DENSITIES AND BEHAVIOUR OF PELAGIC FISH POPULATION ALONG THE JAVA AND SUMATRA COASTSIN WET SEASON

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ABSTRACT

The coastal borders of northern Java and eastern Sumatra have been prospected during the acoustic surveys, in the depth of about 15 to 50 m, in wet season. The measures of relative density per nautical mile, the vertical distribution of the abundance and shoals have been analyzed. The general characters can be drawn : they are the extension of an abundant semipelagic fauna occupying the bathymetric strata from 25 to 45 m, and the existence of a dominant pelagic fauna, more coastal. Shoals, low reverberating, are present in all areas but are dominant in the coastal border; the more reverberating aggregations are more off shore. From the East to the West, their bathymetric localization increases in the sectors near oceanic influences, they are more dense and near the surface. From East to West, the abundance of schools and total density decrease. This fact seemingly has to do with the extension of the relatively shallow zones. Two sectors show a particularity : the Bay of Semarang with densities sometimes big, which could be related to the seasonal topography, and the surroundings of the Sunda Strait, zone of passage and exchange for the deep pelagic population.

Those observations globally confirm the stratification tentative which had been carried out during the Workshop of 1994, in specifying the geographical extension of the coastal stratum, very narrow in front of Java, and in proposing that one part of the semipelagic population which constitutes the wealth of the East of Java Sea in dry season, should migrate in wet season towards the slopes of the coastal border.

KEYWORDS : Java Sea, Sumatra, acoustics, pelagic fish, abundance, aggregation, distribution, zonation.

ABSTRAK

Keberadaan ikan pelagis di perairan pantai utara Jawa dan pantai timur Sumatra pada musim Barat telah diamati melalui survey akustik pada kedalaman antara 15 hingga 50 meter. Pengamatan kepadatan relatif per mil, penyebaran tegak kelimpahan serta keberadaan kelompok ikan dibahas dalam tulisan ini. Hasil pergamatan tersebut memperlihatkan karakteristik bahwa dominasi kelimpahan fauna semipelagis dan pelagis berada pada lapisan kedalaman 25 hingga 45 meter. Pengelompokan ikan pelagis semakin berkurang pada perairan lepas pantai. Penyebaran kedalaman secara membujur ke arah barat semakin dangkal dan dipengaruhi oleh lingkungan oceanik, sedangkan besarnya kepadatan semakin tinggi pada lapisan permukaan. Demikian pula keberadaan dan kelimpahan kelompok ikan serta total kepadatan cenderung berkurang dimana diduga berhubungan dengan semakin dangkalnya kedalaman perairan. Selain itu, dua hal spesifik dapat ditunjukkan berdasarkan hasil penelitian ini yaitu : pertama, kepadatan di perairan sekitar Semarang terkadang tinggi karena adanya pengaruh musim; dan kedua, perairan sekitar Selat Sunda merupakan perairan lintasan ruaya ikan pelagis laut dalam.

Secara umum, pengamatan tersebut memberikan informasi bahwa uji stratifikasi yang telah dilaksanakan pada pertemuan ilmiah pada bulan Desember 1994, khususnya pada stratifikasi kelompok ikan secara geografis, keberadaan ikan pelagis di perairan pantai utara Jawa sangatlah sempit dimana sebagian kelompok populasi ikan semipelagis pada musim timur yang berada di bagian timur laut Jawa bermigrasi kearah pantai pada saat musim barat.

KATA KUNCI : Laut Jawa, Sumatra, akustik, ikan pelagis, kelimpahan, agregasi, penyebaran, zonasi.

Until 1995, the acoustic surveys PELFISH had principally concerned the central zone and the East of Java Sea, which constitutes the zones of seasonal activities of big seiners (Potier and Sadhotomo, 1995). A test of stratification of pelagic population has been realized during the Workshop AKUSTIKAN I, December 1994. It was based on the acoustic data collected during the 2 surveys (October 1993 and February 1994) covering the Java Sea (Petit *et al.*, 1995). The study came to the conclusion that there were 3 strata of population : oceanic, neritic and coastal. The extension and characteristics of the last stratum however remained inaccurate, due to the lack of sufficient sampling.

From April 1994 to May 1995, three surveys have been done along the coastal zone of North of Java and a part of East of Sumatra, in wet season. The following results concern the relative variations of total density as well as variations of behaviour as they appear within the data collected during the nycthemeral cycle.

The sampling has been realized on board of R/V Bawal Putih I, a stern trawler, with a Dual-Beam echo-sounder of 120 kHz frequency and postprocessed with different software described elsewhere (Petit *et al.*, 1997). The integration of echoes per mile has been realized at the speed of about 6 knots, with 10 m interval from the surface to the bottom. The measures of abundance represent the densities by surface and are described in relative units. The vertical localization and the reverberated energy of the schools, always in relative units, have been extracted by observation of echograms. The play back of some transects in laboratory with a higher threshold (42 mV) than the one adjusted during the surveys (33 mV) enables to evaluate the proportion of targets more reverberating. In February and May 1995, the salinity has been measured at fixed station by vertical profiler. During the prospecting, some measures of TS have been performed, but this will not be much elaborated.

MATERIAL AND METHODS

The tracks of these 3 surveys are represented in Figure 1. They were carried out in April 1994 for the sector north of Sumatra, in February 1995 for the eastern part of Java, in May 1995 in the western part of Java and southern side of Sumatra. On this figure are also overlaid the southern transects carried out during the survey of February 1994 which covered the whole Java Sea.

