

Plankton community structure and fish spawning area indicators in the Bay of Biscay, using Laser Optical Plankton Counter

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Nicolas Dupont and Benjamin Planque*

10 In the Bay of Biscay, regular fisheries acoustic cruises are conducted to assess small pelagic fish stocks. Within the frame of the Bay of Biscay integrated project, measurements of additional biotic and abiotic variables have also been carried out regularly to provide a first basis for ecosystem monitoring in the region. Here we report the first results for systematic zooplankton measurements using a Laser Optical Plankton Counter (LOPC) for years 2004 and 2005. The LOPC provides in situ zooplankton abundance per size bins (size spectrum) which can be used to assess zooplankton community structure. This is defined in three major ways for a single observation: integrated by size and depth (total abundance), integrated by size (vertical profile), and integrated by depth (size structure). 13 descriptors were derived from LOPC data. Mathematical analyses such as PCA or Escoufier equivalent vector method permit to select 4 key descriptors representing the best the planktonic community. Clustering from distance matrices derivate from first four PCA components show the appearance of different structures of plankton community. These findings may result from differences in vertical structure and in plankton dynamics. Comparison with hydrological variables has also been carried out but does not show an obvious relation. However, the different plankton states display spatial areas that have already been identified using hydrological and fish egg data. The results constitute a first global view of planktonic community structure in the Bay of Biscay using data from automatic measurements. Furthermore, in an operational scope, thanks to adapted means of sampling and communication, use of the LOPC during next IFREMER cruises should make data on planktonic structure available in near real-time.

30 Keywords: plankton community descriptor, plankton community state, Bay of Biscay, LOPC, fish spawning environment

*corresponding author

35 Nicolas Dupont and Benjamin Planque: IFREMER, Laboratoire Ecologie et Modèles pour l'Halieutique, rue de l'île d'Yeu, BP21105, 44311 Nantes Cedex 3, France [tel: +33 (0)240 37 41 17, fax: +33 (0)240 37 40 75, e-mail: benjamin.planque@ifremer.fr]

Introduction

The Bay of Biscay is a shelf area bounded by Western Europe on its eastern side and open to the Atlantic Ocean on the western side. The area is under coastal and oceanic influences which generate a great variety of physical, chemical and biological dynamics (Koutsikopoulos and Le Cann 1996; Labry, Herbland et al. 2001; Froidefond, Lavender et al. 2002; Planque, Beillois et al. 2003). Fisheries exploitation exists for benthic, demersal, small and large pelagic fish and other activities such as tourism or marine transport are also developed in the area (OSPAR Commission 2000). The management of the Bay of Biscay fisheries therefore needs to include a wide view of the system taking into account the physical, chemical and other biological components of the system, as well as other uses and users. In 2001, the 'Bay of Biscay integrated project' was launched by the Institut Français pour la Recherche et l'Exploitation de la MER (IFREMER) with the aim of better understanding the functioning of the Bay of Biscay in its multiple aspects. The project has combined studies on ocean circulation, sedimentology, benthos, plankton, fish, fisheries and economics. It has provided a unique opportunity to start developing and trying out scientific tools or devices in the view of an ecosystem based approach on fisheries.

To better understand the dynamics of small pelagic fish in the Bay of Biscay, it is necessary to consider the living conditions of those communities. Indeed, as stated by (Gaedke 1995) “a comprehensive understanding of the structure, function and regulation of major ecosystems is necessary to face [...] environmental problems”. This understanding can be made in several ways. In a theoretically way, prediction of time evolution ecosystem studies are done on fish communities or zooplankton communities under pressure of several different phenomena such as fishing, predation or reproduction (Silvert and Platt 1980; Gin, Guo et al. 1998; Benoit and Rochet 2004). In a practical way, several fieldworks have also been carried out to show the structure of various ecosystems (Rodriguez, Jimenez et al. 1987; Sprules and Goyke 1994; Piontkovski, Williams et al. 2003). Related to the Bay of Biscay ecosystem, (Planque, Bellier et al. 2004) based their study on the relation between hydrological variables (surface temperature, mixed layer depth etc...) and distribution of small pelagic fish eggs. In addition, (Bergeron 1993) tried to establish a possible relationship between biotic parameters such as zooplankton indices of production and the development of sole's larvae in the same area.

In the present work, we focus more specifically on the use of plankton informations to derive indices of planktonic state and dynamics in the Bay of Biscay in relation to small pelagic fish spawning areas.

5 Every year, IFREMER conducts regular fisheries acoustic surveys to assess small pelagic fish stocks. Within the frame of Bay of Biscay integrated project, additional measurements of biotic and abiotic variables have also been carried out using automatic acquisition systems. Data resulting from these provide a basis for ecosystem monitoring in the region. The planktonic community is a way to characterize marine ecosystems dynamics (Nogueira, González-Nuevo et al. 2004). Thereby, indices of this community should be
10 developed with the goal of making a global, fast and easy-understanding view on the planktonic state in the Bay of Biscay. To reach this goal, plankton measurements were carried out in 2004 and 2005 during PELGAS spring cruises, using an optical in-situ particle measurement instrument: the Laser Optical Plankton Counter (LOPC) (Herman, Beanlands et al. 2004). This hardware provides data about particles abundance and size distribution in the
15 water column. From these measurements, three types of descriptors are derived. The first ones are global descriptors which provide informations on the plankton community integrated by size and depth. The second type of descriptor is related to the vertical structure of plankton, providing abundance distribution information on the depth profile integrated by size. The third type is related to size structure, and allow for the description of plankton community
20 integrated by depth.

Using a suite of numerical analyses, we show how these descriptors complement each other and how they can be used to describe the state of the plankton community in the Bay of Biscay. The information provided is discussed in the light of operational oceanography and hydrographical structures as well as small pelagic fish spawning areas recorded during the
25 same cruises.

Data and Methods

Cruise sampling plan

30 Pelgas cruises have been conducted every spring since 2000. They are mainly dedicated to the assessment of small pelagic fish stocks, by fishing, acoustic measurements and eggs sampling. These cruises are conducted onboard the R/V Thalassa, which samples about 20 transects perpendicular to the coast, covering all the French part of the Bay of Biscay continental shelf (Fig. 1). The samplings of biological and hydrological variables are

done during fixed stations at night, whilst fish prospecting by acoustics and trawling is done during day time. Plankton data have been collected at night with an LOPC during the last two cruises: in May 2004 and 2005.

5 Plankton measurements

The Laser Optical Plankton Counter is a recently developed device which measures particles size and abundance in the water column by means of a laser field. Particle size is derived from the decrease of the light intensity of the laser field and is converted to the equivalent diameter of a perfect sphere shadow (Equivalent Spherical Diameter: ESD). The LOPC data consists of particle abundance per bins of 15 microns from 100 to 3750 microns of ESD. Since the LOPC was deployed from surface to bottom (with a maximum of 100m), vertical profiles of particle size and abundance can be derived. This is done by depth layers of 5m thickness.

