# DATA STRATIFICATION AND PELAGIC FISH DENSITY EVALUATION IN JAVA SEA

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Abstract

Biomass evaluation by means of echointegration, needs to be applied with strictness. The better will be targeted and analyzed the dominant factors acting on the area, the better will be the accuracy of estimation. A phasis of descriptive observation is necessary, taking into account abiotic and biotic factors, as well as the one on species behaviour, as it can appear throughout the acoustics tool. This descriptive stage will comfort the elaboration of a stratification which will serve as a model to calculate the abundance level and its accuracy. During acoustic cruises performed from 1992 to 1994 in Java Sea open waters, various parameters were measured. Regional differences can be observed, they allow to elaborate a three areas stratification.

Keywords : Java Sea, Pelagic Fish, Acoustics, Methodology, Density.

## Introduction

To evaluate a stock of pelagic fish by the acoustic method requires a whole series of successive operations: the knowledge of the equipment characteristics and those of fish reverberation that are to be evaluated, the choice of a sampling plan depending on the geomorphology of the zone, the environmental conditions and the ones of the fishing activity. It is rare to have an ideal situation and one must always establish a selection according to the objectives, the environmental conditions and the means to be used.

Another difficulty comes up in data processing. pelagic fish species tend to have a contagious distribution because of their behaviour and most of them tend to aggregate. This behaviour would not hinder the evaluations of abundance if the contagious distribution concerned the whole zone, leading thus to a stationary state. Unfortunately, environmental factors interfere in this distribution that becomes heterogeneous. It is necessary to individualize sectors where the data will be more homogenous. That is stratification. Its fitness will be all the more accurate since the borders coincide with the ones of biotic or abiotic factors which were brought to light. Thus, we understand the importance of knowing the behaviour of the stock being evaluated, but also of its environment to reach a definition of these strata. That is the reason why stratification was the point of the Akustikan 1 Workshop (Petit *et al.*, 1995) of which we present the principal results here.

## Materials and method

Two acoustic surveys were carried out in the Java Sea in opposite season : October 1993 (dry season) and February 1993 (wet season) with a dual beam echosounder working at a 120 kHz frequency (Fig. 1). Prospecting took place during night and day with biological sampling (pelagic and bottom trawlings, or samplings on professional seiners). Fish density was integrated per nautical mile. Along the transects, Target Strength measurements (more than 10,000 echoes each) occurred. hydrological profiles (T and S‰) were carried out in the middle and at the end of each transect.

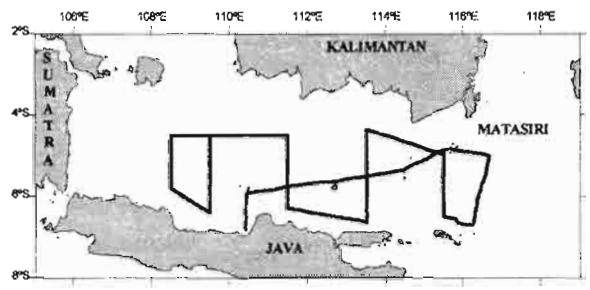


Fig. 1. October 93 and February 94 : echointegration surveys in the Java sea.

The data used concern :

-fish density per mile in relative units,

-mean reverberation index measurements along the transects,

-number and reverberation of shoals (by analysis of echograms),

-vertical profiles of temperature and salinity by station.

Samplings brought little information, because the catches are low and not significant. But knowledge of commercial catches gives quite precise informations on seasonal fishing sectors and above all, on the quantities and species caught.

## Results

### Hydrological conditions

The climatic year in the Java Sea is composed of two main seasons due to the monsoon winds : a wet season (December to March), a dry season (June to September).

During the inter-seasonal change, the conditions of the preceding season continue up until the wind

currents are stablc enough to bring about the reverse situation.

In the wet season, strong precipitations and outflows cause a significant desalinization of waters swept along to the East by NW winds.

In the dry season, SE winds transport waters from the East and cause the resalinization of the Java Sea.

