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Direct assessment of small pelagic fish by the PELGAS17 acoustic survey

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1. MATERIAL AND METHOD

1.1. PELGAS survey on board Thalassa

An acoustic survey (PELGAS) is carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS survey 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.

This survey is 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. This survey 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:

- Continuous acquisition of acoustic data with two different echosounders, 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) and 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.
- 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.

The strategy this year was the identical to previous surveys (2000 to 2016). The survey protocols are described *in Doray M, Badts V, Masse J, Duhamel E, Huret M, Doremus G, Petitgas P (2014).* ***Manual of fisheries survey protocols. PELGAS surveys (PELagiques GAScogne)****.* *http://dx.doi.org/10.13155/30259:*

- 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.

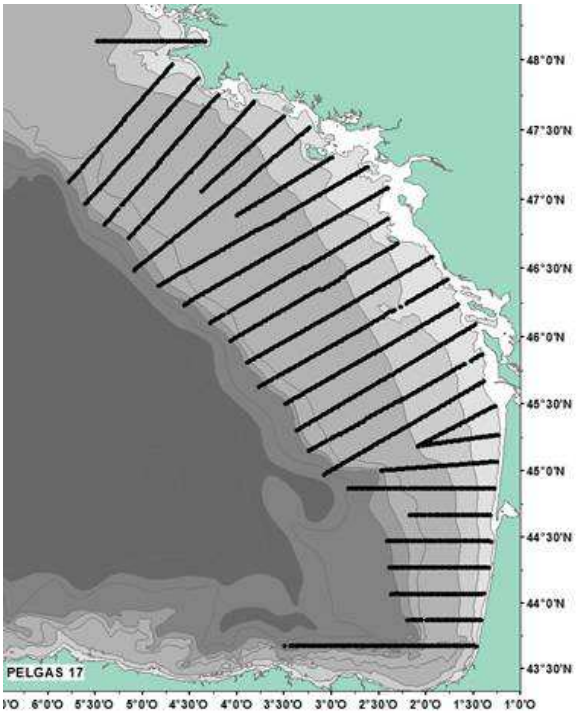


Fig. 1.1.1 - Transects prospected during PELGAS17 by Thalassa.

In 2017, as in previous surveys (since 2009), three modes of acoustic observations were used:

- 1 SIMRAD ME70 multi-beam echo-sounder (21 2 to 7°beams, from 70 to 120 kHz) used essentially for visualisation and observing 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.
- 1 horizontal echo-sounder on the starboard side for surface echo-traces
- this year, the broadband echosounder EK80 was installed and used, instead of the ER60 (single beam, multi frequency)

Energies and samples provided by all sounders were simultaneously visualised and stored using the 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 near Brest, in the West of Brittany, in optimal meteorological conditions at the beginning of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 5171 nautical miles from which 1896 nautical miles on one way transect were used for assessment. A total of 19 461 fishes were measured (including 5 601 anchovies and 4 147 sardines) and 2 990 otoliths were collected for age determination (1 455 of anchovy and 1 535 of sardine).

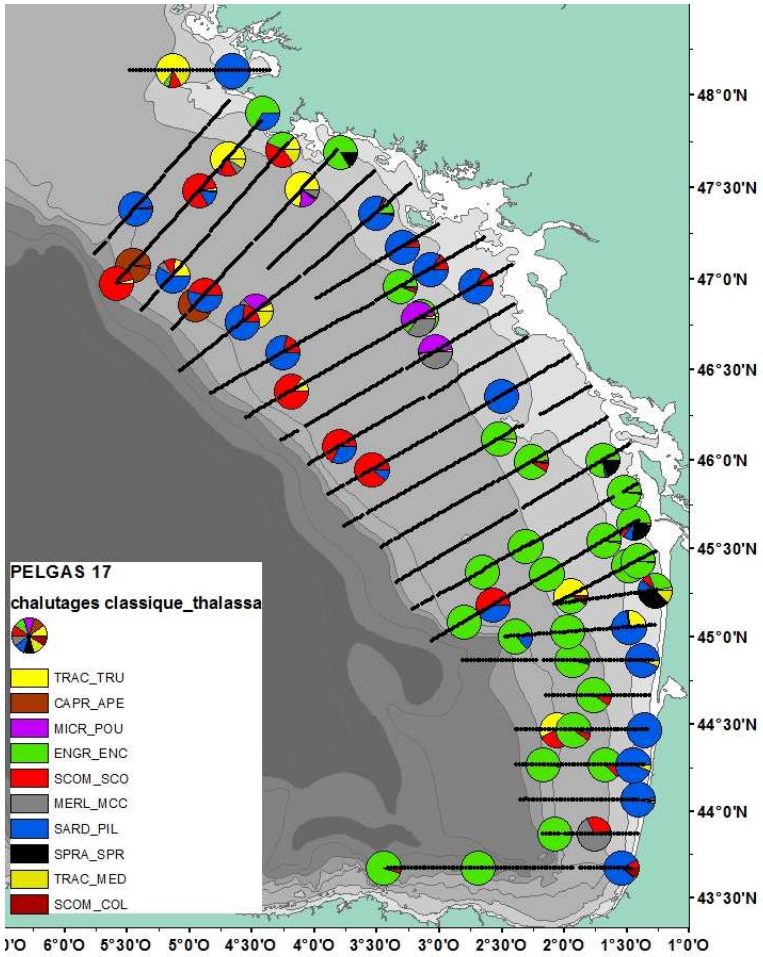


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organised since 2007 with French commercial vessels during 17 days. This approach is in identical to last year's surveys, using the commercial vessel's hauls were for echoes identification and biological parameters to complement hauls made by the R/V Thalassa.

Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS17 survey:

Vessel	Gear	Period	Days at sea
Cintharth / Marilude	Pelagic pair trawl	28/04 to 04/05/2017	7
Les Menhirs / Le Dolmen	Pelagic pair trawl	05/05 to 14/05/2017	9

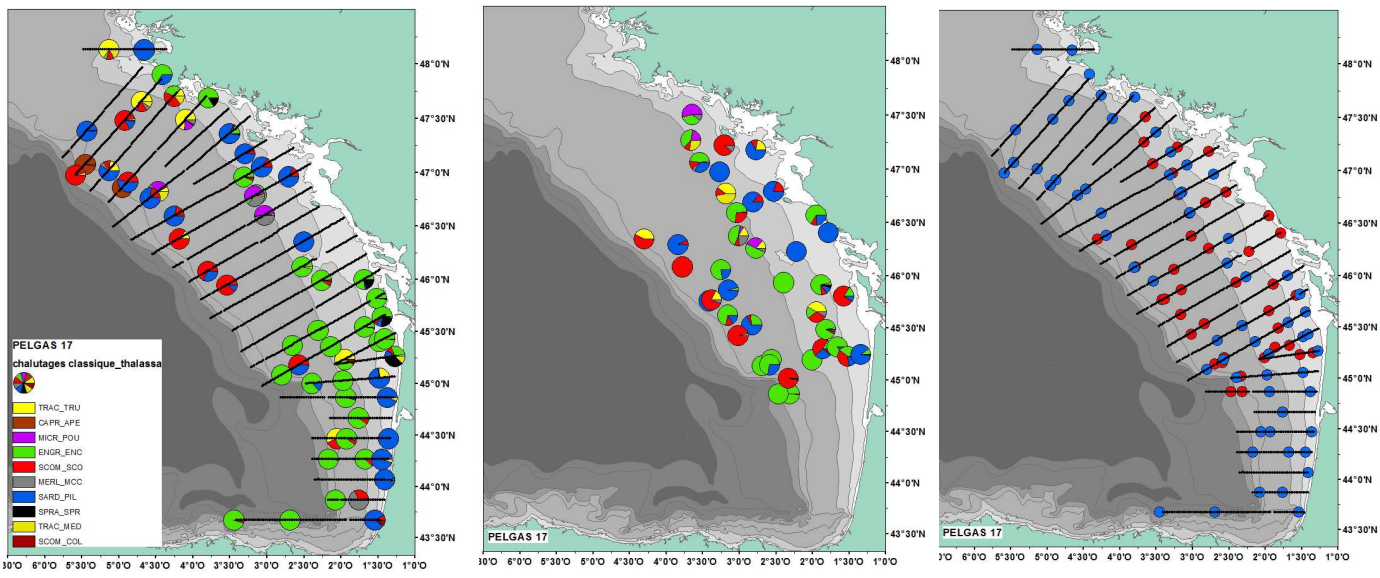
The regular transects network agreed for several years for Thalassa is 12 miles separated in parallel transects. Commercial vessels worked between standard transects and 2 NM northern. Sometimes, they carried out fishing operations on request (complementary to Thalassa,

particularly for surface hauls or in very coastal areas) Their pelagic trawl was up to 25 m vertical opening and the mesh of their codend was similar to the on uses by the R/V Thalassa (12 mm).

A scientific observer was on board the commercial vessel to control every fishing 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, these fishing operation were used 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 the commercial vessels to Thalassa to improve otoliths collection and sexual maturity (220 otoliths of anchovy, 338 of sardine). A total of 5255 fishes were measured onboard commercial vessels, including 1783 anchovies and 1074 sardines.

Catches and biological data were used to complement the sampling made on boar the R/V Thalassa.

