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Location of the anchovy fishery (*Engraulis encrasicolus*) according to the fish distribution observed by acoustic surveys

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1. INTRODUCTION

A French anchovy fishery takes place in the Bay of Biscay all along the year from the Spanish border to the west end of Brittany. This fishery is essentially based on pelagic trawling carried out on the continental shelf. Each year, a migration of the fishery may be observed from the south of the area in spring to the north of the area in autumn. A database of this fishery is compiled and maintained since 1983 at Ifremer. Concurrently, scientific surveys are carried out each year in spring for an acoustic estimate of anchovy biomass. The log-books provide a geographical distribution of marketable anchovy while acoustic data provide the distribution of the whole biomass present on the platform.

In this paper, five years (1991, 1992, 1994, 1997 and 1998) of monthly catch reports are taken into account associated to 5 spring acoustic surveys for the same years. From these surveys, the distribution of all pelagic fish species is described and the related parameters are calculated according to presence area, mixed species area, aggregation patterns and several schools descriptors (positional, morphological and energetical).

The authors study the positioning of the fishery according to the distribution observed during the surveys and analyze the parameters that could lead the fishery according to fish location, multi-species communities and aggregation patterns. Finally they show the usefulness of direct scientific surveys to describe populations along time series in term of extent of geographic distribution, aggregation patterns and species associations compared with the picture provided by log-books when pelagic species are concerned.

Our objective is to make a first approach 1) to explore the possible relationship between fishery strategy (commercial catches), aggregation pattern and species association, 2) to analyse their respective evolution and 3) to explore the possible linkage between spatial distribution of anchovy and fishing strategy.

2. MATERIAL AND METHOD

2.1. data

Acoustic surveys

17 spring acoustic surveys have been done since 1983. The five surveys taken into account in this work are those from 1991, 1992, 1994, 1997 and 1998. Acoustic material used was an echosounder Ossian 1500 at 38 kHz. A total of 179 identification hauls have been done during the five surveys, averaging 36 hauls in each survey.

Fishery statistics

Records from log-books of the French anchovy fishery in the Bay of Biscay (zone VIII of ICES) are available from 1983 through 2002. In the first two years, catches are available only at the level of ICES divisions. After 1985, the proportion of records with a spatial resolution of a statistical square (0.5° latitude by 1° longitude) has been increasing progressively. Regarding time resolution, anchovy catches are grouped by commercial fishing trip, spanning from some days to one month (grouped fishing trips).

2.2. tools methods

Acoustic data

Acoustic data have been acquired and processed with Ifremer's *Movies+* software (Weil, et al. 1993). Samples have been digitized with a scale of about 5 m in the horizontal and 10 cm in the vertical. With the aid of identification hauls, the spatial distribution in terms of area covered by species have been determined, and also the species associations. School descriptors have been obtained by school echo integration function in *Movies+*. Finally an aggregation pattern factor, defined as the ratio between average number of schools by ESDU and the acoustic energy of the schools has been calculated. The maps of area coverage by species and their associations were constructed (Massé & Gerlotto, 2003). With selected schools descriptors, a series of plots were done aiming to show their average behaviour during years.

Fishery statistics

For each of the five years retained for the analysis a selection of records was made to compare with acoustic surveys data. The average landings by statistical square were calculated for the corresponding period of time (1 or 2 months) when the surveys were conducted. These monthly or bimonthly average catches were plotted into maps together with the anchovy distribution as estimated by acoustics and a polygon defining the survey area. Then, we counted the number of statistical squares with 1) anchovy commercial fishing, 2) anchovy presence during acoustic survey, and 3) coincidence of anchovy commercial fishing and anchovy presence during survey. These numbers, relative to the total number of statistical squares in the survey area (according to the polygon mentioned earlier) were plotted to further explore the coincidence between the two sources of data.

2.3. scale problem

Even when the dates of fishery data analyzed have been chosen very close to the time of the survey, a scale problem subsists between both sources of data. The survey observes once at a precise time in a precise area, while the log-books represents a large area (statistical square) averaged on one (or two) months. Nevertheless, small pelagic fish are known to have a significant ability to shift from one area to another in a very short delay, which in turn diminish this effect. Aiming to reduce this problem, an attempt was made to compare the schools criteria with the captures obtained in a specific statistical square. An example is shown for two statistical squares in two different years (fig. 6).

