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Direct assessment of anchovy by the PELGAS06 acoustic survey

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1. Material and method

An acoustic survey was carried out in the bay of Biscay from May 1st to May 30th on board the French research vessel Thalassa. The objective of PELGAS06 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. The results have to be used during ICES working groups in charge of the assessment of sardine, anchovy, mackerel and horse mackerel and in the frame of the Ifremer fisheries ecology program "resources variability".

To assess an optimum horizontal and vertical description of the area, two types of actions were combined :

- 1) Continuous acquisition by storing **acoustic** data from five different frequencies and pumping sea-water under the surface, in order to evaluate the number of fish eggs using **CUFES** system (Continuous Under-water Fish Eggs Sampler), and
- 2) discrete sampling at **stations** (by trawls, plankton nets, CTD).

Satellite imagery (temperature and sea colour) and modelisation were also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy.

Concurrently, a visual counting and identification of cetaceans and of birds (from board) was carried out in order to characterise the higher level predators of the pelagic ecosystem.

This survey was considered in the frame of the national FOREVAR program which is the French contribution to the international Globec programme. Furthermore, this task is formally included in the first priorities defined by the Commission regulation (EC) No 1639/2001 of 25 July 2001 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.

The strategy was the identical to previous surveys (2000 to 2005) :

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20/25 m depth to the shelf break.

-acoustic data were collected only during the day because of anchovy behaviour in this area. This species is usually grouped very close to the surface during night and so "disappear" in the blind layer for the echo sounder between the surface and 10 m depth.

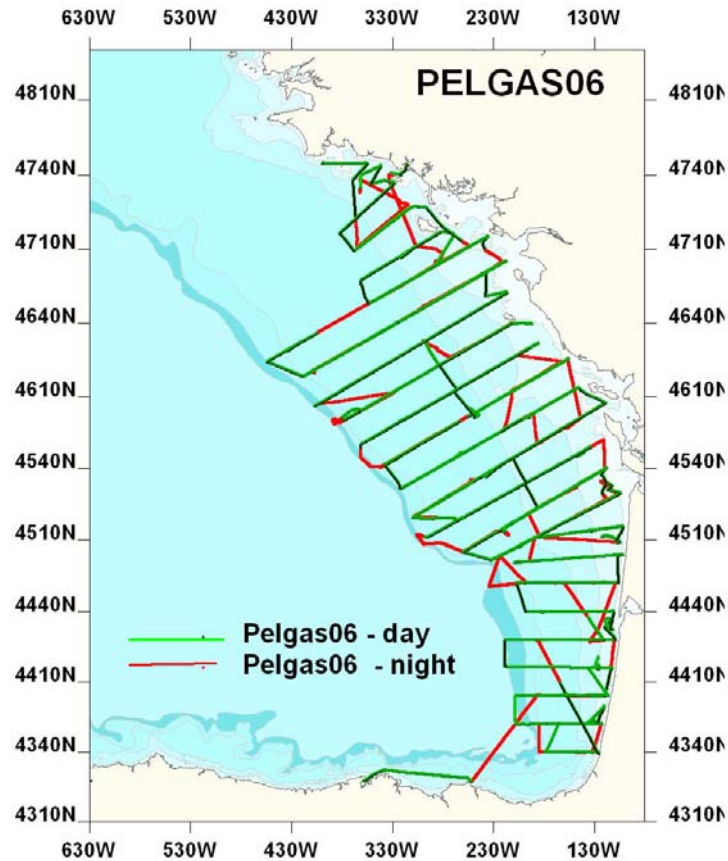


Fig. 1 - Transects prospected during PELGAS06 (day in green and night in red).

Two echo-sounders were used during the whole survey (SIMRAD EK60 and OSSIAN 500). Energies and samples provided by split beam transducers (5 frequencies EK60, 18, 38, 70, 120 and 200 kHz) and simple beam (OSSIAN 49 kHz) were simultaneously visualised, stored using the MOVIES+ software and at the same standard HAC format.

The calibration method was the same that the one described for the previous years (see W.D. 2001) and was performed at anchorage at cap Machichaco on the north coast of Spain in good meteorological conditions.

Acoustic data were therefore collected along a total amount of about 3800 nautical miles during the survey from which 1355 are usable for evaluation. A total of 56 pelagic hauls (figure 2) were carried out for identification of echo-traces from where 21 042 fish were measured and 1749 otoliths were collected for age determinations (anchovy and sardine).

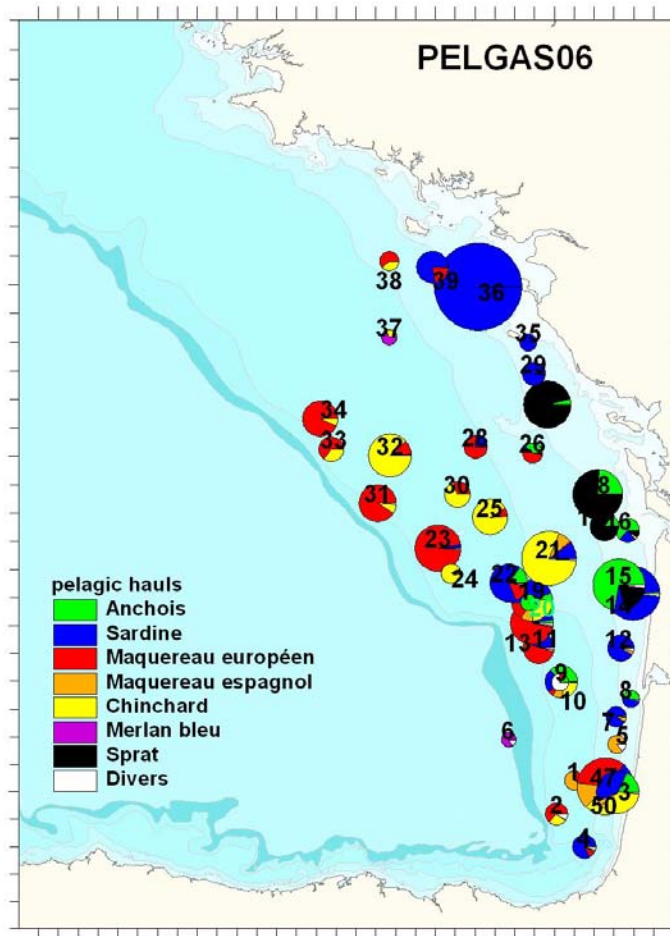


Fig. 2: Species distribution according to identification hauls

2. Acoustics data processing

2.1. Echo-traces classification

All the acoustic data along the transects were processed at the date of the meeting (figure 3) and have been scrutinised. Acoustic energies (S_a) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 5 categories of echo-traces :

D1 – energies attributed to horse mackerel, mackerel and gadoids corresponding to cloudy schools or layers close to the bottom or of small drops in a 10m height layer close to the bottom.

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

D3 – energies attributed to blue whiting and myctophids offshore.

D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface. These echoes are very predominant around the shelf break. Catches showed a predominance of mackerel, sardine, horse mackerel, and anchovy only around "Fer à cheval" area.