A total of 113 hauls (including 7 not valid) were carried out during the consort survey including 65 hauls by the R/V Thalassa and 41 hauls by commercial vessels.



a) Thalassa (nb :65) *b) Commercial vessels (nb : 41)* *c) all fishing hauls (nb :106) Thalassa in Blue and commercial in red*

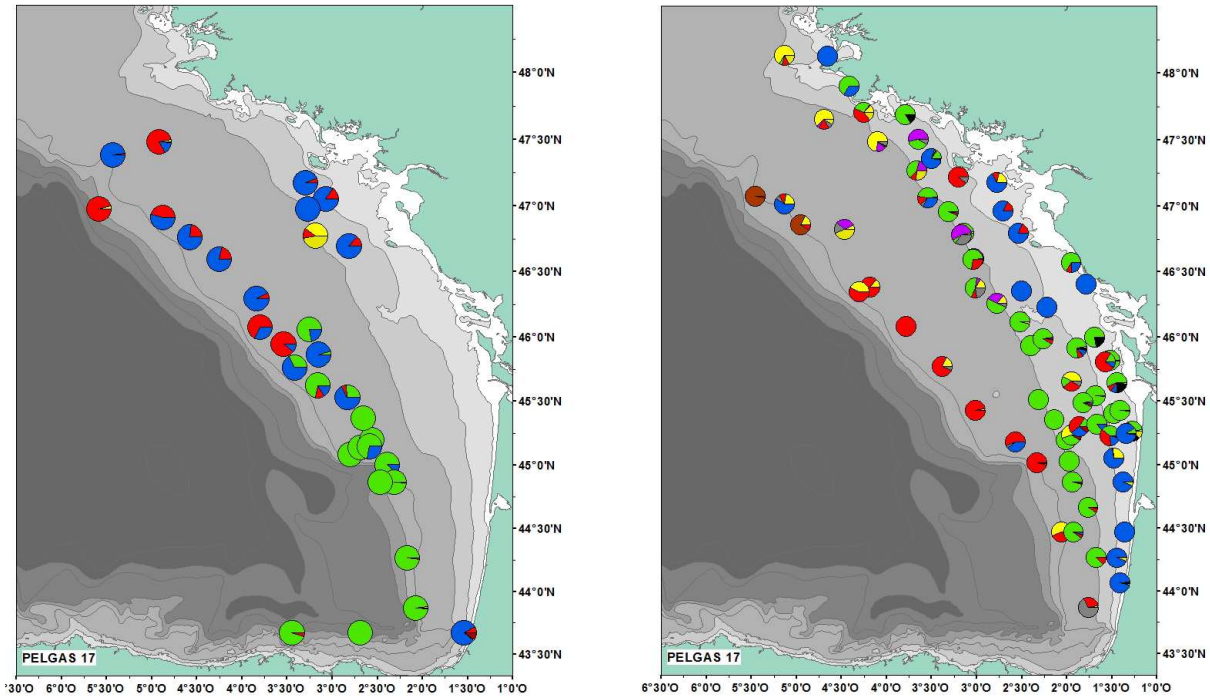
Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS17

The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to 1)explain our methodology to the fishermen and 2) check consistency between scientists and fishermen echo-trace's observation and interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check catches' similarity (in proportion of species and, most of the time, in quantity as well - taking the vertical and horizontal opening into account). As last year, commercial vessels' fishing operations were only carried out at 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.

Table 1.2.3. : Number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS17

	thalassa	commercial	total
classic	**46**	**27**	**73**
surface	**19**	**14**	**33**
null	6	1	7
total	**71**	**42**	**113**



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 and species composition during survey PELGAS17

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, and 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 and sometimes more offshore areas.

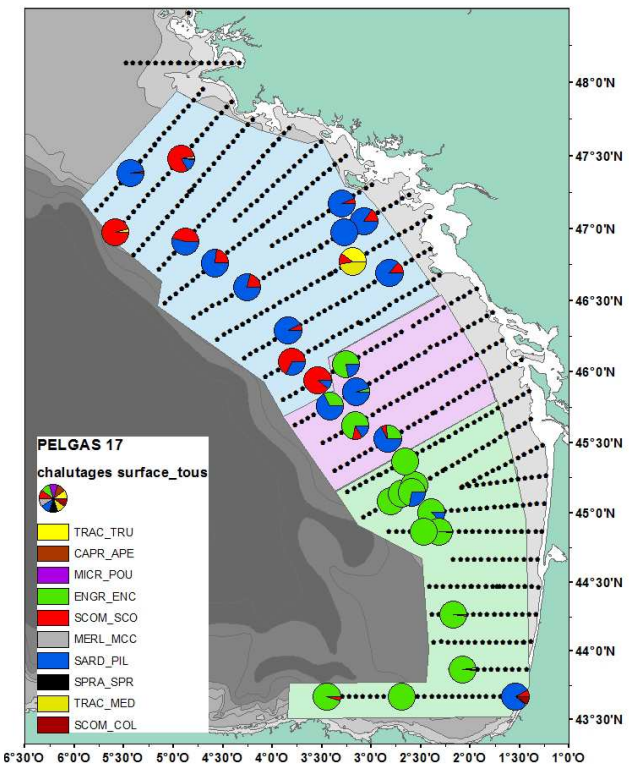
D3 – energies attributed to scattered detection corresponding to blue whiting, myctophids, boarfish, mackerel and horse mackerel.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to echoes very close to the surface. This year, horse mackerel was also allocated in this category

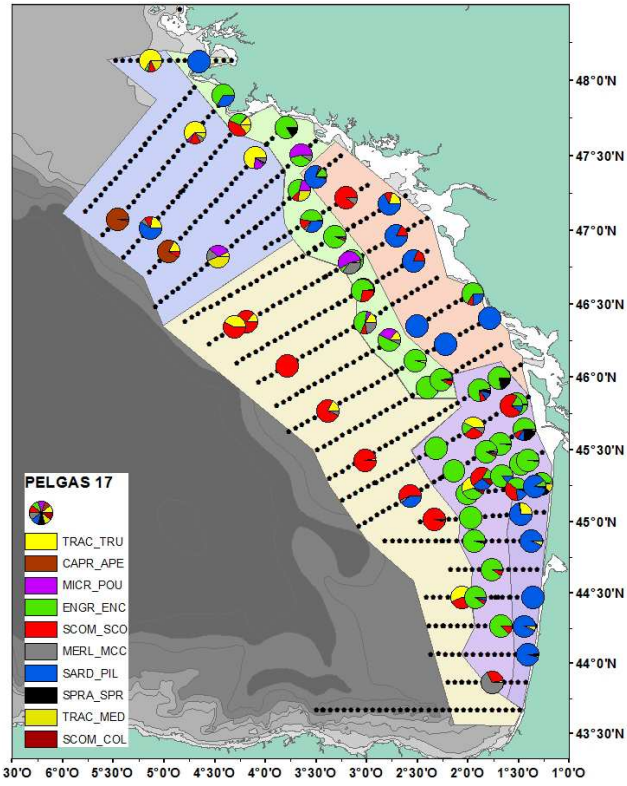
D8 – energies attributed exclusively to sardine (big and very dense schools).

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 different species assemblages. Figure 2.2 shows the strata considered to evaluate biomass of each species. For each stratum, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.



Coherent surface strata



Coherent classic strata

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 PELGAS17 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to benefit of each vessel's efficiency and maximise the number of samples (in term of identification and biological parameters). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fished preferably in the bottom layer. According to previous strata (Figure 2.2), using both Thalassa and consort fishing operations, biomass estimates were calculated for each main pelagic species in the surveyed area.

Biomass indices are presented in tables 2.3.1 and 2.3.2 and in figure 2.3.1. No estimate is 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 more abundant than last year and their abundance was estimated this year at a high level compared to the historical time series (around 135 000 tonnes). Strong densities were observed in the Gironde area. It must be noticed that we observed anchovy on the first transect along the Spanish coast in also high densities, exclusively close to the surface.

Sardine was also more present this year compared to 2016, mainly in coastal waters from the South until the Brittany, and it was also present in variable densities in surface along the shelfbreak.

About other species, another characteristic of this year was that horse mackerel showed a decline of the biomass again, after 3 years of increasing. The biomass reached again a low level compared to the abundance calculated in te first years of the serie.

Mackerel appeared well abundant this year, particularly offshore, close to the bottom, and sometimes near the surface.

Table 2.3.1. Acoustic biomass index for the main species by strata during PELGAS17

	Classic	surface	total
boarfish	11 247		11 247
anchovy	**110 887**	**23 613**	**134 500**
hake	22 494		22 494
blue whiting	36 961	4 507	41 468
sardine	**431 332**	**33 689**	**465 022**
chub mackerel	44 929	3 118	48 047
mackerel	1 208 675	167 186	1 375 861
sprat	15 778		15 778
horse Mackerel	46 628	15 272	61 899

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

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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**	**372 916**	**89 727**	**134 500**
	14 479	29 836	24 988	8 087	15 352	5 008	8 399	8 175	12 174	7 808	25 388	22 078	17 433	24 067	15 786	54 857	23 329	41 517
CV anchovy	*0,064*	*0,141*	*0,113*	*0,132*	*0,167*	*0,171*	*0,136*	*0,100*	*0,162*	*0,112*	*0,147*	*0,0774*	*0,04665*	*0,1282*	*0,062928*	*0,0735509*	*0,13*	*0,15433929*
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**	**416 524**	**229 742**	**465 022**
	62 489	89 743	99 243	53 615	120 122	117 528	54 786	40 143	128 082	94 018	83 189	47 323	31 537	60 200	44 293	85 234	36 759	56 410
CV sardine	*0,083*	*0,117*	*0,088*	*0,241*	*0,121*	*0,135*	*0,117*	*0,159*	*0,139*	*0,098*	*0,091*	*0,0699*	*0,07668*	*0,0738*	*0,065212*	*0,1023153*	*0,08*	*0,06065334*
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**	**91 248**	**36 593**	**15 778**
	5 881	42 752	18 675	9 502	5 627	33 144	9 723	4 570	26 849	24 299	14 482	0	0	17 791	16 337	35 649	32 202	16 631
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*	*0*	*0,1992*	*0,241009*	*0,1953397*	*0,44*	*0,52701049*
Horse mackere	**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**	**77 142**	**119 230**	**61 919**
	36 424	60 814	59 672	54 397	106 791	58 063	98 782	5 863	91 370	10 187	4 385	0	0	20 127	24 141	23 911	71 538	35 705
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*	*0*	*0,3007*	*0,227089*	*0,1549802*	*0,3*	*0,28831771*
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**	**8 684**	**11 852**	**23 944**
	-	-	27 420	512	4 956	30 953	742	1 042	292	1 898	7 125	0	0	7 931	16 891	3 881	3 556	7 042
CV BW	-	-	*0,386*	*0,131*	*0,202*	*0,593*	*0,210*	*0,147*	*0,253*	*0,219*	*0,074*	*0*	*0*	*0,1542*	*0,337606*	*0,2234791*	*0,15*	*0,14706269*

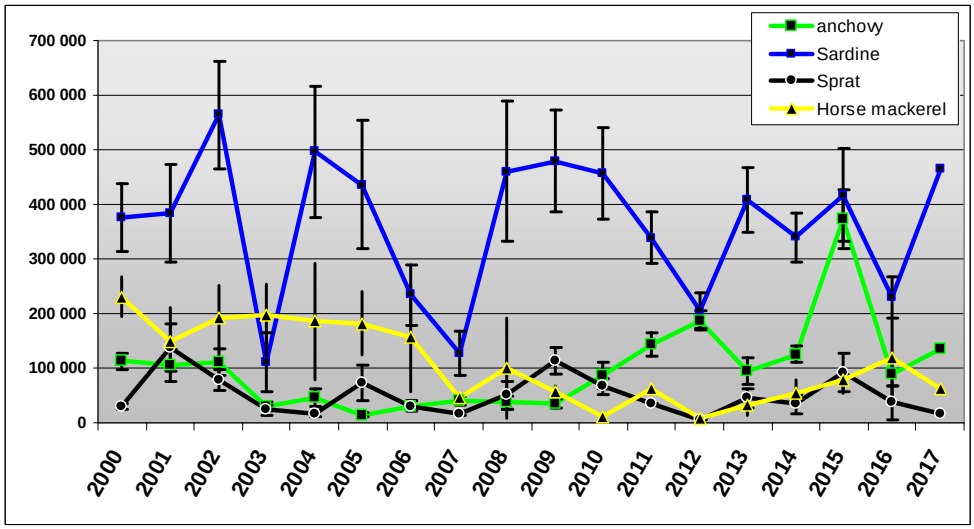


figure 2.3.3. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + commercial vessels) and associated coefficients of variation.