3. RESULTS

3.1. geographic distributions

In figure 1 we show the changes of total area coverage by species (up left) during the five years. The percentage of total surface for the non-mixed (single) anchovy, sardine and horse mackerel (up right), the percentage of total anchovy for the anchovy mixed with other species (down left) and the percentage of total sardine for the sardine mixed with other species (down right). It can be seen that when a species occupies a large area it is also associated with other species.

The general view of the occupation areas by species for each survey is shown in figure 2. The blue points represents the anchovy average catch for the period of time closer to survey dates, and the polygon correspond to the area coverage of the survey.

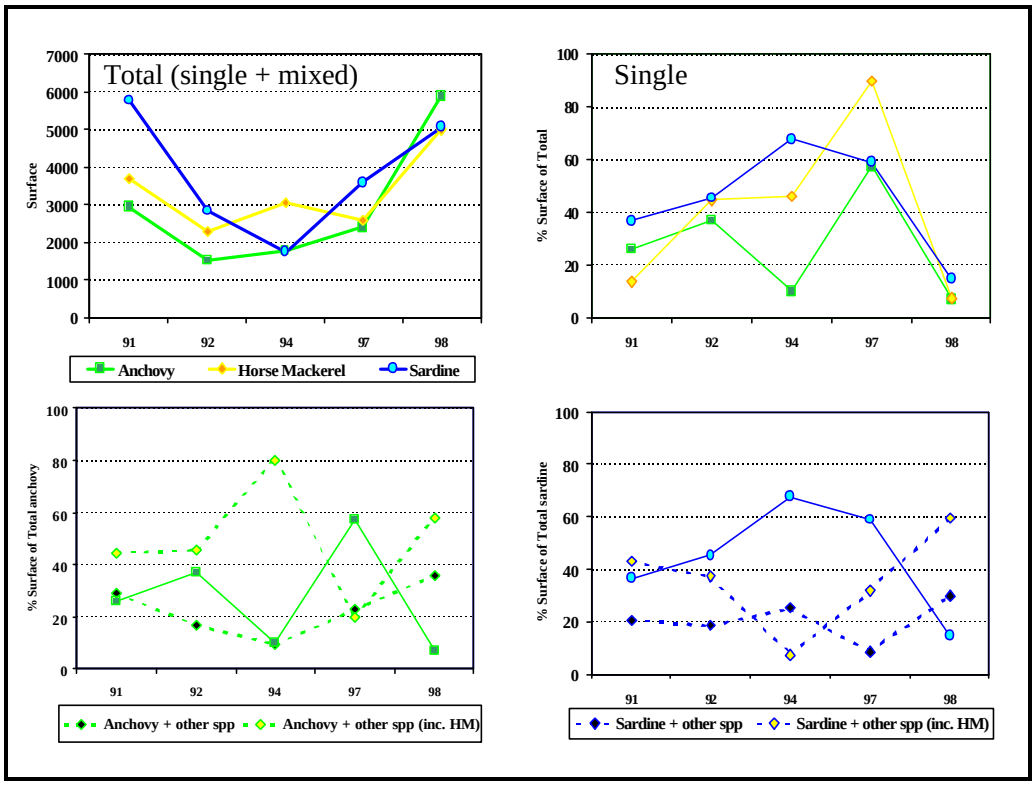

Figure 1. Changes in the occupation area by species during the five analyzed surveys.

