analyzed both (1) through Spearman rank correlations computed by pairs of fishing sets, ordered by distance and by duration and (2) through variograms.
The day to day evolution of the centre of gravity, the spatial extent and the spatial patchiness of the catch positions exhibited a very high variability which may be related to fish re-organization and/or variation in local environmental conditions. The analysis of CPUE residuals showed that the fish aggregations exploited by purse seiners had an order of magnitude of 20 nm in size and 1-2 days in duration (Fig.1). The evolution of these variable are then put in relation with 2 indicators of the local oceanographic conditions: SST and sea surface elevation. We discuss finally on the possibilities opened by the growing availability of spatially explicit fishing data for monitoring fish distribution and completing then the information provided by scientific survey.

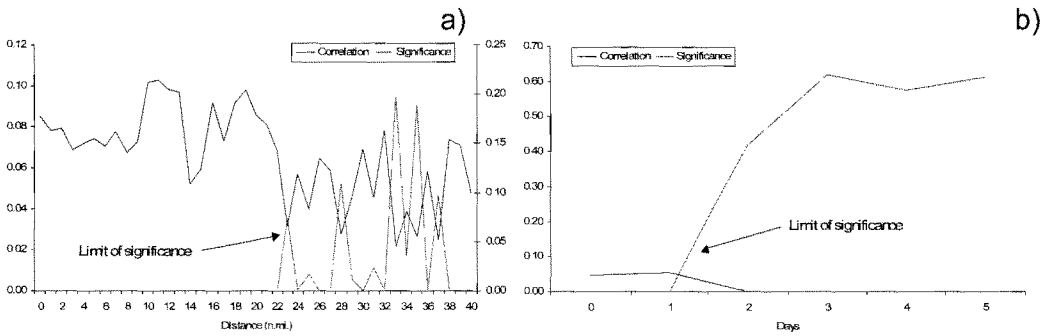

Figure 1. CPUE residual analyses for autumn of 2000. a) Level of correlation (blue line) and corresponding level of significance (red line) between CPUE residuals as a function of the distance separating the fishing sets; b) Level of correlation (blue line) and corresponding level of significance (red line) between CPUE residuals as a function of the duration separating the fishing sets. Spatial correlation is significant up to about 20nm and temporal correlation, up to about 1 day.

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HCS140 - The alternation in spatial distribution of sardine and anchovy in the Humboldt Current: effects of climate, behavioral interactions, or data misunderstanding?

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Anchovies and sardines are known to occupy alternately a given space, especially in upwelling areas. In the case of the Humboldt Current and the Peruvian fishery, the Peruvian anchovy (*Engraulis ringens*) is certainly the most important exploited stock, reaching up to 10 million tons of catch in the years of major productivity. It is also one of the most variable stocks and it may collapse almost completely, as happened during and after the "El Niño Southern Oscillation (ENSO)" events in the early 70s and 80s. The other major pelagic species, the sardine (*Sardinops sagax*) is also present over the Peruvian shelf and may represent the most important biomass when dominating the ecosystem, as It happened during the decade of the 80s, where the catch represented around 3 million tons. These populations of anchovy and sardine display successive and alternate phases of dominance and co-occurrence. Two major reasons are given in the literature explaining such pattern: the role of decadal climatic changes and the behavioral characteristics of schooling fish. In the first case we may cite Chavez et al (2003) who describe the effects of decadal changes in sea temperature (periods "El Viejo" y "La Vieja"); in the last case we could cite as an example the "School trap" hypothesis (Bakun and Cury, 1999) according to which the change in the dominance would be facilitated by behavioral constraints of pelagic fish which have to live in schools and may be "trapped" in school of other species when they are dominant, which implies for them non optimal biological conditions.
The Peruvian coastal pelagic ecosystem presents a particular interest from this point of view, because it represents the world largest fishery, the fisheries statistics show a clear alternation in the catches, usually in phase opposition (figure 1a), and the stocks are constantly monitored by various methods (catch analysis, acoustic surveys, eggs and larvae, etc.), thus many environmental information is available.

Another interesting point is that the same fishing fleet can be adapted for one or the other of these two species: following the great collapse of anchovy in 1972 most of the unemployed anchovy fishing vessels were adapted for the sardine fishery. There was no important fishery dedicated to sardine before the collapse of anchovy and practically no catch existed before the 70s. Then during the "low anchovy production" period, the sardine catches increased regularly (1977-1990) with important interannual variations, began to show a slight decrease in 1989 and collapsed slowly from 1991 to 1999. Sardine fishery has become marginal in Peru after the late 90s.