3. ANCHOVY DATA

3.1. anchovy biomass

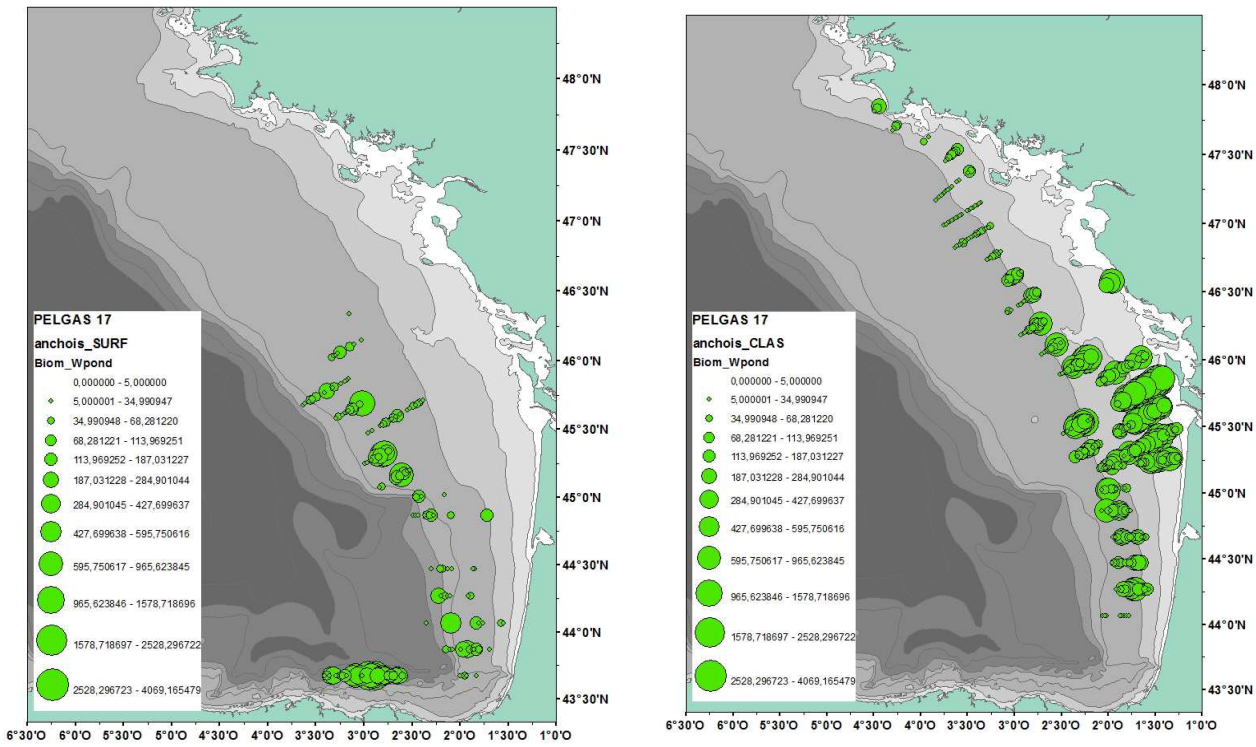
The biomass estimate of anchovy observed during PELGAS2016 is **134 500** tons. (table 2.3.2.), which seems to be a relatively high biomass compared to previous year's, comparable to 2014.

In the Gironde area, the configuration was usual in terms of energy compared to what was observed last years, with a high energy attributed to anchovy.

The one year old anchovies were mostly present front of the Gironde (in terms of energy and, as well, biomass) but they were still well present on the platform, till Brittany along the bathymetric line of 100m. The average size of one year old fish was comparable the average size in recent years (two years really differed from the average: 2012 and particularly 2015 where fishes were much smaller) but shows a clear decreasing trend, year after year.

One years old anchovies were also present, in lower quantities, mixed with older fish, even offshore.

Figure 3.1 shows the vertical distribution of anchovy.



Surface distribution

Near-seabed distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS17 survey.

3.2. Anchovy length structure and maturity

Length distribution in the trawl hauls were estimated from random samples. The population length distributions (figures 3.2) were 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.

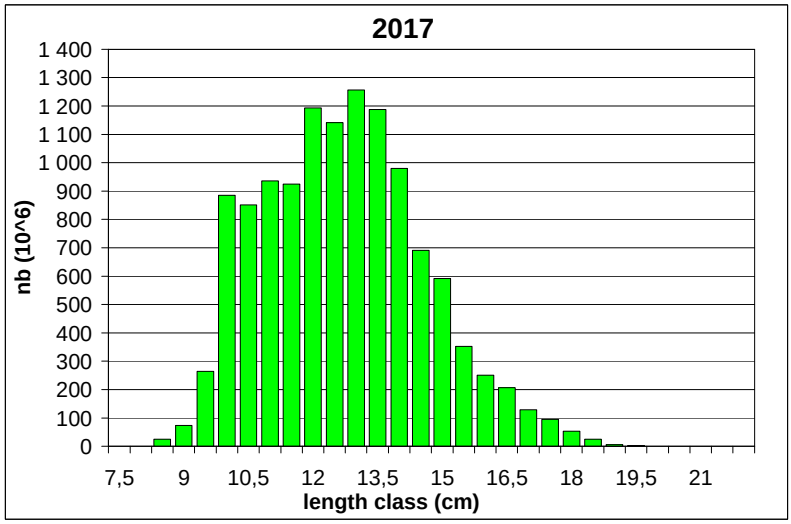


Figure 3.2: length distribution of global anchovy as observed during PELGAS17 survey

Globally we observe that length structure shows an unimodal distribution, with a mode around 13 centimetres (constituted by age 1 and Age 2 fishes). It must be noticed that even if

some individuals were small (less than 10centimeters), almost all fishes were mature and in their spawning period. This observation on maturity contrasted with the 2015 observation where a large proportion of the population was not spawning at the period of the survey.

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 given number of fishes per length class (4 to 6 / half-cm), for a total amount of around 50 fishes per haul. As there was a lot of fishing operations where anchovy was present (as previous surveys), the number of otoliths taken during the survey was still important (1455 otoliths of anchovy taken and 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.

Table 3.3.1. PELGAS2017 anchovy Age/Length key.

Nombre de Age	Age				
Taille	1	2	3	4	Total
7,5	100,00%	0,00%	0,00%	0,00%	100,00%
8	100,00%	0,00%	0,00%	0,00%	100,00%
8,5	100,00%	0,00%	0,00%	0,00%	100,00%
9	100,00%	0,00%	0,00%	0,00%	100,00%
9,5	96,97%	3,03%	0,00%	0,00%	100,00%
10	100,00%	0,00%	0,00%	0,00%	100,00%
10,5	96,00%	2,00%	2,00%	0,00%	100,00%
11	97,22%	2,78%	0,00%	0,00%	100,00%
11,5	94,25%	5,75%	0,00%	0,00%	100,00%
12	91,53%	7,63%	0,85%	0,00%	100,00%
12,5	87,30%	11,90%	0,79%	0,00%	100,00%
13	82,68%	15,75%	1,57%	0,00%	100,00%
13,5	77,10%	20,61%	2,29%	0,00%	100,00%
14	59,83%	30,77%	9,40%	0,00%	100,00%
14,5	44,23%	41,35%	14,42%	0,00%	100,00%
15	16,84%	64,21%	18,95%	0,00%	100,00%
15,5	19,10%	52,81%	26,97%	1,12%	100,00%
16	6,33%	53,16%	40,51%	0,00%	100,00%
16,5	6,78%	50,85%	42,37%	0,00%	100,00%
17	5,00%	40,00%	52,50%	2,50%	100,00%
17,5	5,56%	50,00%	38,89%	5,56%	100,00%
18	0,00%	55,56%	33,33%	11,11%	100,00%
Total	62,55%	25,73%	11,44%	0,28%	100,00%

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 2017 are shown in figure 3.3.3.

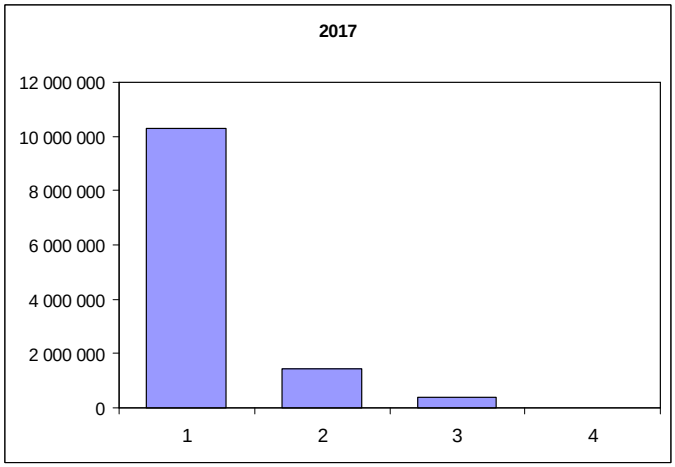


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS17.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seems to be equivalent to 2011 or 2012, far away from the very best recruitment observed in 2015.