D5 – energies attributed to small horse mackerel only when they were gathered in very dense schools

D6 – energies attributed to the same species than D1 and D2 but when this classification was not clear enough

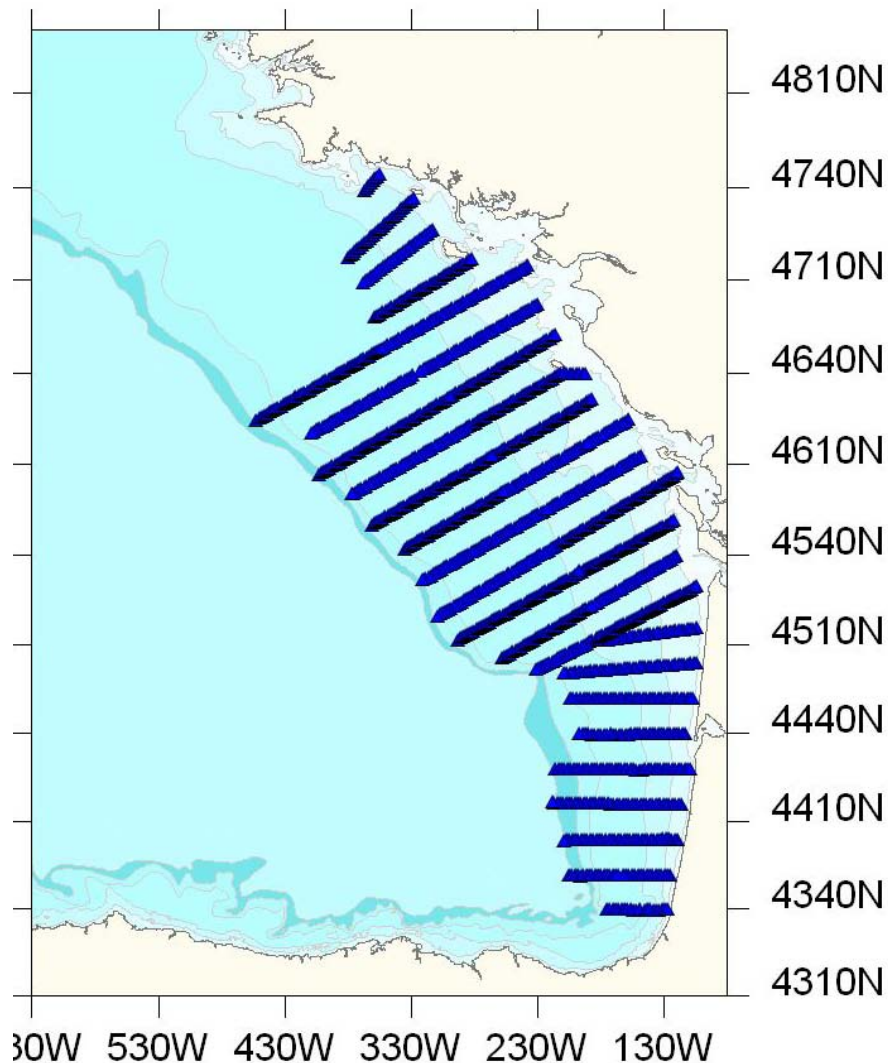


Fig. 3 : Processed data along PELGAS06 transects, valid for assessment

2.2. Splitting of energies into species

Two methods were used to calculate assessments of anchovy : a first one by attributing only one haul to each Esdu (called ref. Haul) and a second one by gathering hauls according to the species communities.

a) Assessment by Ref. Hauls

To each Esdu is affected a haul to split the energy into species according to catches proportions and weighted by TS. The hauls are chosen in respect of the echo-traces types and proximity. Surface hauls are attributed to D4 energies whereas classical hauls are attributed to D1, 2, 3, 5 or 6 energies.

Therefore a biomass is calculated for each Esdu in tons or in numbers. The results from Pelgas06 are represented on figure 4 (they can be compared to the previous years from figure 14). Two distinct areas may be noticed, one inshore along the coast between Bayonne and the Gironde, and the second one offshore in the area called "Fer à cheval" between 100 and 120 m depth.

Biomass are gathered in table 2 :

	biomass	numbers	Coef. Var.
Côte	25 534	1 893 844	14.78
Fer à cheval	5 656	125 423	30.89
Total	31 190	2 019 267	

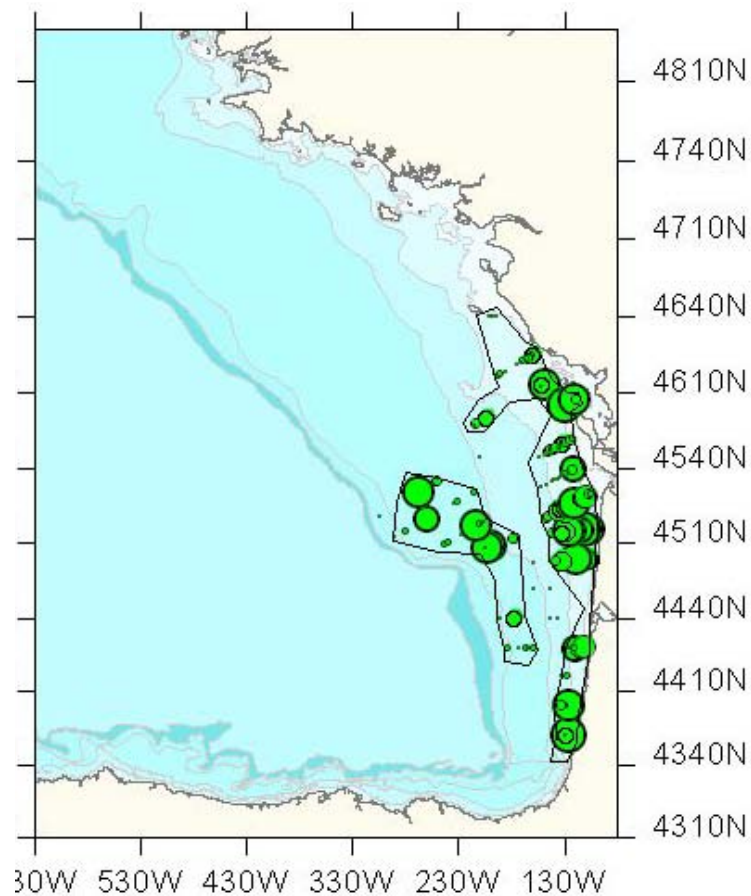


Fig. 4: Anchovy biomass per Esdu as processed after PELGAS06.

b) Assessment by strata

As previous years (except in 2003, see WD-2003) The global area has been splitted into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 5 shows the strata considered to evaluate biomass of each species. For each strata, energies were converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.

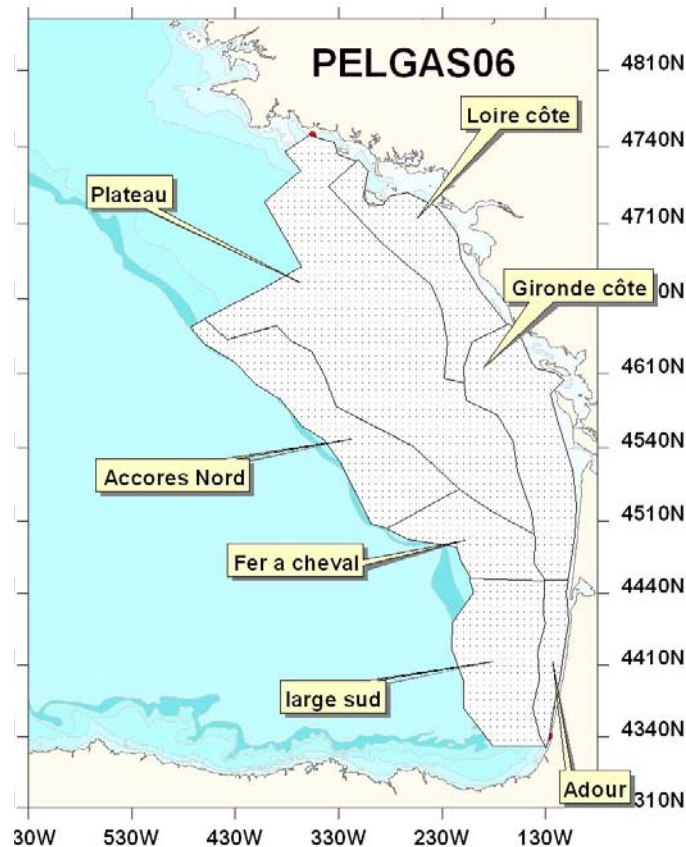


Fig. 5 – areas taken into account for assessment by strata with D1, D2, D3, D5 and D6 types of energy.