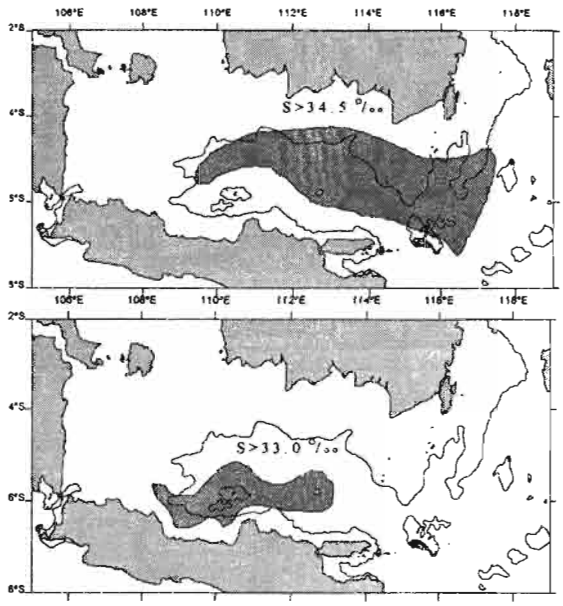


Fig. 2. Location of the mean salinity maxima in October 1993 (up) and February 1994 (down).

Average salinity maps indicate opposite seasonal situations between October and February (Fig. 2).in October, the oceanic influence is strong on the central and eastern part, covering the deep area (more that 50 m) and the shallow zone of the Matasiri Bank. In February, the only oceanic influence is observed on the western part. There is no thermal or saline front during the two seasons.

The fishery data

Coming from another part of the Project, these informations revealed that most of the seiners Fishery is performed in waters with a salinity above 32‰. The catch is twice in October than in February. The bulk of the fishery in October, is centered on the Matasiri Bank; it moves out of the Java Sea , in February. The central deep area of the Java Sea, where a permanent fishery lives along the year represents 9% in February and 20% in October of the total catch. Thus the Matasiri Bank is the most important exploited area during the oceanic influence : the fishery seems highly related to the saline conditions.

The fish densities by acoustics

There is a great difference between the acoustical densities observed by day and the ones by night. The day densities represent less than the half of the night ones , in mean value.

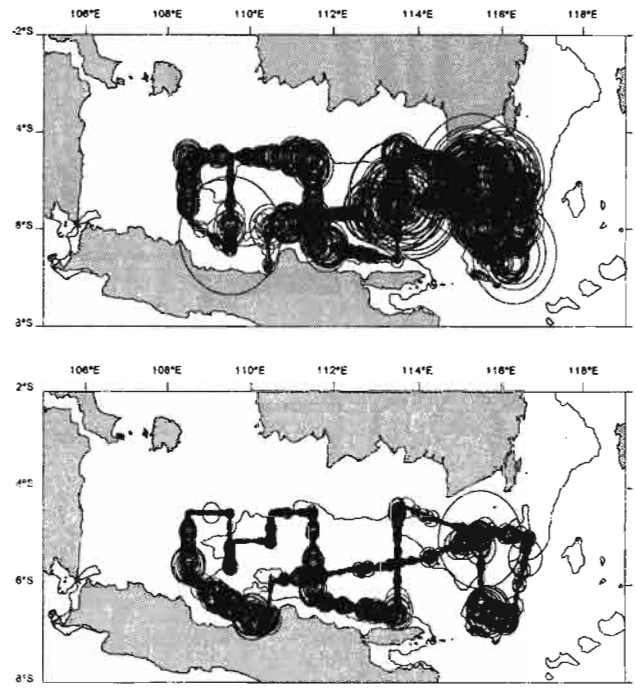

Fig. 3. Relative density of pelagic fish in October 1993 (up) and February 1994 (down).

In October, we can consider that there is a general rising gradient of abundance from West to East, there is no gradient North-South (Fig. 3). In February, there is no gradient West-East. The center of the Java Sea has densities lower than the South one. There is a North-South gradient.

The distribution of shoals

Different parameters have been measured (Nugroho *et al*, 1995). We present here only all about their location and relative reverberation. Benthic shoals are scarce and more concentrated is the eastern part (East of 114°E). The pelagic shoals are generally distributed but are more abundant, West of 111°E and East of 113°E (Matasiri Bank).The histograms of shoals reverberation have been calculated for five strata of 2° longitude large. The first mode (<100) is common all over the area; the second one (200-500) is observed in the eastern and western part, but not between 110°E-112°E ; the third one (>1000) is only present in the eastern part. the eastern and western part, but not between 110°E-112°E ; the third one (>1000) is only present in the eastern part. A global gradient West-east is noted, the 112°E seems to be a natural border between two kinds of structure (Fig. 4).