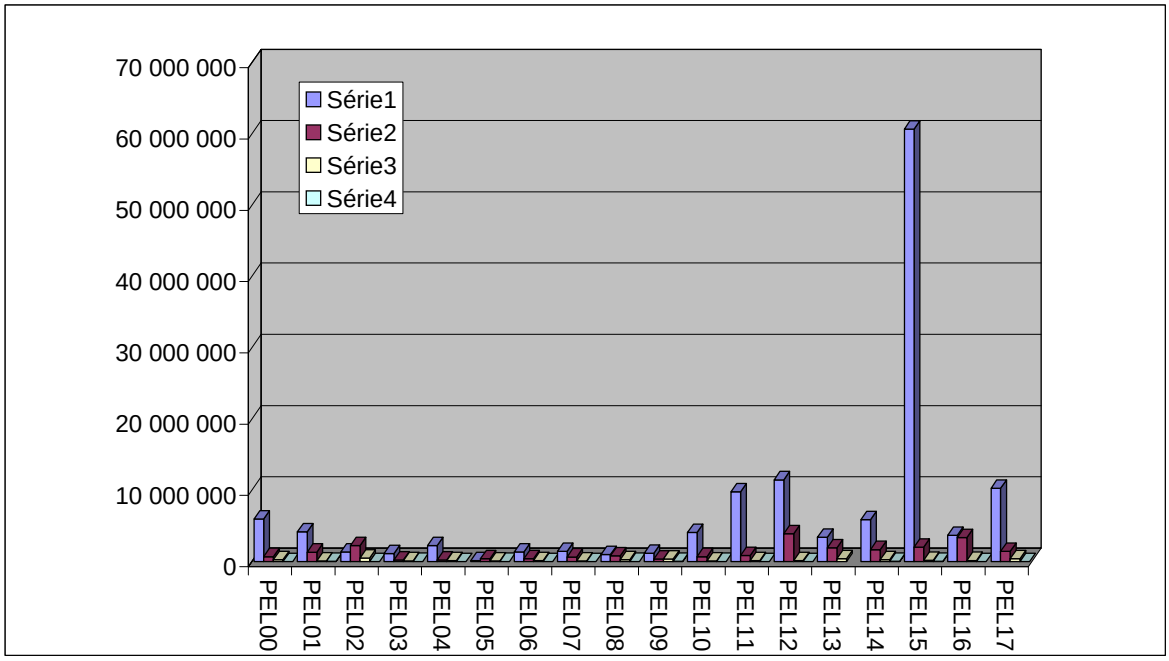


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

The huge 2015 age class last year is not fully followed in 2016 in a high abundance of age 2 this year, and this year as well as age 3. Once again, it could indicate that an overestimation occurred on the recruitment in 2015. Several investigation have been done to explain, without results for the time being.

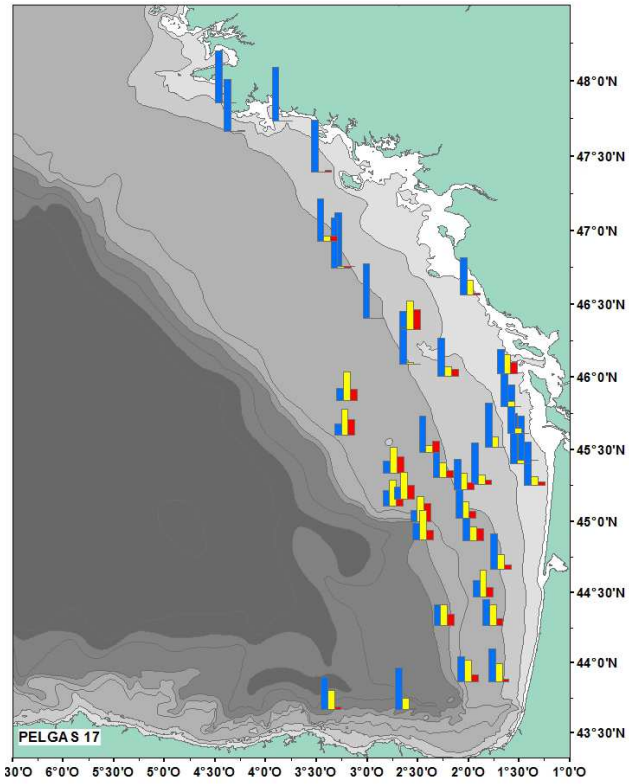


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS17 survey (blue = age 1, yellow = age 2).

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 in 2014, as age 1 were present all over the area where anchovy was present. This one year old anchovy is almost pure front of the Gironde and in the South of Brittany, and mixed with older individuals offshore and closed to the surface.

	PEL17 - N - %
1	84,8%
2	11,8%
3	3,4%
4	0,05%

	PEL17 - W - %
1	62,24%
2	28,13%
3	9,46%
4	0,17%

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS17 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1781 weights of individual fishes, the following weight/length key was established (figure 4.5.):

$W = 0.0029L^{3.314}$ with R2 = 0.9757 *(with W in grams and L in cm)*

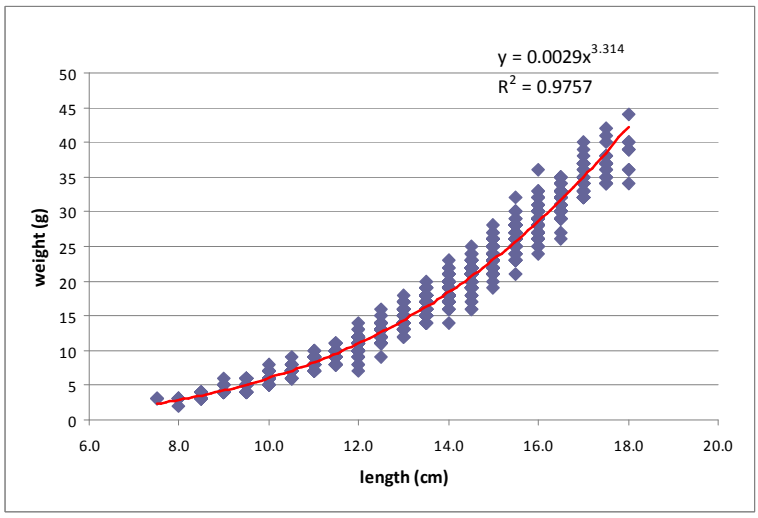


Fig. 3.4 – Weight/length key of anchovy established during PELGAS17

3.5. Mean Weight at age

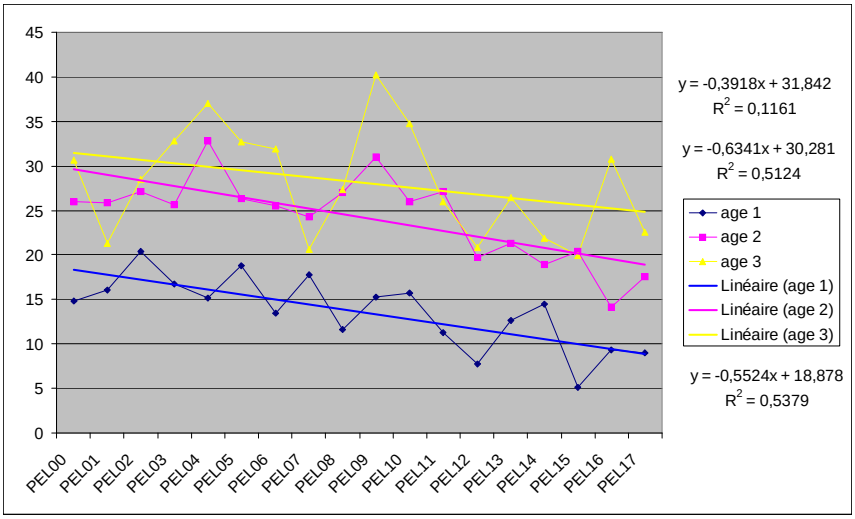


Fig. 3.5. – evolution of mean weight at age (g) of anchovy along pelgas series

As previous years, we observe that globally the trend of the mean weight at age is a decrease. This trend is almost the same for sardine in the bay of Biscay. Further investigates should be done and, if we have some hypothesis (maybe an effect of density-dependance), we do not have real explanation for the time being.

3.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 783 CUFES samples were collected and counted, 65 vertical plankton hauls and 111 vertical profiles with CTD were carried out. Eggs were sorted and counted automatically with the zoocam system, and staged during the survey.

2017, as from 2011, was marked by a large quantity of collected and counted anchovy eggs (Fig 3.6.2).Their spatial pattern of distribution was quite usual, with major part of the abundance South of 46°N. However, eggs are also abundant on 3 more transects than usual North of the Gironde estuary, with a connection all over the shelf between the classical inshore and slope distributions. This may be related to the large extension of the Gironde plume to the North-West, as well as the large adult abundance spreading larger than usual. South of the Gironde eggs are almost everywhere. Small amount of eggs are again found in front of the Loire mouth and along the southern coast of Brittany.

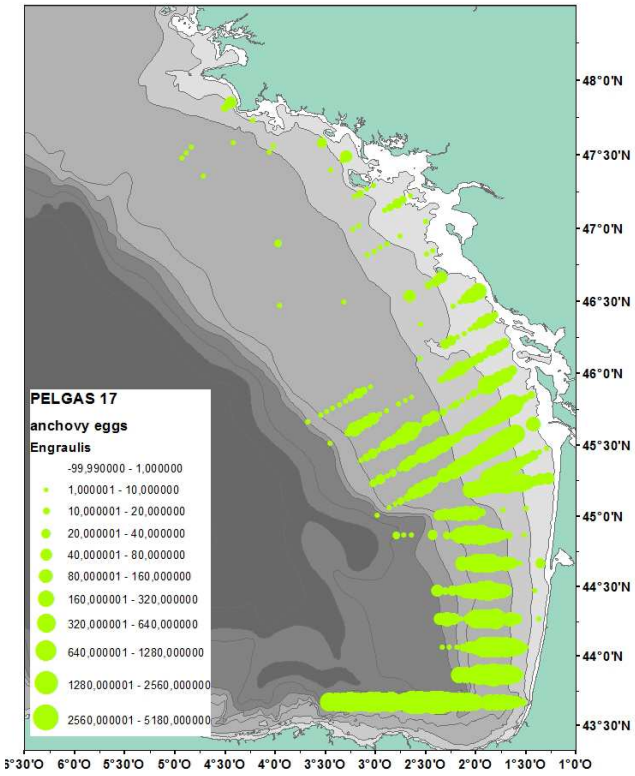


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS17.