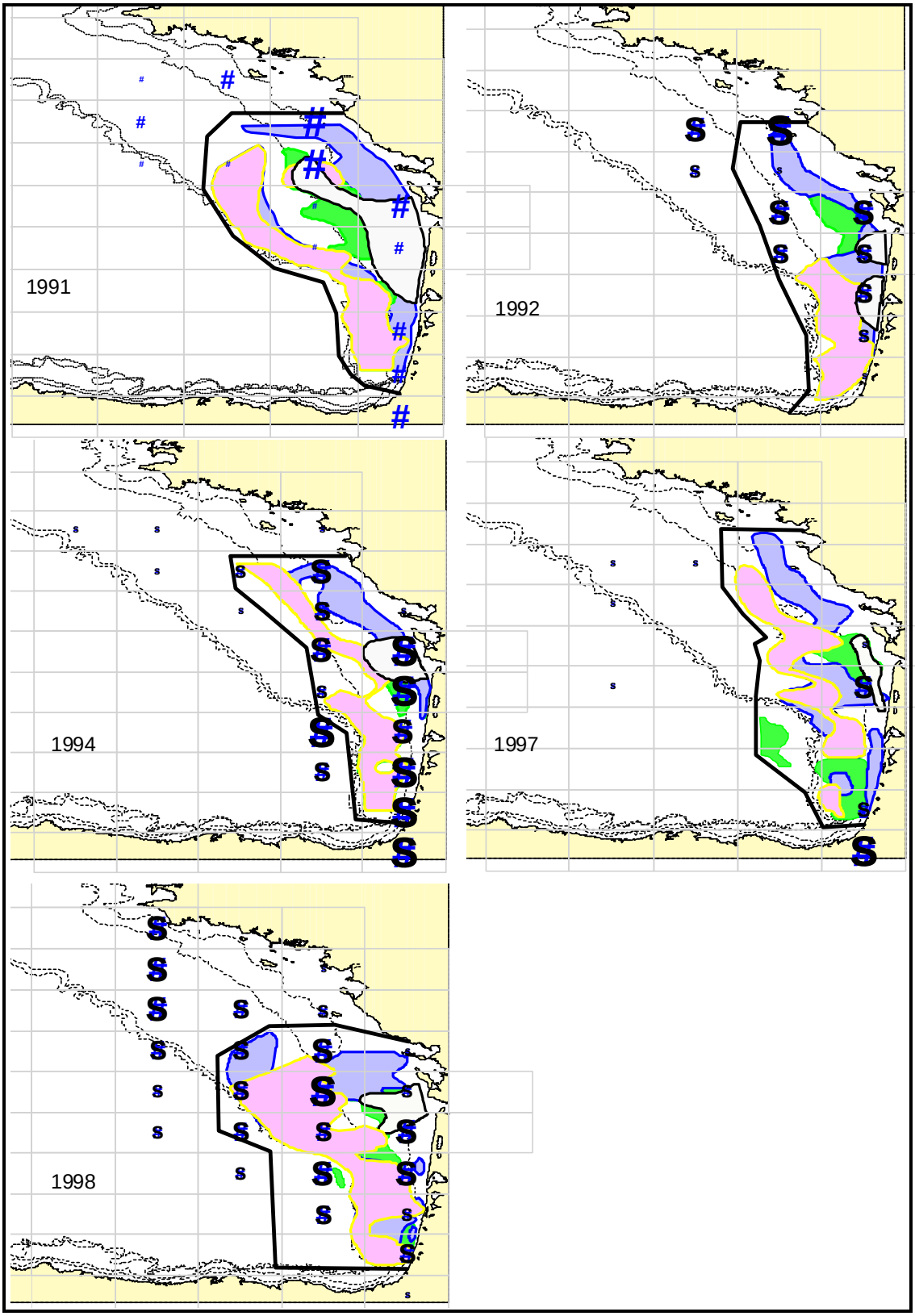

Figure 2. Occupation area by species, species associations and the anchovy average catch (blue points). For the occupation areas: anchovy in green, sardine in blue and horse mackerel in purple.

3.2. spatial distribution

In figure 3, the general tendencies of the school minimal altitude and bottom depth are plotted for the mono-specific schools of anchovy, sardine and horse mackerel. Then, in the left down corner the school minimal altitudes for all the monospecific schools observed in 1991, are plotted as a box and whisker plot representing the minimum, maximum, average and standard deviation. This example based on the minimal altitude in 1991, shows that the descriptors are very variable when calculated for the whole survey area. It is therefore necessary to consider these parameters in a smaller geographical scale.

