RECOPESCA: A NEW EXAMPLE OF PARTICIPATIVE APPROACH TO COLLECT IN-SITU ENVIRONMENTAL AND FISHERIES DATA

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Abstract

Faced to the lack of data to assess precisely the spatial distribution of catches and fishing effort and for the environmental characterization of the fishing area, Ifremer has implemented since 2005 a new project, Recopesca. It consists in fitting out a sample of voluntary fishing vessels with sensors recording data on fishing effort (and at mid-terms catches) and physical parameters such as temperature or salinity. Recopesca aims at setting up a network of sensors, for scientific purposes, to collect data and improve resources assessment and diagnostics on fisheries, and environmental data required for ecosystem-based management initiatives.

The challenge was to develop sensors with no trouble for the fishermen, tough enough to be fixed up on fishing gears, self powered and autonomous. Insofar as the sample of targeted vessels intends to be representative of all the metiers and fleets, the sensors are modular and scalable to collect new data.

Different sensors have been implemented: (i) a temperature-salinity sensor, able to record physical parameters, depth and duration of immersion, for passive and active gears, and (ii) a specific sensor to record number or length of passive gears. A GPS monitors the position of the vessels and the temperature or salinity profiles and series. Each sensor is equipped with a radio device transferring the data to a receiver on-board, called “concentrator” that sends the data to Ifremer central databases by GPRS. An anti-rolling weigh-scale has been developed and is currently on test to record catches per species and fishing operation. The presentation will show the first data and results of this participative approach.

Introduction

Even if different countries have implemented Fisheries Information System for a few years, especially in relation with the EU Data Collection Regulation (Council regulation (EC) No 1543/2000; Commission regulation (EC) No 1639/2001 modified by Commission regulation (EC) N° 1581/2004), the lack of reliable data to assess precisely the catches and fishing effort is undeniable. The evaluation of fishing effort and catches and their spatial distribution are fundamental to assess the states of exploited resources and to make a diagnosis on fisheries. Data currently available for French fisheries comes mainly from the fishermen’s declaration (log-books), at the scale of ICES statistical rectangles (30 minutes latitude, 1 degree longitude). This scale is inadequate for most research projects and a fine analysis of the fishing sector. Moreover, the coverage of these data is often partial and their reliability sometimes hard to appreciate.

Moreover, the local environmental conditions and their variability, especially on the continental shelf, are often little-sampled, especially because of the specific conditions: low depth, significant current (especially tidal current), various human activities (professional and recreational) making vulnerable the measure devices. Thus, even for basic parameters such as temperature or salinity, most of the available measures are limited to the oceanographic campaigns.

Face to this lack of data, especially on areas which are precisely fishing sectors, Ifremer has been implemented since 2005 a new project, Recopesca, consisting in fitting out a sample of voluntary fishing vessels with sensors recording data on fishing effort (and at mid-terms catches) and physical parameters such as temperature or salinity. Recopesca aims at setting up a network of sensors, for scientific purposes, to collect data allowing improving resources assessment and diagnostics on fisheries, and environmental data required for an ecosystem approach to fisheries (EAF) or to feed oceanographic models e.g. for circulation of water masses. Specific sensors are implemented on the fishing gears and aboard a sample of vessels representative of the whole fishing fleets.

Recopesca is a project of national scale, including overseas island and is a concrete achievement of participative approach: scientists and fishermen team up to give to the voluntary fishermen a role of scientific observer. Recopesca provides an innovative tool to collect data, especially through the integrated multidisciplinarity. The collected data can be used by both fisheries scientists and physicists, who will have information for areas non- or little-accessible till now.

Sensors fitted to conditions and constraints aboard fishing vessels

The existence of the project involved the development of sensors and measure devices. The challenge was to develop devices tough enough to be fixed up on fishing gears, self powered, autonomous, affordable and able to run without any intervention of the fisherman neither trouble for the fishing activity. Because the sample of targeted vessels intends to be representative of all the metiers and fleets, the sensors are modular and scalable to collect new data. Different sensors have been developed and implemented onboard.