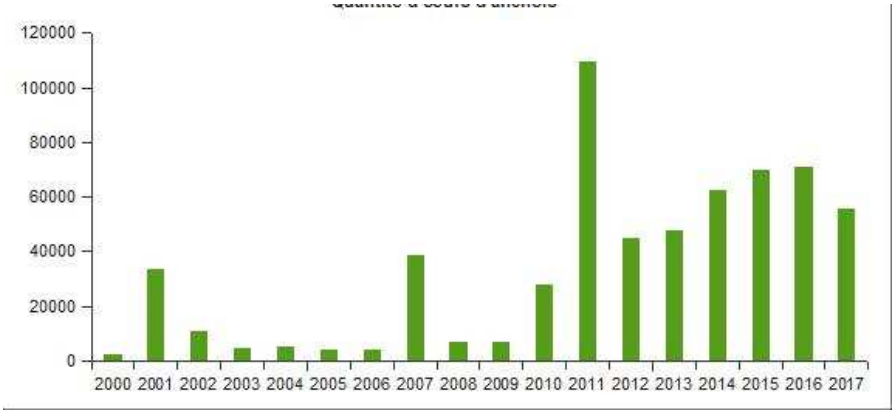


Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2017

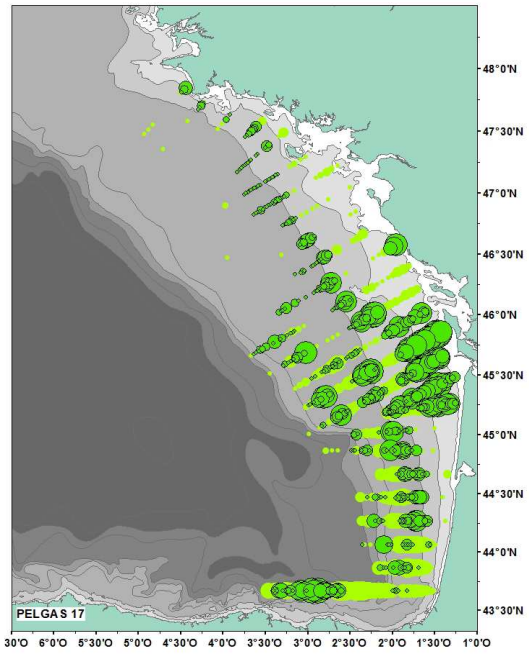


Figure 3.6.3 – Coherence between spatial distribution of adults and eggs. circled point = biomass of adults per ESDU, without circle and light green = eggs

We can see that globally the spatial distribution of eggs match with the adult's one. But on the first transect, at the East, a lot of eggs were counted despite a low abundance of adults. it could be due to the presence of fish completely closed to the surface, in the blind layer of echosounders, or due to some movements of fish to North or West.

4. SARDINE DATA

4.1. Adults

The biomass estimate of sardine observed during PELGAS15 is **465 022** tons (table 2.3.), which constitutes an increase from last year, the biomass reaching a high level of the PELGAS series. It must be enhance that this survey doesn't cover the total area of potential presence of sardine, and 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. Sardine was well present this year, pure along the Lande's coast where an upwelling occurred, rarely mixed with other species along the coast. Sardine appeared also present offshore, close to the surface, along the shelfbreak, contrary to previous year.

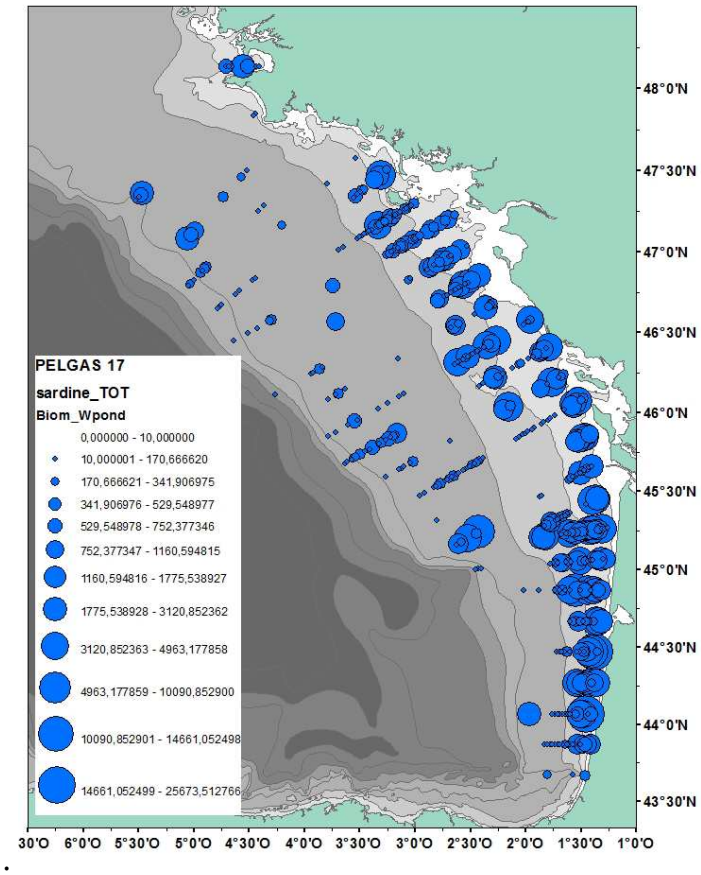


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS17

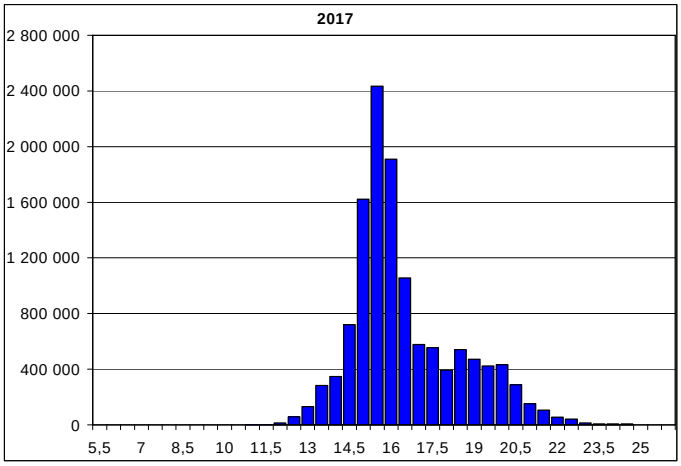


Figure 4.1.2. – length distribution of sardine as observed during PELGAS17

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 the acoustic biomass estimated in the post-stratification regions comprising each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

This year, sardine shows an unimodal length distribution. This mode, about 15cm, corresponds to age 1 and it suggests that a (very) good recruitment occured.

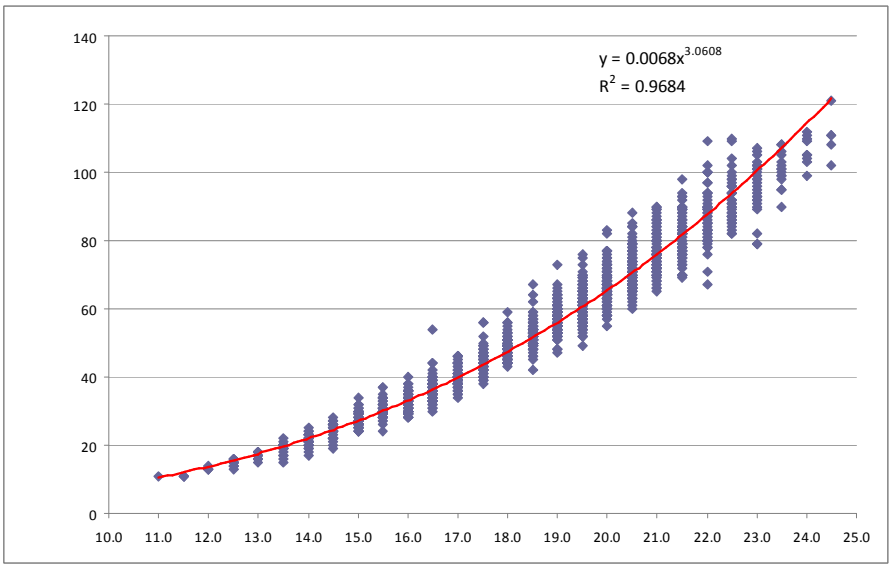


Figure 4.1.3 – Weight/length key of sardine established during PELGAS17

Nombre de age	age										
length	1	2	3	4	5	6	7	8	9	10	Total
11	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13.5	94.74%	5.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16	94.52%	4.11%	1.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16.5	80.56%	18.06%	1.39%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17	56.45%	25.81%	17.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17.5	11.29%	58.06%	29.03%	1.61%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18	4.76%	32.14%	59.52%	3.57%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18.5	0.00%	23.64%	67.27%	8.18%	0.91%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19	0.00%	9.30%	68.22%	16.28%	5.43%	0.78%	0.00%	0.00%	0.00%	0.00%	100.00%
19.5	0.00%	5.84%	50.36%	33.58%	10.22%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20	0.00%	3.01%	32.33%	44.36%	20.30%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20.5	0.00%	2.59%	27.59%	43.10%	25.00%	0.86%	0.00%	0.00%	0.86%	0.00%	100.00%
21	0.00%	1.08%	16.13%	44.09%	33.33%	3.23%	1.08%	1.08%	0.00%	0.00%	100.00%
21.5	0.00%	1.39%	4.17%	31.94%	47.22%	12.50%	2.78%	0.00%	0.00%	0.00%	100.00%
22	0.00%	0.00%	0.00%	17.02%	53.19%	25.53%	2.13%	2.13%	0.00%	0.00%	100.00%
22.5	0.00%	0.00%	0.00%	20.51%	48.72%	15.38%	5.13%	2.56%	7.69%	0.00%	100.00%
23	0.00%	0.00%	0.00%	3.70%	44.44%	18.52%	18.52%	7.41%	3.70%	3.70%	100.00%
23.5	0.00%	0.00%	0.00%	0.00%	13.33%	40.00%	33.33%	13.33%	0.00%	0.00%	100.00%
24	0.00%	0.00%	0.00%	0.00%	0.00%	11.11%	33.33%	11.11%	33.33%	11.11%	100.00%
24.5	0.00%	0.00%	0.00%	25.00%	0.00%	25.00%	0.00%	25.00%	25.00%	0.00%	100.00%
Total	26.55%	9.97%	26.75%	17.90%	13.28%	2.97%	1.25%	0.59%	0.59%	0.13%	100.00%