Biomass estimates

	PEL2006
Anchois	30 649
sardine	229 071
sprat	29 990
chinchard	155 782

A total biomass of 29 052 t of anchovy has been estimated. Anchovy biomass assessments by strata are gathered in the table below:

biomass (in	area (nm²)	In tons	In numbers (10⁶)
Loire côte	1 968	198	6,6
plateau	6 497	0	0
Accores Nord	2 469	0	0
Gironde côte	2 232	13 381	1 125,2
Fer à cheval	1 244	8 610 (7 688*)	196,0
Large sud	2 194	405	11,9
Adour	599	8 055 (814*)	522,7
total	17 230	30 649	1 862,4

* Numbers in brackets are surface biomass exclusively. (They are already included in the preceding total value).

3. Biomass estimate

Main of the anchovy was observed along the coast in shallow waters (from the coast to 50 m depth between Bayonne and the Gironde. It was small fish (from 70 to 180/kg) mixed with sardine and sprat in front of the Gironde and with sardine and horse mackerel in the south. Big fish (20 to 50/kg) was observed at the shelf break in the area of "Fer à cheval", either in the bottom area, or at the surface (between the surface and 30m below).

Based on the two methods described previously, the global estimate for anchovy was between 29 000 and 31 000t.

4. Length structure

Length distribution in the trawl haul were estimated from random samples. The population length distributions (figure 6.1) 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 anchovy is shown on figure 6.2.

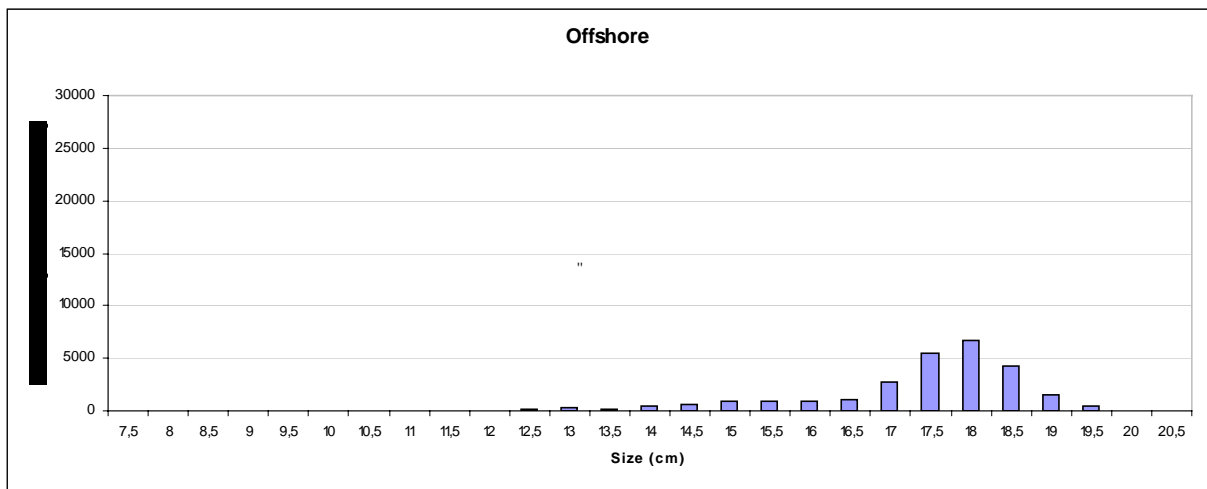
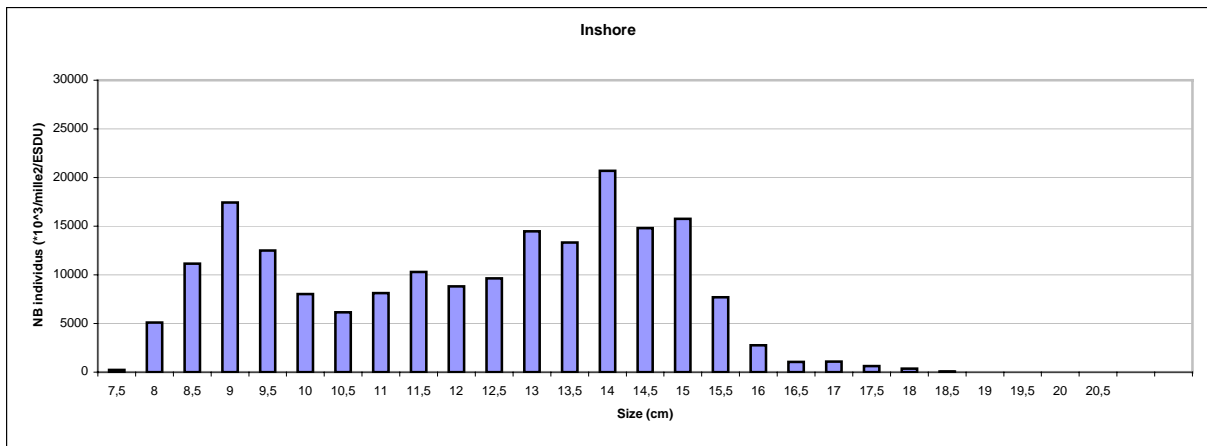


Fig. 6.1 –length distribution of anchovy observed during PELGAS06 (sum of numbers/nm² of each ESDU) survey by areas

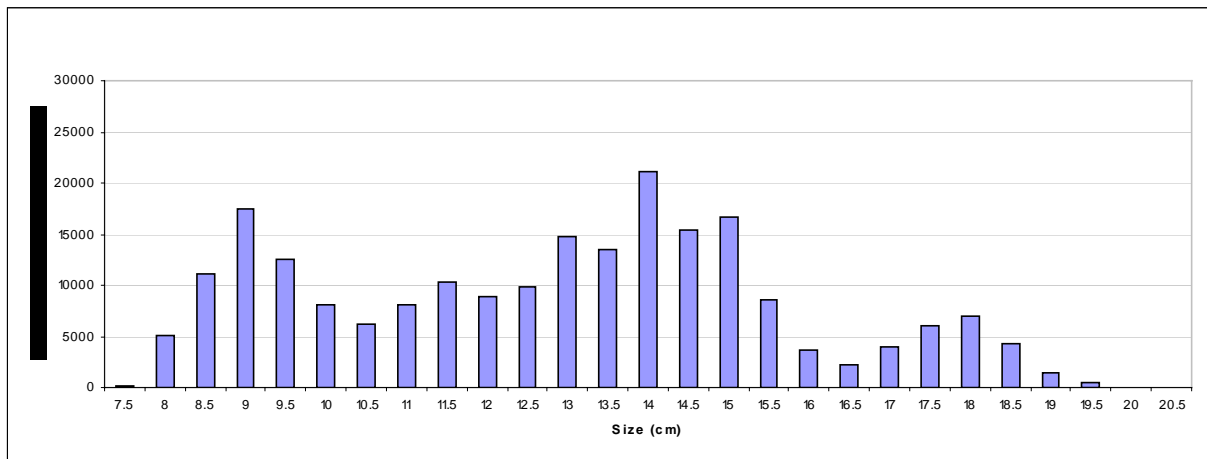


Fig. 6.2:length distribution of global anchovy as observed during PELGAS06 survey

