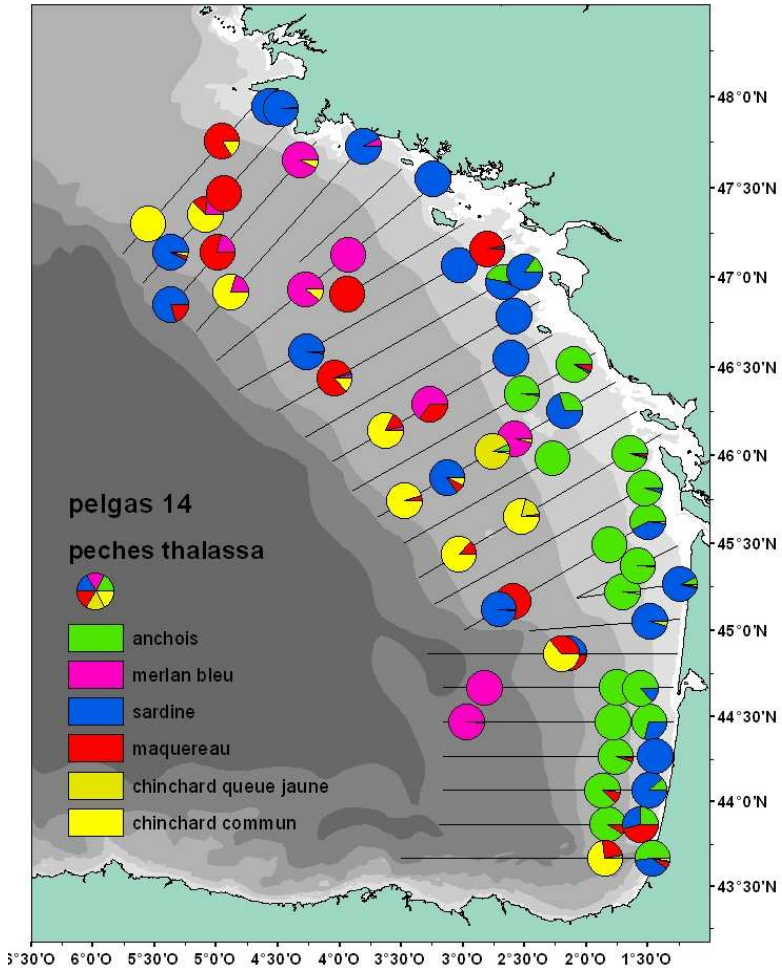


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organised since 2007 with French commercial vessels during 18 days. This approach, in the continuity of last year survey, and their trawl hauls were used for echoes identification and biological parameters at the same level than Thalassa ones.

Five commercial vessels (two pairs of pelagic trawlers during the two first weeks and a single pelagic trawler for the 4 last days) participated to PELGAS14 survey:

Vessel	gear	Period	Days at sea
Le Natif / La Roumasse	Pelagic pair trawl	30/04 to 05/05/2014	7
Le Joker / Ar Raok II	Pelagic pair trawl	06/05 to 12/05/2014	7
Bara Pemdez II	Pelagic single trawl	20/05 to 24/05/2014	4

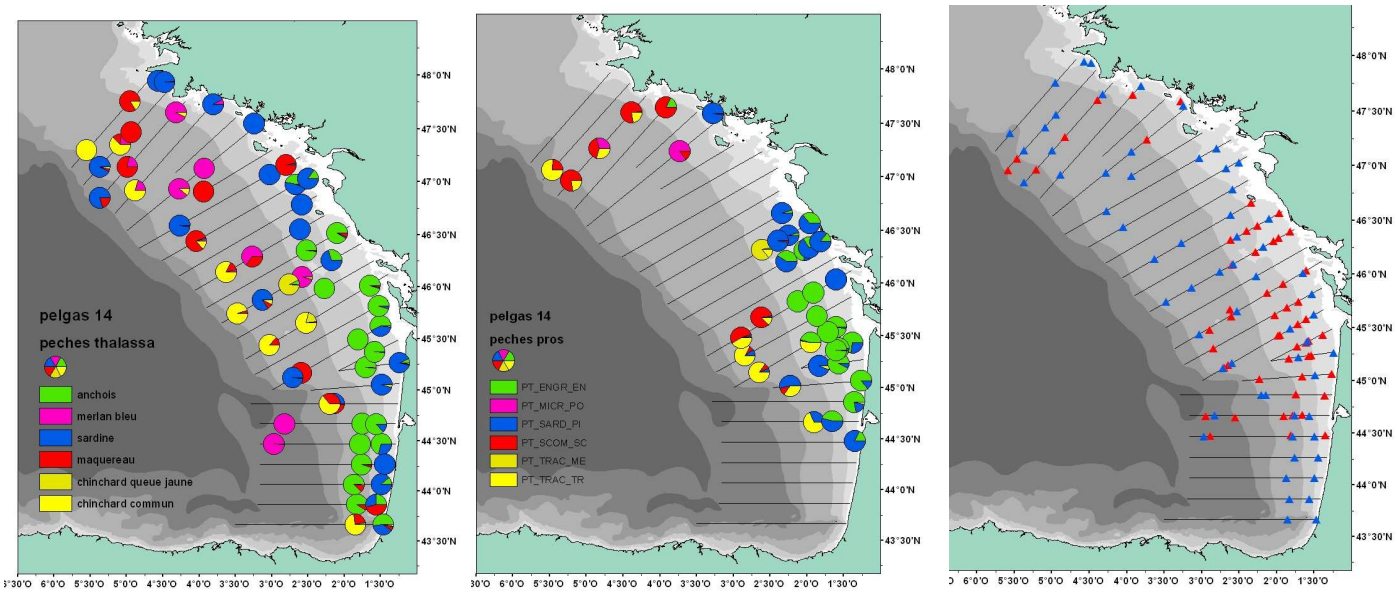
The regular transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 2 NM northern.

Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) Their pelagic trawl was until 25 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Regularly a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (351 otoliths of anchovy, 304 of sardine). A total of 14 648 fishes were measured onboard commercial vessels, including 5599 anchovies and 4044 sardines.

The catches and biological data have been directly used with the same consideration than Thalassa ones for identification and biological characterisation.

A total of 116 hauls were carried out during the assessment coverage including 62 hauls by Thalassa and 54 hauls by commercial vessels.



a) Thalassa (nb :62) *b) Commercial vessels (nb : 54)* *c) all fishing hauls (nb :116) thalassa n Blue and commercial in red*

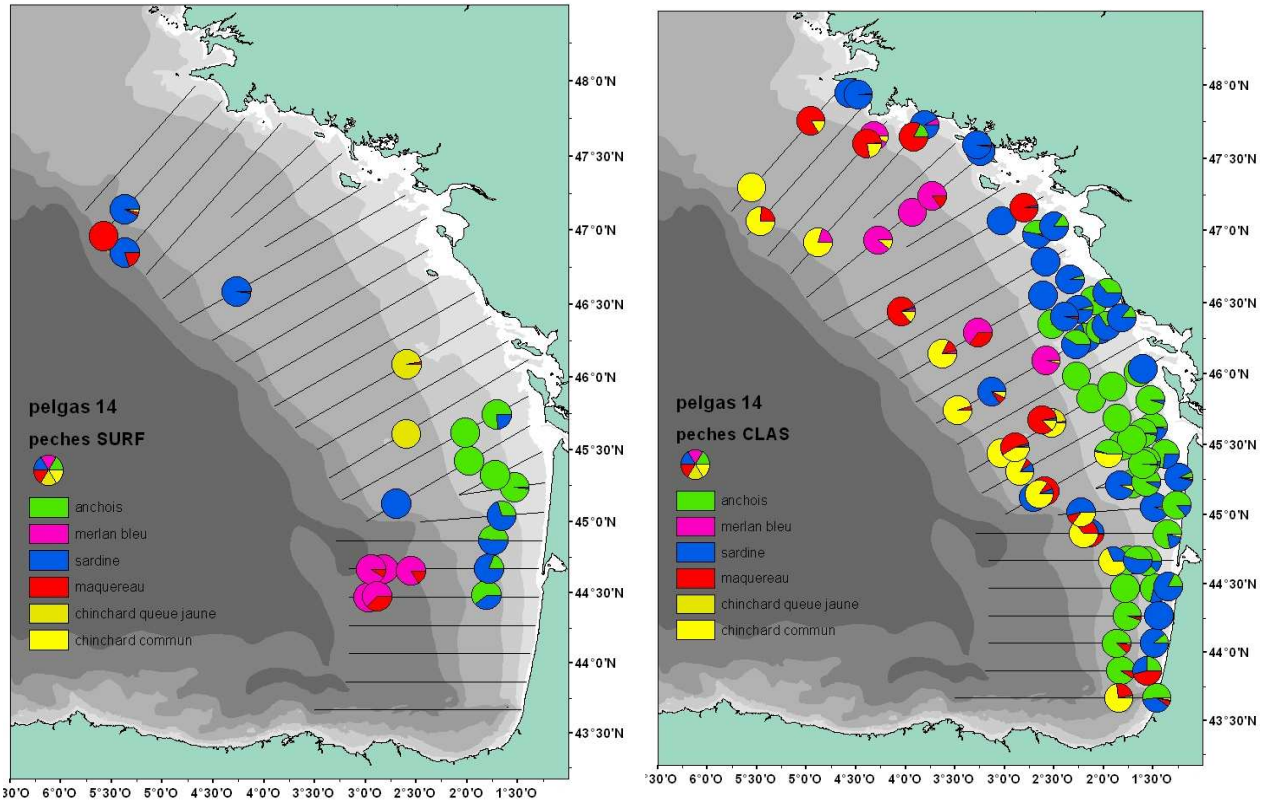
Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS14

The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most

of the time, in quantity as well). As last year, the fishing operations by commercial vessels were carried out only during day time (as for Thalassa) each time it was necessary and preferentially at the surface or in mid-water, since the pair trawlers are more efficient at surface than single back trawlers.

	R/V Thalassa	Commercial vessels	Total
Surface Hauls	**5**	**16**	**21**
Classic Hauls	**52**	**35**	**87**
Valid	**57**	**51**	**108**
Null	5	3	8
Total	62	54	116

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS14



a) Hauls carried out at surface or in mid-water levels (Thalassa & commercial vessels)

b) classic Hauls carried out near the bottom and 50m upper (Thalassa + commercial vessels)

Figure 1.2.4 : Vertical localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS14

2. ACOUSTICS DATA PROCESSING

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised by the date of the meeting. Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 5 categories of echo-traces this year :

D1 – energies attributed to mackerel, chub mackerel, horse mackerel, blue whiting, hake, whiting, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sardine, and sprat corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

D3 – energies attributed to scattered detection corresponding to blue whiting, myctophids, boarfish and mackerel.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to small and (mainly) dense echoes, very close to the surface.

D8 – energies attributed exclusively to sardine (big and very dense schools).

2.2. Splitting of energies into species

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.