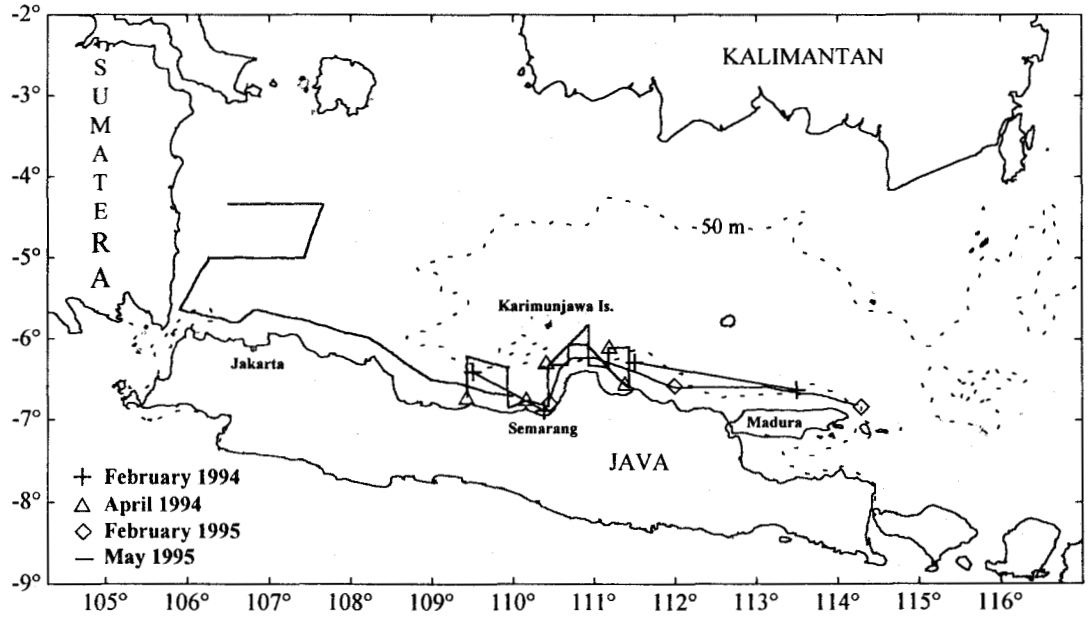

Figure 1 **Location of surveys along the Java coast in February, April and May.**
Gambar 1 **Daerah dan lintasan survey sepanjang Jawa, Februari, April dan Mei.**

Unfortunately, lacking for information on the accurate nature of detected targets -- the rare trawls realized (5 fishing operations upon which 3 pelagic trawling in April, 3 bottom trawls in May) -- practically did not report on the pelagic fauna. However, the inquiries carried out by biologists of the Project at the ports of unloading have given a very accurate information on the composition and proportion in species, at least those concerning the commercial targets in the fishing zones, that is all the north coast of Java, but not Sumatra. It concerns essentially the sardines (among which *Sardinella gibbosa* and *Dussumieria acuta*), the scads (*Decapterus russelli*, *Selar crumenophthalmus*) and the mackerel (*Rastrelliger spp.*) (Hariati *et al.*, 1995; Potier and Sadhotomo, 1995).

RESULTS

Haline situation

Following the whole surveys realized by the Project, a synthesis of the haline seasonal evolution has been described (Petit and Cotel, in this book).

In February, the maximum phase of desalinization in the Java Sea begins. The action is marked in the northern part with precipitation on Sumatra and Kalimantan. The Java coast begins to be influenced by local precipitation and the important desalinization remains coastal (delay of flow). During the survey of February 1995, the water is between 32.5 and 33‰, with persistence of vertical gradient in the extreme East (oceanic influence in depth) whereas near by the coast, in front of Semarang, the desalinization is well-moved forward (water lower than 33‰). Off shore, in front of Semarang, there is a zone of water higher than 33‰, phenomenon which has already been observed in February 1994.

In May, the survey has taken place in the period of inter-season along the west coast of Java and East of Sumatra. The desalinization, by vertical mixing reaches its maximum effect with disappearance of gradient. On the transects where the depth is lower than 40 meters, the salinity is practically constant from the surface to the bottom, 32.5‰ in average; the salinity is little higher in the South of Belitung Island. Between February and May, the whole of vertical and horizontal gradients have disappeared, that leads, then, to a maximal standardization of the salinity in the Java Sea, towards the lowest one. During the survey of April 1994, in front of Semarang, no observation has been collected.

Survey of February 1995

Four transects at 10-20 miles from the coast are represented, beginning from the East of Madura Island till Semarang. The mean depth decreases from 47 m in the East until less than 30 m along the Java coast.

The variations of abundance (vertical density per mile, Fig. 2) indicate the presence of 3 zones from East to West. Far out from the Java coast, in deeper zones, the densities are the weakest, in particular at the longitude of Surabaya; these densities increase along the coast towards to West (bottom lower than 30 m) and the maximum is found near the Bay of Semarang. The playback of echo-integration data with higher threshold than during prospecting (42 mV instead of 33 mV) shows that the enrichment towards the West is also qualitative : the proportion of more reflecting targets, 18% in the East, exceeds 24% along the Java coast and attains 30% in the Bay of Semarang.

The nycthemeral cycle on the abundance shows a different influence depending on whether we are in the East or in the West (Fig. 3); outside the coastal border, the nightly effect on the abundance is weak; the nocturnal enrichment becomes very great along the Java coast.