A specific sensor allows to record physical parameters at the bottom and along the water column, pressure (and thus depth) and duration of immersion. A first version included only temperature sensor (Figure 1a), a second one has been developed to measure salinity (Figure 1b). Autonomous and small-size, he is tough enough to be fixed up on all types of fishing gears, active (trawls, dredges) or passive (nets, long-lines, pots). The sensor records the parameters along each stage of the fishing operation (descent, fishing action and raise of the gear) with a frequency configurable according to the gears and their carrying out. The device allows building temperature or salinity series and profiles. The maximum immersion depth varies from 300 to 1200 meters, depending on the version. In addition to the environmental parameters, the measure of duration of immersion is a good indicator for the fishing time of the gear, active or passive.

Figure 1a
Temperature-depth sensor fixed on a net

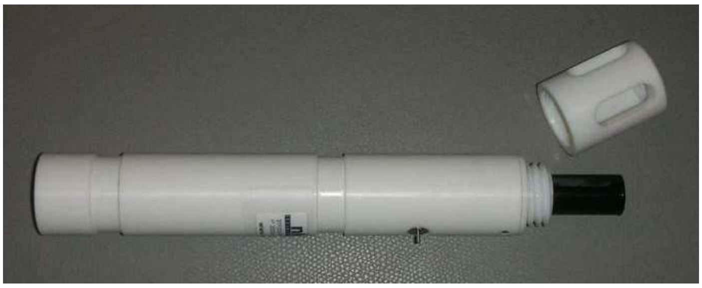


Figure 1b
Temperature-conductivity-depth sensor

Another specific sensor, called the “turns-counter”, has been specified to equip the hauler of passive gear (gill-nets, pots or lines). Fixed on the rotation axis, the sensor records the number of turns, from which is deduced the number or length of passive gears hauled at each fishing operation. As well as the other sensors, this device is autonomous and small-size (Figure 2). This sensor is currently on test on a netter vessel.

Figure 2

The “turns-counter” fixed in a gill-net hauler

In order to know the position of the physical measures and follow the course and areas of fishing activity of the vessels, a GPS is implemented on-board and tracks the location of a given vessel at configurable and regular frequency (most of the time, a quarter of an hour). The knowledge of its speed allows moreover characterizing approximately the different actions of a fishing trip (on fishing, on route…).

Furthermore, in the European Community regulation framework, vessels over 15 meters overall length are concerned by the Vessel Monitoring System (VMS): electronic devices, or "blue boxes", are installed on board vessels and automatically send data to a land base station and the appropriate monitoring centre (CROSS ETEL in France). Recopesca solicits the fishermen's agreement to have an access to their VMS data in order to validate the Recopesca GPS data by cross-checking.

Finally, a proposal of both scientists and fishermen was to develop and install an "anti-rolling" weigh-scale onboard (Figure 3). Recording the catches per species and fishing operation, and in association with the other Recopesca sensors, this device allows linking fishing effort and catches at the finest scale of the fishing operation. The first weigh-scales have been implemented aboard voluntary vessels at the end of 2009. First results will be available later in the year 2010.

Figure 3

Recopesca weigh-scale (pan and command module)

Between the last years, the developments and tests carried out with around thirty voluntary vessels allowed analyzing mechanic tolerance of the sensors, improving their resistance, validating their autonomy and their maintenance needs and optimizing their placement onboard and on the gears. During the period, the sensors have considerably evolved, especially to improve the quality and reliability of data, take into account the autonomy constraints and give more security and durability in their use. Furthermore, each sensor has been equipped with a radio device transferring the data to a receiver on-board, called "concentrator" (containing the GPS device) that sends the data to Ifremer central databases (Figure 4). The automatic transmission of the data at land is done by GPRS, once the vessel is within range of GPRS network, without any human intervention. This approach (quasi real time) has been chosen in order to track quickly dysfunction, interruption or loss of sensors.