Nevertheless the right side of this figure shows already that the zone characteristics (bottom depth) seems to influence the vertical distribution of schools

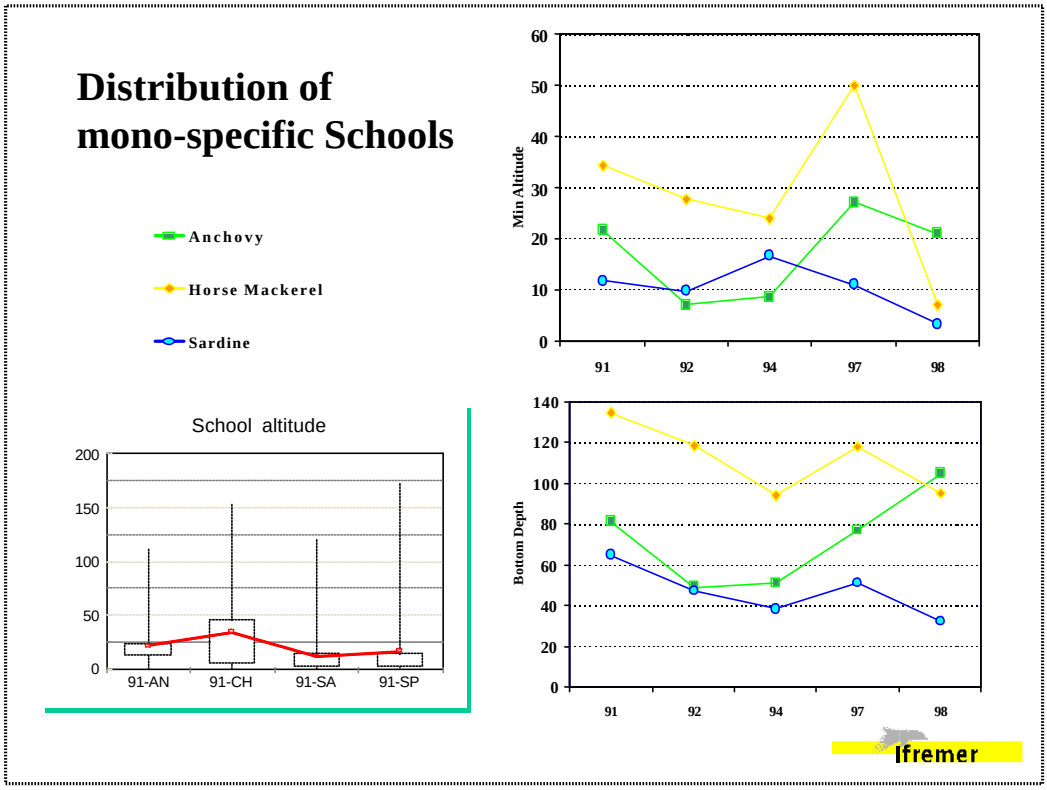

Figure 3. Minimal school altitude and bottom depth for monospecific schools. Left: total variation in 1991. Right: global averages.

The calculated aggregation pattern factors of anchovy, sardine, horse mackerel and associated anchovy are represented as the changes in fragmentation during the five years (figure 4).