5. Demographic structure

An age length key was constituted for anchovy from the trawl catches. Sub-samples (948 otoliths for the whole survey) which were taken from the previous samples, according to a stratified scheme based on length classes. The population length distribution was estimated by a weighted use of length distributions in the hauls. Weights used are acoustic coefficients ($Dev \cdot X_e \cdot Moule$ in thousands of individuals per n.m.²) which correspond to the abundance in the area sampled by each trawl haul.

length (cm)	Age - Offshore				Age - Coastal area			
	1	2	3	4	1	2	3	4
7.5	-	-	-	-	100.0%	0.0%	0.0%	0.0%
8	-	-	-	-	100.0%	0.0%	0.0%	0.0%
8.5	-	-	-	-	100.0%	0.0%	0.0%	0.0%
9	-	-	-	-	90.9%	9.1%	0.0%	0.0%
9.5	-	-	-	-	100.0%	0.0%	0.0%	0.0%
10	-	-	-	-	84.0%	16.0%	0.0%	0.0%
10.5	-	-	-	-	86.7%	13.3%	0.0%	0.0%
11	-	-	-	-	86.5%	13.5%	0.0%	0.0%
11.5	-	-	-	-	87.8%	12.2%	0.0%	0.0%
12	-	-	-	-	69.4%	28.6%	2.0%	0.0%
12.5	100.0%	0.0%	0.0%	0.0%	70.5%	27.3%	2.3%	0.0%
13	100.0%	0.0%	0.0%	0.0%	72.9%	20.8%	6.3%	0.0%
13.5	100.0%	0.0%	0.0%	0.0%	75.6%	17.8%	6.7%	0.0%
14	83.3%	16.7%	0.0%	0.0%	65.2%	21.7%	13.0%	0.0%
14.5	84.6%	15.4%	0.0%	0.0%	71.1%	15.6%	13.3%	0.0%
15	84.2%	15.8%	0.0%	0.0%	71.1%	20.0%	8.9%	0.0%
15.5	75.0%	25.0%	0.0%	0.0%	74.2%	22.6%	3.2%	0.0%
16	63.0%	25.9%	11.1%	0.0%	55.2%	41.4%	3.4%	0.0%
16.5	50.0%	38.5%	11.5%	0.0%	42.9%	42.9%	14.3%	0.0%
17	4.0%	64.0%	28.0%	4.0%	9.5%	61.9%	28.6%	0.0%
17.5	6.5%	74.2%	19.4%	0.0%	0.0%	72.7%	27.3%	0.0%
18	0.0%	75.0%	25.0%	0.0%	0.0%	66.7%	25.0%	8.3%
18.5	0.0%	74.1%	25.9%	0.0%	0.0%	66.7%	33.3%	0.0%
19	0.0%	54.5%	40.9%	4.5%	12.5%	62.5%	25.0%	0.0%
19.5	0.0%	41.7%	58.3%	0.0%	-	-	-	-
20	0.0%	0.0%	100.0%	0.0%	-	-	-	-
20.5	0.0%	0.0%	100.0%	0.0%	-	-	-	-

Applying the age distributions to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated and gathered in the following table. The total biomass used here has been up-dated with the value obtained from the previous method based on strata.

	biomass	numbers (10 ⁶)	G1	G2	G3	G4
Coastal area	21 634	1 654.5	1 249.7	338.6	65.7	0.5
Offshore	9 015	207.9	34.93	126.2	44.7	2
Total	30 649	1 862.4	1 289.6	464.8	98.6	1.6
Mean weight			12.5	23.5	31.5	43.3

Age distributions per area and global are shown in figures 7.1, 7.2 & 7.3. The age distributions compared from 2000 to 2006 are shown in figure 7.4.

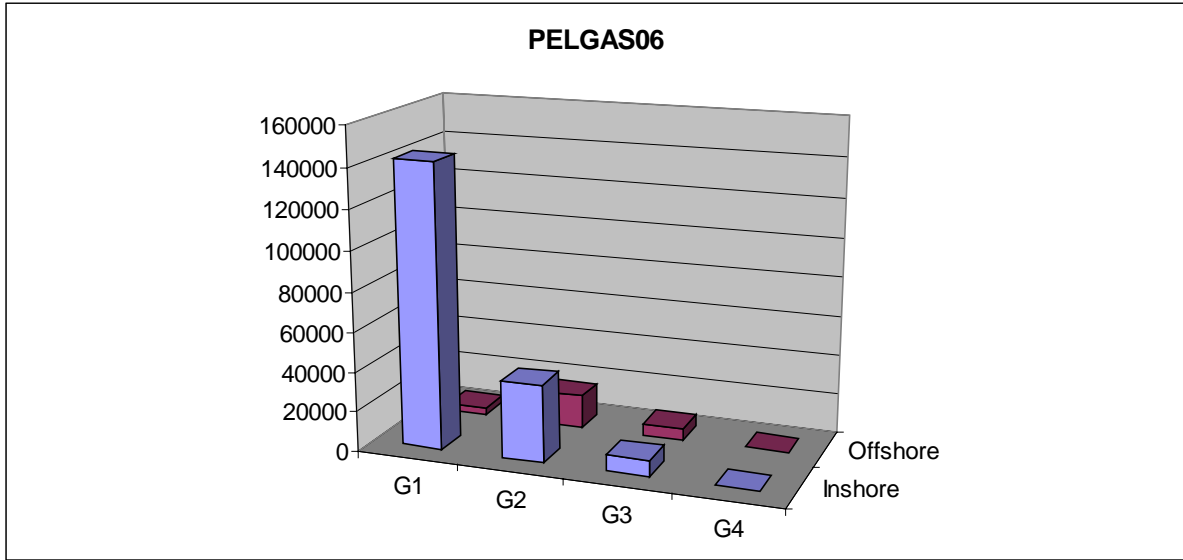


Fig. 7.1– Number of anchovy per age group during PELGAS06 in numbers (sum of numbers/nm² per ESDU)

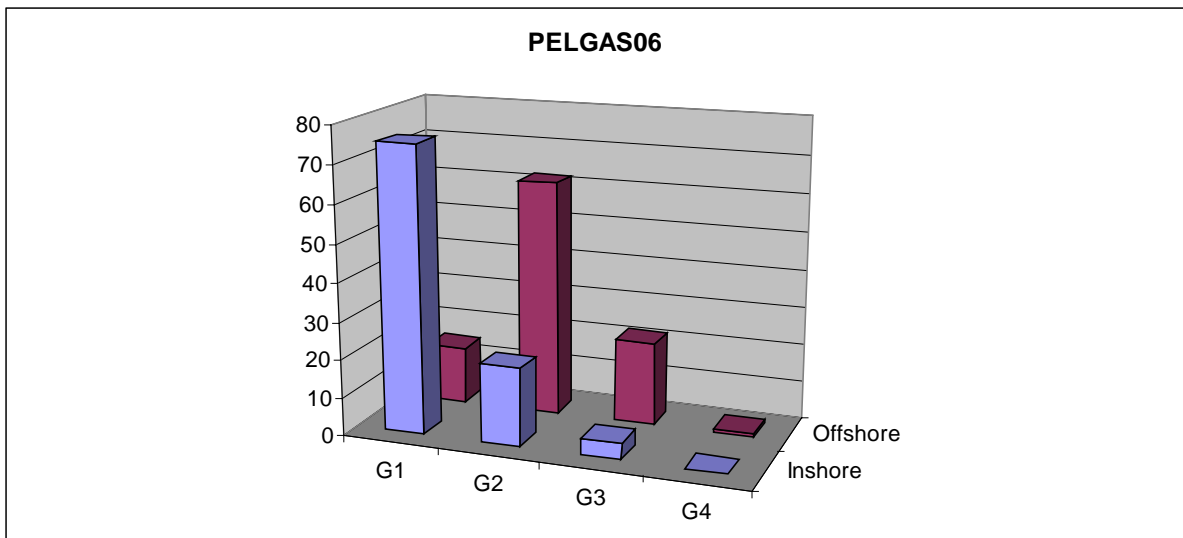


Fig. 7.2– Age proportions for anchovy during PELGAS06 (in %)