Table 4.1.4 : sardine age/length key from PELGAS17 samples (based on 1535 otoliths from Thalassa and commercial vessels)

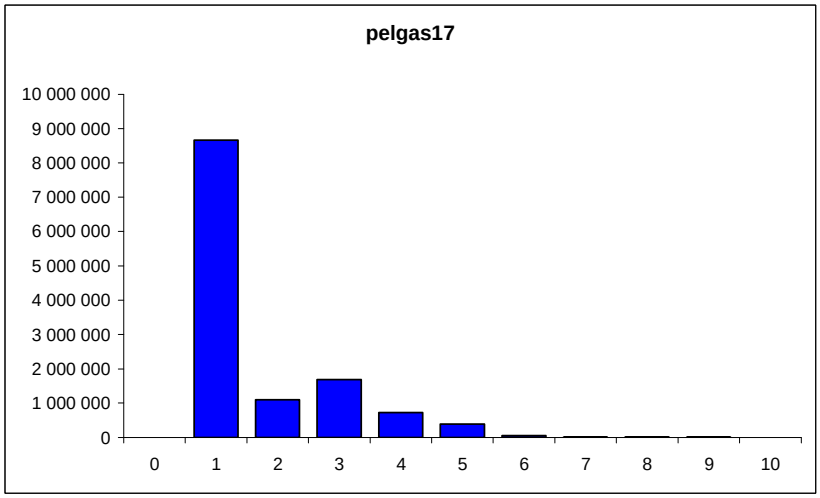


Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 17

	PEL 17 - N - %
1	68,41%
2	8,71%
3	13,33%
4	5,73%
5	3,11%
6	0,42%
7	0,12%
8	0,07%
9	0,08%
10	0,01%

	PEL17 - W - %
1	43,57%
2	11,63%
3	21,92%
4	12,86%
5	7,82%
6	1,28%
7	0,39%
8	0,23%
9	0,28%
10	0,04%

Figure 4.1.6 percentage by age of the sardine population observed during PELGAS17 in numbers (left) and biomass (right).

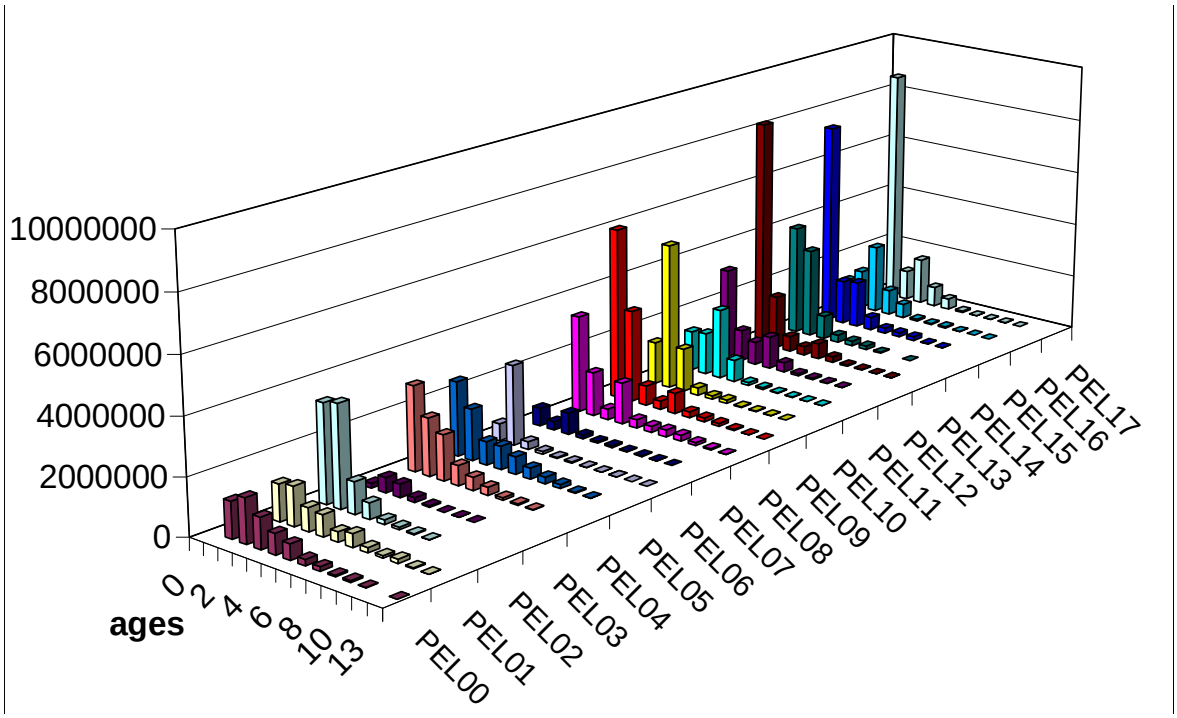


Figure 4.1.7- Age composition of sardine as estimated by acoustics since 2000

PELGAS serie of sardine abundances at age (2000-2017) is shown in Figure 4.1.7. Cohorts can be visually tracked on the graph particularly in the past : the respectively very low and very high 2005 and 2008 cohorts denote atypical years in terms of environmental conditions, and therefore fish (and particularly sardine) distributions. this is less true in recent years, with the good recruitment in 2013 which doesn't profit to incoming years.

The 2017 recruitment at age 1 seems to be high, maybe the best one for the whole serie, comparable to the 2013 one. It must be noticed that some sardine juveniles (age 0) were detected last year (*see WGHANSA report 2016*), which eventually could be linked with the very good recruitment at age 1 this year.

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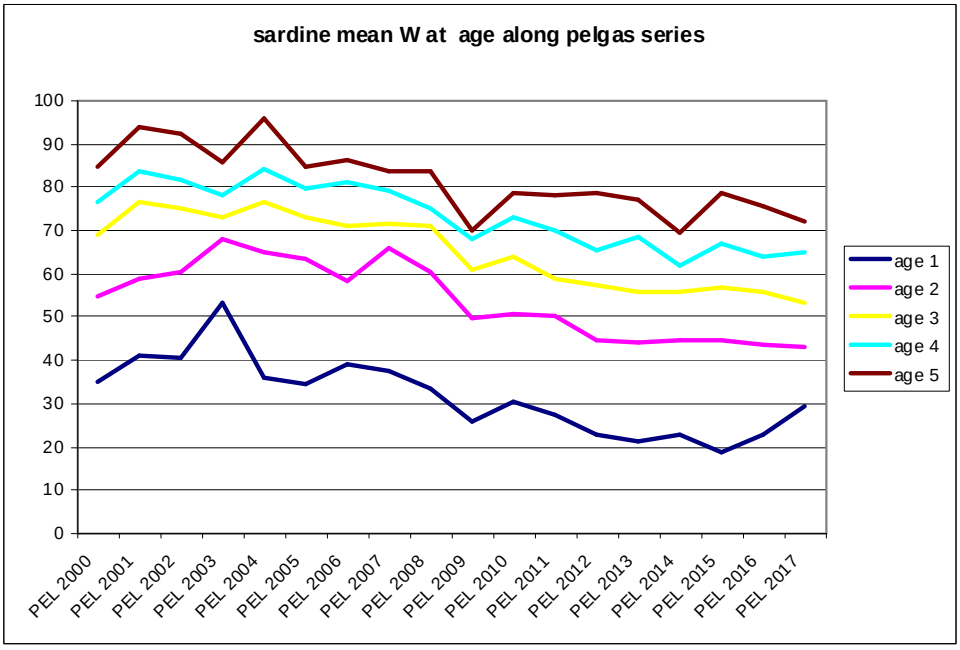

Figure 4.1.8- evolution of mean weight at age (g) of sardine along pelgas series

The PELGAS sardine mean weights at age series (Figure 4.1.8) shows a clear decreasing trend, whose biological determinant is still poorly understood. It must be noticed that mean weight at age 1 seems to increase again for the second consecutive year. Further work must be conducted to explore the causes of the fluctuation of mean weights at ages.

4.2. Eggs

The spatial pattern of sardine eggs overlaps with the one of anchovy, with a further north distribution along the coast, and also along the shelfbreak.

For sardine, egg abundances are at a mean level with regards to the whole Pelgas time-series.

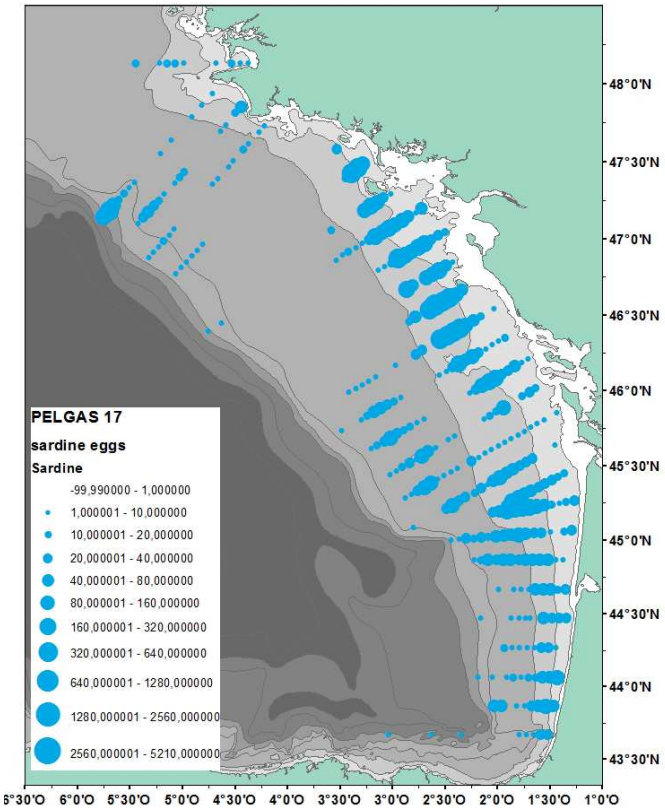

Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS17.