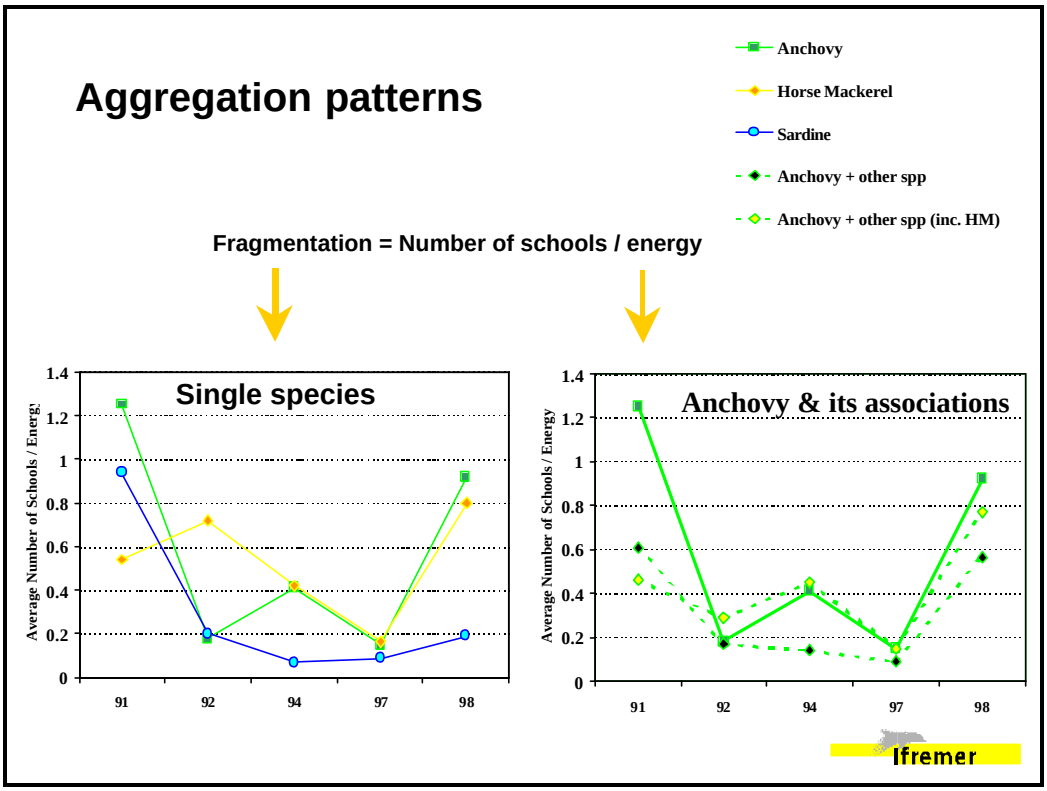

Figure 4. Aggregation patterns of single anchovy, sardine and horse mackerel (left) and associated anchovy (right).

In figure 5, the level of coincidence between what is observed during the acoustic surveys and the anchovy commercial catch in survey area is shown. Generally anchovy is catched in a wider geographical extent than observed during the surveys, this may be due to fish displacement during the considered fishing period. However it can be seen that a good degree of coincidence exists between the two, excepting 1997. In this case we cannot exclude that the causes may be due to fishery related factors.

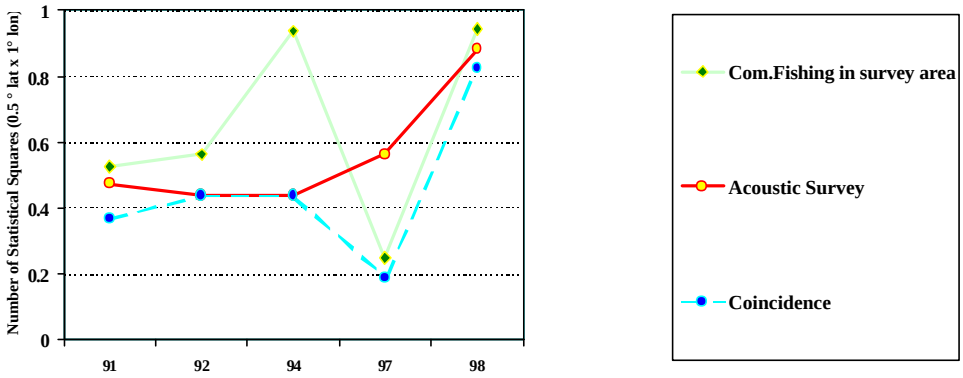

Figure 5. Relative numbers of statistical squares with anchovy commercial fishing, anchovy detected during surveys and their coincidence.

3.3. sharp scale approach

During the analysis of descriptors calculated globally it has become evident the need to consider a narrow spatial window to compare our two sources of data. Therefore, a new approach was attempted for some specific situations to explore which type of relationships such an approach can reveal. Figure 6 shows the criteria represented before at a global level, in a more local scale: the statistical square. To illustrate the expected results of this approach two especially demonstrative statistical squares were represented for two different years. In these particular cases greater captures have been obtained in the statistical squares where the schools were found to be higher during the surveys, and also when some proportion of single anchovy was present.