Figure 4: "Concentrator" of data onboard

Regarding the computing infrastructure, Recopesca relies on existing operational data centers:

- Coriolis, for operational oceanography
- The Fisheries Information System, FIS (Leblond et al., 2008) of Ifremer and its database Harmonie

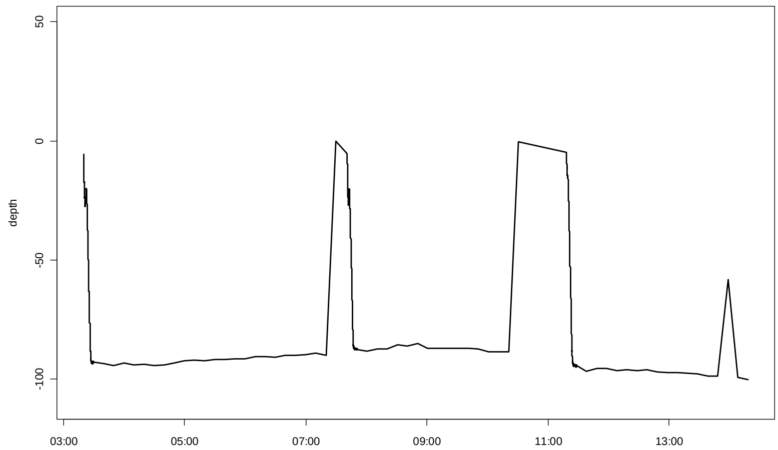
Once the data emitted by the "concentrator" is received by Ifremer, the physical data (temperature and salinity series and profiles) are stored in the *Coriolis* database. As for the fisheries data (per fishing operation), they are stored in the *Harmonie* database.

This management of data by the thematic data centers ensures quality control and dissemination of data to the users. Confidentiality of individual datasets (especially fishing data) is also guaranteed.

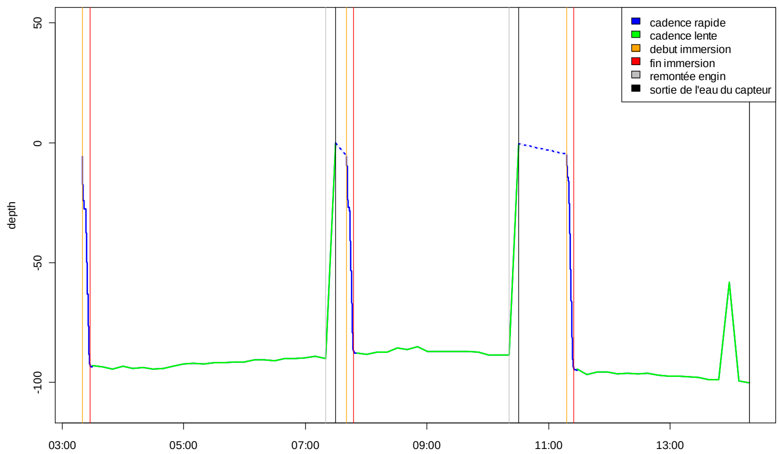
A new source of objective fisheries data

The fisheries data (activity, fishing effort and catches), resulting from direct measures, and not from fishermen's declarations or estimation by survey, supply the Fisheries Information System of Ifremer. However, information from sensors and GPS can not be used directly and has to be processed to become usable. Two generic algorithms have been developed:

- The first one aims to define/rebuild the fishing trip of a given vessel, on the basis of GPS positions (generally with a frequency of 15 minutes) or VMS positions (1 hour). Especially, the date and port of the beginning and the end of the fishing trip are identified, on the basis of the distance from the nearest port and the speed of the vessel. Moreover, the algorithm allows identifying the fishing and steaming period of the vessel, on the basis of the speed between two positions and the following assumption: if the average speed between 2 positions is less than 4.5 knots, the vessel is fishing. Otherwise, it is steaming (Laurans and Leblond, 2009).
- The second algorithm processes the data of the physical sensors implemented on fishing gears, and especially the depth and duration of immersion, and allows rebuilding the different fishing operation of a trip. It analyzes the depth profile of the sensor and reconstructs the key stages of each fishing operation: launching of the gear, arrival at the bottom, beginning of the rise and end of the operation (figure 5).



(a)



(b)

Figure 5: From depth profiles (a) to fishing operations (b): identification of fishing operations (Example of a trawler). An algorithm processes the depth data, collected by a sensor fixed on the trawl, to identify the key stages of the fishing operation: launching of the gear (orange line), arrival at the bottom (red line), beginning of the rise (grey line), and end of the operation (black line).