From this data (abundance spectrum) by 5 meters layer depth, three main types of descriptors are derived. The first one is the general descriptor type (depth and size integrated). This represented by the total abundance and total biomass of particles in the water column. Biomass ($B(g_{ww})$ in g) is calculated from the size data and abundance by an allometric relation (eq 1) based, by means of the length-width ratio (ell-ratio), on the conversion from a spherical volume (derived from ESD in cm) to an ellipsoid volume (vol in cm^3). Biomass ($B(sb)$) of a size bin is obtained by multiplication with the number of particles in the size bin (Nsb).

$$vol = \frac{4}{3} \pi \left(\frac{ESD}{2} \right)^3 \cdot \frac{1}{\sqrt{ell-ratio}} \quad (eq 1)$$

$$B(g_{ww}) = vol \quad B(sb) = B(g_{ww}) \cdot Nsb$$

Total abundance and biomass are simply calculated by adding up these values through the size scale and then through the depth. Abundance and biomass were log-transformed to account for non-normal statistical distribution.

The second type of descriptor is composed by vertical descriptors (size integrated). These descriptors provide information on the vertical distribution profile of particles abundance and biomass in the water column. They are based on the cumulative frequency of biomass or abundance along the vertical profile. Three basic indices are first derived: depth

where 50% of the total abundance is reached (Fig. 2a), which shows if there is a peak of abundance in the profile. This value also depends on the depth of the station. Indeed two stations with the same profile will show differences on this parameter if they do not have the same sampling depth. The difference between depths where 80% and 20% of total abundance (valA 20-80%) or biomass (valB 20-80%) is reached (Fig. 2a): this difference is an indicator of the thickness of the layer which contains most of the plankton. The depth at which 99% of the total abundance (valA 99%) is reached: this is an indicator of the thickness of the layer which contains all of the plankton. Indices are also derived from the first ones to make a complementary view. The ratio of depths for 50% abundance to 50% biomass is also derived. This ratio is an indicator of size distribution along depth: a ratio of one corresponds to homogeneous size distribution at each depth, a ratio lower than one indicates greater abundance of small particles at depth and a ratio greater than one indicates greater abundance of small particles near the surface. Pielou's regularity index (Pielou 1966) is the ratio of Shannon diversity index of the vertical profile (derived on depth) to the maximum Shannon index (reached in a totally homogeneous profile). This descriptor is derived from frequency of the vertical distribution of abundance or biomass and takes values from 0 to 1. It shows the degree of homogeneity (1 is equal to homogeneity) of the vertical profile. This index is derived for both abundance and biomass (respectively RA and RB).

The third type of descriptor summarizes the size composition of the community integrated by depth. This one is less easy to describe than the others, due to the numerous aspects the integrated data can show in relation with biological phenomena as growth, reproduction or predation. First, we have calculated the Shannon diversity index (Legendre and Legendre 1984). The index serves as a general measure of diversity among size classes but doesn't provide indication on the shape of the size spectrum. Secondly, we use an adjustment model to handle homogeneous parameters to more easily describe integrated data aspects. The size distribution is described by a Pareto function which depicts the probability of finding a particle above a given weight (probability density function). The Pareto function is related to the normalised biomass spectrum (Platt and Denman 1977), by the way that from this function we can reconstruct the normalised biomass spectra. This spectrum represents the total biomass of a bin divided by the size (in weight) of this bin. A model II of the Pareto function (eq 2) (Vidondo, Prairie et al. 1997) based on the log-log values of probability to find a particle of a superior weight and particle weight (W) was used to summarise the size spectrum.

$$\log[\text{prob}(w \geq W)] = c \log(K + D) - c \log(W + D) \quad \text{eq 2}$$

The model requires the calculation of three parameters respectively named c , K and D (Fig. 2b). C parameter is related to the slope after the inflexion point of the parabolic curve describing at which speed the normalised biomass decreases. K parameter is related to the curve height. D parameter is related to this inflexion point: low values mean that small sizes are more proportional to the big ones (Sourisseau 2003). These parameters define the shape of the Pareto function (Fig. 2b).

10 Hydrography

In addition to LOPC data, hydrographical variables were measured at every station by use of a Conductivity-Temperature-Depth probe (Sea-Bird Electronics). Each hydrographical profile has been summarised by a restricted number of indices following the methodology of (Planque, Lazure et al. 2004). The indices retained are: surface temperature ($^{\circ}\text{C}$) and salinity, 15 bottom temperature and salinity, depth of the mixed layer (m), potential energy anomaly (J) and a topographic measurement: bottom depth (m) which was not included in the methodology of Planque.

Fish eggs

20 Pelagic egg abundance was also measured using a Continuous Underway Fish Egg Sampler (CUFES) (Checkley, Ortner et al. 1997) during daytime transects. Egg data is available for sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) as well as for all other species combined. Egg abundance is given in number per 10m^3 of filtered sea water at 3m depth.

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Data analysis

Plankton and hydrological variables totalise 20 descriptors (13 for plankton, 7 for hydrology) and it is likely that several descriptors may be correlated to each other. Thus mathematical analyses are needed to see how descriptors get together. To explore the 30 relationships between descriptors and to reduce the number of descriptors needed to describe the data set, we have performed a Principal Component Analysis (PCA) (Legendre and Legendre 1984). The PCA allows for relationships between variables in the multivariate space, by creating linear, independent combinations (components) of variables that

summarize natural associations within the data. For both studied years (2004 and 2005) the plankton data was compiled into a matrix in which each row represents a sampling station and each column represents a plankton or hydrological descriptor. The PCA has been performed using the plankton descriptors only and the hydrological descriptors have been used as supplementary variables, i.e. only plankton information is used for the construction of the principal components, but the hydrological descriptors can be added to the final PCA representation. The plot of correlation between the original axes (original plankton descriptors) and components (new independent axes) can be used to reveal how descriptors are related to each other. By adding correlation of hydrological variables within plankton components, the correlation plot shows the relation between the two sets of descriptors.

The PCA was complemented by the method known as the equivalent vector's method from Escoufier (Escoufier 1970) with the aim of reducing the number of plankton descriptors and retaining only the most significant ones. The principle of Escoufier's method is based on the measure of correlation between two different matrices. This correlation is described by a value (called RV value) which varies between 0 and 1: 0 means that the directions of the components of PCAs from the two matrixes are orthogonal. In contrast 1 means that the directions of components are heading the same direction. The method can be used for comparison between a full matrix (all descriptors) and a restricted matrix (a subset of all descriptors only). In this case, the method provides information (by the RV value) about similarity between PCA with all descriptors and PCA with a reduced number of descriptors. It is therefore possible to select a reduce set of descriptors for which the RV value is high (generally above 0.8) and which therefore contains most of the information of the full original matrix.