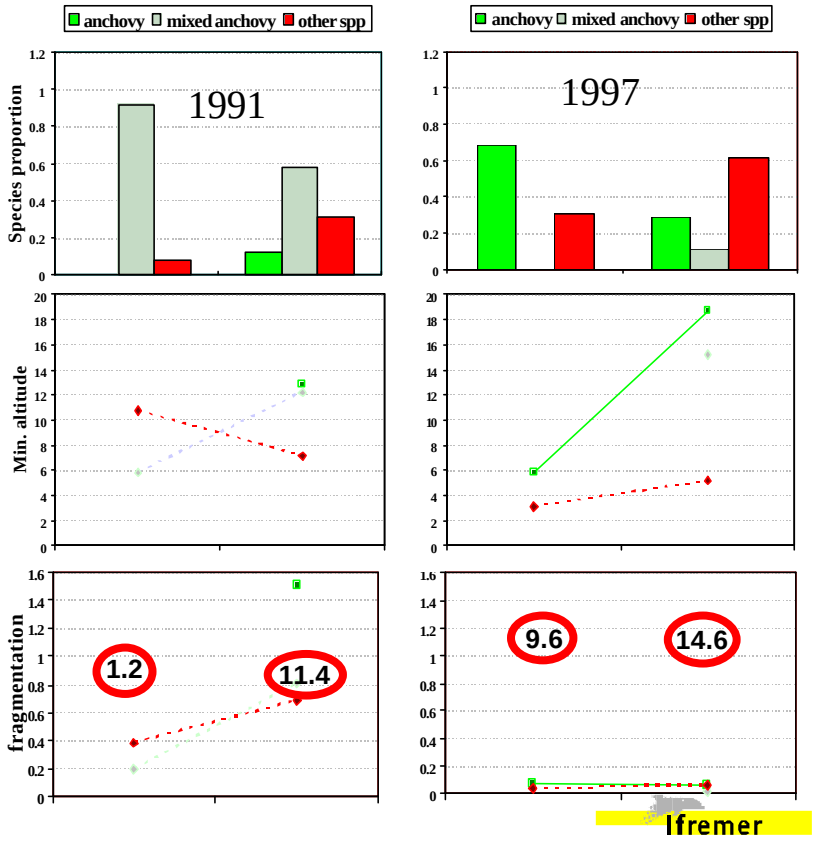

Figure 6. Example of a small scale approach attempting to relate school descriptors to fishery catch for selected statistical squares. Encircled numbers: average commercial catch in the statistical square.

4. CONCLUSION AND DISCUSSION

It is necessary to keep in mind that the survey area coverage differs from year to year. Therefore, to observe clearly the changes in species area coverage, species associations

and aggregation patterns it is necessary to represent those areas relatively to the corresponding survey area. Nevertheless, acoustic surveys clearly represent a great advantage to observe the species changes in distribution from one year to another. There is a great variability both intra- and inter-annual for all the criteria taken into consideration (association of species, vertical distribution and rate of disintegration). This exercise has raised the need to analyse those criteria at a smaller scale, as many parameters (positional, morphological, and perhaps also the energetical) may be dependent on the characteristics of the area were the fish are observed. We need also to find a better way to analyse the coincidence between fishery catches and the anchovy distribution observed during the surveys, taking into account the differences in species abilities to move horizontally or vertically in a short period of time. Besides the species particularities it will be also necessary to take into account the size of fish by itself, because differences in behaviour between small and large horse mackerel, and that of anchovy associated to small or large horse mackerel are known to exist (Massé, et al., 1996).

At this step the small scale approach seems to show that the spatial distribution is more important than abundance by itself, probably in terms of catchability. Apparently, the vertical level of target species is determinant to obtain a better catch, certainly because that improves the accessibility. But also the greater catch was associated to the presence of anchovy as a pure species, perhaps because in that case it is not necessary to sort the catch.

5. REFERENCES

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