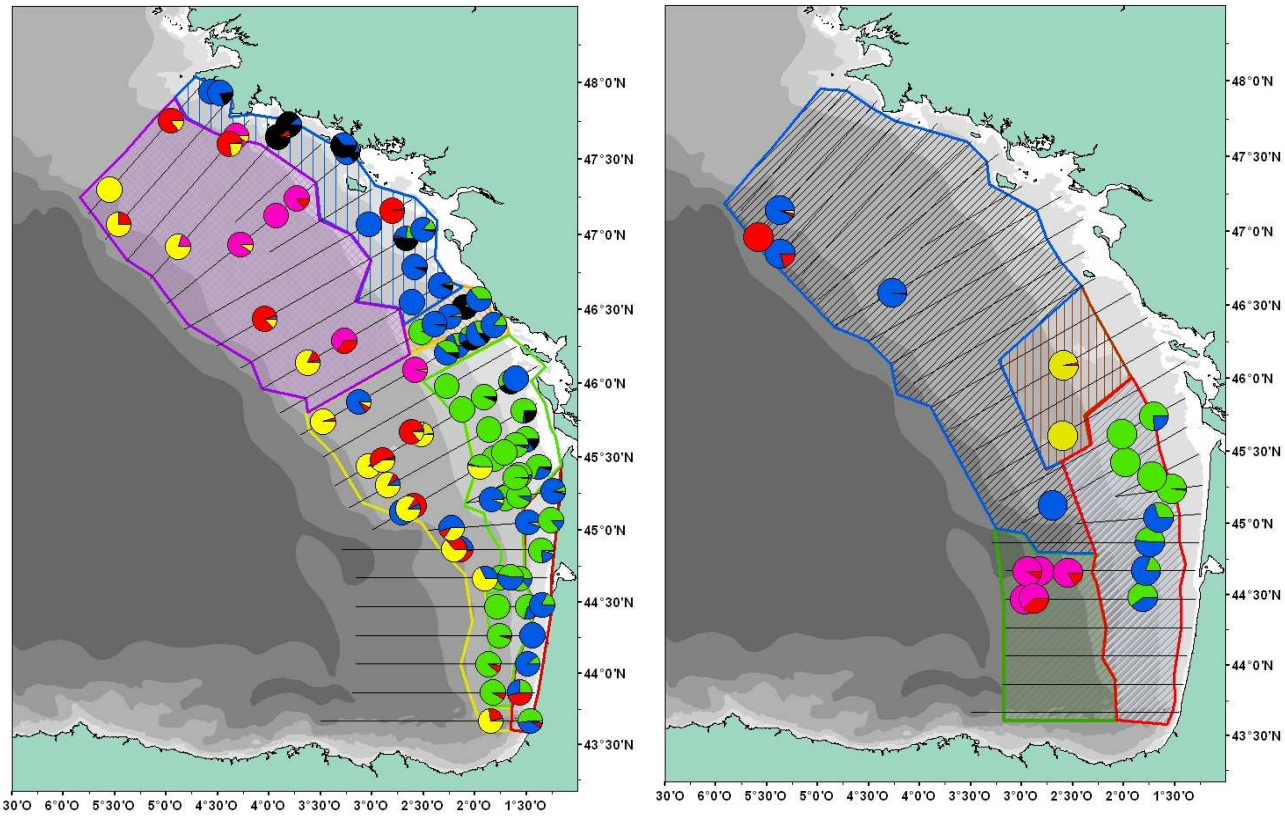


Fig. 2.2. – Coherent strata (classic and surface), in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS14 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to profit of the best efficiency of each vessel and maximise the number of samples (in term of identification and biological parameters as well). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fish preferably in the bottom layer. According to previous strata, using both Thalassa and consort fishing operations, biomass estimates have been calculated for each main pelagic species in the surveyed area.

Biomass indices are gathered in tables 2.3.1. and 2.3.2., and in figure 2.3.1. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is scattered and mixed with plankton echoes.

Anchovy was present this year as a relatively high abundance index (above the average of the serie), with a bit more than 125 000 tonnes, exclusively from the coast to the depth of 100m.

Sardine was still well present this year, mostly in coastal waters from the South until the North of the bay of Biscay. It was also spotted offshore (mainly in the Northern part), in lower quantity, near the surface.

About other species, an other characteristic of this year is that horse mackerel shows a small increase of the biomass, but keep a low level at this period in the bay of Biscay.

Mackerel appears very dispersed all over the area, and mainly close to the surface. It was the most abundant specie close to the surface, all clupeids appearing this year in coastal waters.

	Classic	Surface	Total
Anchovy	110 343	15 084	**125 427**
Sardine	308 759	30 848	**339 607**
Sprat	33 894		**33 894**
Mackerel	110 174	300 006	**410 181**
Horse Mackerel	53 154		**53 154**
Blue whiting	25 015		**25 015**

Table 2.3.1. Acoustic biomass index for the main species by strata during PELGAS14

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**	**125 427**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.07741*	*0.04665*	*0.12821*	*0.062928*
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**	**339 607**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.06991*	*0.07668*	*0.07382*	*0.065212*
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**	**33 894**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.19922*	*0.241009*
Horse mackerel	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**	**53 154**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.30067*	*0.227089*
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**	**25 015**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.15422*	*0.337606*

Table 2.3.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

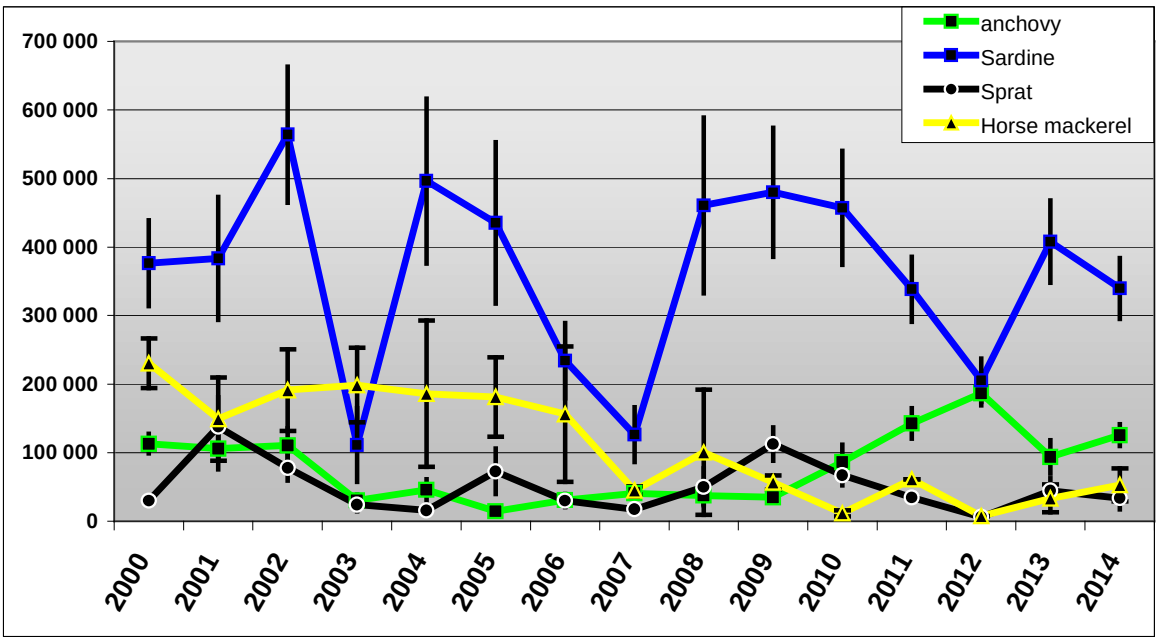


figure 2.3.1. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + commercial vessels) and coefficients of variation associated.

2.4. Validation of the echotraces srutinizing

This year, a study was done on the impact of the person operating the srutinization of the echotraces. As last year, 4 people were able to do it (including a new one). Some transects analyses were done in parallel by each “srutinizer” to assess the impact on the biomass calculation. This impact is low for the two most important species targeted by the PELGAS survey (sardine and anchovy, less than 10% of difference for these two species in terms of final biomass estimate).

Nevertheless, this bias seems to be more important on mackerel and horse mackerel : for 3 “scrutinizers”, the result is good with differences of less than 10 percent for each biomass calculation for the same species. But for one person (the new one), the difference in the final index seems to be significant with an increase of 30 % compared to the other ones.

This exercise will be carried on again next years, with a real intercalibration, and probably a workshop before the next survey to teach everybody the scrutinizing of the echoes in the same manner.

3. ANCHOVY DATA

3.1. anchovy biomass

The biomass estimate of anchovy observed during PELGAS13 is **125 427** tons. (table 2.3.), which is at a high level on the PELGAS series, and constituting a new increase of this biomass in the bay o Biscay.

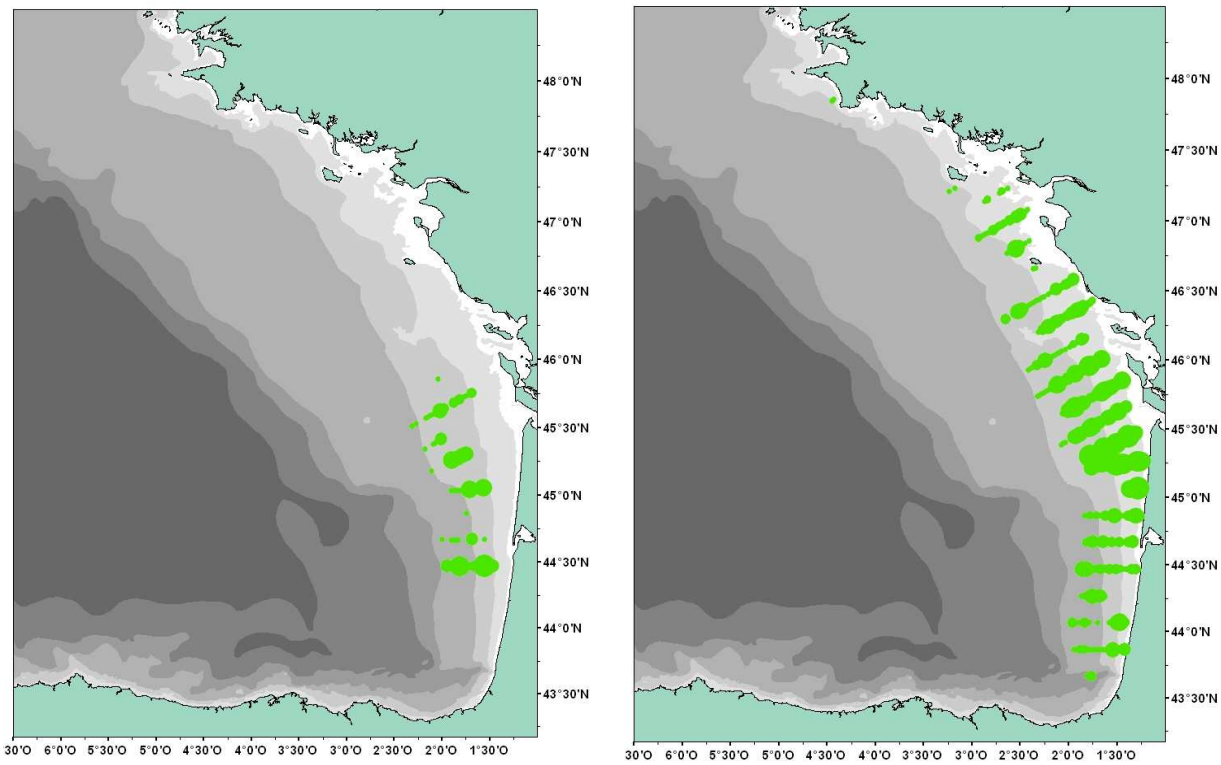
The main observation in 2013 is that sardine, anchovy and sprat were well present in important densities in coastal waters. These echoes were systematically identified on each transect and revealed almost pure anchovy in the Gironde area (mainly one year old in front of the river plume).