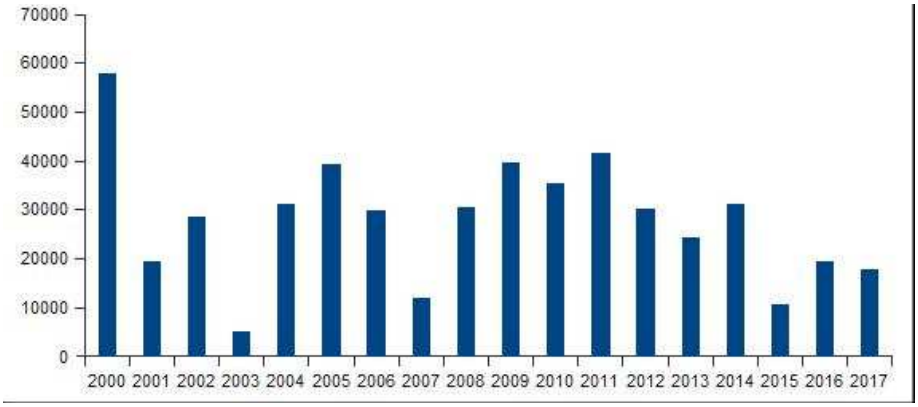

Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2017

2017 was marked by a medium abundance of sardine eggs as compared to the PELGAS time-series. It must be noticed that this year almost all sardines were mature and in spawning period, except in the South along the coast where 1 year old sardine was well present in a zone where an upwelling occured. This fish was just starting his maturation.

5. TOP PREDATORS

For the fourteenth consecutive year, monitoring program to record marine top predator sightings (marine birds and cetaceans) has been carried out , during the whole coverage of the transects network (from the 22nd of April to the 24th of may 2017).

A total of 272 hours of sighting effort were performed for 32 days (Figure 5.1.), with an average of 8.5 hours of sighting effort per day. Weather conditions were generally medium : 60% of the time with good conditions, 40 % of medium or bad conditions.

During the survey, 4243 sightings of animals or objects were recorded. Seabirds constitute the majority of sightings (83%). Most of the surveys, other most frequent sightings concern either litter drifting at sea, but they were strangely less detected this year, with only 4.2 % of the sightings (mabye because of the regular wind). Other sightings are constituted by fishing ships (6.5%) and buoys (3.55%). Cetaceans only account for less than 2% of sightings.

5.1 – Sighting effort and conditions

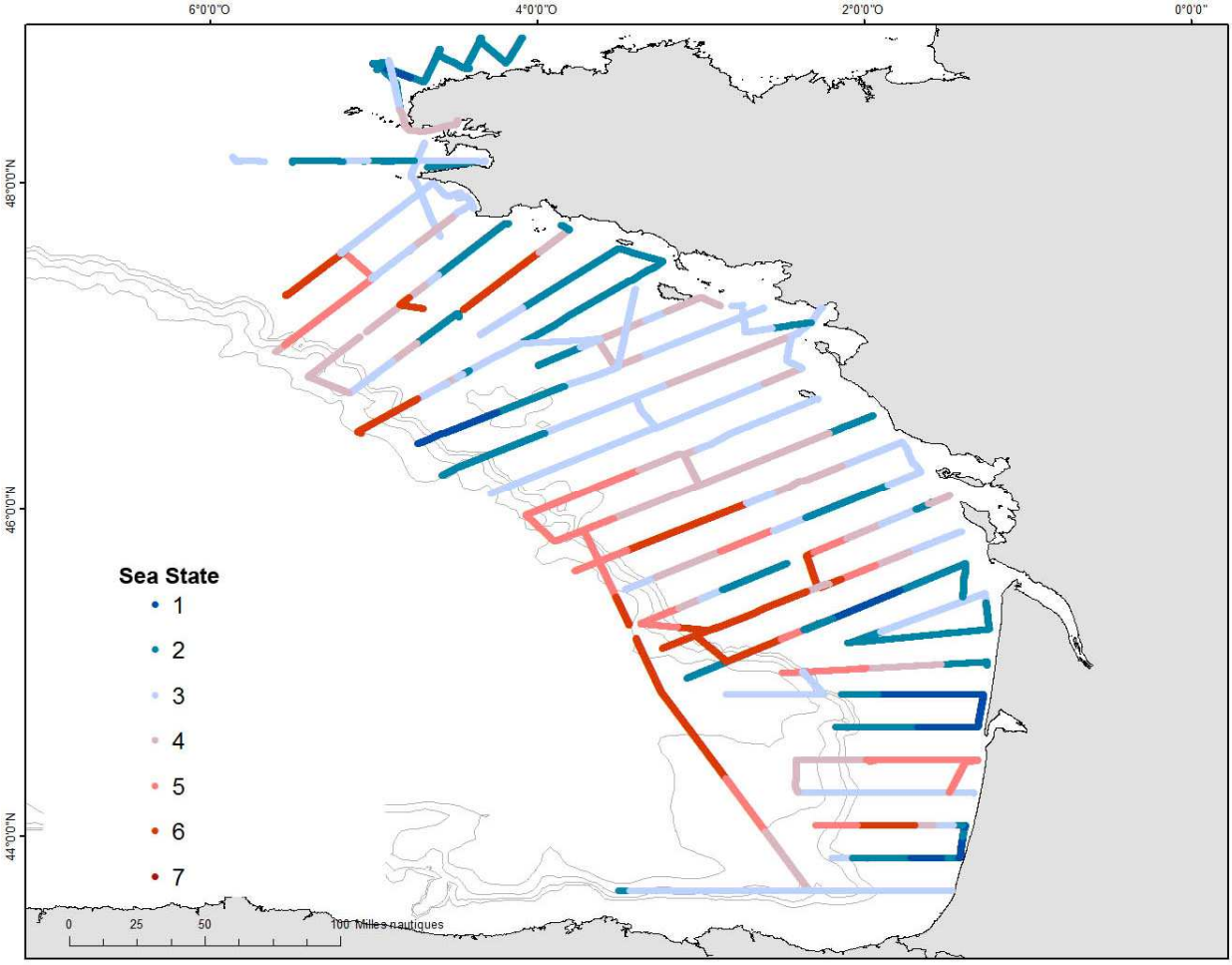

Figure 5.1. Sighting effort and conditions

The worst conditions were met in the central part of the bay of Biscay, offshore and the best along the coast. Globally conditions of sightings (including rain, fog and wind) were considered as "variable" : 45% as good, 18% as medium and 37 % as bad.

5.2 – Birds

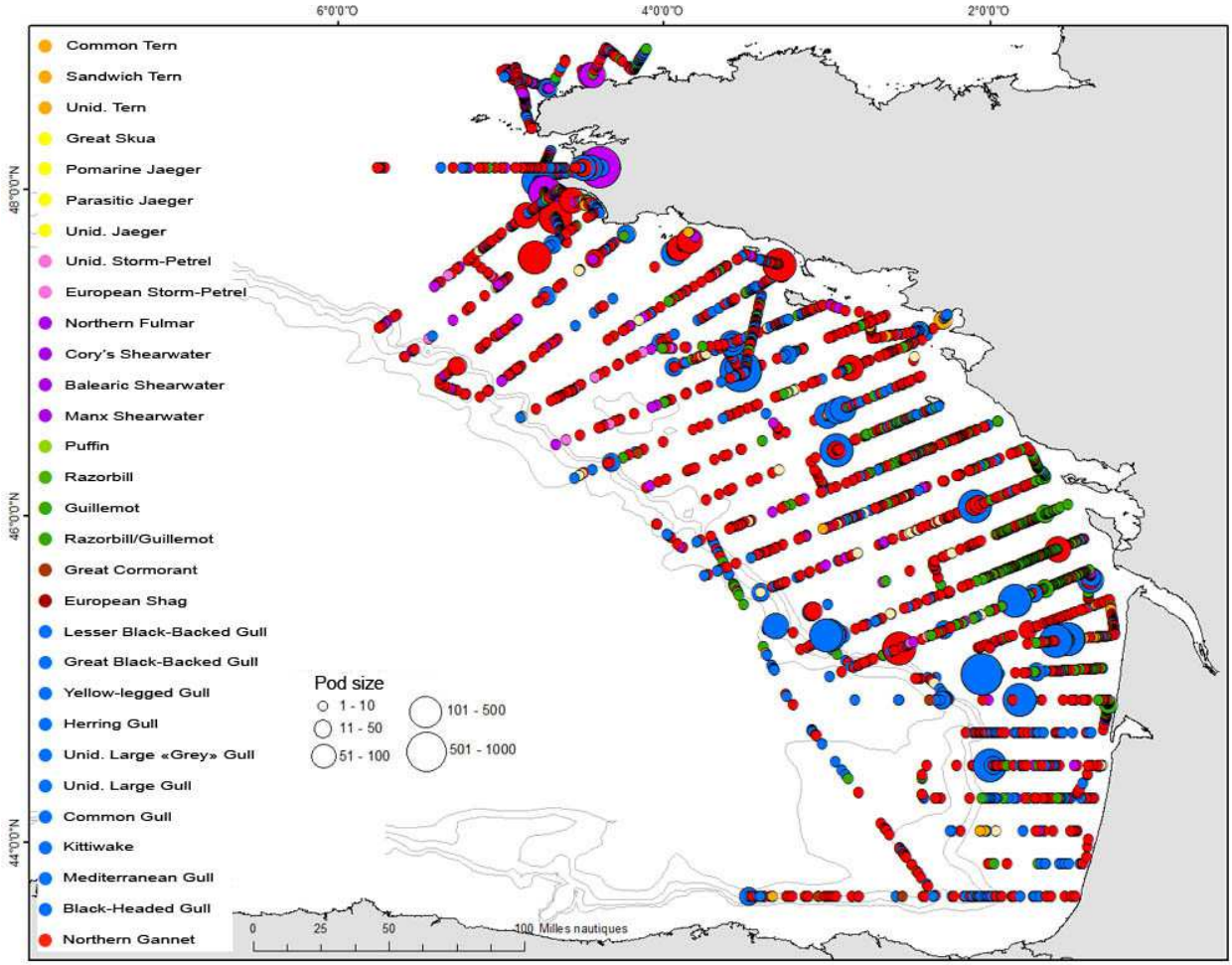

Figure 5.2. Distribution of birds observed during the PELGAS17 survey

Birds constitute the vast majority of sightings. Shorebirds and passerines accounted for less than 4% of bird sightings. 3304 sightings of seabirds were found all over the Bay of Biscay (Figure 5.2), divided into 26 identified species and a raw estimate of 14 697 individuals.

Northern gannets accounted for 52% of all seabird sightings: its distribution is homogeneous across the Bay of Biscay. It must be noticed that this year they were particularly numerous, with more than two times more individuals than last year (3975 ind.).