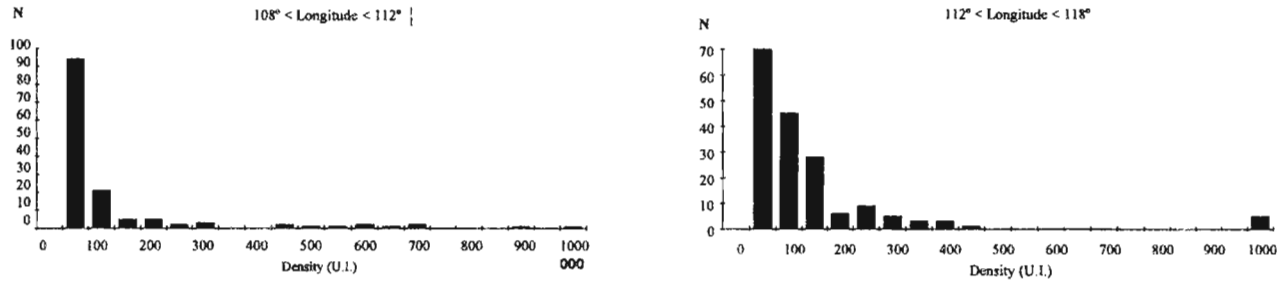


Fig.4. Distribution on both sides of the longitude 112°E of the number (N) of fish schools according to density in October 1993 (survey 34).

The TS distributions

We observe that the mean TS are higher in October than in February. They are also higher in waters more than 50 m depth in the two seasons. The day-night variability seems typical of surveys : night TS are higher than day TS.

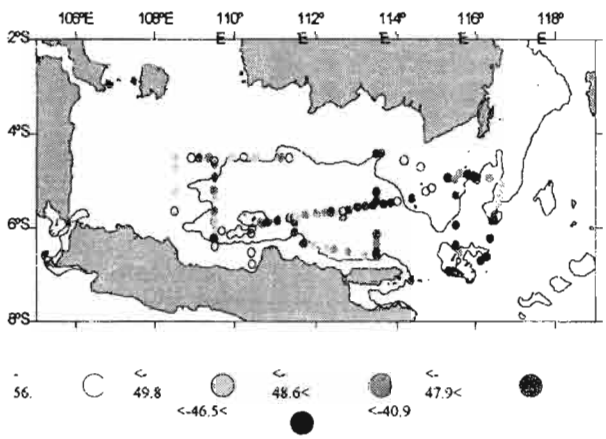


Fig. 5. Repartition of the mean TS values (in dB) in October 1993.

There is a trend in the fish length : the smaller are in the West of the area. There is also a trend regarding to the depth or latitude : the fishes remaining in the deep part of the Java Sea are bigger than the ones out of this area, except the Matasiri Bank in October (Fig. 5). Within the year, the fish migrate, the big fish being close to the deep area or out of the zone in February, present in a large part of the area in October. The migration could follow the movement of the salted water mass along the deep area

The vertical distribution of density

This aspect is studied apart (Luong and Petit, in press). The preliminary works made along a West-East transect (Semarang to Matasiri) revealed that two populations are living at the same place : the first one remains pelagic by day and night; the second one pelagic during night, disappears during the day. The density increases suddenly at around 6.00 pm and decreases at 5.00 am. Thus the horizontal layers are traversed by a population moving upwards by night. This later can be considered as semi demersal.

The spatial structure

The spatial structures have been characterized by computed variograms. The variogram is the measure of variance between points function of the distance separating them. It enables to dissect the total data variance into correlation variability occurring at various scales (Petitgas, 1991).

The parameters are the sill, the maximum variability between points, and the range, the distance at which the sill is reached. It measures the average diameter of the structures ; the nugget measures an heterogenity in the spatial distribution ; if high and low values are neighboring, the nugget measures the variance associated with this discontinuity. Here the nugget is low ; the local variability is low. The day and night structure are very similar. There is a small structure of 5 to 20 nautical miles. At distances longer than 50 miles, we have a trend generating an increase on the variogram (Fig. 6).

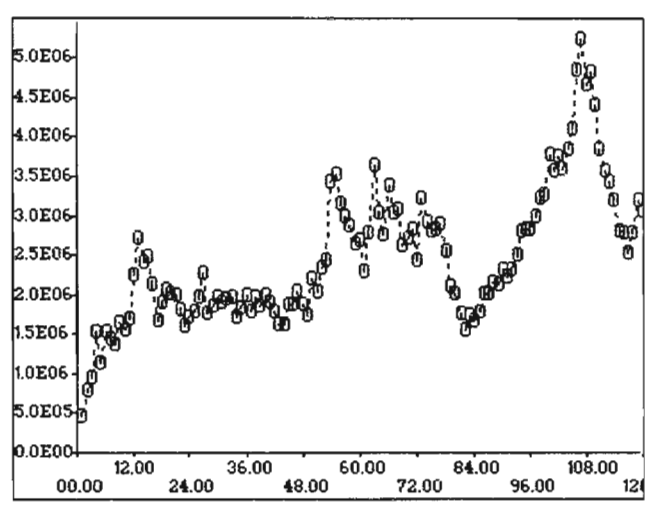


Fig. 6. Variogram on the night densities in October 1993.