In the Gironde area, we found a configuration more classic (in size and in Sa), with an acoustic energy attributed to anchovy about the average, and far away from the very high energies from 2012. Nevertheless, anchovy was predominant in this area. The most part of the age 1 of anchovy was there, in size class comparable with a “normal” year (all, except 2012 where the fish was much smaller).

In the South part of the bay of Biscay, anchovy was also well present in the middle of the platform, in the whole water column (close to the bottom until the surface).

On the South coast of Brittany, sightings of anchovy occurred around the Loire river and in much lower quantities in the south west of Brittany, still along the coast.

One thing must be noticed this year, the absence of anchovy along the shelf break, neither at the surface, nor at the bottom.



Surface distribution

Classic distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS14 survey.

3.2. Anchovy length structure

Length distribution in the trawl hauls were estimated from random samples. The population length distributions (figures 3.2.1 and 3.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

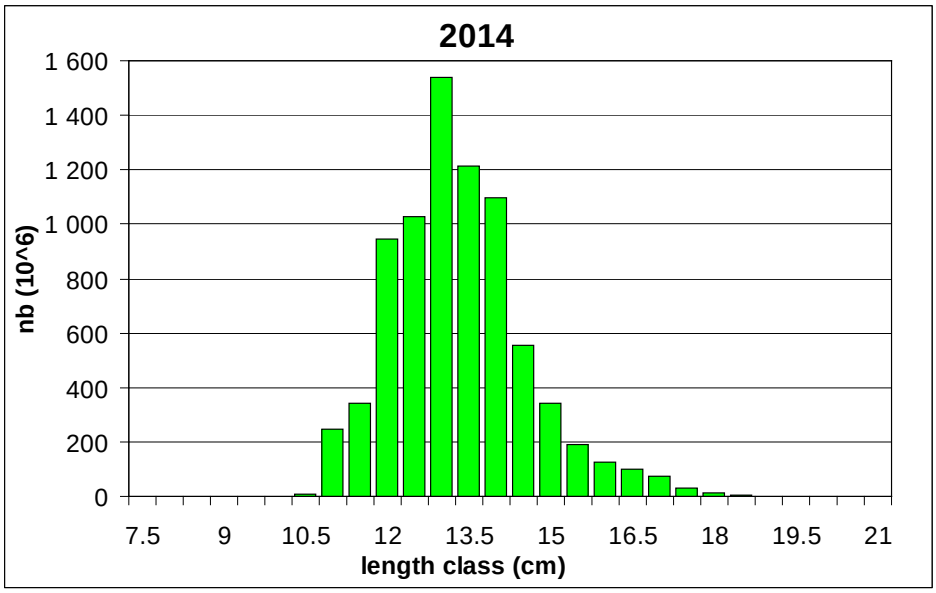


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS14 survey

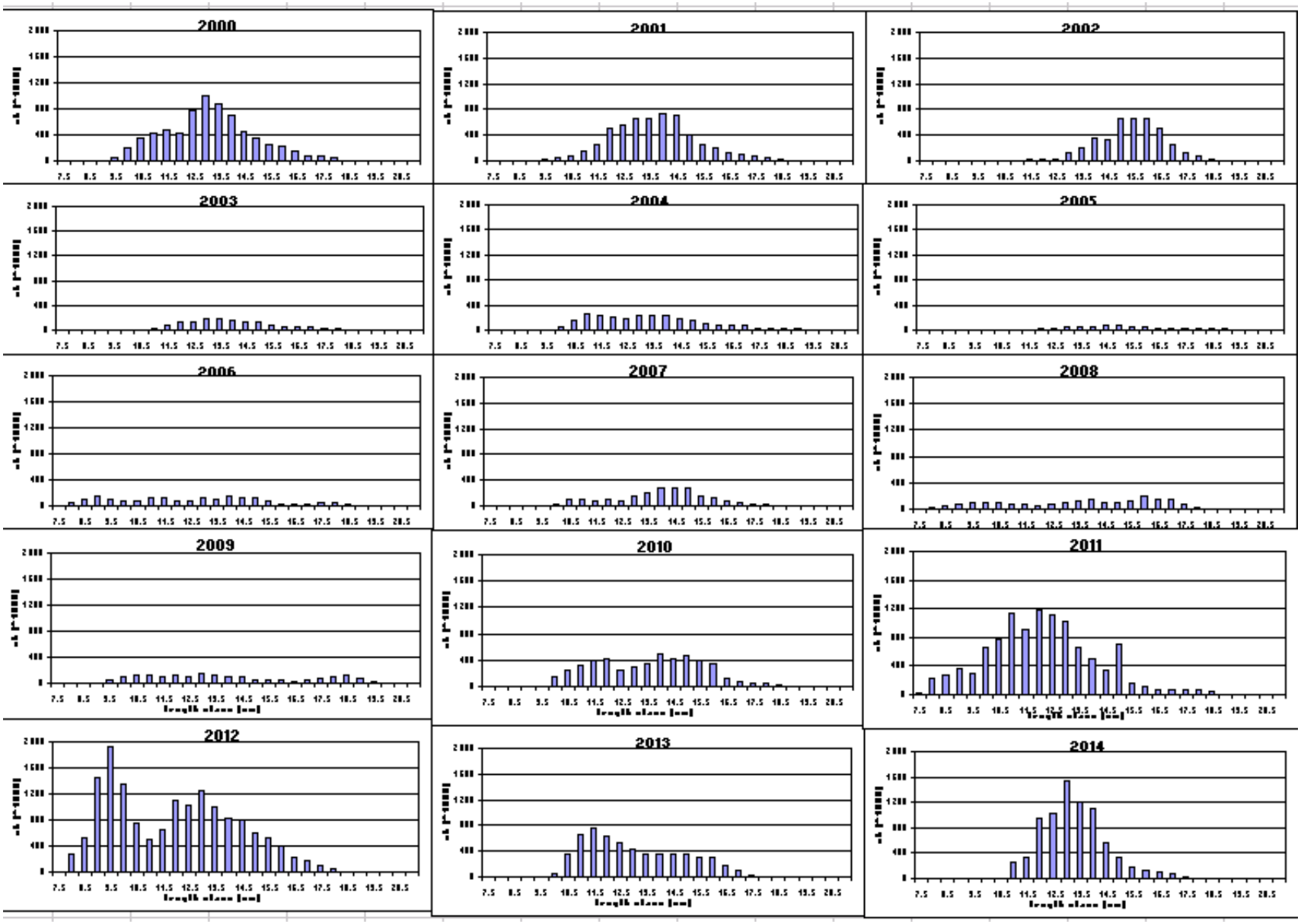


Figure 3.2.2. – length composition of anchovy as estimated by acoustics since 2000

. 3.3. Demographic structure

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and samples from commercial vessels. We took the otoliths from a set number of fishes per length class (4 to 6 / half-cm), for a total amount of around 50 fish per haul. As there was a lot of fishing operations where anchovy was present, the number of otoliths we took during the survey was more or less the same as the 3 last years (1197 otoliths read on board), The population length distributions were estimated by a weighted use of length distributions in the hauls, weighted as described in section 3.2.

NB age	age				
length (mm)	1	2	3	4	Total
85	100.00%	0.00%	0.00%	0.00%	100.00%
90	100.00%	0.00%	0.00%	0.00%	100.00%
95	100.00%	0.00%	0.00%	0.00%	100.00%
100	100.00%	0.00%	0.00%	0.00%	100.00%
105	100.00%	0.00%	0.00%	0.00%	100.00%
110	88.89%	3.70%	7.41%	0.00%	100.00%
115	77.42%	19.35%	3.23%	0.00%	100.00%
120	92.00%	6.67%	1.33%	0.00%	100.00%
125	89.36%	10.64%	0.00%	0.00%	100.00%
130	85.93%	14.07%	0.00%	0.00%	100.00%
135	84.72%	13.19%	2.08%	0.00%	100.00%
140	66.42%	31.39%	2.19%	0.00%	100.00%
145	57.63%	38.14%	3.39%	0.85%	100.00%
150	46.15%	43.27%	9.62%	0.96%	100.00%
155	27.27%	61.36%	9.09%	2.27%	100.00%
160	13.85%	64.62%	18.46%	3.08%	100.00%
165	2.13%	74.47%	17.02%	6.38%	100.00%
170	0.00%	61.11%	33.33%	5.56%	100.00%
175	0.00%	51.85%	37.04%	11.11%	100.00%
180	0.00%	30.77%	61.54%	7.69%	100.00%
185	0.00%	66.67%	33.33%	0.00%	100.00%
190	0.00%	0.00%	100.00%	0.00%	100.00%

Table 3.3.1. PELGAS14 anchovy Age/Length key.

Applying the age distribution to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2014 are shown in figure 3.3.3.

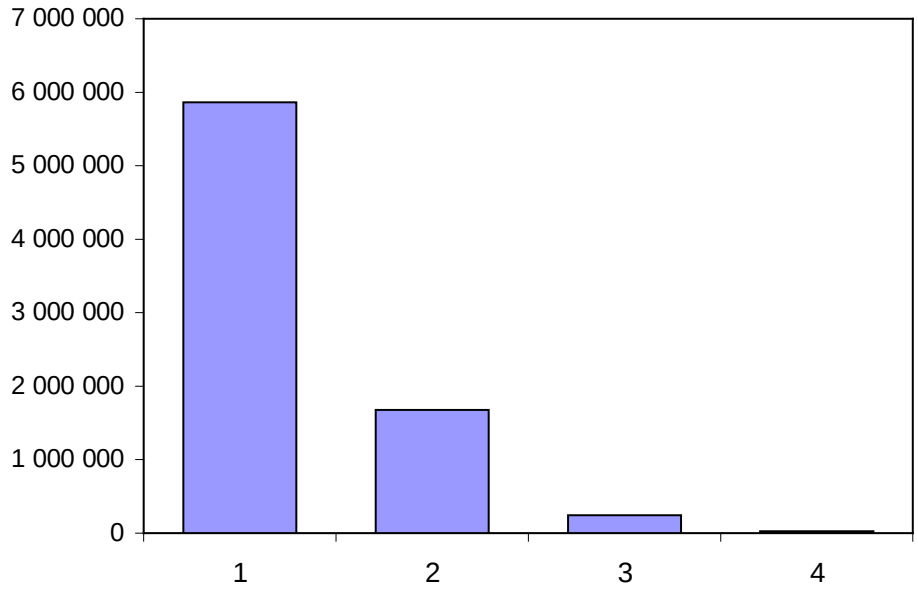


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS14.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seems to be around the average of the serie, but far away from the 2011 and 2012 levels of recruitment.