25 Data representation

Spatial representation of data in the Bay of Biscay has been performed using an inverse-distance interpolation scheme.

Plankton types

The identification of major types of plankton structures in the Bay of Biscay has been done by clustering. The similarity (or distance) between stations has been defined on the basis of their proximity (or distance) in the PCA space, using the Euclidean distance metrics between components (axes) that totalise more than 75% of the original variance. A flexible agglomerative clustering method see (Legendre and Legendre 1984) has been applied to the

resulting distance matrix. The groups obtained can be directly related to original plankton descriptor values and are represented on Bay of Biscay area.

Results

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PCA results

The first four axes of the PCA represent about 78% of the original variance, which indicate that the data set can be described with a lesser number of descriptors. The saturation plot of the PCA performed on the two years of study combined (Fig. 3a) reveals the relationships between plankton and hydrological descriptors. The three types of plankton descriptors (general, size-integrated and depth-integrated) are well individualised with type 1 (general) positively correlated with component 1, type 2 (size-integrated) positively correlated with component 1 and negatively with component 2 and type 3 (depth integrated) orthogonal to type 2. It is noticeable that the PCA saturation plots on individual years show little difference (Fig. 3b,c) and that grouping the two years in a single analysis (Fig. 3a) is sensible.

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Escoufier's method results

The application of the Escoufier method on the data set of 2004 reveals that four descriptors are sufficient to obtain a RV value of about 0.88, i.e that most of the plankton related variations between stations can be summarised with only these four descriptors: logarithm of biomass (logB), depth difference between 80-20% of cumulative frequency of biomass (B20-80), Pielou's index for biomass (RB) and the D parameter of the Pareto curve (D). The method applied to the data set of 2005 selects for the same list of descriptors, with a RV value of 0.86. These results show that variations can be summarised by the same set of four variables.

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Spatial distribution in the Bay of Biscay

The spatial distribution of the key plankton descriptors (as identified from the equivalent vector method) is shown in Figure 4.

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Log-biomass values (Fig. 4a,b) vary from 1.3 to 2.5 for both years and 2005 is characterised by lower biomass values than 2004. However, in some areas high biomass values are always observed: near the Loire's estuary or to the south of the Bay of Biscay. Similarly some areas display low plankton biomass in both years: the Pertuis Charentais (cf

Fig 1). In contrast, plankton biomass appears to vary greatly between the two years at the shelf break and at the western part of the Bay of Biscay.

The depth range of 20-80% biomass (20-80B) is spatially structured in both years (Fig. 4c,d). Although this coefficient depends on the depth of the station (the index is lower if the station shallower), the structure is not exactly that of the Bay of Biscay bathymetry. In particular, it is noticeable that the index is maximum in the central part of the shelf and lower values can be observed towards the shelf break, as in 2005. The information provided by the regularity index of Pielou calculated on biomass (RB) complements the maps of 20-80B. RB index is not dependent upon the total depth of the sampling station (but only on the vertical distribution of biomass). High values of RB (i.e. biomass regularly distributed along the vertical) are observed in the central part of the Bay of Biscay in both years and towards the coast, north of the Gironde estuary in 2004 (Fig. 4e,f). On the other hand, low values of RB (i.e. biomass peaking at certain depths) are observed in the generally in the coastal regions, close to the major estuaries. Whether the spatial differences in plankton vertical distributions result from spatial variations in hydrography and in production dynamics, or both, remains to be clarified.

D parameter (the inflexion point of the Pareto II model) gives an overall view of the shape of the size structure. In his study (Sourisseau 2003) describes relations between community dynamics and size structure. He shows that D and c parameters are strongly correlated. Furthermore, high values of D correspond to high material transport efficiency through the ascendant size bins and to a strong dynamic of the community. Plankton size structure index D is also well structured in space (Fig 4g,h), although both years display real different structures. High values are close to major estuaries and at the shelf break in 2004, whereas low values are located to the north of the Bay of Biscay. In 2005 the spatial structure is clearly different. High values are in the middle of the bay. Major estuaries do not display clear structure with high values as 2004. Low values are located on the major part of the Bay of Biscay at the South and at the North indicating for this year less dynamic communities than 2004.

30 **Clustering results**

Clustering from the first four PCA components differentiates four groups (Fig. 5a,b,c,d) that can be related to four different states of plankton community. Normalised key plankton values are represented for each group in box and whisker plots. This drawing represents the key plankton values distribution, red line indicates median of the distribution.

The first group is distinguished by shallowness of station and a non-homogeneous vertical profile as shown by a low 20-80B and RB index whereas log-B and D display mean values (Fig. 5a). The second group is characterised by high values of D that indicates strong community dynamism. The values of log-b is equivalent to the mean, others descriptors remaining as low as the first group (Fig. 5b). The third group shows mean values of 20-80B and RB but low values of both logarithm of biomass and D parameter which indicates low dynamics and material content (Fig 5c). The fourth group values are relatively near from the mean, although log-b and RB have sensitive higher values than the three other states (Fig. 5d). The four groups are dissimilar showing differences on material content (log-b), vertical profile (RB) and dynamics (D). Each group represent a particular structure of the plankton community in the Bay of Biscay.

Hydrological data are derived from plankton clustering (Figure 6a, b, c, d). Relations between hydrological variables and planktonic ones remain difficult to see. Only the type 2 key descriptors (size integrated) seem to be related with hydrology (depth and surface and bottom temperatures). As plankton define animals spatially distributed depending on the water physics (density, stream etc...) it is normal to see their vertical profile related to hydrology. On the other hand, log-b and D parameter do not make an obvious relation with any hydrological variable. However, there are still hydrological peculiarities that made structures or states different from each other. First, opposition between plankton community structure 1 and 2 with low depth, mixed layer depth and potential deficient energy (Fig 6 a,b), and structure 3 and 4 with higher values (Fig 6 c,d). Second, structure 2 differentiates with high bottom temperature and low bottom salinity compared to structure 1. Structure 3 shows a bottom temperature lower than structure 4.

Spatial organisation of plankton structures in the Bay of Biscay (Fig. 7a,b) shows that structures 1 and 2 remain coastal on both years, whereas structure 3 and 4 remain offshore ones. Furthermore, structure 3 seems to be related to the North part of the Bay of Biscay, whereas structure 4 is more related to the South part. Moreover, on the shelf break area community structure seems to be unstable, community is changing in a short distance in 2004. On both consecutive years, first and second states seem to remain spatially constant whereas third and fourth states show spatial variations notably at the shelf break.