An application has been developed to visualize and validate the processing of the data from both algorithms. It produces a graph, for each Recopesca fishing trip, showing the result of the processing (limits of the fishing trip and operations) and the speed recorded by the GPS and VMS (figure 6).

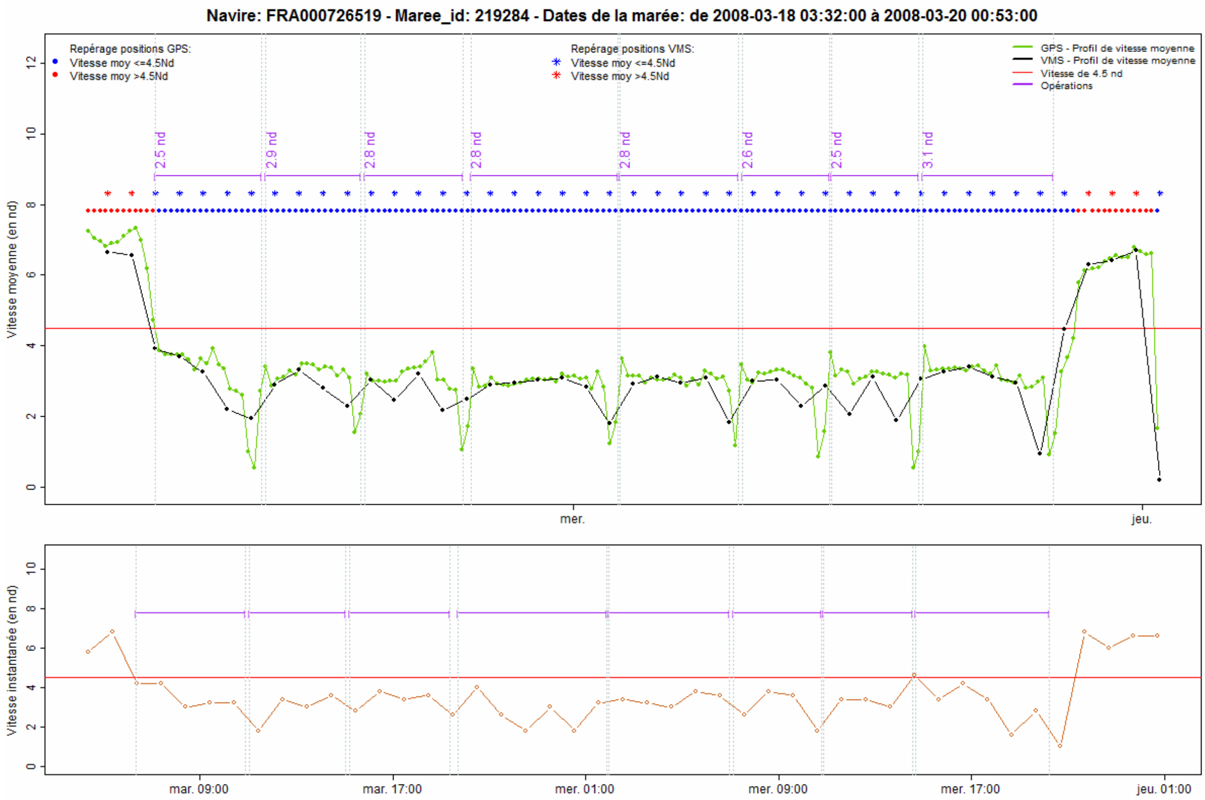


Figure 6

Example of graphs produced by the Recopesca application for a trawler fishing trip between March 18 and 20. The top graph shows the average speed profile calculated on the basis of GPS positions (*green curve*) and average speed profile from VMS positions (available only for vessels over 15m, *black curve*). The *red line* indicates the threshold of 4.5 knots used to distinguish fishing and steaming periods. The dates of GPS and VMS recordings are represented respectively by dots and asterisks: *blue* when the average speed between two points is less than 4.5 knots, and *red* when the average speed is more than 4.5 knots. The purple segments indicate fishing operations, based on the deep profile of sensors positioned on the gear. Above each purple segment is shown the average speed of the vessel when the gear is at the bottom. The bottom graph shows the profile of instantaneous speed (provided by the VMS only) and includes the purple segments of fishing operations.