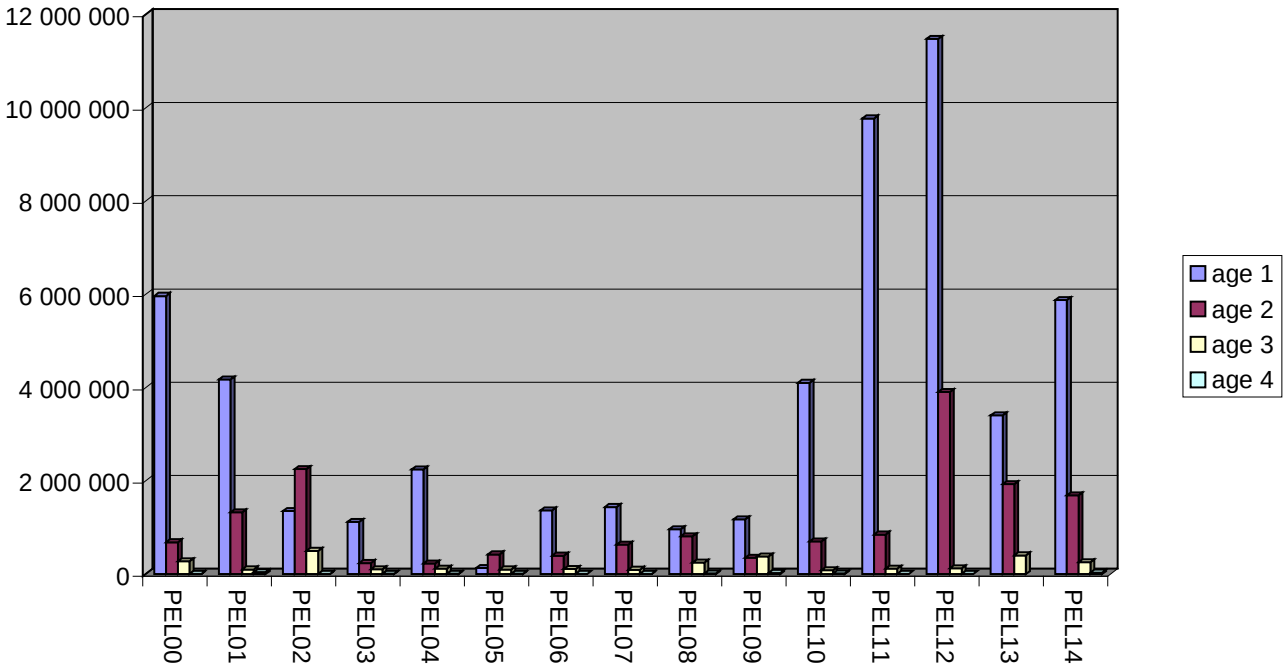


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

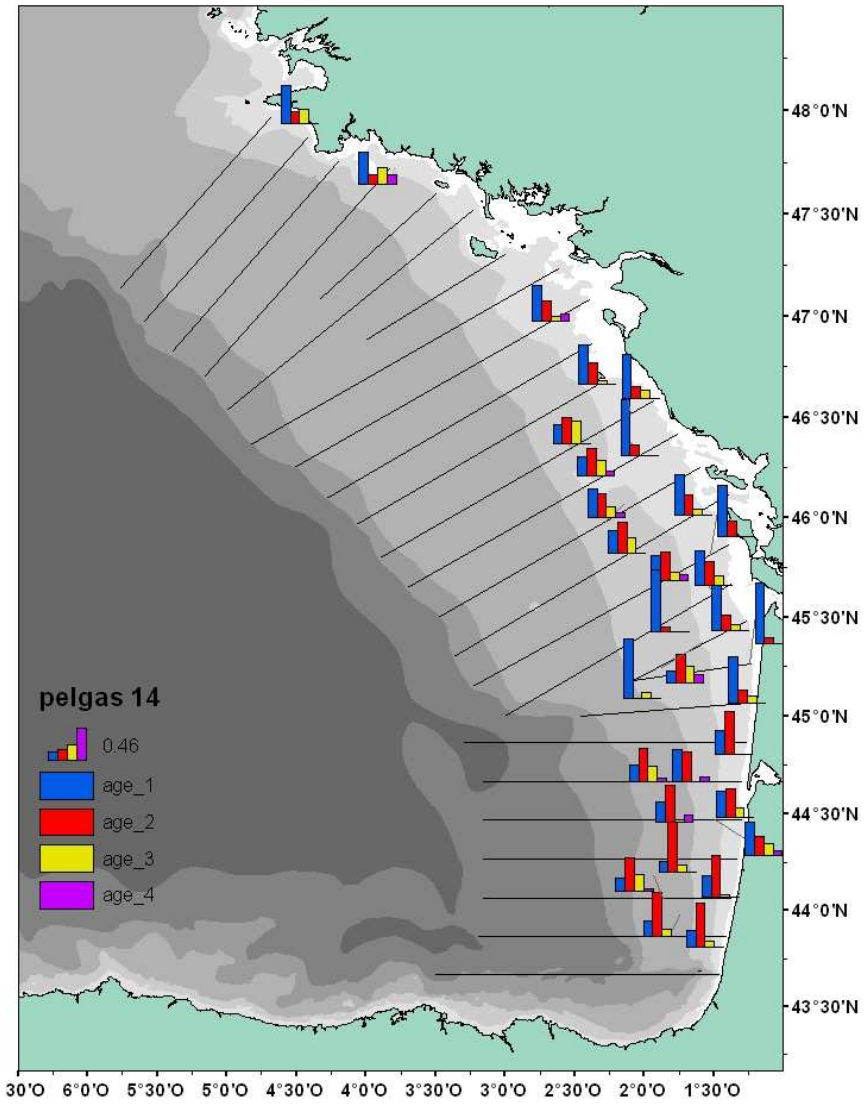


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS14 survey.

During previous surveys, anchovy was well geographically stratified depending on the age (*see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.*). It is less true this year as age1 were as usual predominant in the Gironde area, but also dispersed on the platform, mixed with age 2..

age	PEL14 % - nb
1	74.8
2	21.5
3	3.3
4	0.4

age	PEL14 - % W
1	69.1
2	25.7
3	4.5
4	0.7

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS14 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1197 weights of individual fishes, the following weight/length key was established (figure 4.5.) :

$W = 2E\text{-}06L^{3.2032}$ with R2 = 0.9537 *(with W in grams and L in mm)*

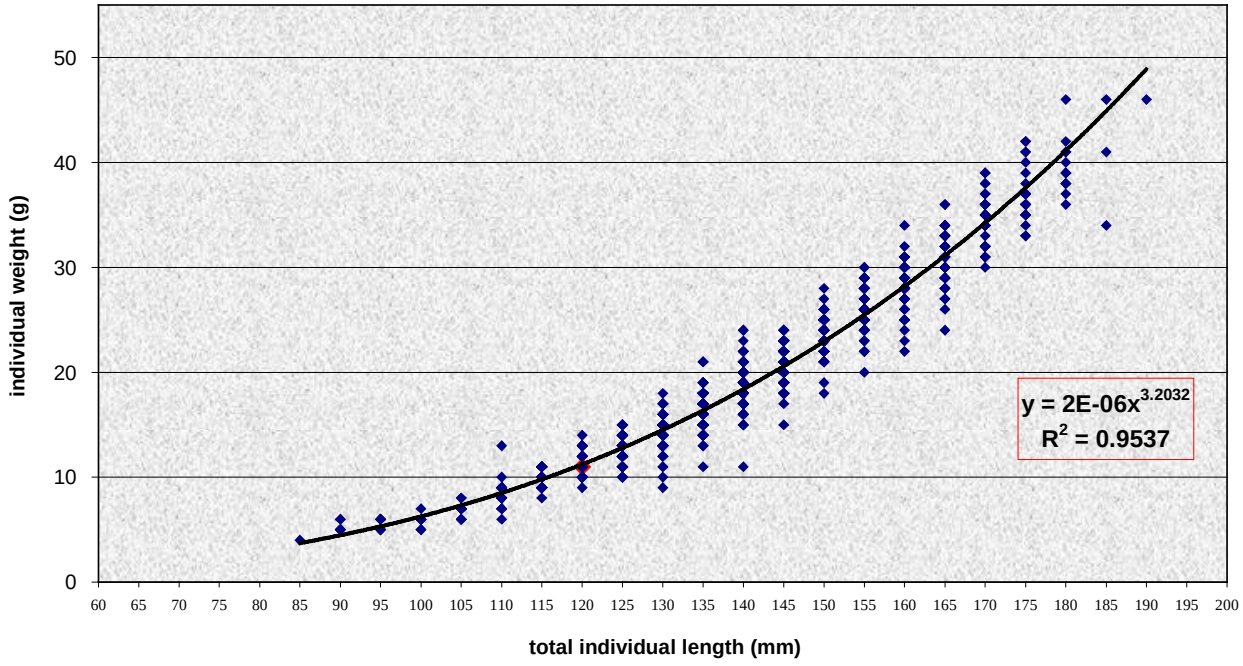


Fig. 3.4. – Weight/length key of anchovy established during PELGAS14

3.5. Mean Weight at age

mean weigth at age (g)	AGE			
survey	1	2	3	4
PEL00	14.78	25.98	30.62	36.06
PEL01	16.09	25.91	21.28	36.39
PEL02	20.41	27.17	28.49	36.85
PEL03	16.73	25.63	32.79	28.79
PEL04	15.12	32.83	36.98	52.32
PEL05	18.80	26.29	32.75	30.74
PEL06	13.39	25.47	31.87	46.12
PEL07	17.80	24.28	20.66	
PEL08	11.57	26.94	27.34	27.37
PEL09	15.26	31.04	40.24	41.59
PEL10	15.74	25.94	34.78	48.11
PEL11	11.33	27.13	26.02	60.54
PEL12	7.72	19.70	20.85	35.36
PEL13	12.61	21.34	26.46	
PEL14	14.52	18.92	21.82	28.53

Fig. 3.5. – mean weight at age (g) of anchovy for each PELGAS survey

3.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 788 CUFES samples were collected and counted, 67 vertical plankton hauls and 110 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

This year was classical in terms of eggs spatial distribution, according to the adults, with maximum for anchovy in the middle of the shelf, a few along the coast North of the Gironde, and a very low abundance along the shelf break (fig 3.6.1).

Looking at the time series from 2000 to 2014 (Figure 3.6.2. and 3.6.3.), anchovy eggs abundance is above the average of the time series since 2000, but far away from the 2011 strong peak.

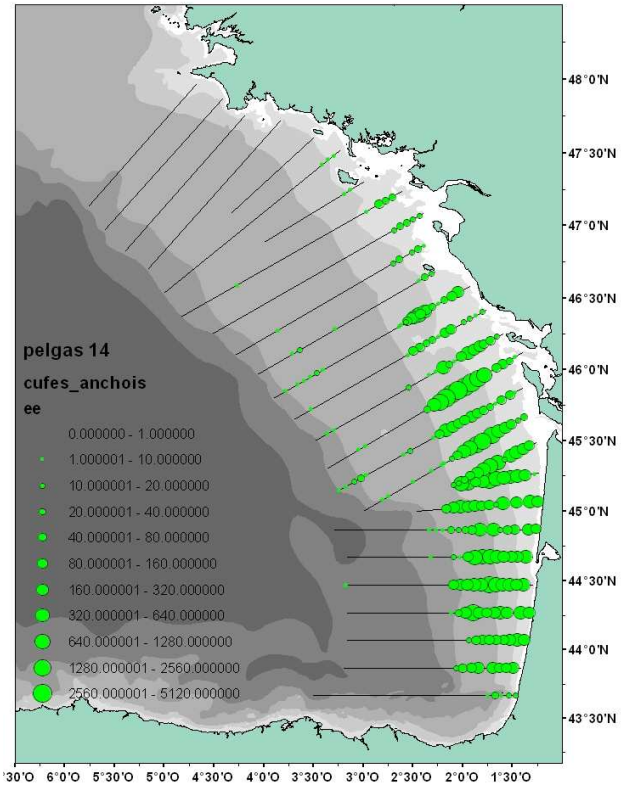


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS14.