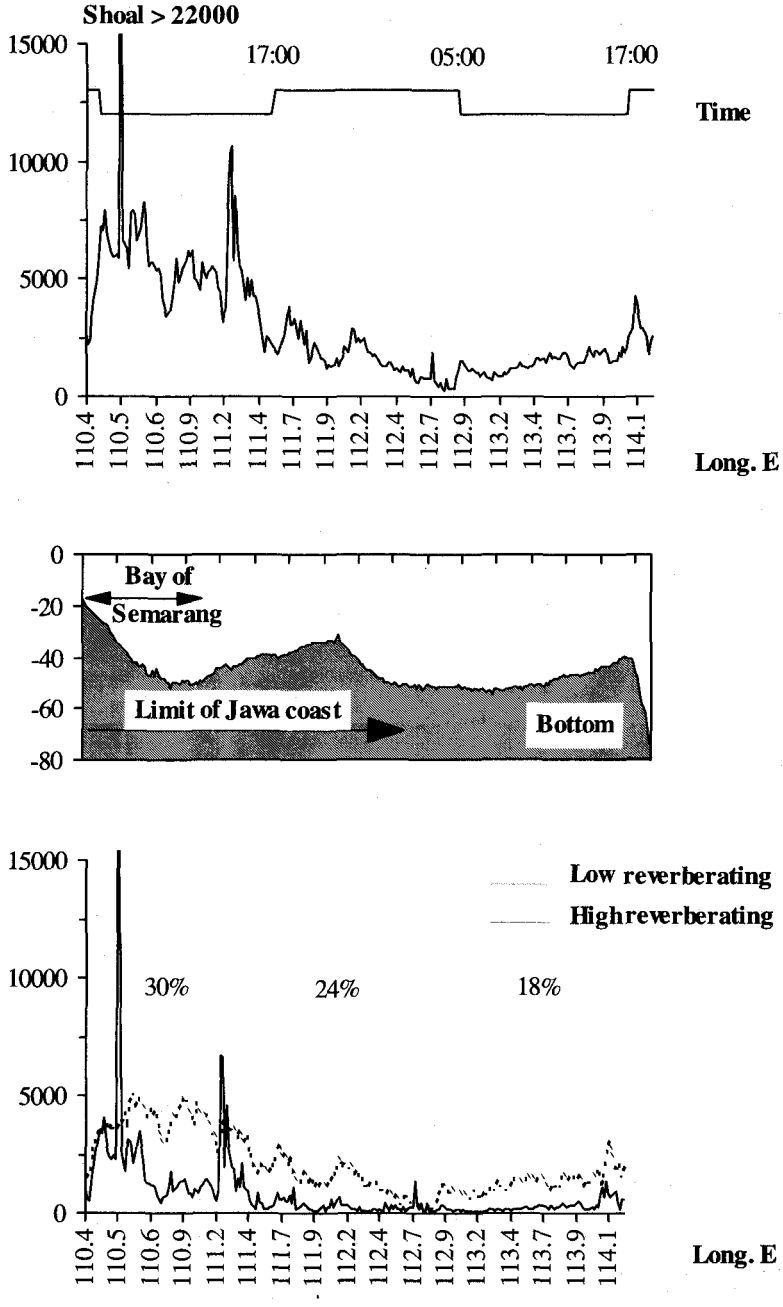

Figure 2 **Density by mile (relative units) in February 1995, from Semarang to the East; up, total density, down, density relative to the high and low reverberating targets.**

Gambar 2 **Kepadatan (dalam unit relatif) per mil , Februari 1995, dari Semarang ke arah Timur; atas, kepadatan total; bawah, densitas terhadap tingkat reverberasi tinggi dan rendah.**

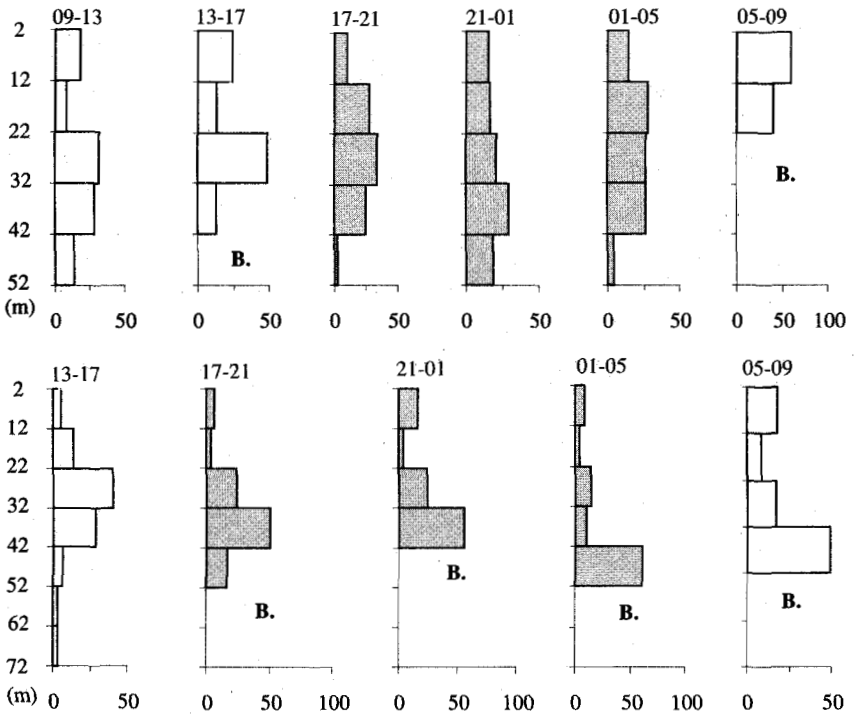

Figure 3 **February 1995 (Survey 52) : Diurnal vertical distribution of the density in percentage, along the east Java coast from Semarang (up) and out of the Java coast (down). (B. : position of the bottom).**

Gambar 3 **Februari 1995 (survey 52) : Sebaran tegak kepadatan diurnal dalam percen. Atas, sepanjang pantai dari Semarang ke Jawa Timur; bawah, lepas pantai. (B. : posisi dasar perairan).**

In February 1994, longer transects through the open sea were prospected (25 to 30 miles from the coast). In the East of Semarang, the densities are comparable to the ones in February 1995. In the West, by moving away from the coast, the densities decrease, suggesting that the high densities encountered in 1995, in the same sector of the bay, do not extend any more to the West (Fig. 4). In 1994 like in 1995, a great proportion of more reflecting targets in the surroundings of the bay is observed. The analysis of vertical distribution of density by layer of 10 m thickness indicates that the half of the deepest water is richer. As for the variation of abundance, a difference can be noted between the bordering domain of Java where the maximum of abundance varies in the depth between the night and the day (strong nocturnal vertical migration), and the eastern part where the maximum remains at the bottom all time. In February 1994, the same difference of nycthemeral behaviour is observed : permanent richness near the bottom in the East and vertical migration of the abundance with dispersion by night in the West.

Figure 5 represents the spatial and vertical distributions of the schools. Along the transect, the relation aggregation -- diurnal phase is clear, although such relation is less visible along the coast of Java; the aggregations are in the half upper water mass and the proportion of very small shoals (low reverberating) is dominant. It seems that there are 2 types of aggregations : those low reverberating which are dominant near the surface and those more reflecting without preferential localization.