First conclusions of the analysis show that fishing operations identified on the basis of the sensors are consistent with the observations of average speeds calculated on GPS or VMS positions. The 15 minutes positions (GPS) allow a finest representation of fishing operation than VMS data (1 hour), the tendency of the curve being very close to the course of operations deduced form depth sensors. Furthermore, the average speeds are more representative of the fishing activity than instantaneous speed (provided only by the VMS system). Finally, the assumption of 4.5 knots, historically based on the bottom trawlers behaviour, seems to be a good compromise for all the gears that have been equipped (nets, pots, dredges and trawls).

Recopesca can provide an objective measure of activity and fishing effort, especially for vessels less 15 meters overall length or coastal vessels, part of the fleet generally poorly known (in particular because of a lighter legal framework). Especially, it provides:

- A comprehensive and detailed view of all the fishing trips realized by the vessels.
- A map of the path traveled by the ship during the trip (figure 7) and the precise location of the fishing sector exploited by the vessel.
- For each trip, the identification and description of all the fishing operations: duration, location, depth, environmental conditions such as temperature and salinity (table 1).

- A fine estimation of the fishing effort by fishing sector (figure 8).

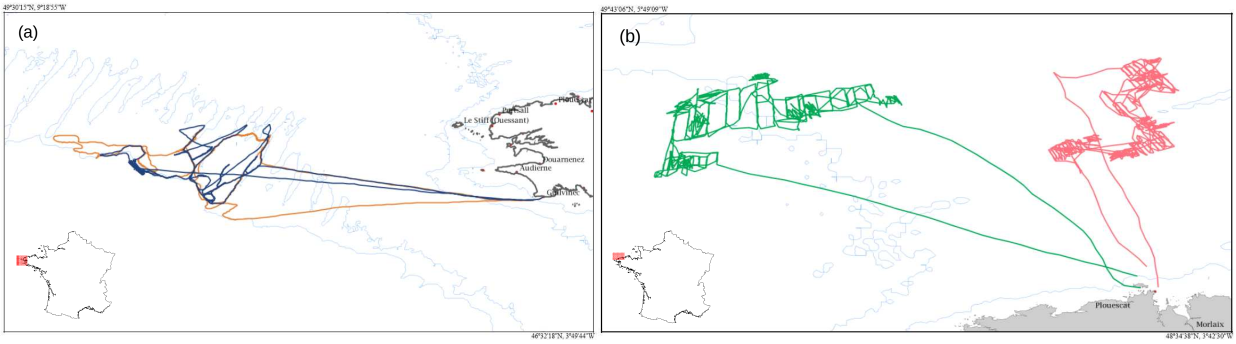


Figure 7

Examples of path recorded by Recopesca GPS. (a) Trawler fishing trips from South Brittany.
(b) Potter fishing trips from North Brittany. (Coastlines: SHOM©, NOAA / NGDC©; Bathymetry: GEBCO ©).

#	General characteristics of the fishing trips						Average parameters at the bottom				
	Beginning of the fishing operation		End (Hauling of the trawl)		Duration (hh:mm)	Distance (naut. miles)	Duration (hh:mm)	Speed (knots)	Depth (m)	Temp. (°C)	Salinity (PSU)
	Date	Position	Date	Position							
1	26/04 9:28	48.18°N, 6.92°W	26/04 15:28	48.34°N, 6.97°W	06:00	13.45	05:33	2.2	152	11	35.7
2	26/04 15:32	48.34°N, 6.97°W	26/04 21:22	48.32°N, 7.28°W	05:50	14.03	05:21	2.4	154	10.9	35.6
3	27/04 03:27	48.16°N, 7.43°W	27/04 9:28	48.07°N, 7.54°W	06:01	13.63	05:30	2.3	162	11	35.7

Table 1

Examples of parameters of fishing operations obtained from Recopesca sensors implemented on a trawler.