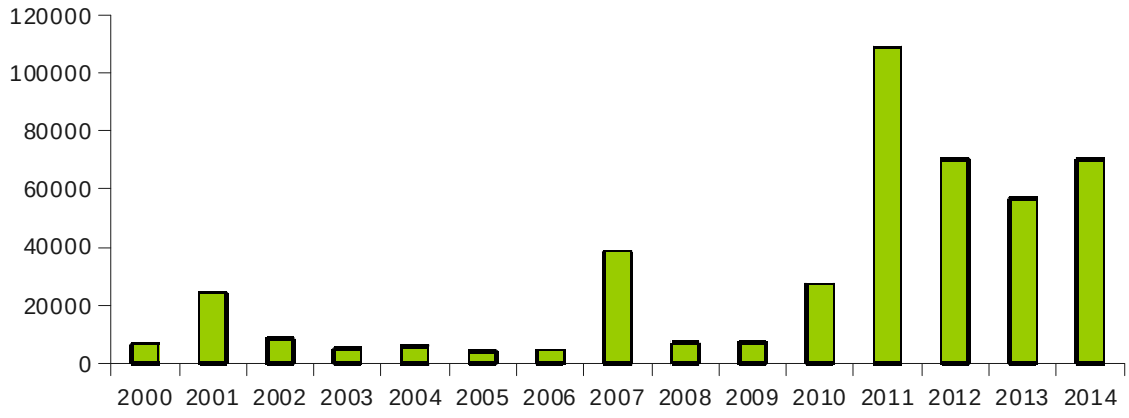


Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2014

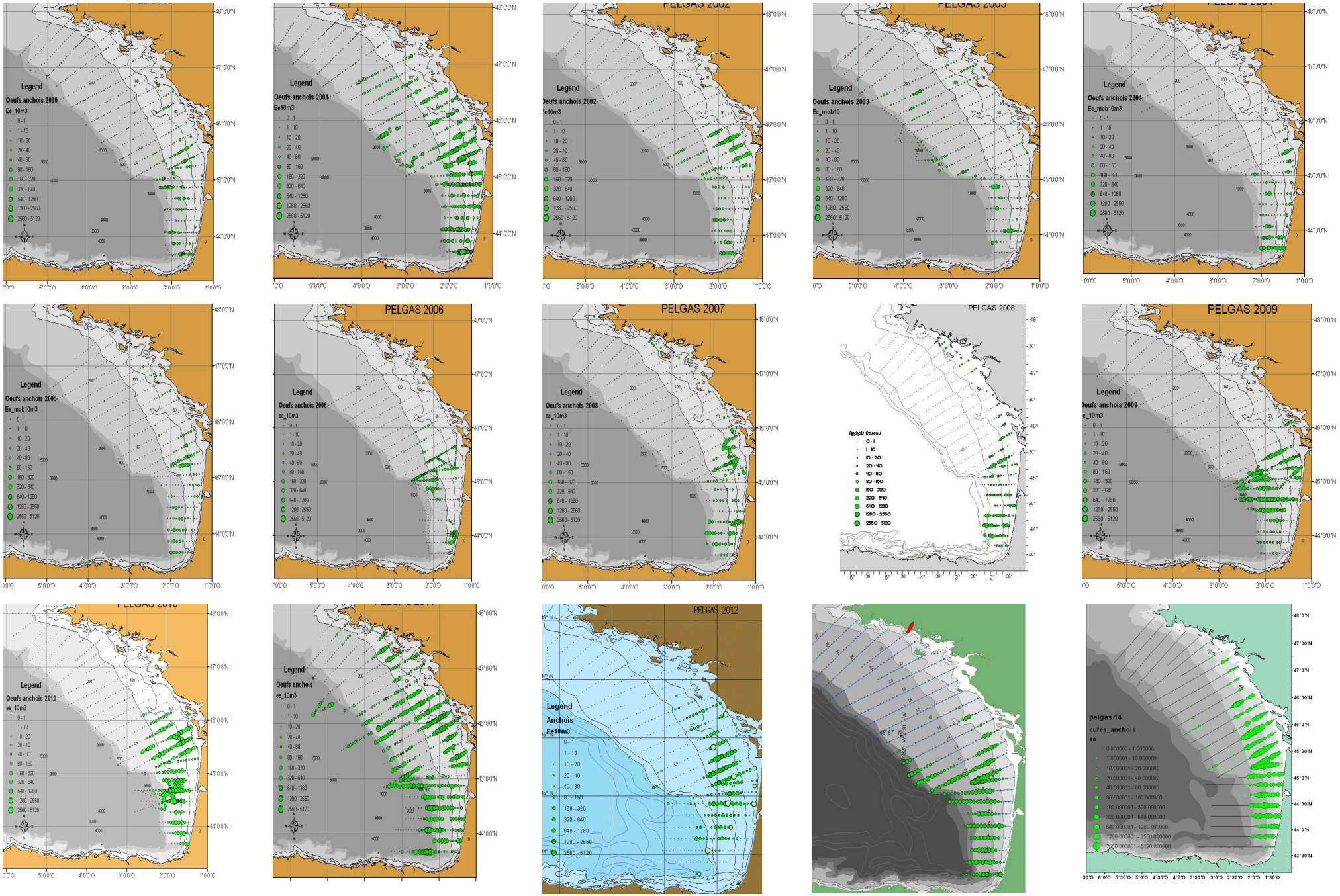


Figure 3.6.3 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2014 (number for $10m^3$).

3.7. Coherence between CUFES and Acoustic survey indices

Taking advantage of the fact that we have an egg survey (CUFES) providing Ptot and an acoustic survey providing B, we may simply estimate the daily fecundity (DF: # eggs g-1 d-1) by the ratio Ptot/B. Note that here, DF is the egg production by gramme of stock (i.e., both females and males). Because the two indices Ptot and B are linked through DF, the coherence between the egg (CUFES) and the acoustic survey indices of PELGAS can be investigated.

The daily egg production was estimated as described in Petitgas et al. (2009) with the developments made by Gatti (2012) and discussed at the benchmark workshop WKPELA 2013. Briefly, the eggs at each CUFES sample are staged in 3 stages, the duration which are temperature dependent. The CUFES egg concentration is converted into egg abundance (vertically integrated) by using a 1-dimensional distribution model which takes input account as parameters the egg buoyancy and dimension, the hydrological vertical profile, the tidal current and wind regime (Petitgas et al., 2006; Petitgas et al., 2009; Gatti, 2012). The complete serie is shown on figure 3.7.1.

In 2014 the estimates are : B=125 427 tonnes ; Ptot= 1.37 10^{13} egg d^{-1}

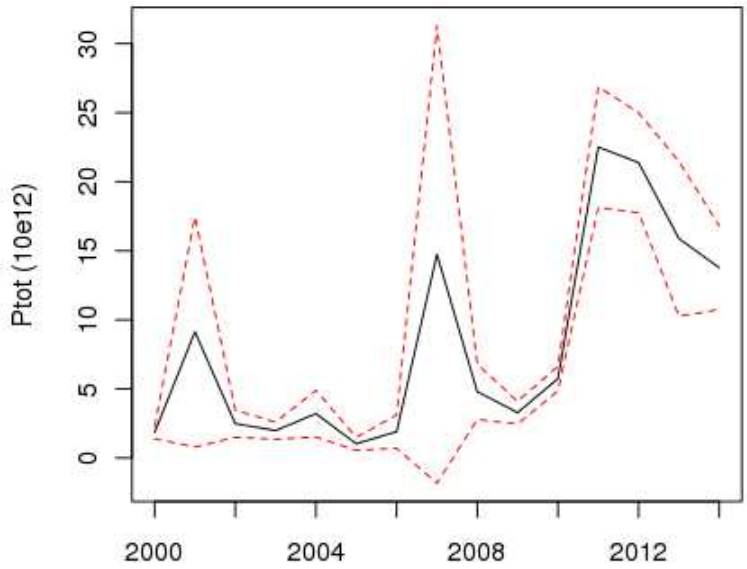


Figure 3.7.1 – Ptot serie from the CUFES index

The daily egg production Ptot depends on the spawning biomass (B) and the daily fecundity (DF). DF depends ultimately on environmental and trophic conditions, which determine individual fish fecundity (e.g., Motos et al., 1996). Daily egg production (Ptot) and spawning biomass (B) were linearly related (Fig 1). The slope of the linear regression is a (direct) estimate of the average DF over the series. Its value is : 92.26 eggs g-1. Residuals are particularly important for 2000, 2002 and 2007.

For first years of the serie (2000 to 2002) the mesh of the collector was 500 µm and is now 315 µm. But more investigation should be processed to asses the impact of the change of the mesh size on the aspect of the eggs collected, and on the number of them in each sample as well.

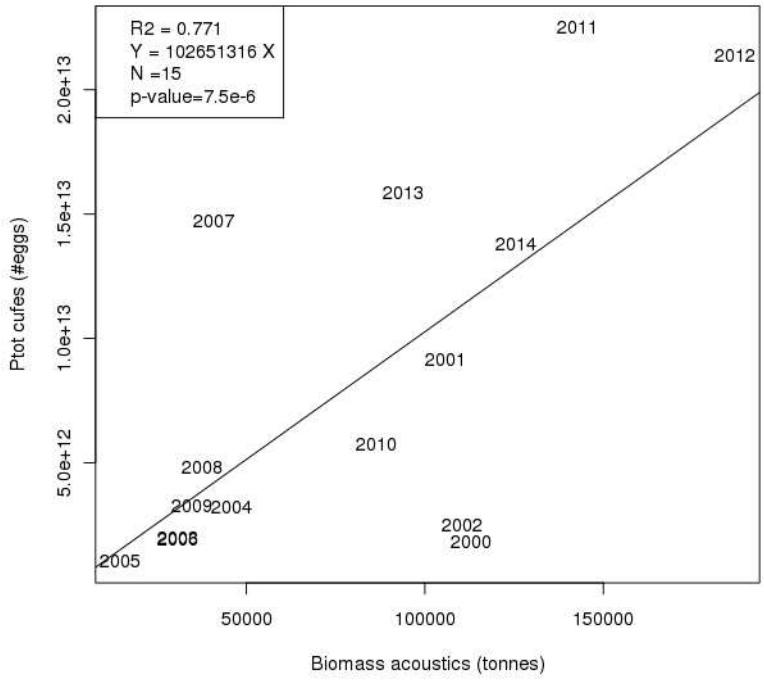


Figure 3.7.2 – Coherence between CUFES and Acoustic PELGAS survey indices

4. SARDINE DATA

4.1. Adults

The biomass estimate of sardine observed during PELGAS14 is **339 607** tons (table 2.3.), which is at the average level of the PELGAS series, and constituting a small decrease of the biomass compared to last year. It must be enhance that these survey don't cover the total area of potential presence of sardine. It is possible that some years, this specie could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, more or less regularly. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed all along the french coast of the bay of biscay, from the south to the North. Then, sardine appeared almost pure along the Landes's coast, where an upwelling occurred. Sardine was also present mixed with anchovy from the Gironde to the South coast of Brittany. Sardine appeared also close to the surface in the Northern part of the bay of Biscay, along the shelfbreak, sometimes mixed with mackerel, but in lower abundance than previous years. It must be noticed that, even adults appeared in lox quantity in this offshore area, eggs were well present (*see chapter 4.2).* an hypothesis could be that sardine was so closed to the surface that a part of it couldn't be detected by the echosounders in the blind layer. An other possibility could be that this sardine offshore is bigger than individuals along the coast, and presents an higher fecundity.