This trend is oriented West-East during October, as higher values stand on the Matasiri Bank, and it is North-South during February, because higher values are near the Java coast.

Tentative of stratification

Having all these informations, we can try a stratification of the Java Sea. The main interest of this, is to better describe each single stratum in term of biology and ecology of the populations and to decrease the variance in each structure[1].

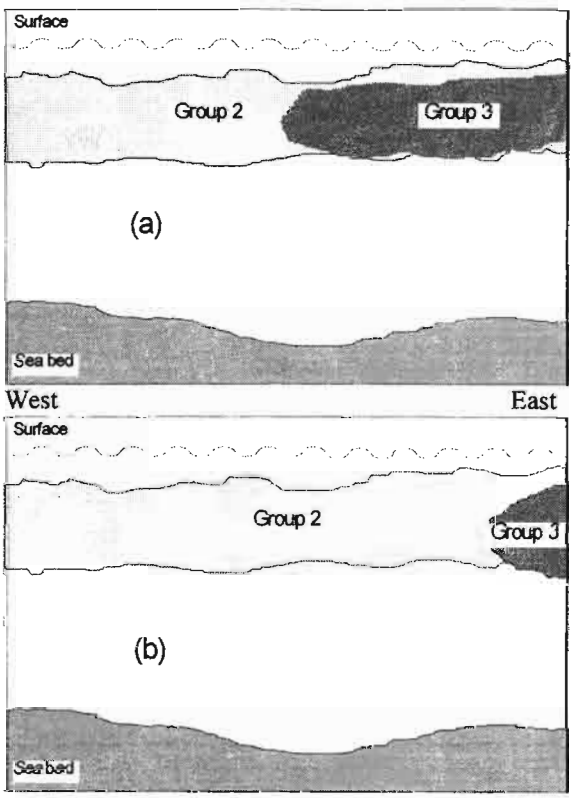


Fig. 7. Group 2 and 3, night annual distribution of pelagic fish from West to East of the Java Sea : (a) October, (b) February.

Until this level of description, we can consider that three main populations are present in the Java Sea (Fig. 7) :

- a group (1) identified as a coastal group, recorded close to Semarang and on which very few samplings have been done. It is more apparent in wet season ;
- a group (2), scattered all over the area, with a permanent kind of small structure, around 10 nautical miles, with low dispersed densities. This population is pelagic in permanence ;
- a group (3) on the East, which suffers the most important part of the fishing exploitation and may migrate from the area. It is more apparent in dry season; this group would be in majority semi pelagic.

So, we can propose the following stratification (Fig. 8) :

- the stratum A, South of 6°20S, West of 114°E,
- the stratum B, North of 6°20S, West of 114°E,
- the stratum C, North of 6°20S, East of 114°E.

We can test, inside each stratum, whether the distributions are more homogeneous and calculate the variograms (Fig. 9). According to the histograms of density, the stratum A reveals a net difference between the season, with a more important nocturnal density in February. The histograms for other strata in February are similar (absence of group 3), the difference between stratum B and C appears in October with big nocturnal densities into this later (group 3). The variograms show not anymore nugget effect inside the strata, but the small structure (15-20 nautical miles) is observed everywhere.

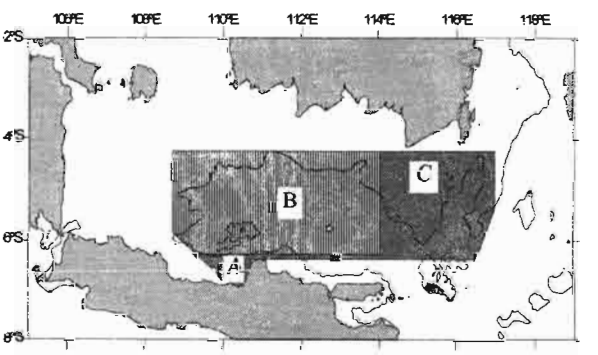


Fig. 8. The 3 strata of the Java sea, following the location of the main fish populations.