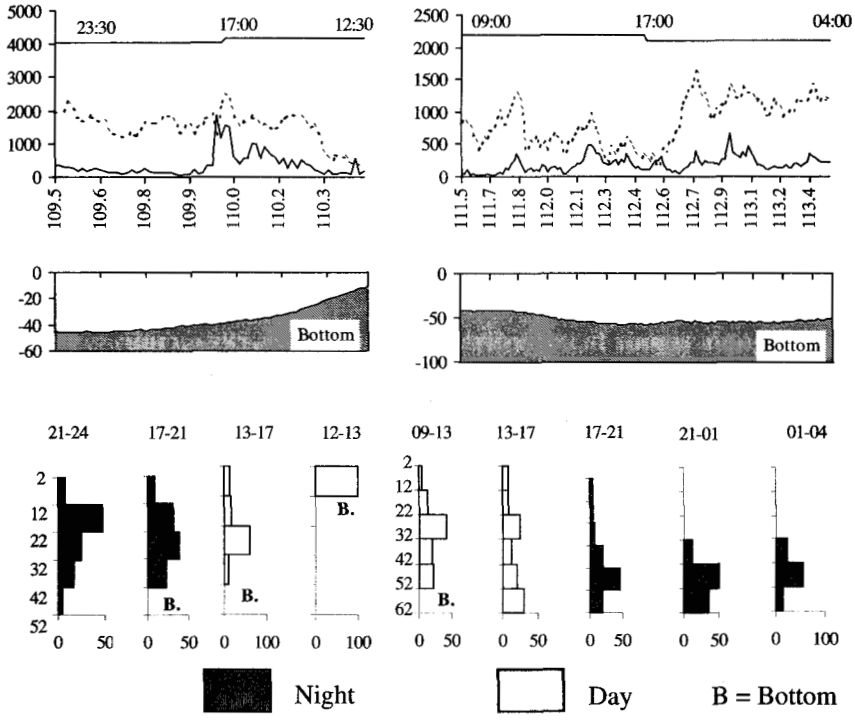

Figure 4 **February 1994. Up, density per thousand (relative units) for low reverberating (dash) and high reverberating (line) targets, West (left) and East (right) of Semarang. Down, for each zone, the vertical location of the density, in percentage, related to the time.**

Gambar 4 **Februari 1994. Kepadatan (dalam unit relatif) reverberasi rendah (tanda hubung pisah) dan reverberasi tinggi (garis lurus), pada sebelah Barat dan Timur Semarang. Bawah, penanpang tegak kepadatan dalam percen menurut waktu dan zona.**

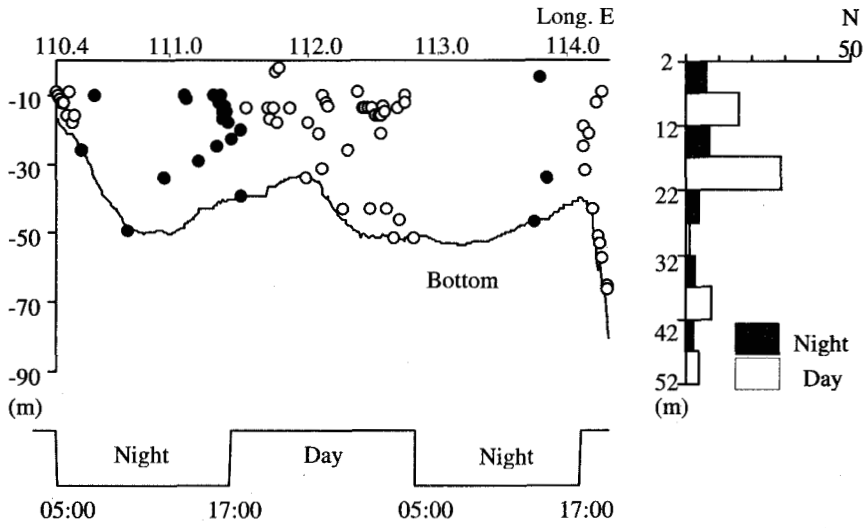

Figure 5 **February 1995. Bathymetric distribution of shoals along the east Java coast and the global day night distribution (up); their location (down). The densities are in relative units.**

Gambar 5 **Februari 1995. Distribusi kelompok ikan berdasarkan kedalaman sepanjang pantai Utara Jawa Timur (Kepadatan relatif unit). Atas, distribusi global siang dan malam; bawah, lokasinya.**

Survey of April 1994

It is a "Greek" survey from the coast to open sea, centered in the zone of the Bay of Semarang. The transects of 30 miles concern the depths from 15 to 50 m. Figure 6 represents the distribution of density per mile by day and night : on the one hand, there is a decreasing gradient from the coast to the open sea, on the other hand there is a very great nocturnal enrichment, which seems to take advantage of the coastal area. In fact, the representation of density variations along the distance coast-open sea shows that the nocturnal effect takes place particularly in a bathymetric sector of 25 to 40 m. That zone of nocturnal enrichment concerns the bay as well as the transects in the East of the peninsula. The variogram on the whole of data (day and night) indicates structures of about 20 miles of range, dimension probably in relation with the intervals where great variations of density are found along the transects. The variograms of abundance, diurnal or nocturnal, show the presence of structures lower than 10 miles, already observed previously in the Java Sea (Petit *et al.*, 1995).

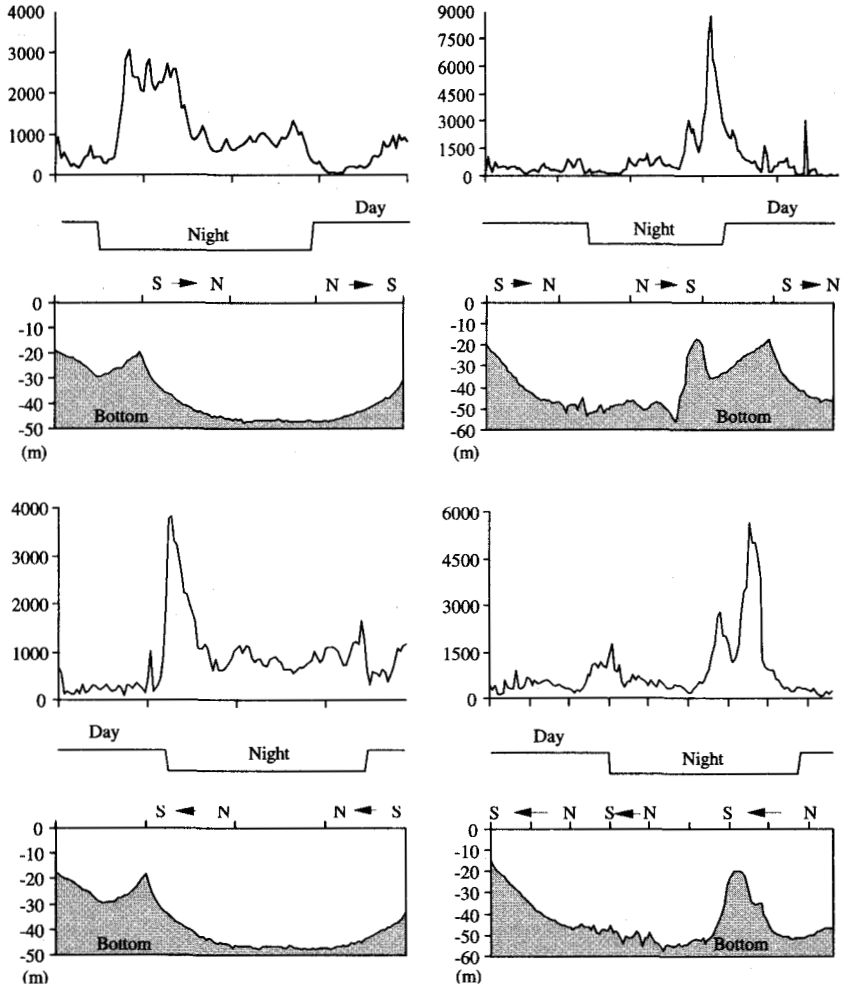

Figure 6 **April 1994 (Survey 42); Density per mile vs the distance. Left, go and back in the West of Semarang; right, go and back in the East.**