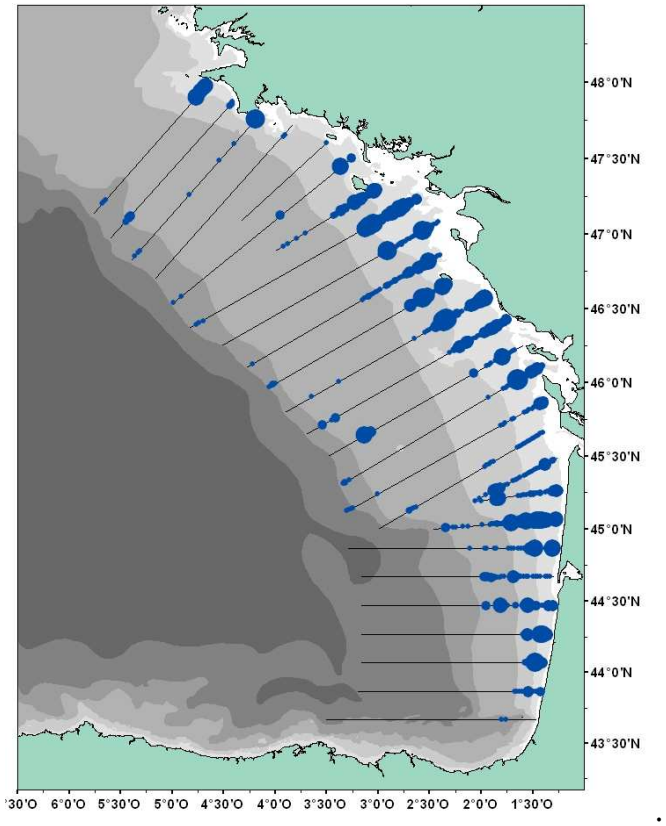


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS14

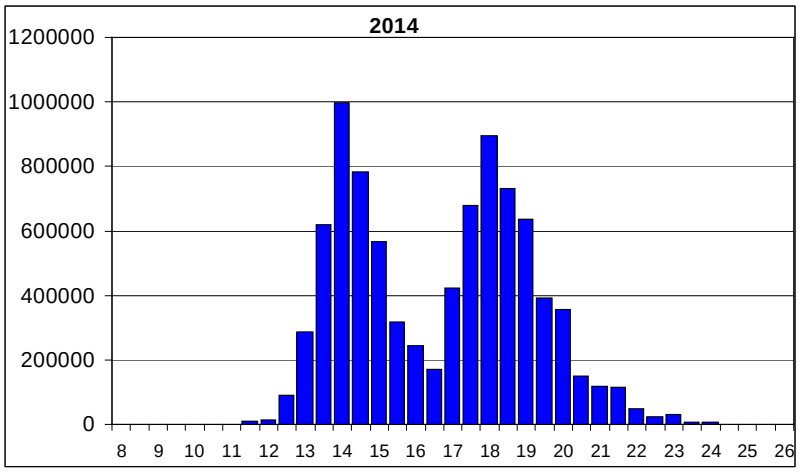


Figure 4.1.2. – length distribution of sardine as observed during PELGAS14

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

As usual, sardine shows a bimodal length distribution, the first one (about 14 cm, corresponding to the age 1, and present this year along the coast) and the second about 18 cm, which is mainly constituted by the 2 years old (still very well present a bit more offshore than the 1 year class, mainly between depths 60 and 80 m). The biggest individuals, along the shelf break are older (age 4 and more).

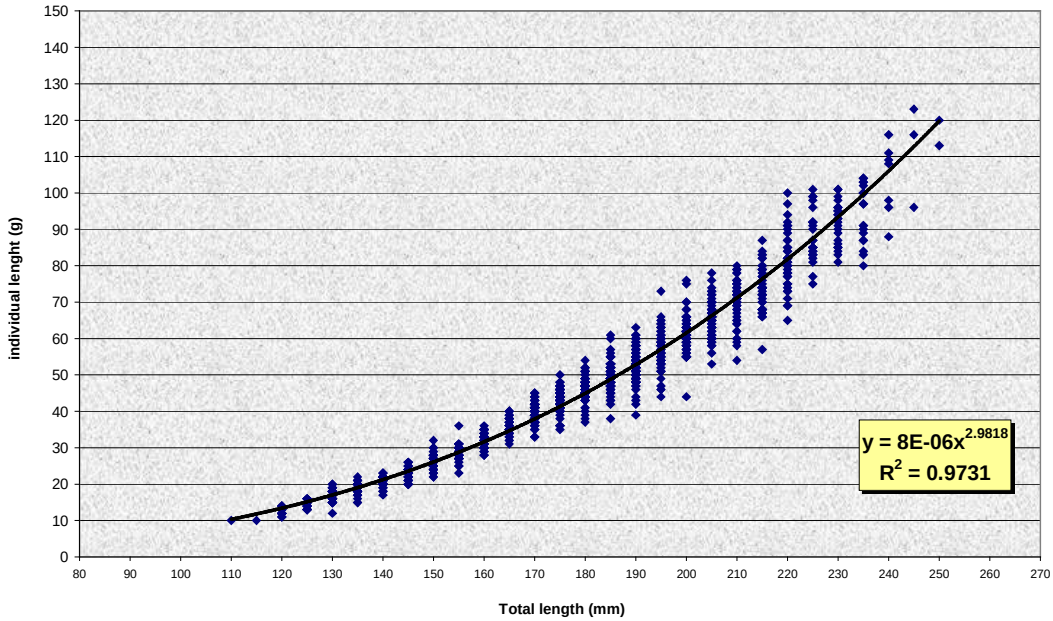


Figure 4.1.3 – Weight/length key of sardine established during PELGAS14

NB age	âge								
length (mm)	1	2	3	4	5	6	7	8	9
110	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
115	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
120	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
125	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
130	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
135	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
140	**97.67%**	**2.33%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
145	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
150	**93.33%**	**6.67%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
155	**86.84%**	**13.16%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
160	**56.52%**	**43.48%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
165	**42.86%**	**57.14%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
170	**22.22%**	**73.61%**	**4.17%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
175	**4.55%**	**93.18%**	**2.27%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
180	**2.94%**	**90.20%**	**5.88%**	**0.98%**	0.00%	0.00%	0.00%	0.00%	0.00%
185	0.00%	**81.63%**	**16.33%**	**2.04%**	**0.00%**	0.00%	0.00%	0.00%	0.00%
190	0.00%	**60.00%**	**31.58%**	**5.26%**	**2.11%**	**1.05%**	0.00%	0.00%	0.00%
195	0.00%	**36.84%**	**48.68%**	**7.89%**	**6.58%**	0.00%	0.00%	0.00%	0.00%
200	0.00%	**25.37%**	**35.82%**	**26.87%**	**5.97%**	**2.99%**	**2.99%**	0.00%	0.00%
205	0.00%	**5.36%**	**48.21%**	**19.64%**	**17.86%**	**7.14%**	**1.79%**	0.00%	0.00%
210	0.00%	**1.79%**	**33.93%**	**12.50%**	**23.21%**	**23.21%**	**3.57%**	0.00%	**1.79%**
215	0.00%	0.00%	**18.60%**	**23.26%**	**27.91%**	**27.91%**	**2.33%**	0.00%	0.00%
220	0.00%	0.00%	**14.29%**	**17.14%**	**34.29%**	**28.57%**	**5.71%**	0.00%	0.00%
225	0.00%	0.00%	0.00%	**4.00%**	**40.00%**	**36.00%**	**20.00%**	0.00%	0.00%
230	0.00%	0.00%	0.00%	**7.41%**	**25.93%**	**40.74%**	**22.22%**	0.00%	**3.70%**
235	0.00%	0.00%	0.00%	0.00%	**10.53%**	**47.37%**	**36.84%**	0.00%	**5.26%**
240	0.00%	0.00%	0.00%	0.00%	0.00%	**57.14%**	**28.57%**	0.00%	**14.29%**
245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**66.67%**	0.00%	**33.33%**
250	0.00%	0.00%	0.00%	**100.00%**	0.00%	0.00%	0.00%	0.00%	0.00%

Table 4.1.4 : sardine age/length key from PELGAS14 samples (based on 1261 otoliths)

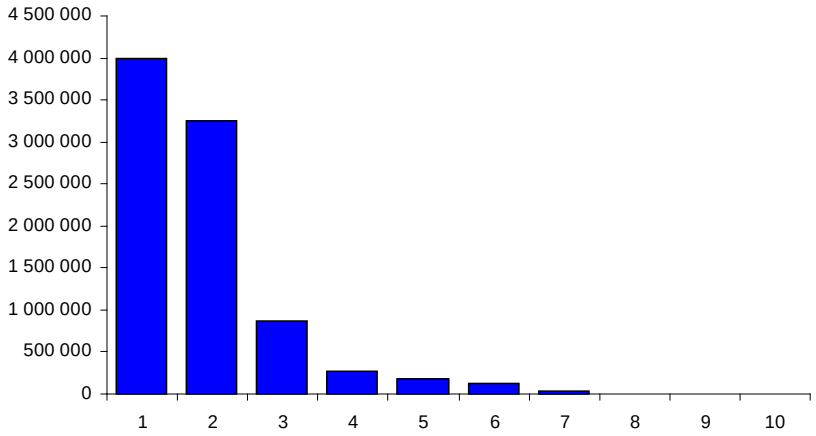


Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 14

age	PEL14 % - N
1	45.72%
2	37.16%
3	9.90%
4	3.10%
5	2.10%
6	1.52%
7	0.46%
8	0%
9	0%

age	PEL14- % W
1	27.82
2	44.40
3	14.70
4	5.07
5	3.86
6	3.06
7	0.97
8	0
9	0.13

Figure 4.1.6 percentage by age of the sardine population observed during PELGAS14 in numbers (left) and biomass (right).

The relative high abundance of age 2 (37% in number, but 44 % in mass) confirms the (very) good recruitment observed last year.

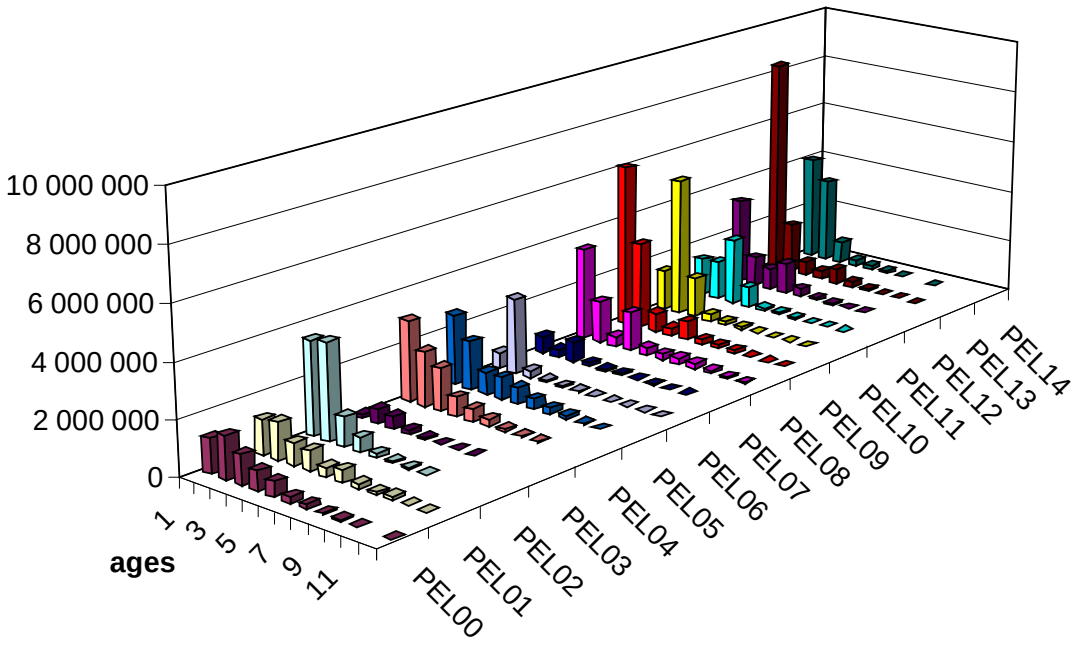


Figure 4.1.7- Age composition of sardine as estimated by acoustics since 2000

The series of age distribution in numbers since 2000 are shown in figure 4.1.7. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or very high 2008 age class). 2003 and 2007 were atypical years in terms of environmental conditions and therefore fish (and particularly sardine) distributions.