Discussion

The use of the LOPC as a means of planktonic community assessment in the Bay of Biscay is an answer to present problems of comprehension and management of environment and marine ecosystem of the Bay of Biscay. Fisheries management was first seen as management of single species (Troadec and Boncoeur 2003). In the last couple of years, it has become obvious that fisheries management and their sustainability could not be properly achieved without taking into considerations the ecosystem of fishing species. Further expansion of the research field to study this wider ecosystem has highlighted our lack of knowledge and data on marine ecosystems (Larkin 1996; Degnbol 2002). The Reykjavik declaration in 2001 (Degnbol 2002) puts forward the need to identify and describe the structure, components and functioning of relevant marine ecosystems. Although studies have already been done as in the Wadden Sea (Lanters and Enserink 1998) or by Continuous Plankton Recorder (CPR) data (Brander, Dickson et al. 2003), the scientific community currently lacks the ecological indicators and descriptors for regional ecosystems (Degnbol 2002; Rogers and Greenaway 2005).

Indeed, living resources management should be based on multispecific knowledge that takes into account species interactions (predation, competition) (Gislason, Sinclair et al. 2000). That shows the need to study plankton as lower level of food chain making a link between primary producers and fishes (Pope and Symes; Planque and Reid 1998). Plankton data and regional descriptors are recommended for monitoring changes in the pelagic system. Moreover, shifts in the planktonic community should provide convincing visual indications of change in pelagic ecosystem state (Defra 2004a). Studies on both size and biomass are a way to understand underlying the ecological and physiological structure of the system (Dickie, Kerr et al. 1987a). Further studies are needed to understand processes in the water column. Moreover, data acquisition with classical sampling methods (e.g. plankton net) are usually top costly in time and money (Degnbol 2002). In a study on determining in-situ growth and mortality rates of zooplankton (Edwardsen, Zhou et al. 2002), the authors recommend the use of rapid sampling methods, such as automated optical or acoustical instruments, to limit the time scale mismatch. The use of LOPC is favoured for its simplicity and fastness to extract data from the water column.

Uses of rapid sampling methods are of interest for operational oceanography. Several sectors are concerned with using near real-time ocean data (remote sensing and in-situ data) in

particular the fishing industry. Indeed, there is a need of information (both physical and biological) on the ocean in order to efficiently harvest marine stocks (Le Traon, Rienecker et al. 1999). Furthermore, as explained above maintaining sustainable fisheries is also a growing concern. The Bay of Biscay benefits from an operational scheme that includes systematic sampling, use of real-time data acquisition instruments (e.g. CTD for hydrological variables) and a center for evaluation, stocking and transmission of collected data. Situated in IFREMER center of Brest (France), CORIOLIS is a structure collecting physical data from IFREMER cruises and autonomous buoys. CORIOLIS center transmits data to operational model such as MERCATOR model (Loaec, Carval et al. 1999). In the Bay of Biscay, this structure should allow to use the LOPC in an operational way, appropriate to ecosystem approach based on fisheries. On the other hand, LOPC data give scientists a base to study plankton community.

The ecosystem of the Bay of Biscay has been studied in hydrology (temperature, salinity, currents etc...) (Koutsikopoulos and Le Cann 1996) and in fish biology by description of fish spawning areas (Motos, Uriarte et al. 1996; Planque, Bellier et al. 2004). These studies help at the management of the Bay of Biscay fisheries, to identify areas of particular physics or biology. Moreover, both have already been related together, showing that there are multiple ways to describe the Bay of Biscay ecosystem in an approach based on fisheries (Borja, Uriarte et al. 1996; Motos, Uriarte et al. 1996; Planque, Bellier et al. 2004). Planktonic community areas derived from LOPC data can be well related geographically to previous areas derived from hydrological or biological data. This emphasises a strong argument for the use of plankton data in an ecosystem approach.

Coastal areas are represented by community states 1 and 2, as well as by river plume freshwater influence, which shows low salinity at surface, strong vertical gradients because of the intense warming up during spring and low depths (Motos, Uriarte et al. 1996). Furthermore, coastal areas are also remarkable to high egg densities (Figure 8a,b,c,d) and are known to be anchovy spawning areas which are mainly located in the river plumes of south of the Bay of Biscay (Fig. 8a,b) (Motos, Uriarte et al. 1996).

The South offshore area is represented by community structure 4. This area is not well identified by hydrological data. Studies have not established an obvious hydrological pattern (Koutsikopoulos and Le Cann 1996; Motos, Uriarte et al. 1996; Planque, Bellier et al. 2004). However, high egg densities have been found in this area (Fig. 8a,b,c,d). Indeed, (Motos,

Uriarte et al. 1996) reports that the spatial evolution of anchovy spawning starts from the coastal area in April and disperse afterwards to the West.

The North offshore area is represented by community state 3. In this area (Koutsikopoulos and Le Cann 1996) reports the presence of the “cold pool” as “a relatively
5 homogeneous cold water mass (temperature never reaches 12°C) extending from southern Brittany down to the latitude of the Gironde estuary”. Moreover, in this area influenced by the “cold pool” the presence of cold water mass is unfavourable to fish spawning (Planque, Bellier et al. 2004). But for the both studied years, the “cold pool” is located in more coastal areas (Planque, pers. comm.). Nevertheless, the presence of community structure 3 goes with
10 low egg densities for both sardine and anchovy (Figure 6c and 8a, b, c, d).

Community structure 1 and 2 areas remain generally constant in space and time in both years (Fig. 7a,b) whereas planktonic community structure 3 and 4 are more unstable, notably on shelf break area (Figure 7a,b). The shelf break is described as shelf edge front (Motos, Uriarte et al. 1996) between shelf waters and more cooler oceanic water.
15 Furthermore, (Koutsikopoulos and Le Cann 1996) reports the presence of slope currents in this area, showing evidence of a mesoscale oceanographic feature. Variations of speed and locations (Koutsikopoulos and Le Cann 1996) of these features may induce the planktonic community state to be very unstable in this area.

Conclusion

20 Currently, only hydrological variables are recorded by a CTD device during Pelgas cruises and these are sent to the data center “Coriolis” which is an operational center of qualification, stocking and assimilation for hydrological data within the operational model Mercator. The use of an in-situ automated instrument as the LOPC also permits measurements on the
25 plankton community without having to treat samples in a laboratory. In an operational way, recorded data could be available in real time. The present need of ecological descriptors for fisheries management and existence of adapted means of sampling and communication should make use of the LOPC (as well as other automated measurements instruments), for planktonic data, a constant in assessment campaigns. Moreover, use of LOPC data allowed us to
30 commence our study on planktonic oceanography in the Bay of Biscay. Thus, establishing an overall view of the planktonic structure is possible. Furthermore, the fact that planktonic areas in the Bay of Biscay correspond to hydrographic and fish spawning areas shows the relevance of planktonic descriptors. However, we must not target that these are only community

descriptors, the way to build robust indicators of planktonic community structure and state is still an area of further exploration.