Gambar 6 **April 1994 (survey 42). Kepadatan per mil menurut jarak. Kiri , ulang-alik bagian Barat; kanan, ulang-alik bagian Timur Semarang.**

The vertical distribution of density (Fig. 7) is basically the same in all the area : the densities are higher in deeper half water mass, with tendency to dispersion of fish by night; the phenomenon is only greater in some bathymetric sectors.

The geographical localization of the shoals shows a gradient : they are more abundant and less reverberating in the coastal zone and in the bay (Fig. 8). The most remarkable is their bathymetric localization : the majority is in the deeper half water mass; because of absence of environmental data, it is not possible to suggest an explanation to the phenomenon; in the western part of the Java Sea the vertical distribution of the aggregations is almost the same.

In the East of the bay (Fig. 9), it seems that there are 3 sub-groups of aggregations : the low reverberating shoals which are present everywhere, the 2 other groups more reverberating, one in the open sea, the other closed to the coast. These latter are separated by the bathymetric zone occupied by high nocturnal densities.

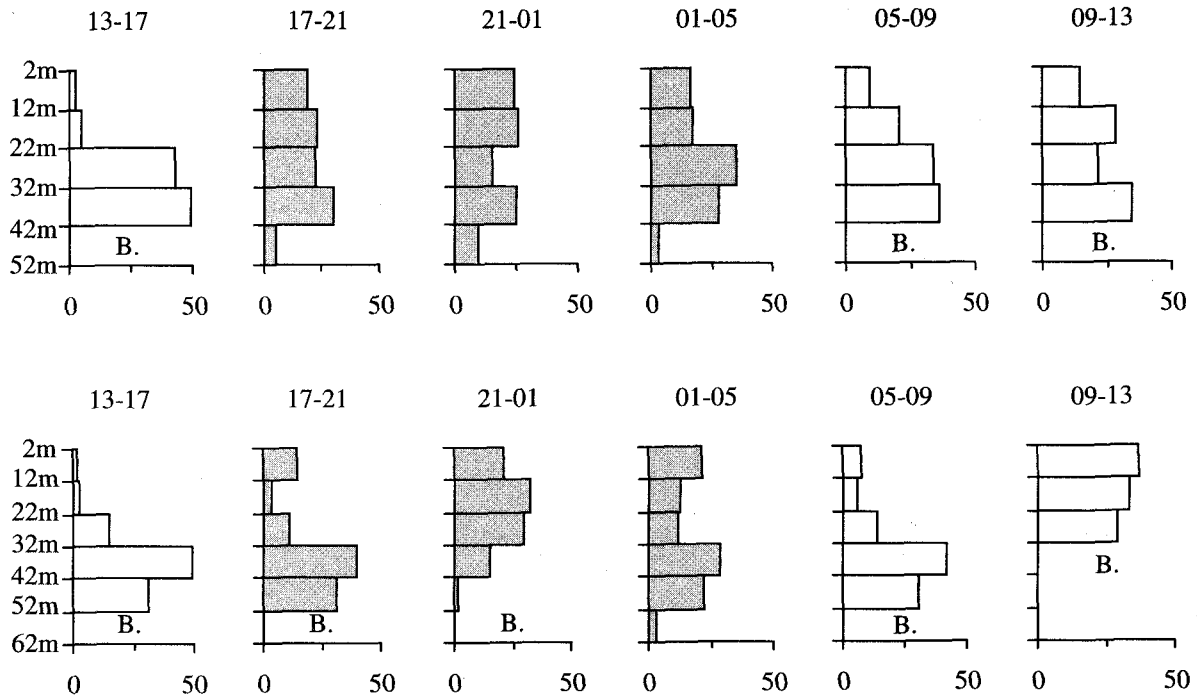

Figure 7 **April 1994. Diurnal vertical distribution of the density, in percentage, West (up) and East (down) of Semarang (B., position of the bottom).**

Gambar 7 **April 1994. Distribusi tegak kepadatan diurnal, dalam persen : atas, bagian barat; bawah, bagian timur Semarang (B. : dasar perairan).**