The high abundance of age 2 (see above) should be followed next couple of years.

	age									
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05		
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09		
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15	
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83	
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50	

Figure 4.1.8- mean Weight at age (g) of sardine for each PELGAS survey

4.2. Eggs

Sardine eggs were observed mainly along the coast between the 50 and the 100m isobaths, from the south of the bay of Biscay to the south of Brittany, except front of the Gironde plume, where the most important anchovy were detected. Then, another concentration was visible along the end of the continental slope, northern than the “fer à cheval”, according to the presence of a low abundance of adults close to the surface (see paragraph 4.1).

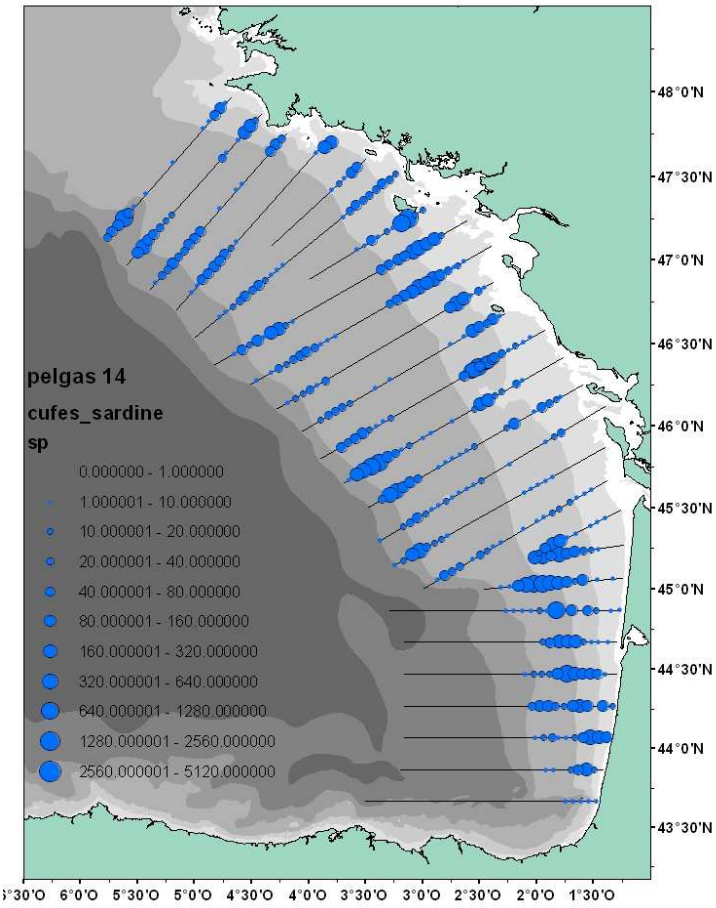


Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS14.

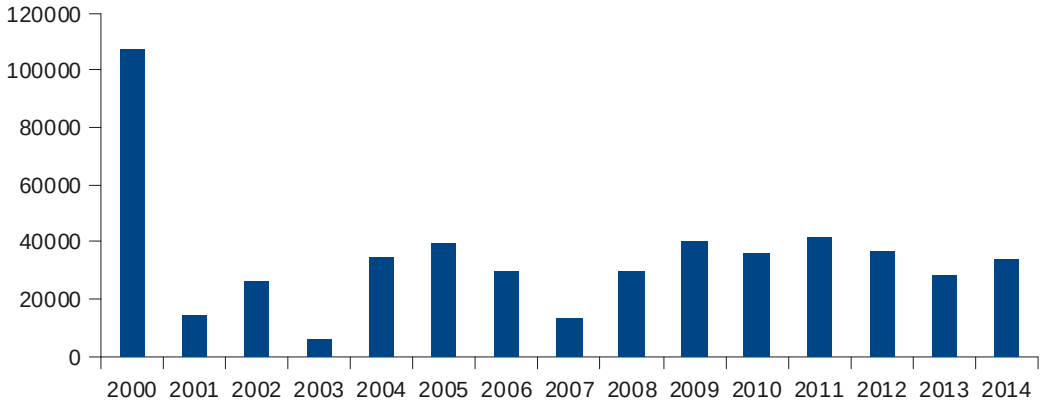


Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2014

The number of eggs collected by CUFES during the PELGAS14 survey was comparable to previous years but still far below the maximum observed in 2000.

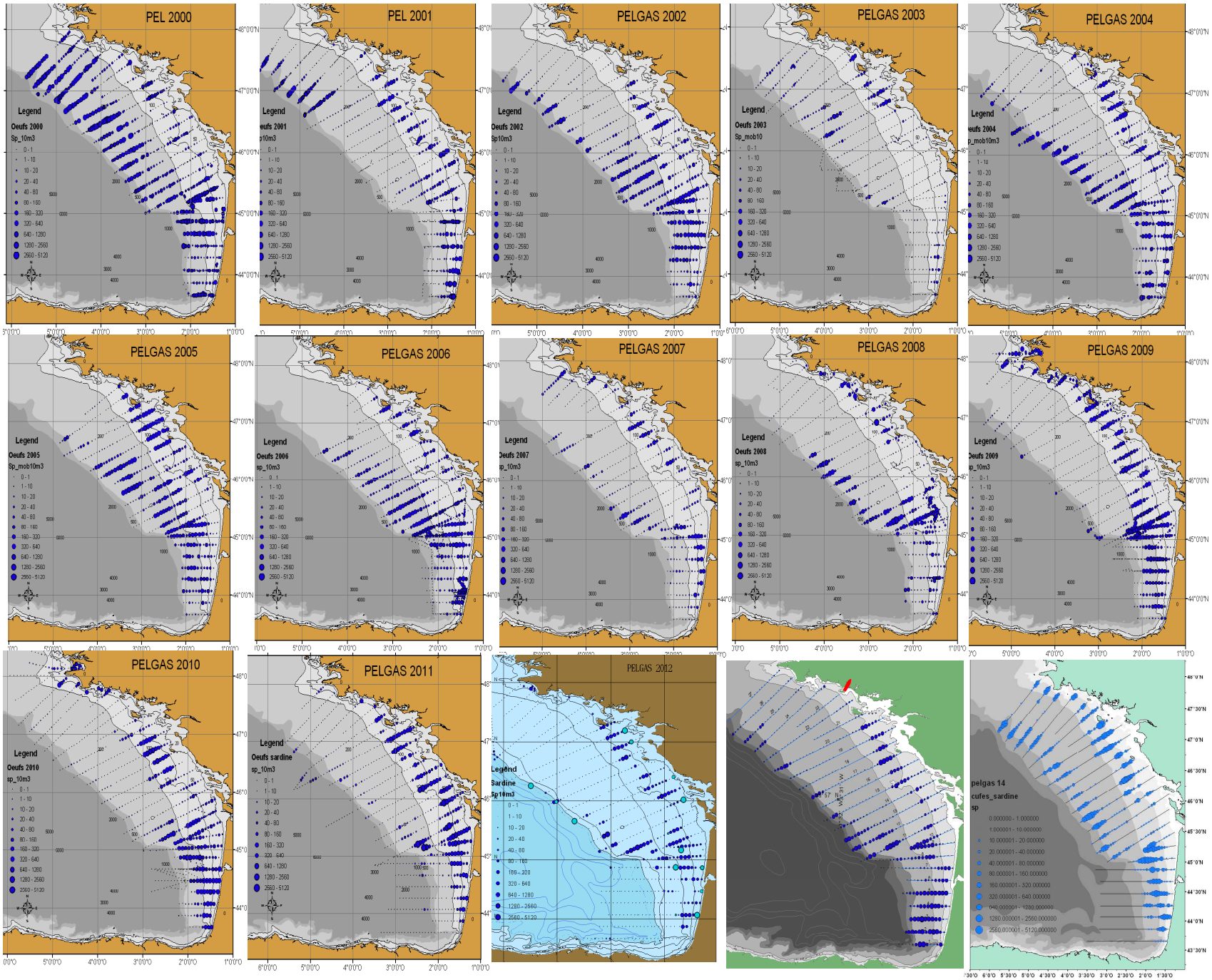


Figure 4.2.3 – distribution of sardine eggs observed with CUFES during PELGAS from 2000 to 2014 (number for $10m^3$).

5. TOP PREDATORS

For the twelth consecutive year, monitoring program to record marine top predator sightings (marine birds and cetaceans) has been carried out , during two first legs of PELGAS survey (from 25th April to 25nd May 2014).

A total of 260 hours of sighting effort were performed for 30 days (Figure 5.1.), with an average of 8.5 hours of sighting effort per day. Weather conditions were generally not favorable with a majority of the effort deployed in limit conditions to detect most things as possible around the vessel.

During the survey, 3 247 sightings of animals or objects were recorded. Seabirds constitute the majority of sightings (68%). Other most frequent sightings concern either litter drifting at sea (13%), fishing ships (5%) and buoys (6%). Cetaceans only account for 2% of sightings.

5.1 – Birds

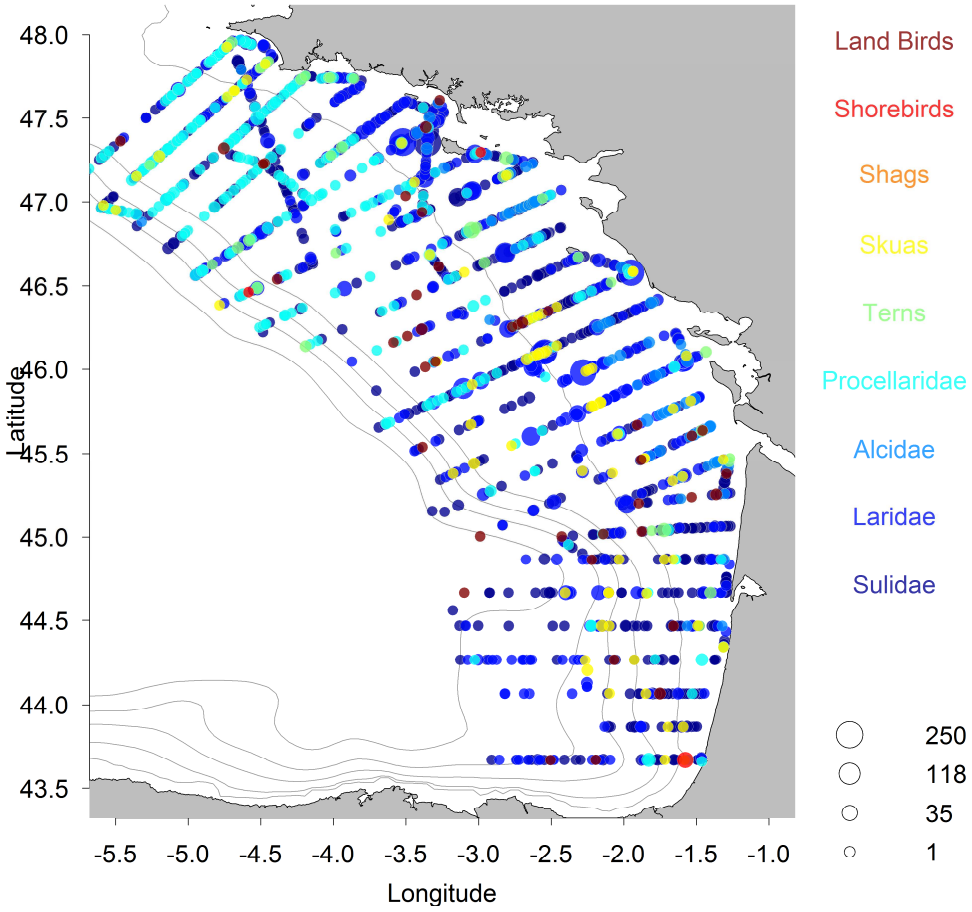


Figure 5.1. Distribution of birds observed during the PELGAS14 survey

Birds constitute the vast majority of sightings. Shorebirds and passerines accounted for less than 2% of bird sightings. 2202 sightings of seabirds were found all over the Bay of Biscay (Figure 5.1.), divided into 21 identified species and a raw estimate of 6060 individuals.