The paper analyses the different spatial strategies of the two species, and evaluates the possible effect of one species over the other through competition, coexistence, etc. An important question prior to validate any hypothesis is whether information from catch data may give a proper image of these changes through which sardines and anchovies may collapse so suddenly and alternate synchronously. We assume that, despite of its own limitations, acoustics, being a direct source of observation, is more reliable than fishery data for describing the dynamic changes in the population levels of the two species along the last decades, and can be used as reference information. The spatial distributions of the two species are compared in time and space through the analysis of 17 years of acoustic surveys (1985-2000). The respective effects of fish spatial strategies and climatic conditions are considered. The role of fishing data in determining a possible alternation of species is scrutinized. From these results the following conclusion were drawn: (i) no obvious competition for space is visible since spatial overlapping along the studied period is rather small (Figure 1b); (ii) in the places where anchovy and sardine co-occur the acoustic densities of each species are positively correlated; (iii) fishing activity existed during the 1997-98 El Niño, and were directed towards mixed schools of juvenile sardines and adult anchovies; (iv) the major reason for alternation and dominance of one species on the other is climatic, and not behavioral (Bertrand et al, 2004) ; (v) the apparent competition of species during co-occurrence periods (e.g. 1985-1999) is artificially magnified by the catch data (figure 1c).

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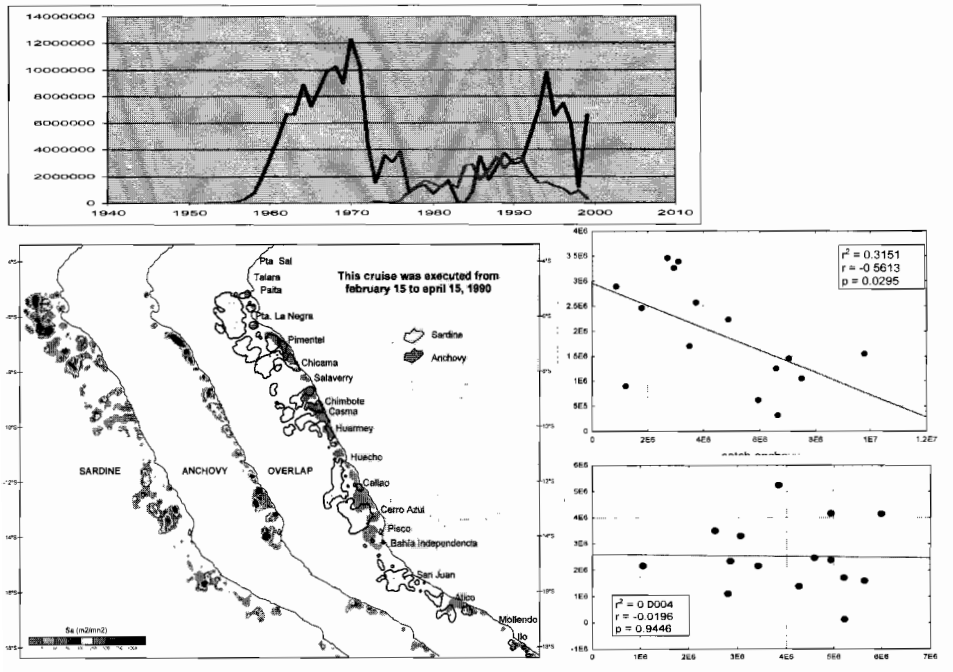

Figure 1. Description of alternation between anchovy and sardine along the Peruvian coast:

- ⇒ *1a (above): annual catches of sardine (blue) and anchovy (red) from 1952 to 2000. Catches in tons. This figure shows the evidence of alternation at decadal scale.*
- ⇒ *1b (below left): example of overlapping in areas occupied by sardine and anchovy in 1990, year of maximum co-occurrence, as observed through acoustic surveys. The figure shows that overlapping is weak, sardine being offshore and anchovy remaining closer to the coast*
- ⇒ *1c (below right): comparison of correlation between catches of anchovy (x axis) and sardine (y axis) catches (above), and between anchovy (x axis) and sardine (y axis) biomasses (below) during period 1985-1999, corresponding to the longest period of co-occurrence where acoustic data were available. The negative correlation observed between catches does not appear with the biomasses, demonstrating that correlation is more related to fishery strategies (a vessel chooses to catch sardine OR anchovy) than to species behavior.*

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