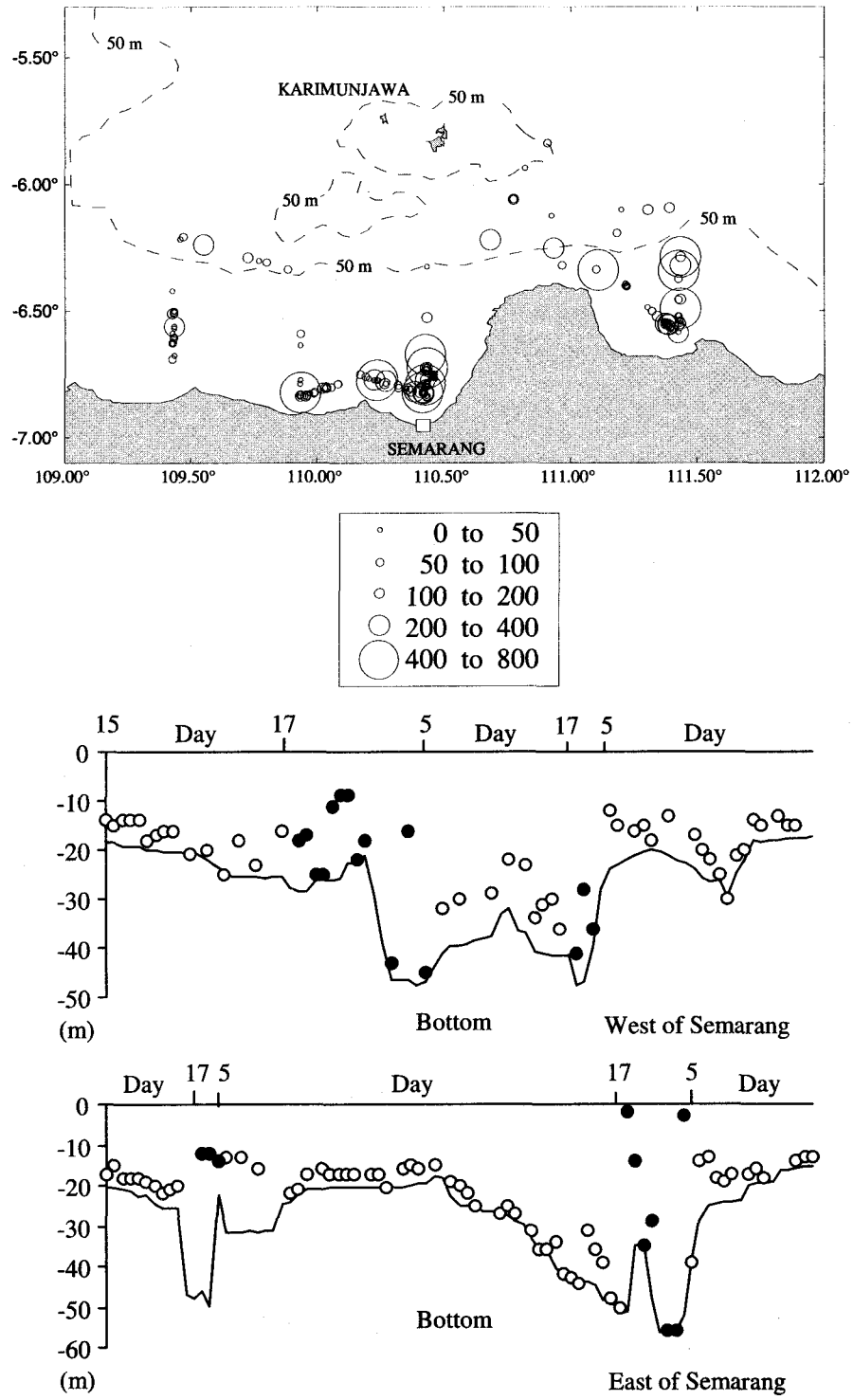

Figure 8 **Up, location of shoals in April 1994 around the Bay of Semarang. Down, their bathymetric distribution in the West and in the East of the Semarang longitude.**

Gambar 8 **Atas : lokasi kelompok ikan pada bulan April 1994 di perairan sekitar Semarang; bawah : sebaran membujur kedalaman perairan di bagian barat dan timur Semarang.**

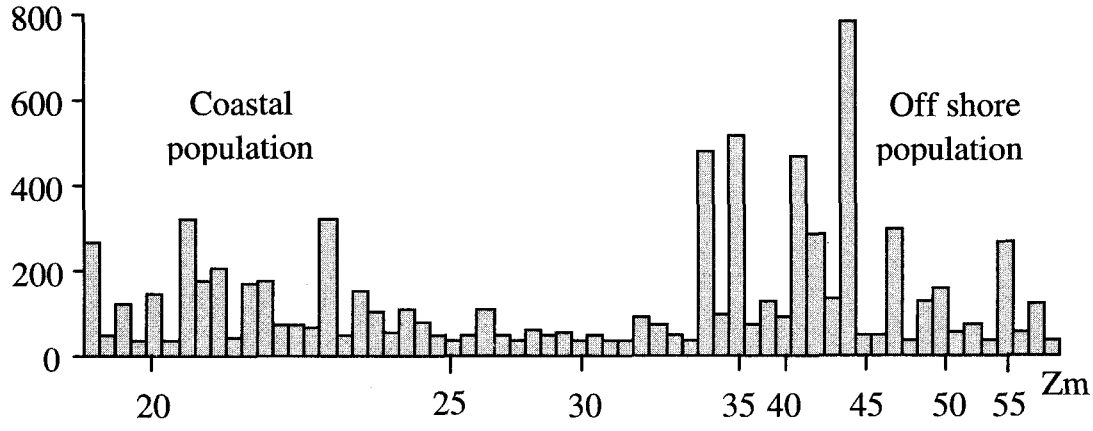

Figure 9 **April 1994, density of the shoals vs depth the East of the peninsula.**
Gambar 9 **Sebarang kepadatan kelompok ikan menurut kedalaman di perairan sebelah timur Semenanjung (Mandalika).**

Survey of May 1995

The survey has been realized when the haline homogenization of the Java Sea is intensified. It is a go and back along the coast of west Java, with two transects towards the open sea, on the eastern side of Sumatra (Fig. 1). In the West of Java, the transects are at 15-20 miles from the coast, by depth of 25 to 45 m (65 m in front of Sunda Strait). In Sumatra, the transects coast-open sea are of 60 miles (depth between 15 and 25 m). All along the route, the vertical salinity varies a little (32.2 to 32.8‰).

Along the western coast of Java (Fig. 10), the variations of abundance are linked to the nycthemeral cycle and to the increase of bathymetry : the transects by night and in deeper areas are richer. It can be considered that going from the Bay of Semarang to the West, the densities tend to decrease, whereas the bathymetry remains the same. The increase in front of the Sunda Strait would be the fact of a new pelagic stock linked to the strait.

Along the western side of East-Sumatra, the go and back course is the same for the southern transect only. Away from the strait, the water becomes poorer along the coast as well as towards the open sea (depth less than 25 m). In the northern part, where the round trips have been different, the densities remain very weak, except in the farthest north-east where the densities are relatively important by depth of 20-25 m.

Apart from general poor condition of water, the most prominent aspect in all that area is the absence of nocturnal enrichment, contrary to the western part of Java. Here, by day and by night, the most superficial layer is the richest, while, in the western border of Java, more than two third of the abundance is localized in the deeper half of the water mass. The greatest proportions near the bottom have been found at the surroundings of the Bay of Semarang and at the proximity of the Sunda Strait, which are also the richest sectors.