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Figure Legends

15

Figure 1. Spatial location of LOPC stations (full circle) and CUFES sapling midpoints (dots) during the cruise PELGAS 2005. The location of Loire and Gironde's estuary as well as the "Pertuis charentais" and the shelf break are indicated. Bathymetry for 20, (0, 100, 200, 500 and 1000m isobaths is also indicated.

20 **Figures 2.** a) Example of cumulative frequency distribution depending on depth for biomass (full line) and abundance (dotted line). Locations of different descriptor values are indicated on both distributions, such as value for 50% of cumulative frequency (valA 50% and valB 50%) and value of depth difference between 20 and 80% of cumulative frequency (valA 20-80% and valB 20-80%). b) Example of Pareto distribution (points) and her adjustment (full

25 line) under values of c, K and D from Pareto model II.

Figures 3. a) Representation of original descriptors in the correlation circle for the first two components of the PCA for the data set from the both years 2004 and 2005. b) Same representation with data set from 2004. c) Same representation for the data set from 2005.

30 **Figures 4.** The spatial distribution of 2004 (left) and 2005 (right) for the selected planktonic variables by the Escouffier's method. a,b) logarithm of biomass for the both years (g.m^{-2}). c,d) depth difference of cumulative frequency between 20 and 80% of total biomass for the both years (m). e,f) Pielou's index for profile homogeneity for the both years. g,h) D parameter from the Pareto model II for the both years.

35 **Figures 5.** Box and whisker plots for the data set of selected planktonic variables from the both years 2004 and 2005. Each graph represents a group individualised by the clustering method. a) group 1. b) group 2. c) group 3. d) group 4. Mean value of the global data set is represented by a dotted line.

Figures 6. Box and whisker plots for the data set of hydrological variables from the both years 2004 and 2005. Each graph represents a group individualised by the clustering method on planktonic values. a) group 1. b) group 2. c) group 3. d) group 4. Mean value of the global data set is represented by a dotted line.

5 **Figures 7.** The spatial representation of groups in the Bay of Biscay. Group 1 is represented with asterisks (*), group 2 is represented with circles (o), group 3 is represented with squares (□), group 4 is represented with pentagrams (★). a) May 2004. b) May 2005

Figures 8. The spatial distribution of egg densities (nbr of egg.10m⁻³) in the Bay of Biscay for both years. a) anchovy in 2004. b) anchovy in 2005. c) sardine in 2004. d) sardine in 2005