Discussion

The stratification is the logical way through a mean density evaluation in which subsists only the part of variance peculiar to every stratum. However, if the tentative of stratification seems to go in the sense of a personalization for every zone (histograms) it does not allow, until now, to define rigorously the geographic borders. What is the real seasonal extension for the group 3 population ? Where are the limits in the coastal zone for the groups 1 and 2 ? The coastal stratum has been under-prospected during the surveys and the structures are not precisely described there.

On the assumption that the borders are better defined, a lack of information remains about the proportion of the species living in every each stratum. The experimental catches yield too low quantities to be significant, the seiners that operate without positioning, catch all the time more or less identical proportions of species.

[1] Three others transects Semarang-Matasiri Bank which we do not report here were also used during the workshop to elaborate the stratification.

Taking into account the structures in the Java Sea, it is possible to evaluate the accuracy of the mean densities measured in the whole area of surveys. During the workshop, Petitgas (*in* Petit *et al*, 1995) proposed a stratification by square of 0.2 degree along the transects. The variance estimation on the whole area can be partitioned in two terms : the error made on the estimation of the squares mean and the error made on the estimation of the area mean. This later is given by the variogram of the square means. The relative error on the squares mean is then, about 15% for the day or night data.

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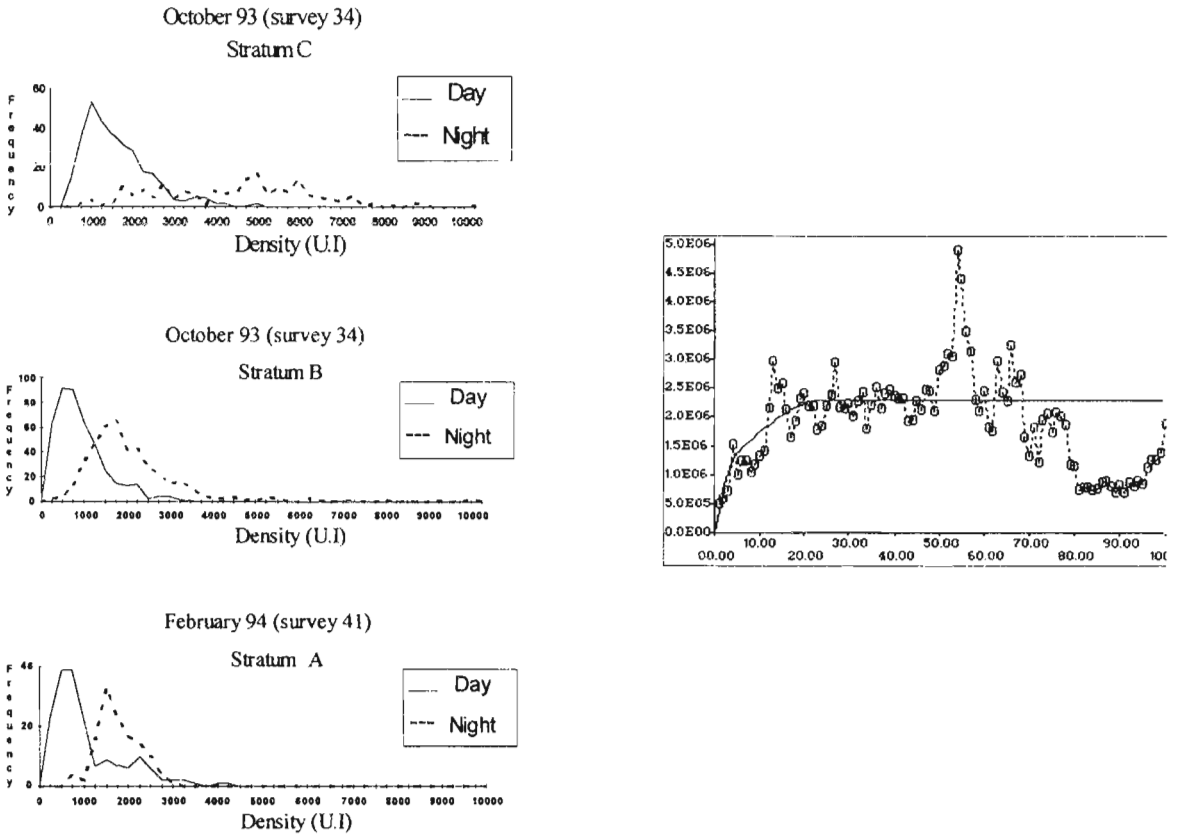


Fig. 9 : After stratification, frequency distribution of densities into the 3 strata and one aspect of variograms (here, for the stratum B, night densities, in October 93).

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