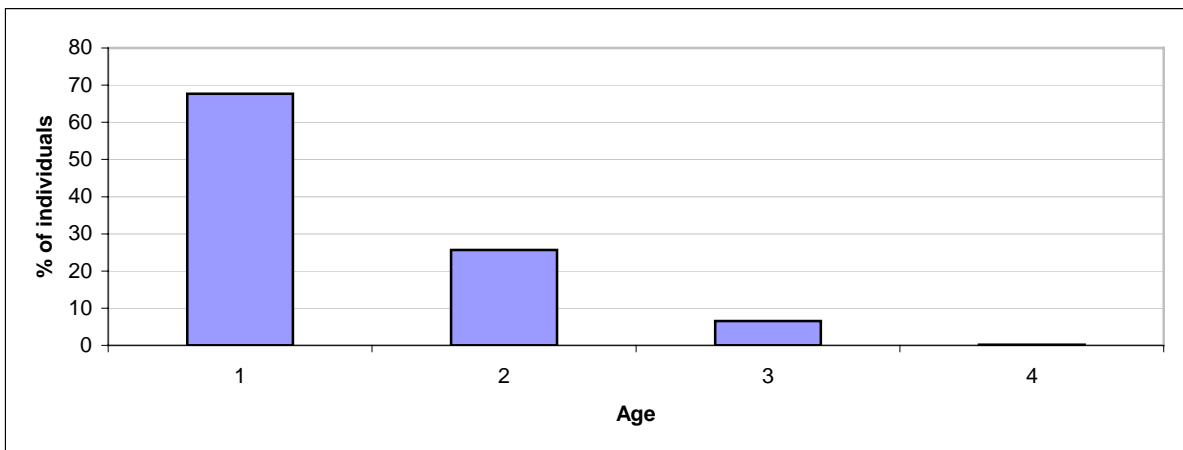


Fig. 7.3 – Age proportions of global anchovy as observed during PELGAS06 survey

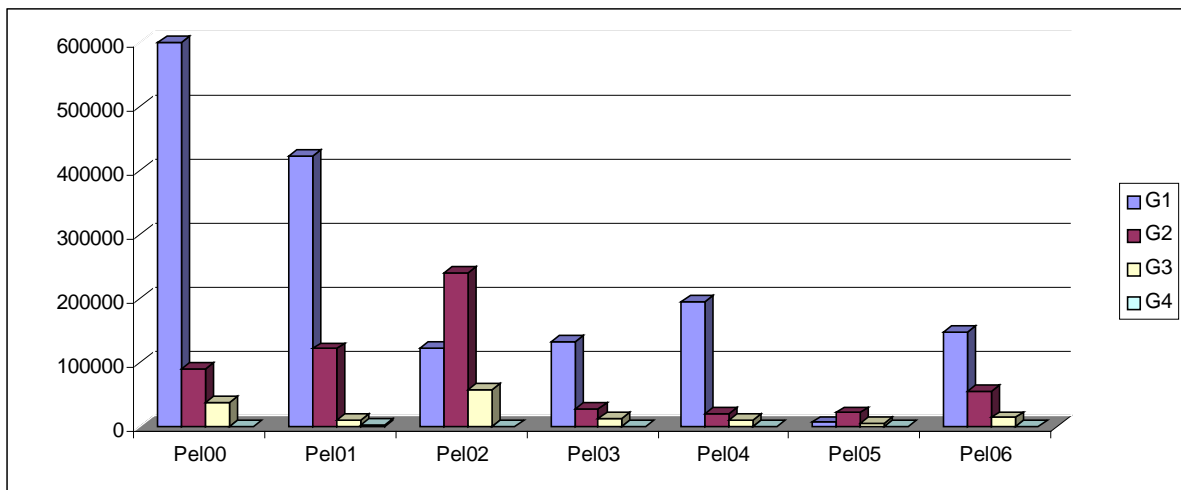


Fig. 7.4 – Age proportions of anchovy as observed during PELGAS surveys since 2000
6. Weight/Length key

Based on 4245 weight of individual fishes, the following weight/length key was established (figure 8) :

$$W = 0.0057 L^{3.959} \quad (\text{with } R^2 = 0.9658)$$

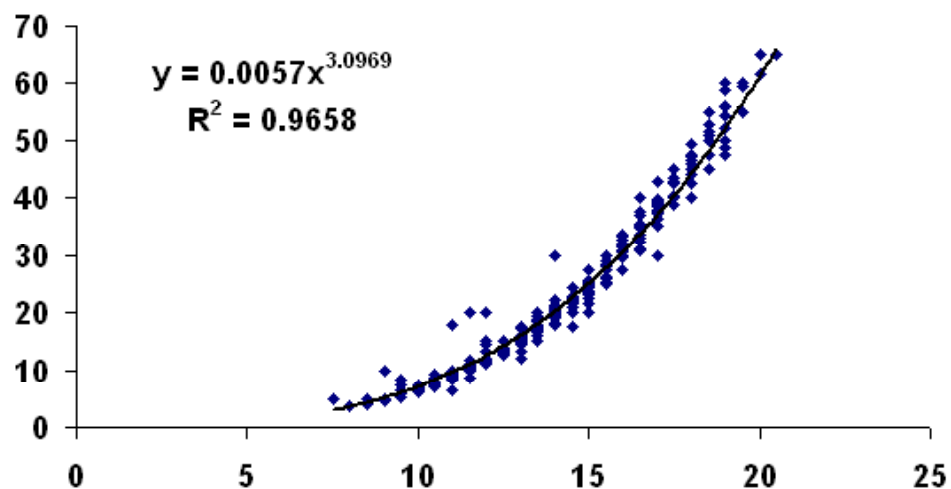


Fig. 8 – Weight/length key of anchovy established during PELGAS06

7. Eggs

During this survey, more than acoustic transects and pelagic trawl hauls, 888 CUFES samples were collected and counted, 44 vertical plankton hauls and 82 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

Because of bad weather, the last ten days were mostly used to prospect once more the southern area (where climate conditions were better) on three studies areas (figure 9) : the

Gironde, the "Fer à cheval" and Adour. The main objective was to study the nyctemeral behaviour of anchovy, the coherence between the eggs distribution and the adults one and to collect data on eggs density. The last experiments were carried out in order to validate a vertical model of distribution which could be usable in the future to validate CUFES data for a quantitative use.