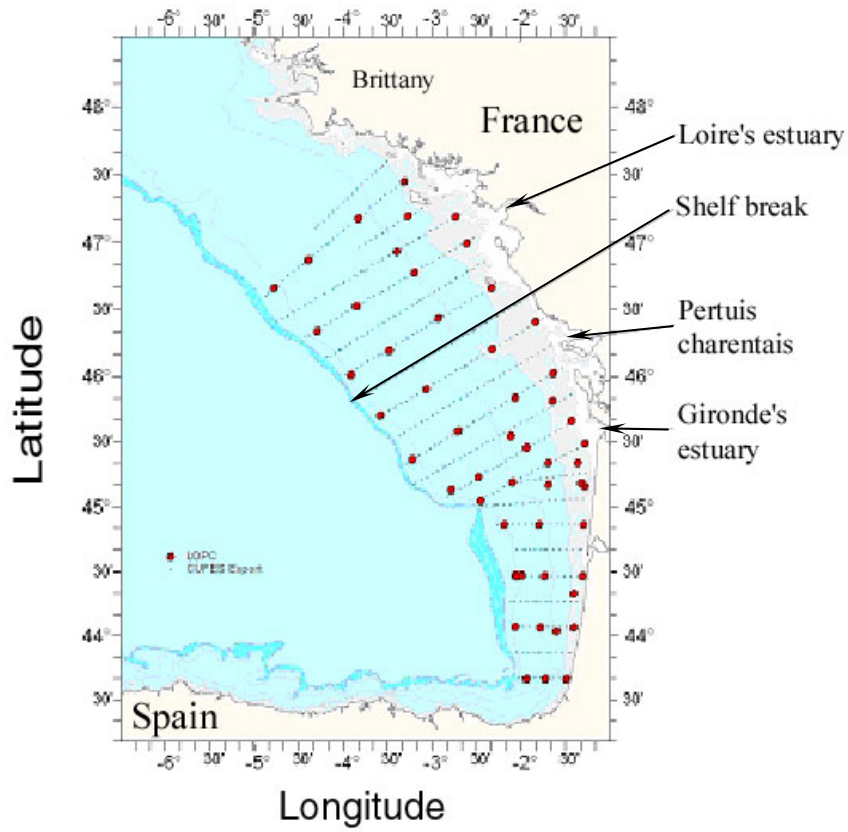


Figure 1

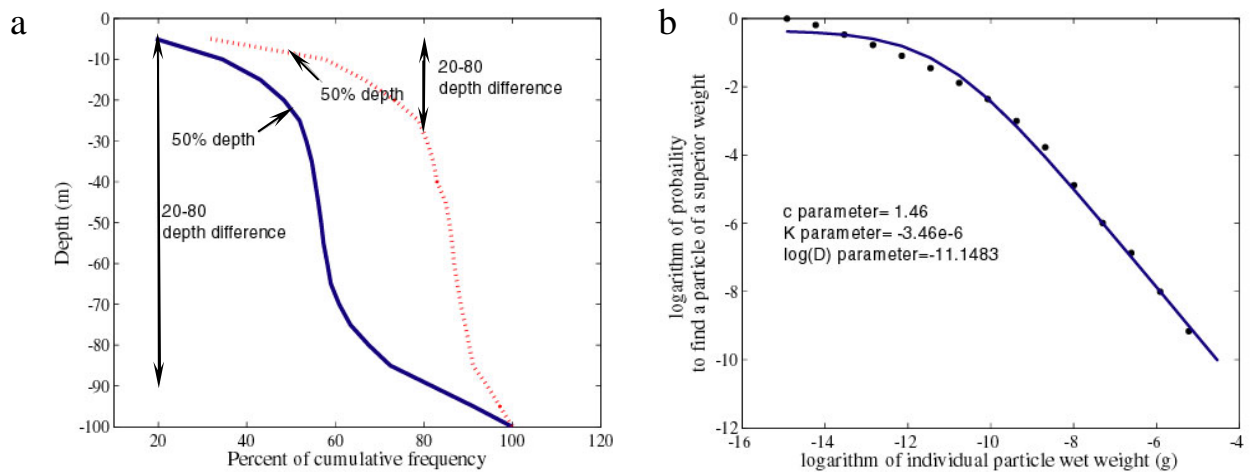


Figure 2

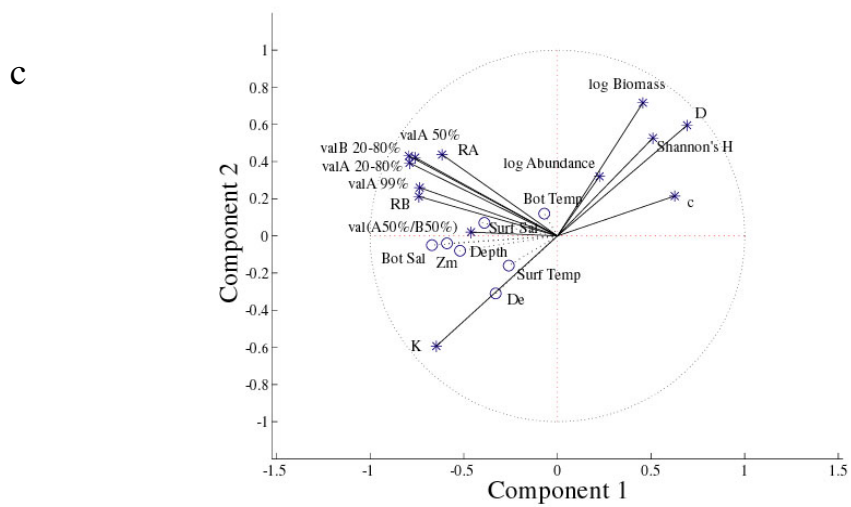
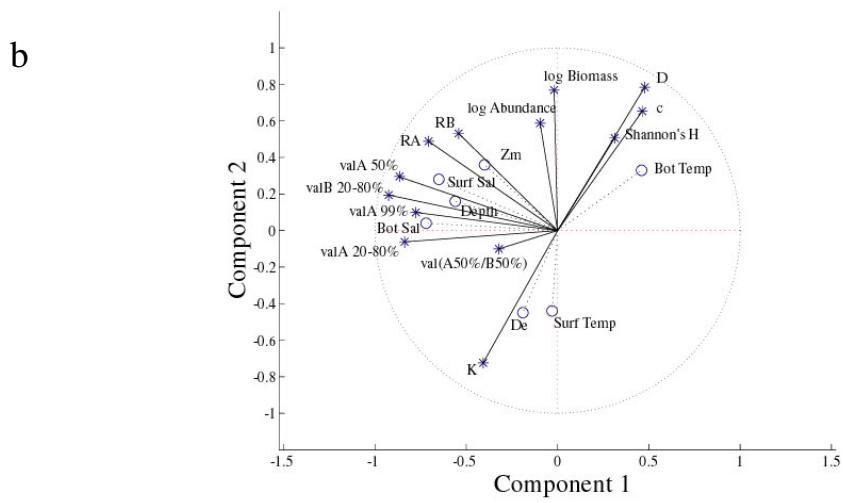
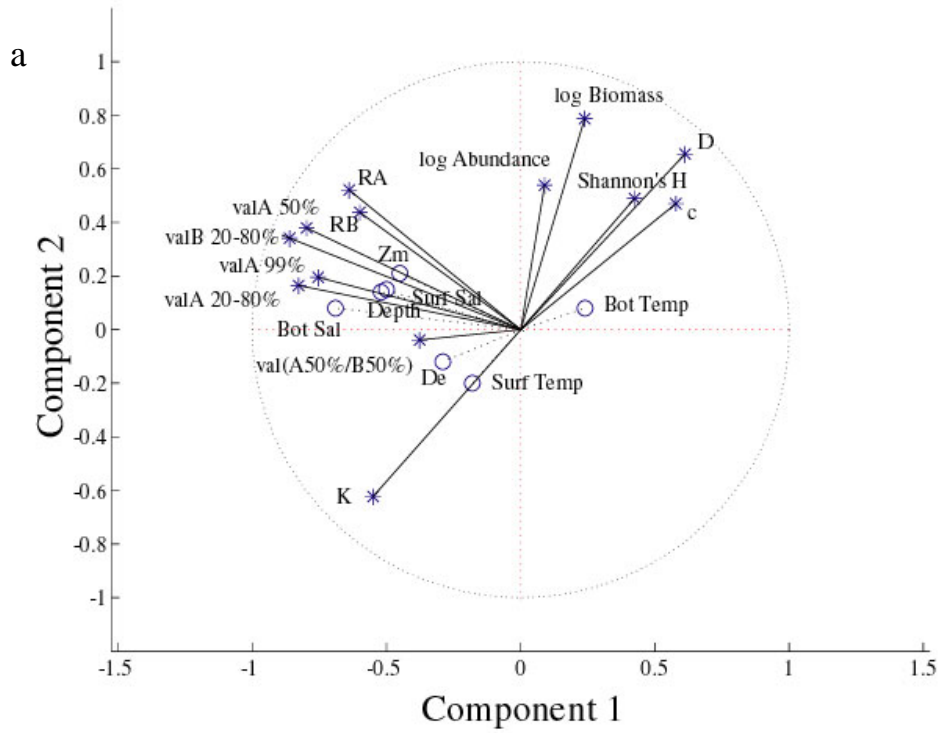