An other group of species was also well met : the larids, including the sea gulls and Black-legged Kittiwake (4 species observed this year in this family). They represent the first most important number of individuals observed during the survey, with a total of 7399 birds. Some groups are really huge in terms of numbers of birds.

Alcids (guillemot, razorbill) are well present this year, representing 16.5 % of the total sightings observations.

5.2 – Mammals

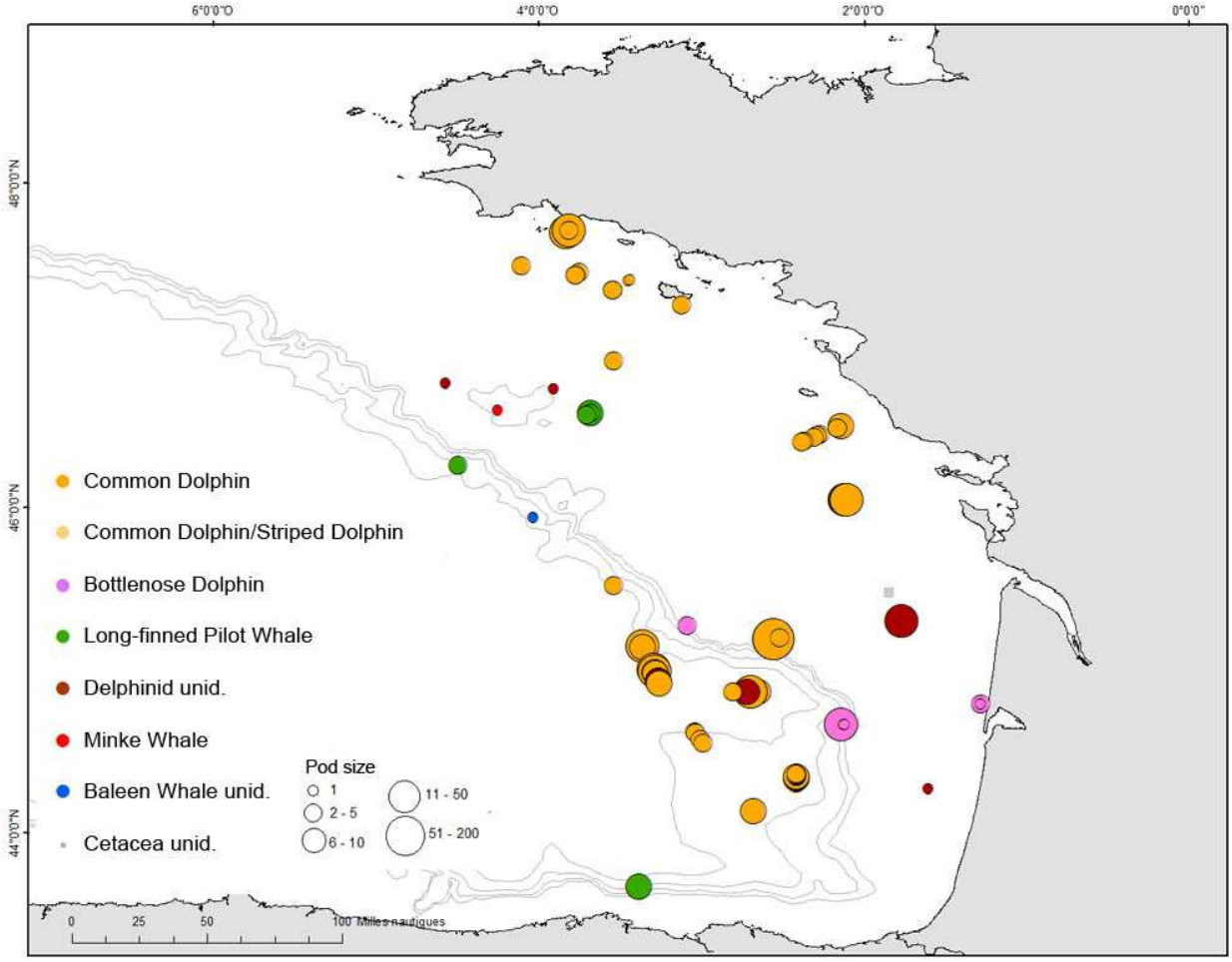

Figure 5.2. Distribution of mammals during the PELGAS17 survey.

A total of 88 sightings were recorded corresponding to a raw estimate of 746 individuals and 4 species of cetaceans clearly identified (Figure 5.2). The greatest diversity of marine mammals was observed in the central part of the Bay of Biscay. The overall distribution pattern is similar to that of previous PELGAS spring surveys.

The raw number of cetacean observed this years is three times lower than in 2016, and the number of species detected is the half (4 against 8 in 2016).

Common dolphin is the most recorded species (74% of total observations, 629 individuals). Common dolphins were present on the continental shelf, particularly in the northern part of the Bay of Biscay. Offshore, there were located around the "fer à cheval" area.

no Striped or Risso's dolphins were sighted this year, but as usual in lower quantities than Bottlenose dolphins. However, few long-finned pilot whales were sighted on the continental slope in the central part of the Bay of Biscay and at the shelfbreak.

very few bottlenose dolphins were detected this year (5 sightings), all located front of the Gironde, in small groups (3 to 15 individuals).

6. HYDROLOGICAL CONDITIONS

Early spring weather was mild and calm. It was also dry, in the continuity with a fresh and dry winter. Warming and stratification (thermal mostly with lack of significant river runoff) set up during this early spring, with blooms occuring from late February in the south of the bay of Biscay.

Change in weather conditions in mid-April, with an atmospheric flux from the North, significantly slowed down the warming. Associated with an earlier timing of survey as compared to previous years, this resulted in fresh conditions during the survey, with surface temperatures most often below 14°C.

An upwelling was generated along the coast of 'Les Landes', with a very low surface temperature signature (below 13°C). The 'cold pool' has also a strong signature north of the Gironde, with bottom temperatures around 11°C.

Thermal stratification is however established, with a chlorophyll maximum in sub-surface over most of the shelf. Though it does not prevent mixing over the slope (internal waves ?), with in that area chlorophyll concentrations more homogeneous throughout the mixed-layer.

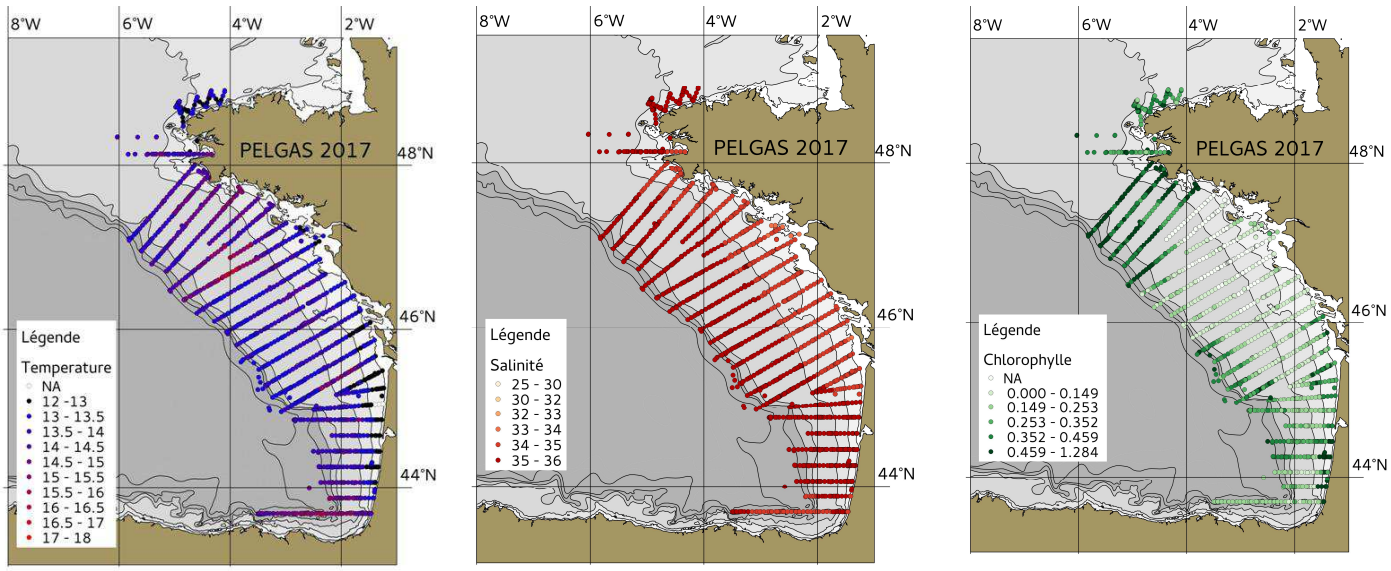

Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS17.

7. CONCLUSION

The Pelgas17 acoustic survey has been carried out with medium weather conditions (regular wind, low atmospheric 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 60 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. Vessels (and the scientific observer onboard) are founded by EMFF (European Maritime and Ficheries Found) for the period 2017- 2019, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS17 were close to the average of the serie, with a surface temperature still relatively cold (just above 14°C) maintained by low atmospheric temperature and a regular wind from North during the survey and some time before.

The PELGAS17 survey observed a relatively high level of anchovy biomass (**134 500 tons**), which seems to be higher to previous year, comparable to 2011 and far away from the 2015 biomass (which was probably overestimated but it is not explained for the time being). Offshore, anchovies were present closed to the surface in the South. As previous years, we observe that globally the trend of the mean weight at age is a decrease. This trend is globally the same for sardine in the bay of Biscay except for age 1 since last year. Further investigates should be done and, if we have some hypothesis (maybe an effect of density-dependance), we do not have real explanation for the time being.

The biomass estimate of sardine observed during PELGAS17 is **465 022 tons**, which constitutes a strong increase from the last survey. It confirms that this specie shows a variable abundance in the bay of Biscay at this period.

The proportion of age 1 (68% in number, and 43 % in mass) seems to be very high compared to last year. 2017 should be the best recruitment at age 1 for the whole PELGAS serie. 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. But it must be noticed that global weights and lengths at age are regularly decreasing in the bay of Biscay, maybe due to an effect of density-dependence or other reasons not well known at this time. Old individuals (>5 years old) seems to be less an less present in the bay of Biscay, year after year.

Concerning the other species, mackerel was relatively well present this year compared to recent surveys, while horse mackerel seems to decline, after 3 years of increasing biomass. Sprat, according to very low river discharges, was not present in the surveyed area.