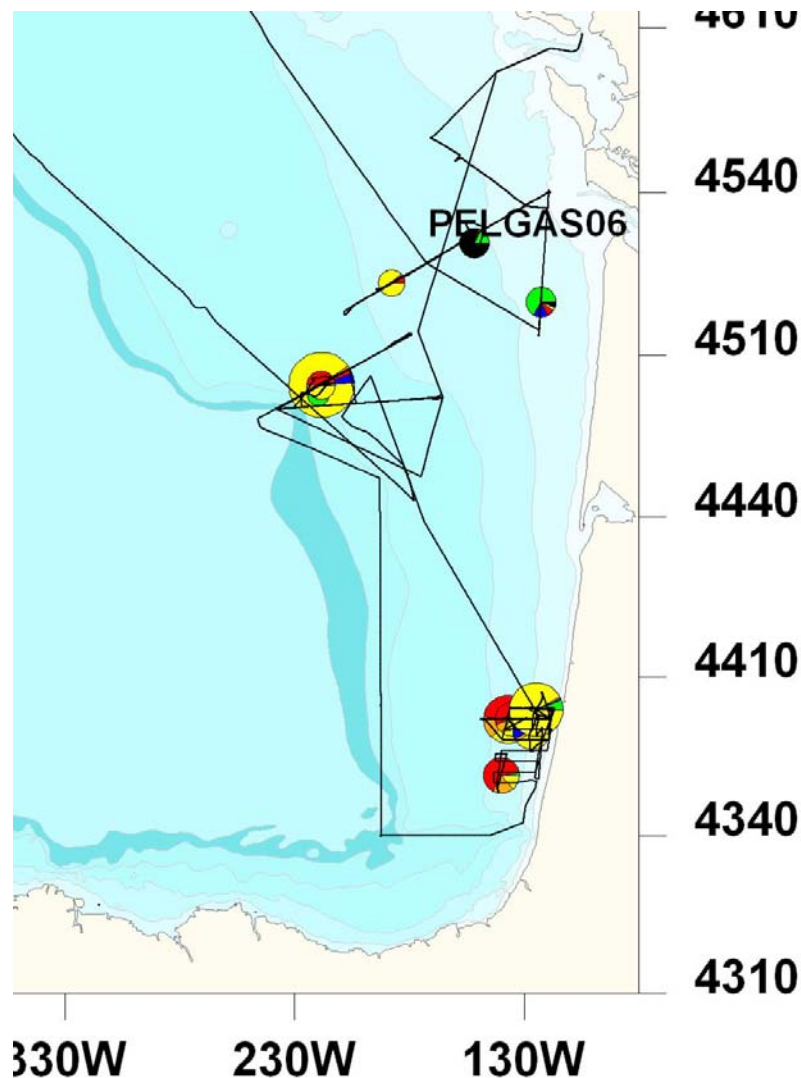


Fig. 9 – Studied area prospected during the last week of the PELGAS06 survey

This second coverage of the southern area confirms the presence of anchovy in "Adour" area very close to the coast, which were suggested by the presence of eggs during the first part of the survey, but not in evidence according to the two hauls carried out too offshore

The number of eggs collected by CUFES during the survey (figure 10) was similar to the one observed the previous years (except 2001 where eggs numbers were extremely high) (figures 11 and 12).

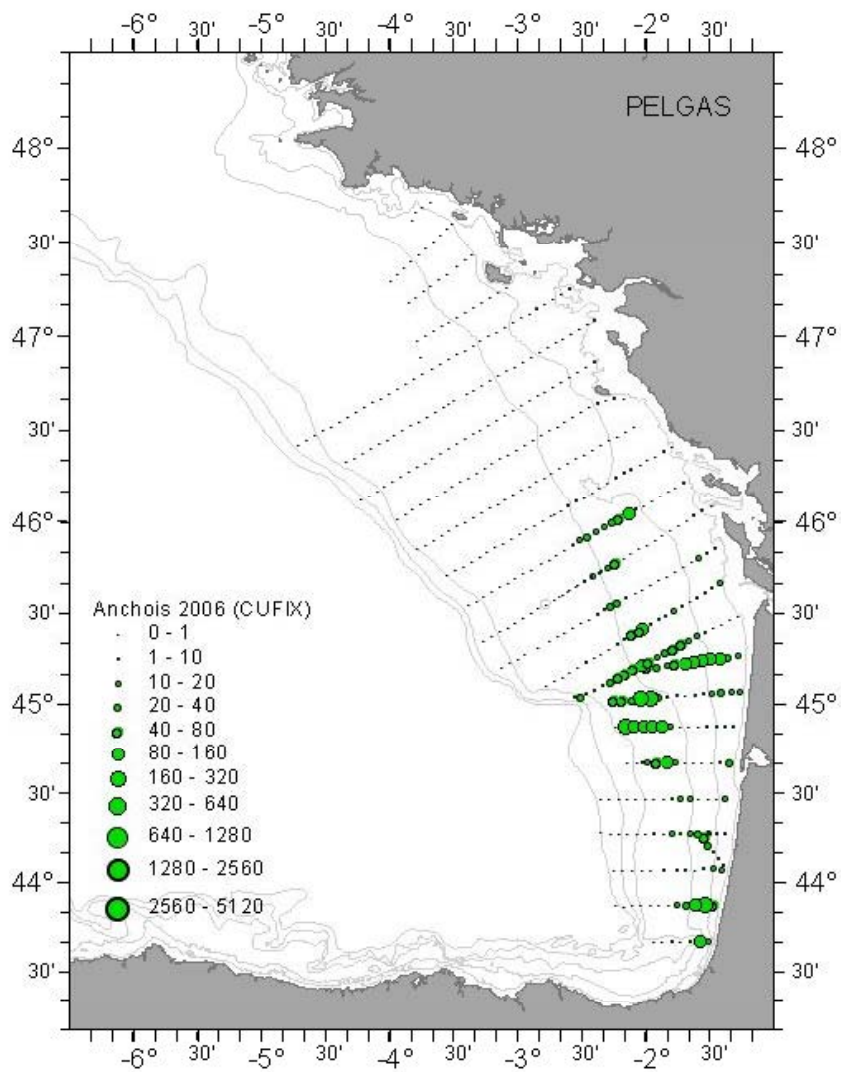


Fig. 10 – distribution of anchovy eggs observed with CUFES during PELGAS06

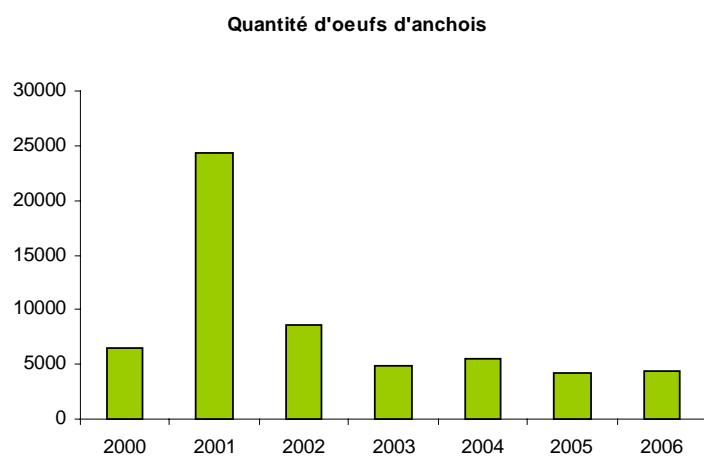


Fig. 11 – Number of eggs observed during PELGAS surveys from 2000 to 2005

The spawning areas were localised in the south of the Bay of Biscay (Adour), in front of Gironde and offshore along the "Fer à cheval" area. The distribution of eggs was in good agreement with the adult distribution, except in front of the Gironde where the eggs seemed to appear mainly offshore with CUFES and the adults were mainly inshore.

8. Hydrological conditions

Hydrological conditions observed during PELGAS06 are similar to classic years with a beginning of warming up suggested by surface temperatures, an upwelling along the southern coast (Landes) and moderate river flows (see figures 13.1 and 13.2).