Figure 3

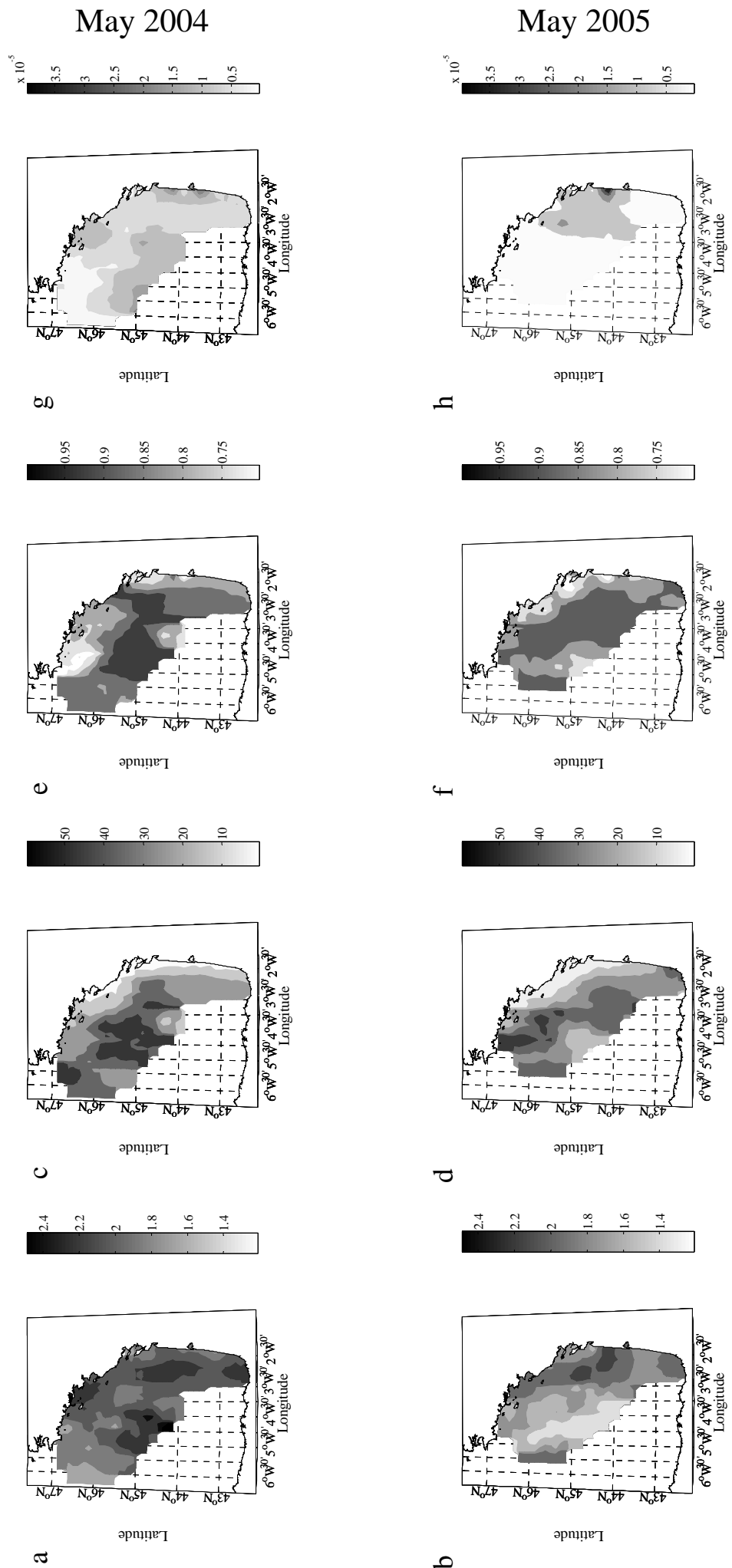


Figure 4

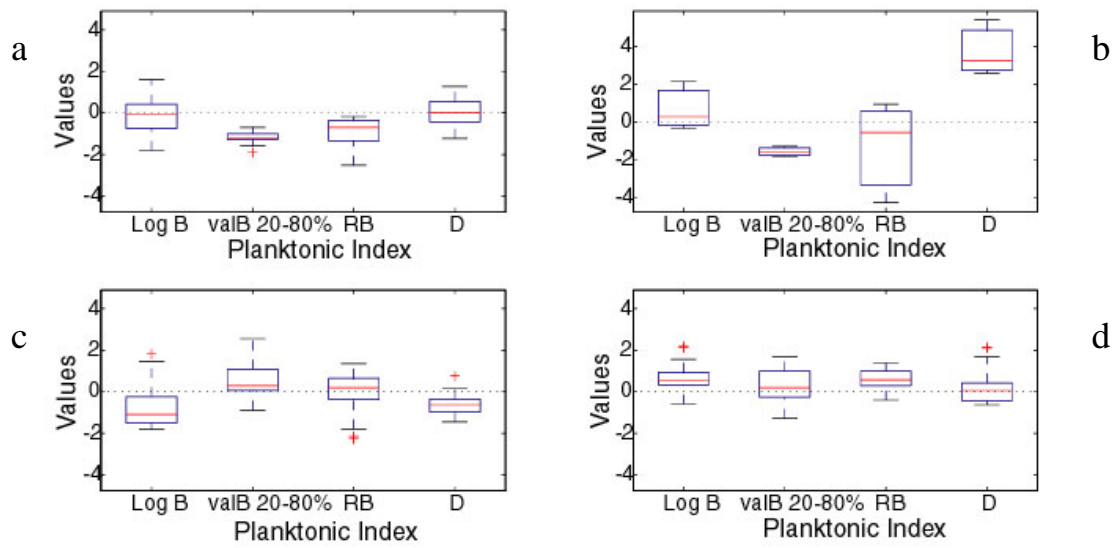


Figure 5