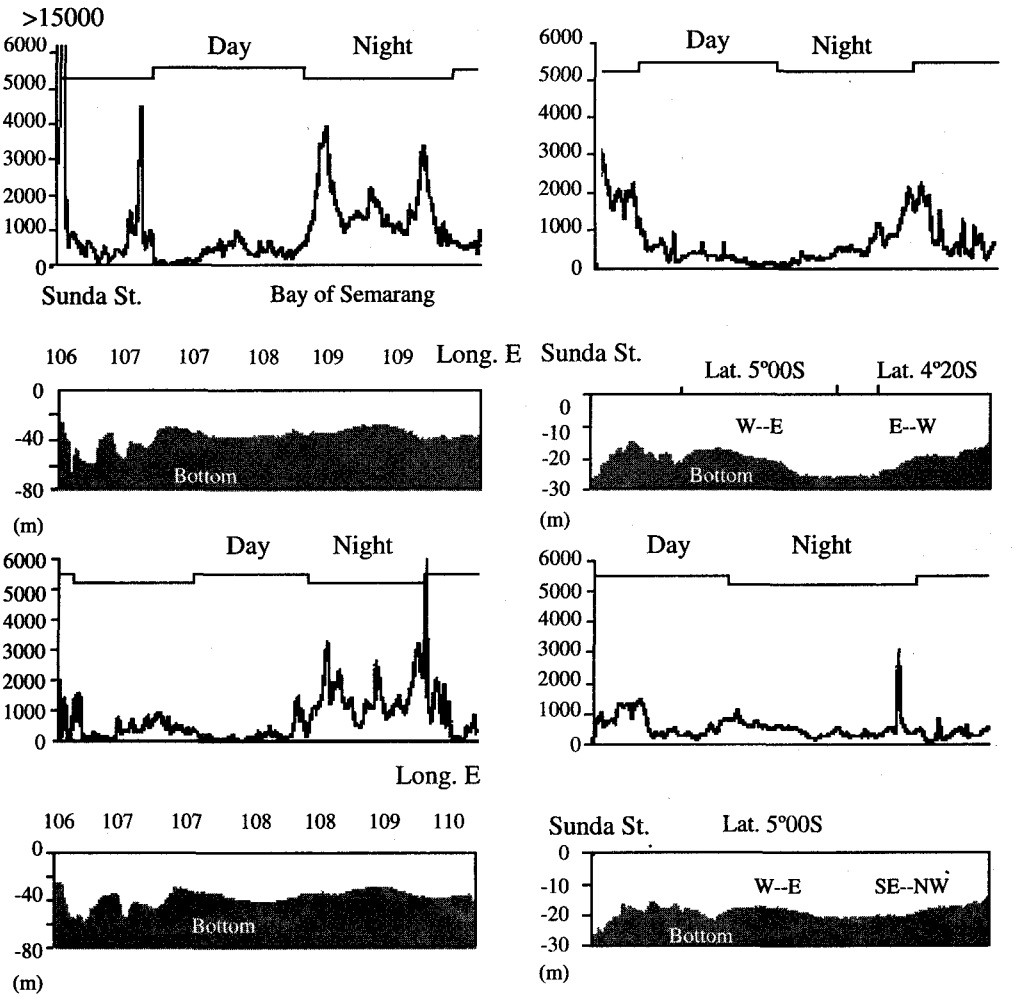

Figure 10 **May 1995 (Survey 53). Density by mile; left, along the west Java coast (go and back, identical transects); right, along the border of Sumatra, transects different.**

Gambar 10 **Mei 1995 (survey 53). Kepadatan per mil; kiri : sepanjang pantai Utara Jawa bagian Barat (ulang-alik lintasan yang sama); kanan : sepanjang pantai Sumatra (ulang-alik lintasan berbeda).**

The analyses of the shoals concern only the go-trip; the back-trip would bring only some supplementary information, because the courses by day or night are practically the same. Many shoals of very low reverberation have been found along the transects and only the most reverberating ones are considered, like in previous surveys. In the western side of Java, the aggregations seem abundant by day as well as by night and localized in the deeper part of the water mass (Fig. 11). The area near the Sunda Strait takes on its own characteristics with dense shoals by night and near the surface. Along Sumatra, the aggregations are exclusively present by day and their number is reduced (Fig. 12).

In the two previous surveys, the TS measurements have not been analyzed. In the survey of May, the calculation of averaged TS by station shows a regular decrease of the index from East to West (-52 to - 58 dB), with exception of a temporary increase in front of the Sunda Strait.