9. Conclusion

The Pelgas06 survey could cover the anchovy distribution with suitable weather condition to carry out its biomass assessment by acoustic. The biomass observed during spring 2006 is globally lower than the biomass observed on the period 2000-2004, but higher than in 2005. In spring 2006, the anchovy spatial distribution was characterised according to two main regions: the Adour and Gironde, which are gathered in "coastal area" and the Fer à cheval called "offshore area". In the Adour region (from Spanish coast to 44°40N), anchovy were observed on a smaller area than the previous years and very close to the coast, mixed with sardine and mackerel. In the Gironde region (from 45°N to 46°20N) higher concentration of small anchovy were observed compared to last year and also close to the coast. They were mixed with sardine in the southern part of the region and mixed with sprat in the northern part. Anchovy from the Gironde (9 to 13cm) region were the smallest. 75% of these coastal fish were estimated to be of 1 year old, and 20% of 2 years old. However, due to the minimum water depth required by vessel to fish (20-25m), the inshore limit of anchovy distribution could not be defined and the underestimation of young fish is likely. The anchovy observed offshore in the Fer à Cheval region were much larger, with a mean size of 17cm (about 20-25 individuals per kilo). 14% of these fish were 1 year old and 62% 2 years old.

The anchovy biomass from the Pelgas06 survey has been estimated at 29 000t. The number of 1 year old anchovy was estimated at 1 290 millions fish, indicating a higher recruit than in 2005. The global population observed in the Bay of Biscay was composed of 71% of age 1, 23% of age 2 and 5% of age 3. However, a questionable point arises from the results obtained : the number of age 2 reach 418 millions of fish in 2006 whereas the recruit in 2005 was estimated at 107 millions of fish. The higher number of G2 in 2006 than G1 in 2005 requires further data exploration. For instance, the interpretation of otolith patterns should be discussed with experts and hypotheses on a possible under-estimate of age 1 last year or effects of migration and/or catchability should be tested.

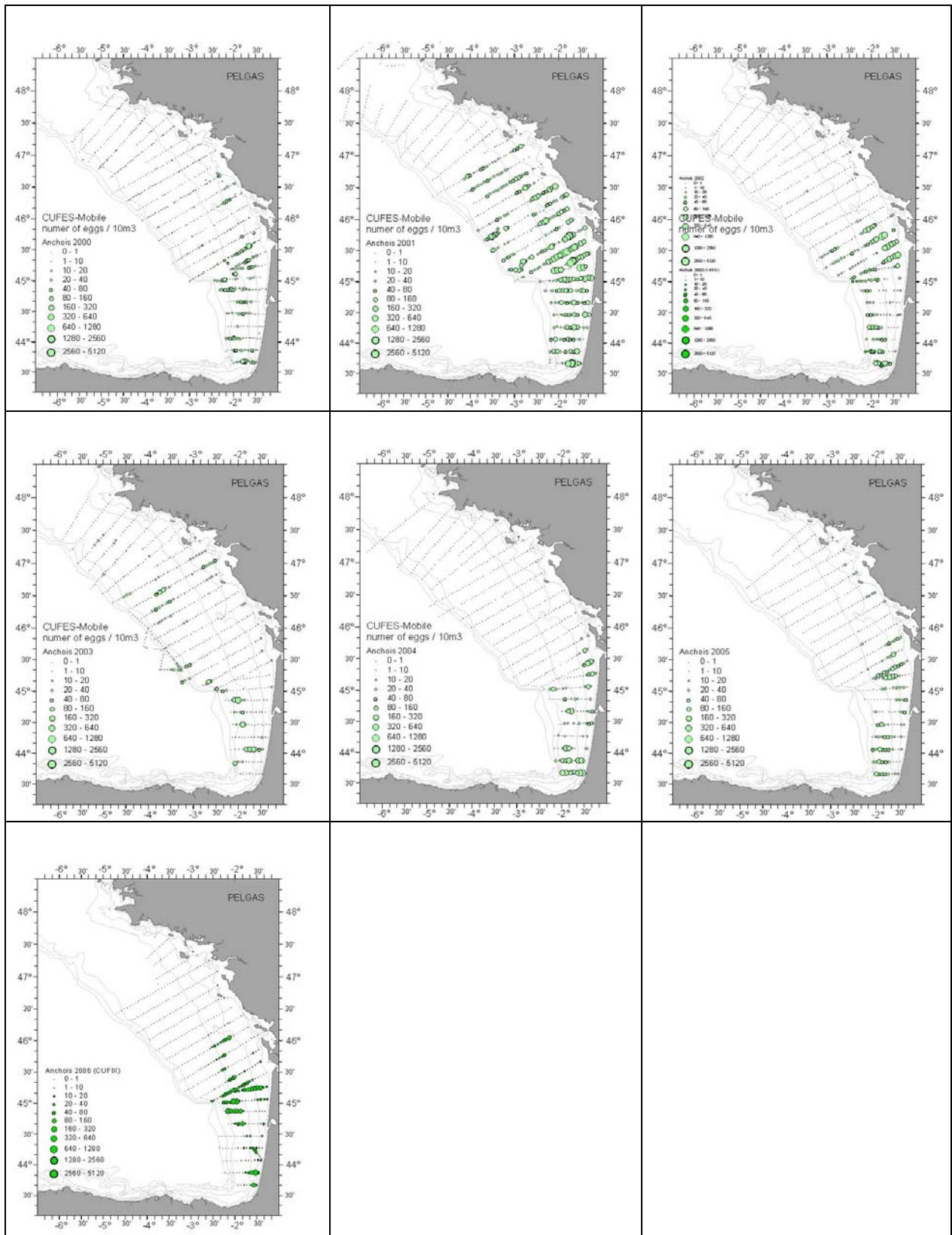


Fig. 12 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2006.

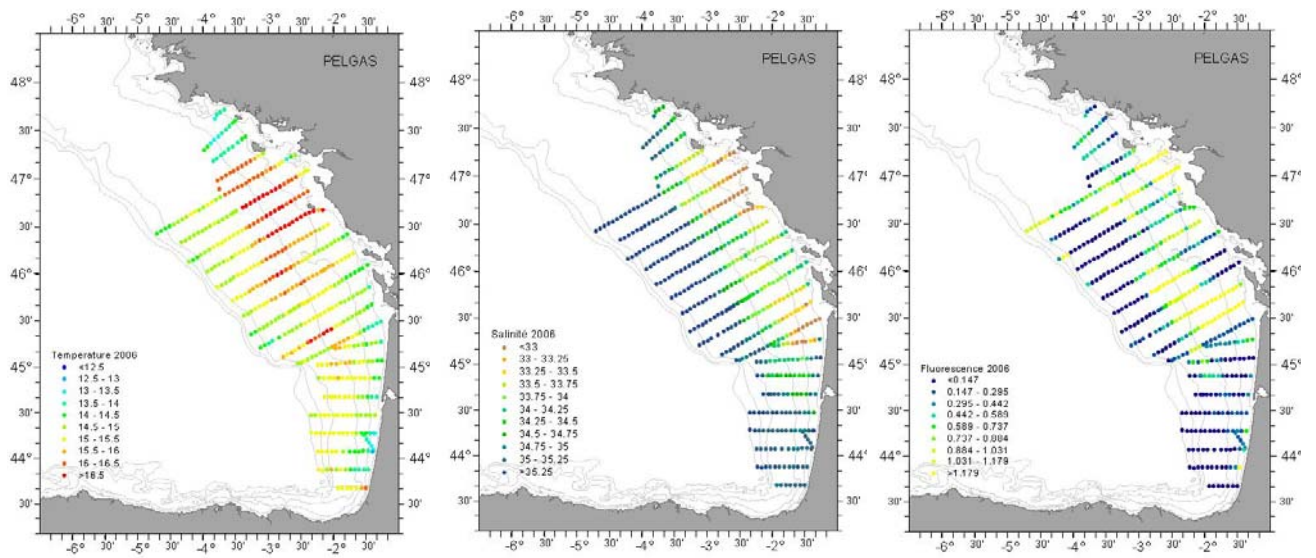


Fig. 13.1 – Surface temperatures, salinity and fluorescence observed during PELGAS06