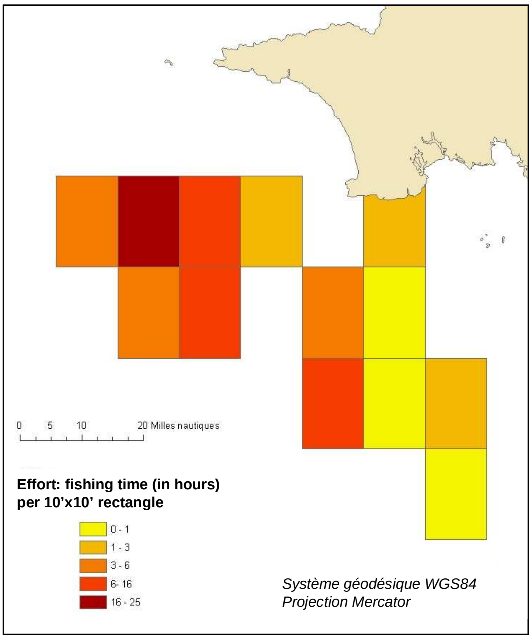


Figure 8

Spatial distribution (10' latitude x10' longitude rectangle) of fishing time
of a Bay of Biscay nephrops trawler during May 2008.

A description of the whole water column, from the surface to the bottom

The physical environmental data of Recopesca are available in *Coriolis* which supplies oceanographic research, operational oceanography tools or hydrodynamics models. The current activity of *Coriolis* represents around 350.000 stations (profiles) per year. The perspective of Recopesca, with a 400 vessels sample, could be more than 200.000 further stations. Since 2008, more than 8000 profiles of temperature and/or salinity recorded in the Atlantic Ocean by around 15 vessels have been loaded into *Coriolis*.

Figure 9 presents the location of CTD casts obtained during 2009 specifically in the Bay of Biscay. Over the whole year, 1706 casts have been collected, they are distributed as follows: respectively 257, 378, 559 and 512 in winter, spring, summer and autumn (namely January-March, April-June, July-September, and October-December). This total has been obtained with 7 fishing vessels equipped. We benefit of a good spatial cover over limited areas, ie; the offshore coastal water located South West and South of Brittany, the slope area near 48°N and South of the Gironde estuary. In these areas, a nearly diurnal CTD cast is available. This high frequency at the seasonal scale allows a good description off the annual variability over the shelf.

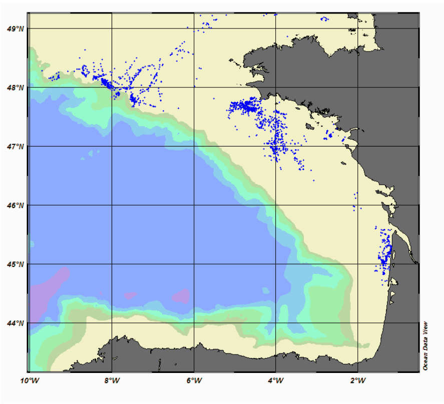


Figure 9

Location of CTD casts obtained during 2009 in the Bay of Biscay

As an example, figures 10 and 11 show time evolution of temperature from surface to bottom. Each vertical line is a cast. Localisation of the casts is shown on the map. Temperature variability at seasonal scale (figure 10) and interannual scale (figure 11) are illustrated:

Temperature at seasonal scale (Figure 10)