Northern gannets accounted for 47% of all seabird sightings : its distribution is homogeneous across the Bay of Biscay.

The second most sighted species is the Northern Fulmar (Fulmar glacialis), mostly present in the northern part of the Bay of Biscay. Few terns were sighted, even off known breeding colonies (e.g. Arcachon). A large number of skuas were sighted in 2014. Seabirds sightings have substantially decreased compared to 2013. The several winter storms may be to blame for an increased mortality rate of seabirds at sea, which could explain this decrease.

5.2 – Mammals

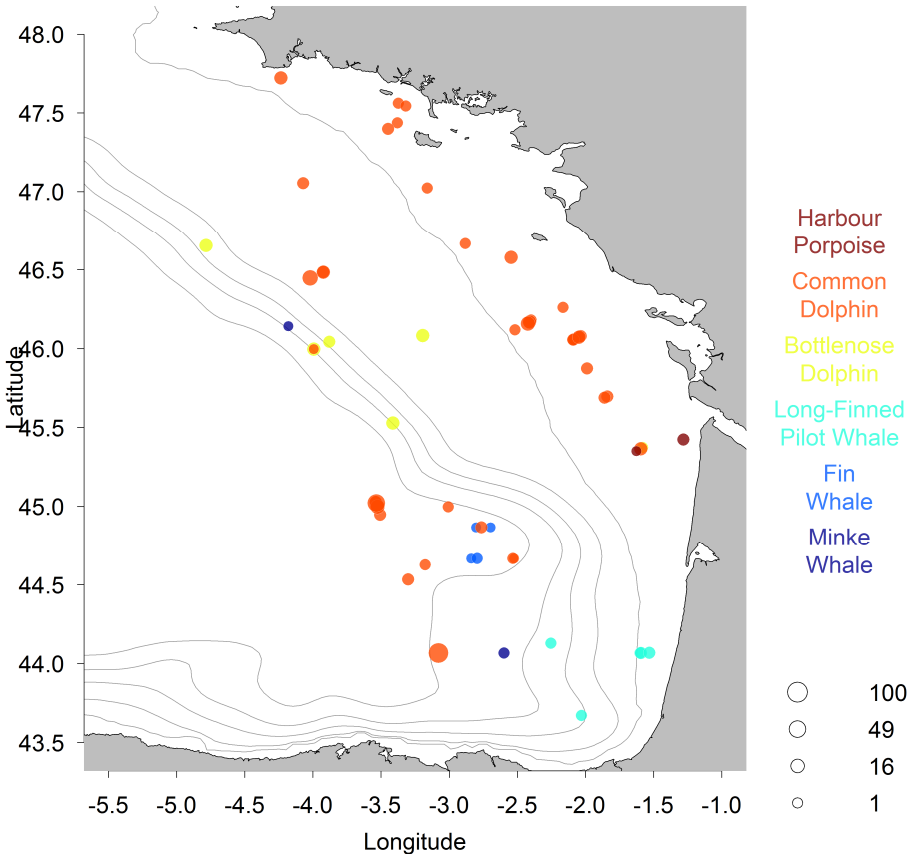


Figure 5.2. Distribution of mammals during the PELGAS14 survey.

A total of 76 sightings were recorded corresponding to a raw estimate of 559 individuals and 6 species of cetaceans clearly identified (Figure 5.2.). The greatest diversity of marine mammals was observed in the Southern part of the Bay of Biscay. The overall distribution pattern is similar to that of previous PELGAS spring surveys.

As usual, common dolphin is the most recorded species. Common dolphins were present on the inshore part of the continental shelf, a typical pattern during springtime. No striped dolphins were sighted in 2014. However, harbour porpoises were sighted twice off the Gironde estuary.

Pilot whales were only sighted in small pods in the southern part of the bay of Biscay. Bottlenose dolphins were sighted mainly on the continental slope. Large baleen whales (fin/minke whales) were sighted in the Cap Ferret canyon, although sometimes they were too far from the boat to permit an unambiguous identification at the species levels.

6. HYDROLOGICAL CONDITIONS

After a very wet and stormy winter (numerous depressions), weather conditions became more stable between mid-march and the beginning of the survey (mid-April), and some very strong planktonic blooms occurred on the platform and even more offshore, kept by the strong mix in the water column and the high cumulated river discharges.

Wintery precipitation drove to desalinate water on the entire column for the whole platform (salinity <34 psu), explaining early planktonic blooms, with high chlorophyll concentrations since march. These early and strong blooms probably led to impressive abundance of gelatinous organisms, particularly salps, covering the whole platform in the northern part of the bay of Biscay during the survey.

Anti-cyclonic conditions between mid-march and mid-April led to a light thermal stratification, but sea surface temperature stayed cold (around 14 °C), closed to the average temperature, principally because of regular wind and fresh atmospheric temperature.

A West gust of wind at the beginning of the survey apparently led to a phenomena of downwelling along the Landes's coast, showed by temperature slightly upper than offshore and an important level of oxygen saturation on the whole water column.

The stratification of the water column was light, and the regular windy events during the survey can explain heterogeneous concentrations of chlorophyll at the surface, in the mixed layer of the column.

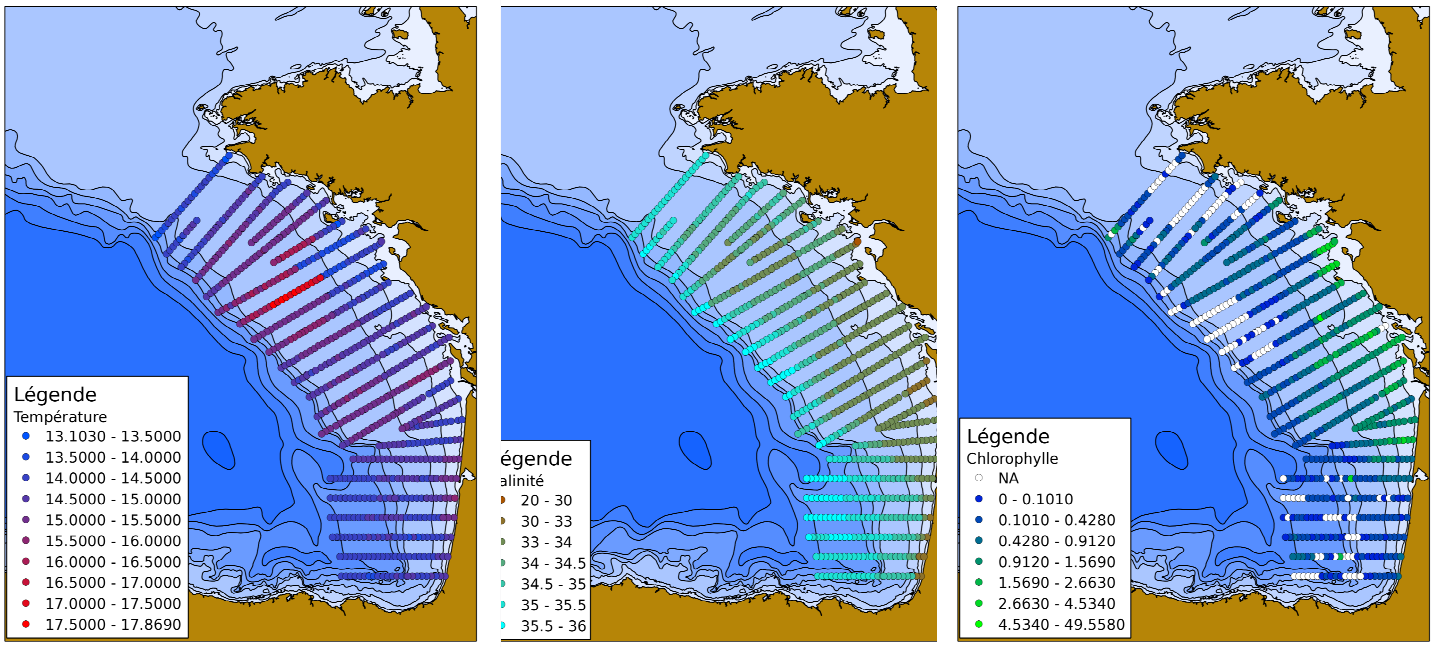


Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS14.

7. CONCLUSION

The Pelgas14 acoustic survey has been carried out with medium weather conditions (regular wind, cold temperatures) for the whole area, from the south of the bay of Biscay to the west of Brittany. The help of commercial vessels (two pairs of pelagic trawlers and a single one) during 18 days provided about 110 valid identification hauls instead of about 50 before 2007 when Thalassa was alone to identify echotraces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS13 were affected by rather bad weather conditions before and during the survey. During the whole survey, water column showed a light stratification, with a surface temperature around the average of the serie (14°C). It must be noticed that wintery precipitation drove to desalinate water on the entire column for the whole platform (salinity <34 psu), explaining early planktonic blooms, with high chlorophyll concentrations since march. These early and strong blooms probably led to impressive abundance of gelatinous organisms, particularly salps, covering the whole platform in the northern part of the bay of Biscay during the survey.

The PELGAS14 survey observed a high abundance of anchovy (125 427 tons), far from the highest level observed on the time series (186 865 tons in 2012) but anyway, one of the three best abundances in the bay of Biscay since 2000. In the South, anchovy was mostly concentrated in the middle of the platform, and the small individuals as usual were mostly present in the Gironde area.

The biomass estimate of sardine observed during PELGAS14 is 339 607 tons, which constitutes a small decrease of the last year level of biomass, but this specie is still at a high level of abundance in the bay of Biscay. The relative high proportion of age 2 (37% in number, but 44 % in mass) confirms the (very) good recruitment observed last year, maybe the best of the whole serie (since 2000). The global age structure of the population and his evolution trough years confirms the validity of age readings and the fact that we can follow sardine cohorts in the sardine population of the bay of Biscay. Geographical distribution looks as usual, with maximum around the Loire river but show a presence all along the coast from the south of the bay until the west point of Brittany, and in lower quantity, along the slope in the Northern area.

Concerning the other species, mackerel was less present this year compared to 2013, while horse mackerel seems to be a bit more abundant, but still showing a low biomass.

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