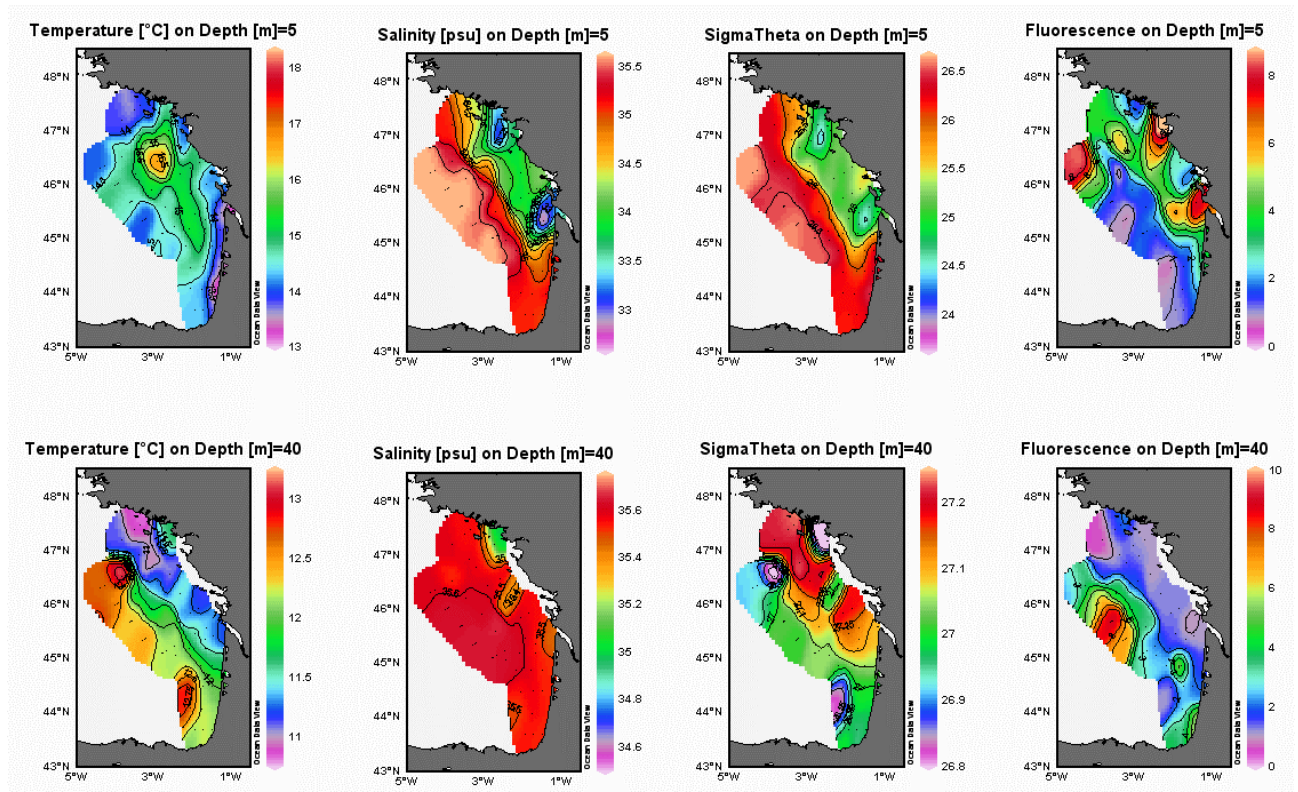


Fig. 13.2. –temperatures, salinity, densities and fluorescence observed during PELGAS06 at the surface (top) and at 40 m depth (bottom)

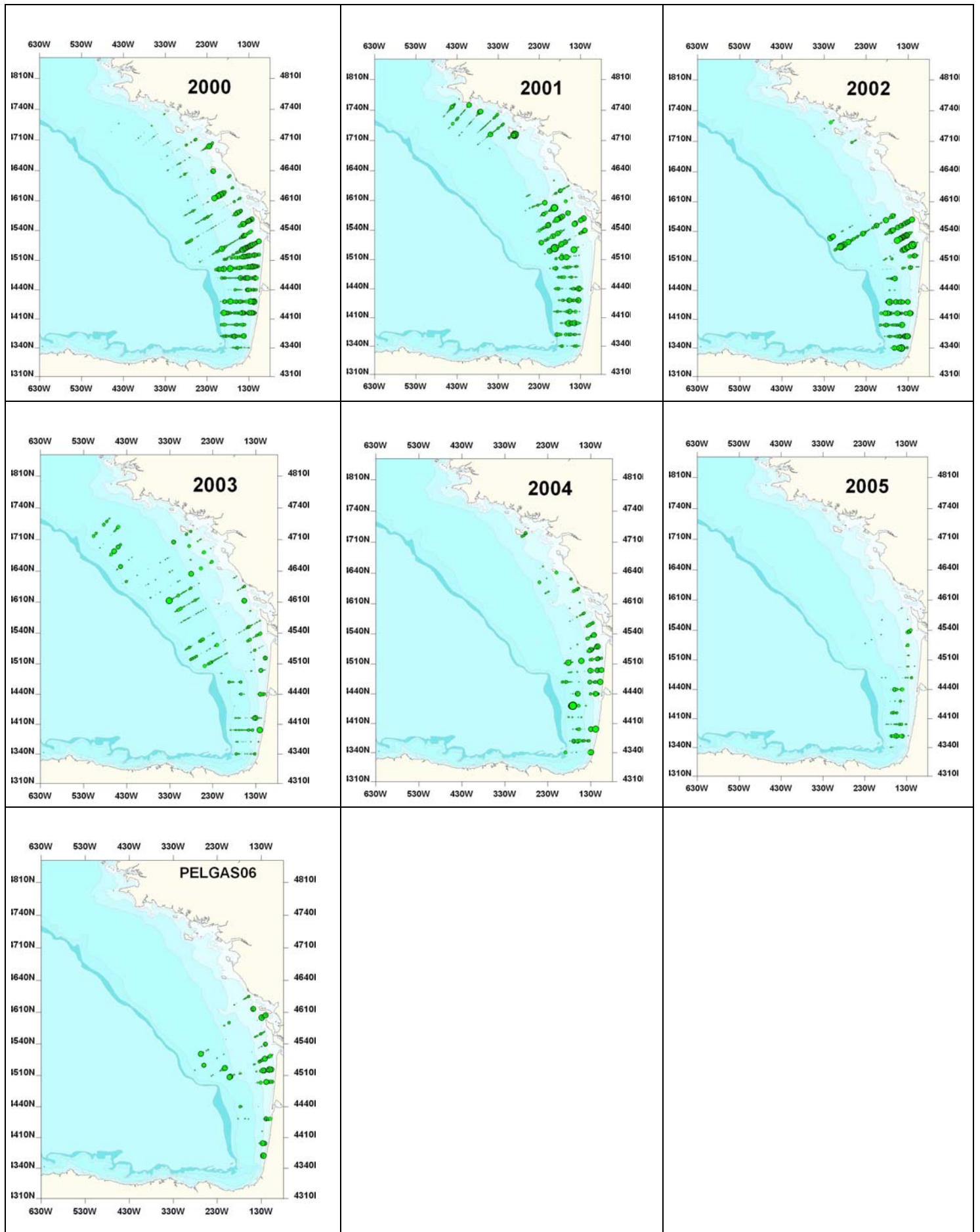


Fig. 14: Anchovy biomass per Esdu as processed after PELGAS from 2000 to 2006.