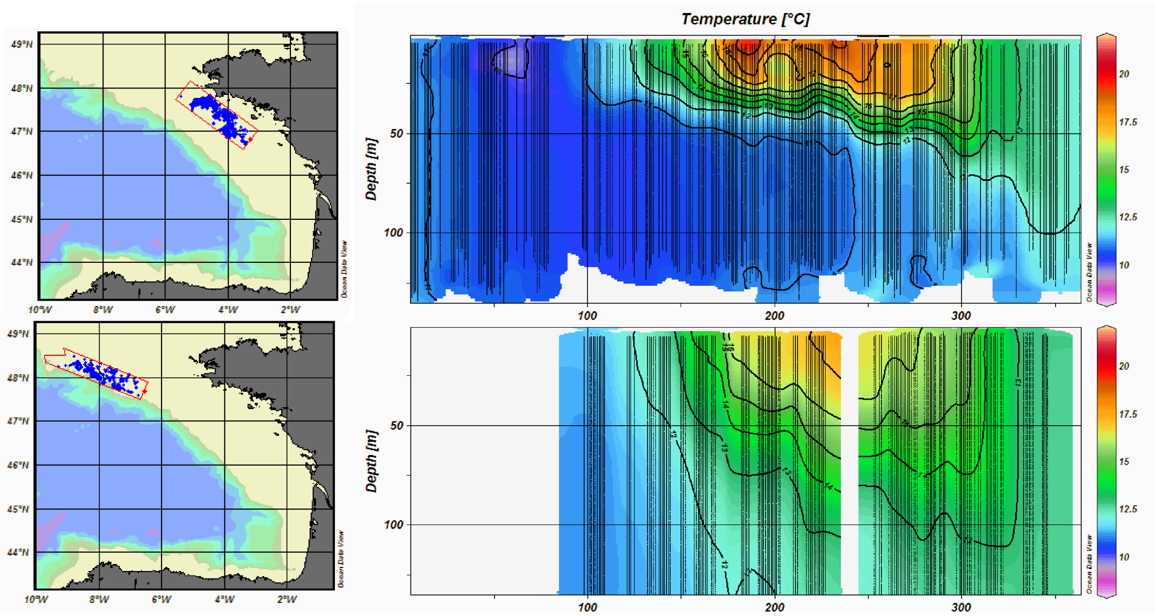


Figure 10

Evolution of temperature in 2 areas over the Bay of Biscay shelf during 2009.
Location of CTD casts is shown on the maps located on the left.

Over the shelf, the stratification begins at the end of March. Maximum temperature occurs in summer (from end of June to end of August) and reaches 19℃ at 1m below the surface. A t the end of August, surface temperature decreases slowly to 12℃ at the end of the year. This cooling reduces the density differences between surface and bottom layers. Meanwhile, autumnal episodic strong winds induce an enhancement of the vertical mixing. As a result, the thermocline deepens: the 12℃ isotherm located 25m below the surface in May reaches 100m at mid December. Whereas bottom temperature is nearly constant at 10.4-10.8℃ from January to September, it slowly increases to a maximum at 11.9℃ by mid December. Near the shelf break, temperature distribution exhibits a different pattern. The heating of surface layer begins in March but is distributed of a thicker layer. As a result, the maximum temperature barely reaches 17.6 ℃ in August. The thermocline is much less pronounced than over the shelf, denoting a greater mixing in this area. This mixing is induced by internal tides which are known to be of great amplitude in this area (Pingree *et al*, 1986).

Inter-annual variability of bottom temperature (Figure 11)

Another advantage of that network is that daily to weekly observations in a limited area allows a continuous monitoring of water properties which are not accessible by satellite observations, namely non surface temperature or salinity. Figure11 illustrates the differences between the summer 2008 and 2009 over the shelf in south Brittany. 400 CTD casts have been collected over the shelf in summer 2008 and 230 during summer 2009. Some interesting features are visible: whereas the depth of the thermocline is nearly the same, the bottom temperatures differ. They vary in the range 10.65℃-10.8℃ in 2009, whe reas it was between 11.3℃ to 11.7℃ in 2008. This inter-annual variabi lity of bottom temperature has been previously suspected and described with few campaigns (Puillat *et al*, 2004). The Recopesca data allow a more robust description because the evolution of bottom temperature is described throughout the year and not only during specific (but rare) field trip.