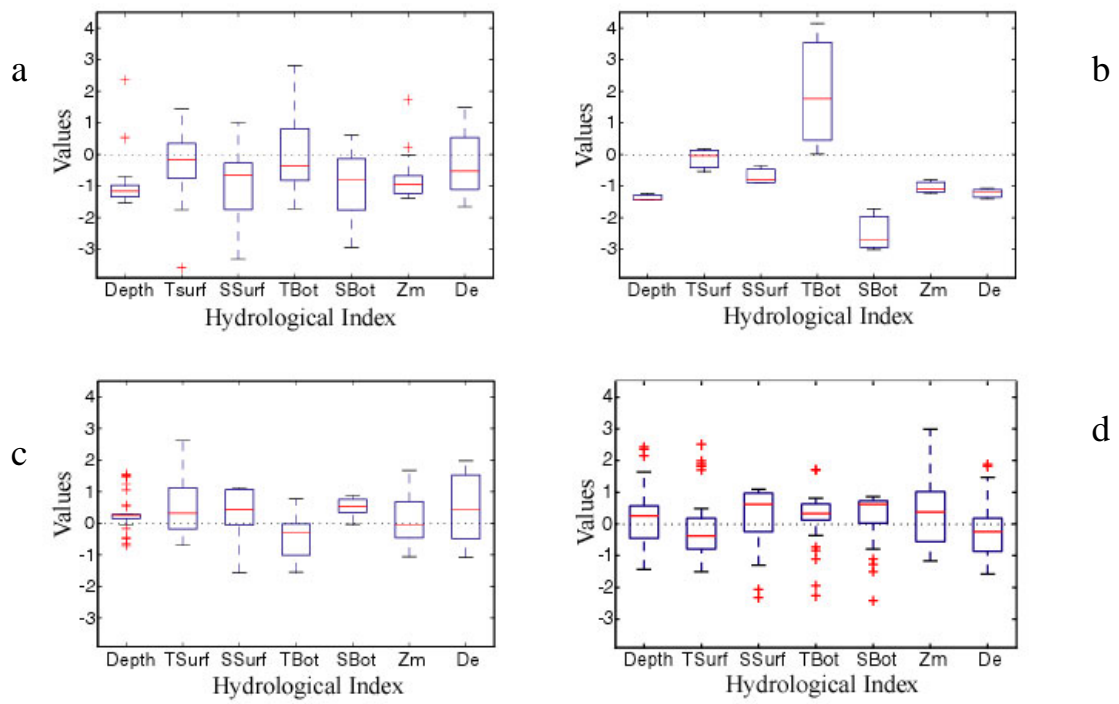


Figure 6

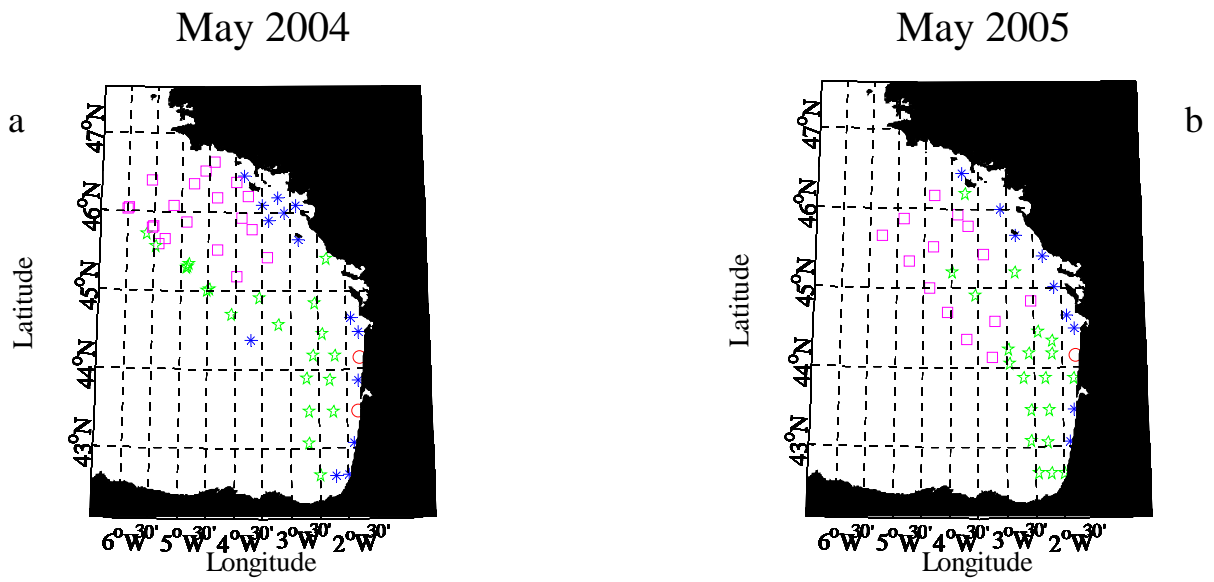


Figure 7

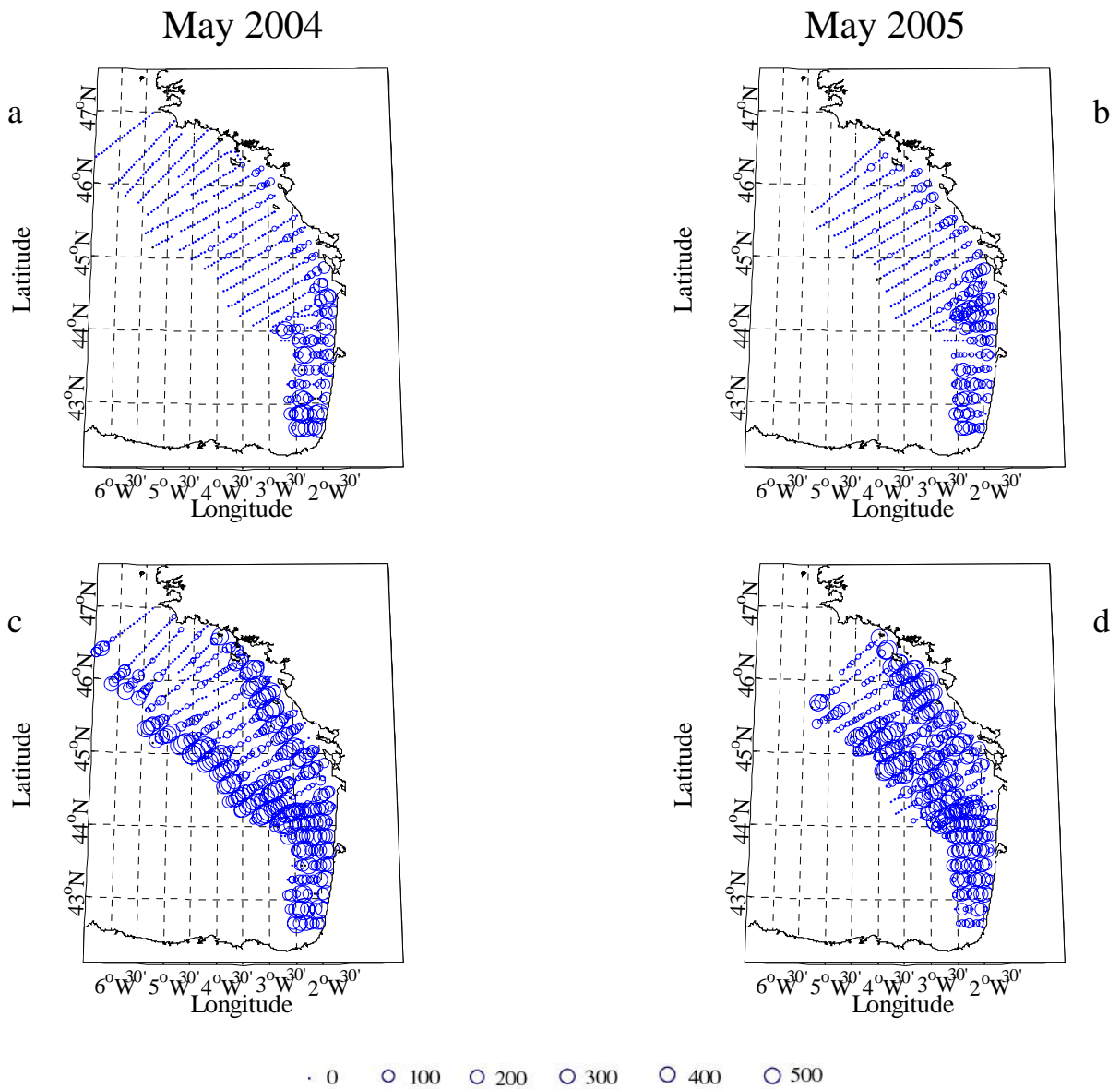


Figure 8