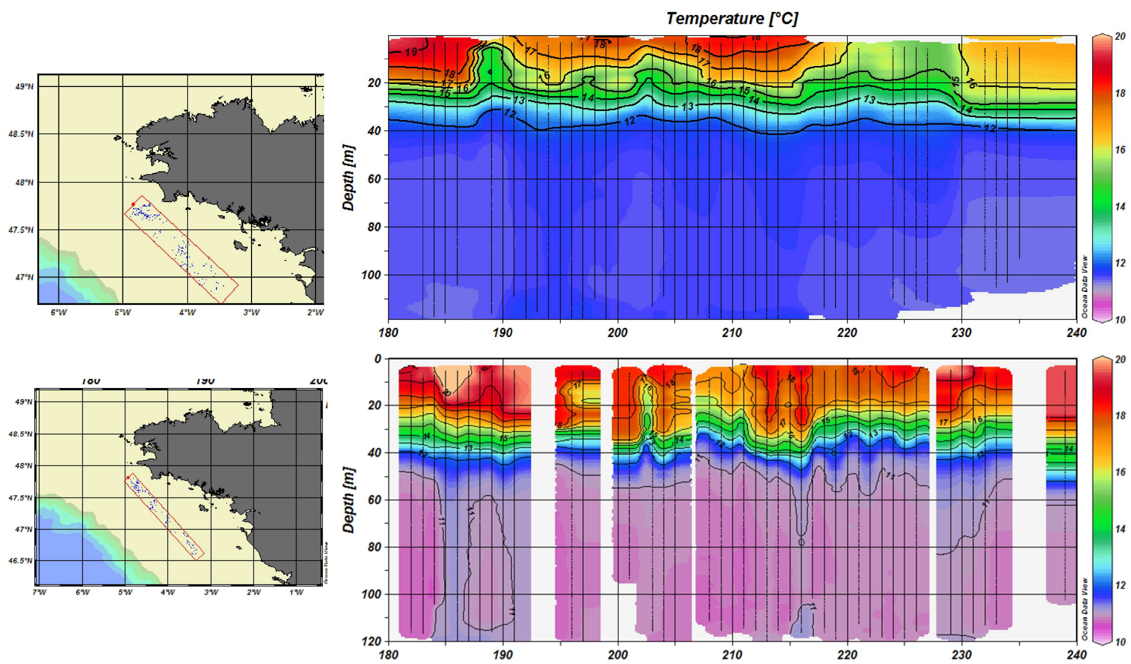


Figure 11

Evolution of temperature during summer 2008 (top panel) and summer 2009 (bottom panel)

Conclusion

Recopesca constitutes an innovative tool to collect data and contributes to supply the existing information systems. It must be considered as a means and not as a goal in itself.

The fisheries data (activity, fishing effort and catches), resulting from direct measures, and not from fishermen's declarations or estimation by survey, supply the Fisheries Information System of Ifremer. Especially, Recopesca provides an objective measure of activity and fishing effort for vessels less 15 meters overall length or coastal vessels, part of the fleet generally poorly known (especially because of a lighter legal framework). Through the FIS (Fisheries Information System), the Recopesca fisheries data can contribute to the whole fisheries research projects, especially in the framework of an ecosystem approach to fisheries, and for fishing stock assessments. They are complementary with log-books and VMS data.

Regarding physical data, from the two years experience of Recopesca data, some first conclusions can be drawn:

- The Recopesca observations are restricted to limited regions with a good temporal frequency. It allows a seasonal to annual monitory depending of fishing activities of the basic hydrological parameter
- It gives a description of the whole water column, from the surface to the bottom. It allows a first monitoring of the bottom temperature which is of great importance for the analysis of the benthic ecosystem and the repartition of demersal and benthic fishes.

The main point to be improved now is the salinity measurement which is not fully satisfactory. So far, the precision which is 0.2 PSU is suspected to be rarely reached (the precision of temperature is less than 0.05℃). However, the validation of salinity is a difficult task because of the great variability of salinity on the shelf in the Bay of Biscay due to large inputs of fresh water and strong inter-annual variability. Some crude qualifications based on the range of reasonable variations of salinity (from 25 to 35.6 PSU) have leaded us to reject a lot of measurements. A more severe maintenance is required to bring more confidence on the observations.

Recopesca has begun the deployment of an operational and autonomous sensors network during the last two years. In early 2009, approximately 30 vessels, divided on the Atlantic coast and the Caribbean Islands, are equipped. This panel may seem low, but the deployment has been moderate while computer and technological development are completed. Now that an operational and autonomous system is available, allowing to provide data to data center and voluntary fishermen, the deployment is about to resume at an expected rate of 40 vessels per year. Recopesca aims to establish a network of 300 to 400 vessels, split along the French coasts. The deployment plan is built in accordance of the need of both fisheries scientist (a sample representative of the diversity of the fleets and the fishing metiers) and physical oceanographers. The mobilization of fishermen is carried out by the observers' network of the Fisheries Information System (FIS) of Ifremer.

Acknowledgements

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