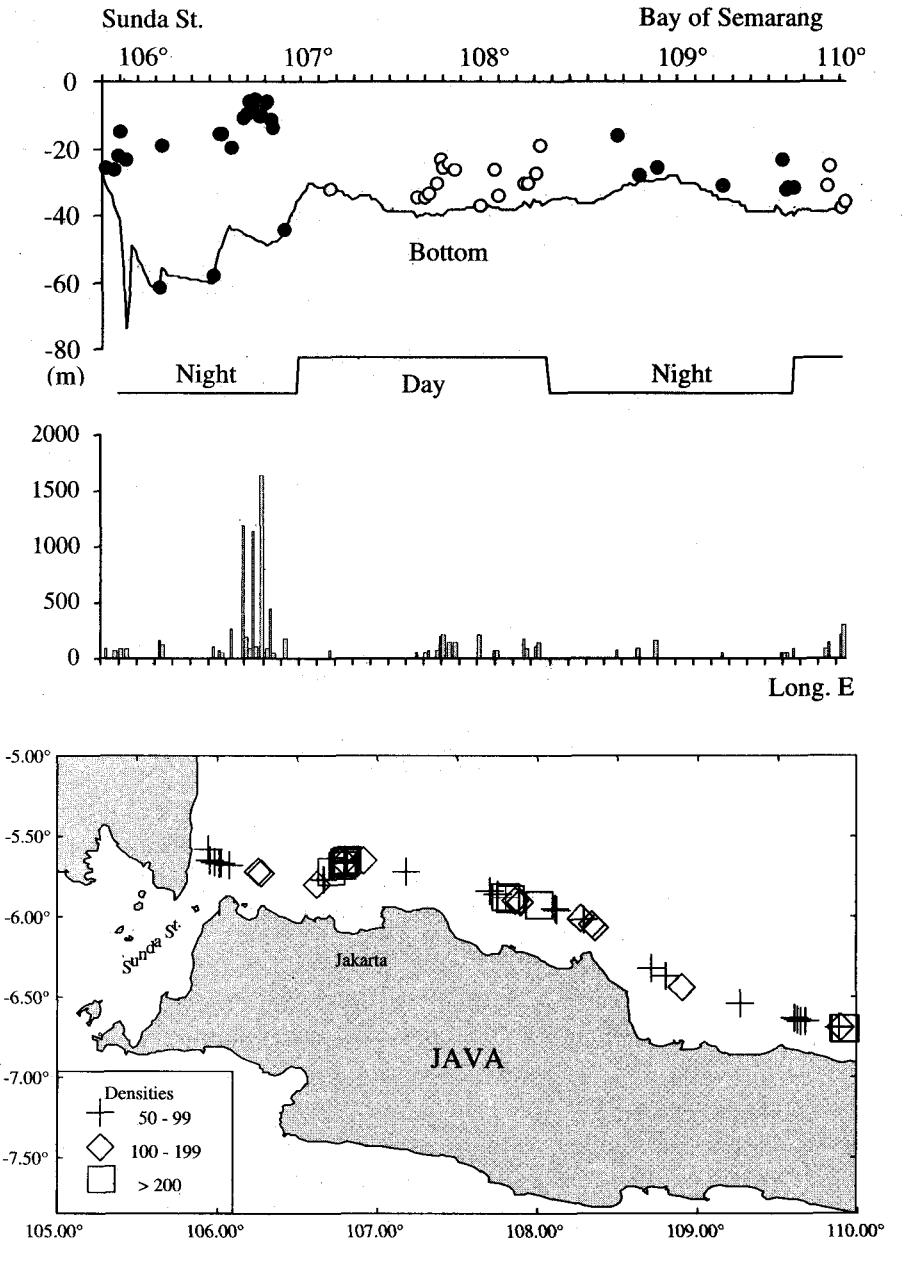

Figure 11 **May 1995. Up to down : bathymetric distribution of shoals from Semarang to the Sunda Strait, their relative density and location.**

Gambar 11 **Mei 1995. Atas ke bawah : distribusi kelompok ikan menurut kedalaman dari Semarang sampai Selat Sunda, kepadatan relatif dan lokasinya.**

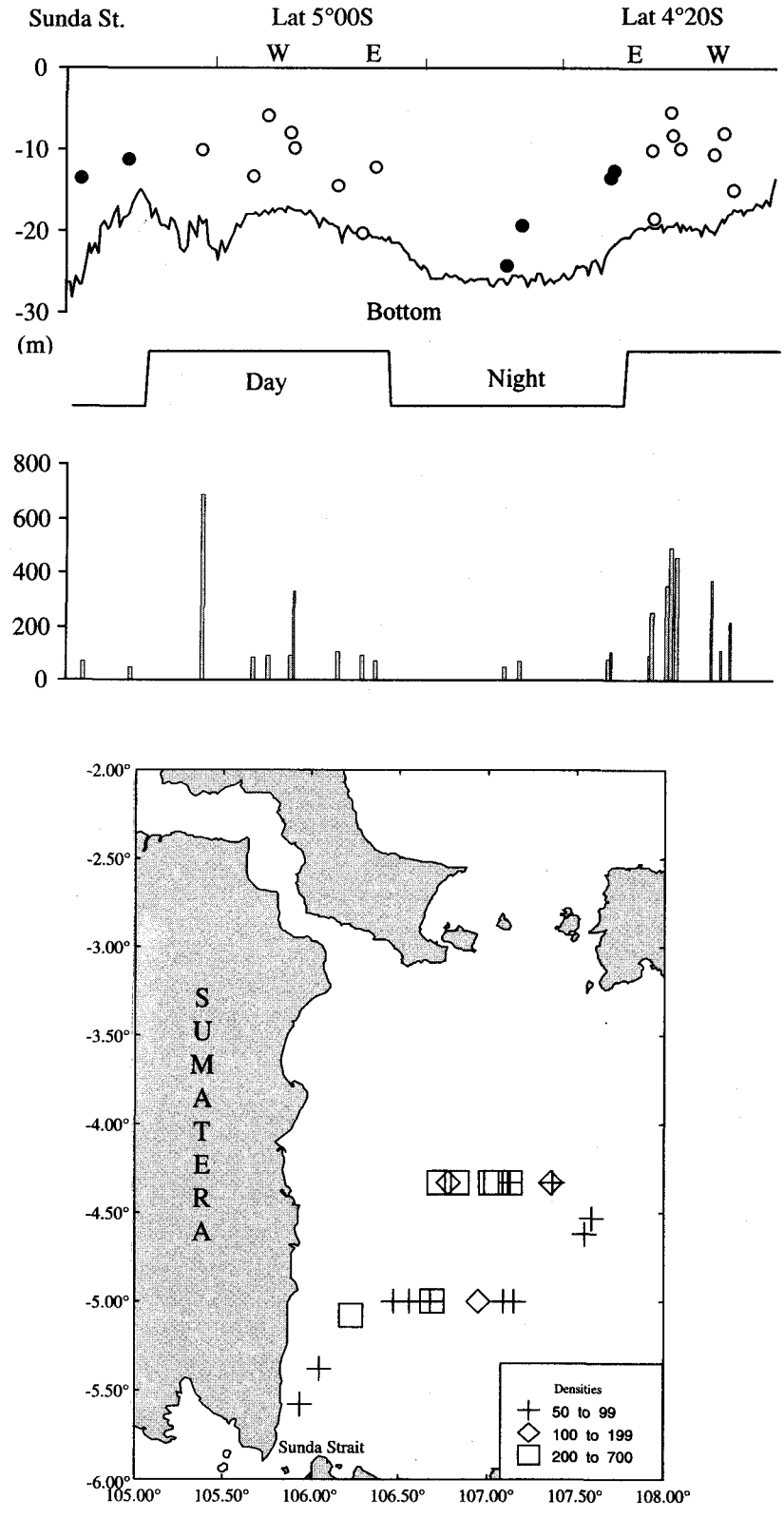

Figure 12 **May 1995. Up to down : bathymetric distribution of shoals on the border of Sumatra, their relative density and location.**

Gambar12 **Mei 1995. Atas ke bawah : distribusi kelompok ikan menurut kedalaman sepanjang timur Sumatra, kepadatan relatif dan lokasinya.**

CONCLUSION

Realized in different geographical zones and relatively near the coasts, the 3 surveys should have shown the influence of local environment (topography, particular coastal factors). From that fact, trying to extract the general characters can be risky. The Bay of Semarang with its strong density of small coastal schools and the values of very high global density seems to present a particular environment, similar to the case of the Sunda Strait sector, where we have found shoals of high reverberation at the surface, by night. On the other hand, the surveys took place in the seasonal periods which are not thoroughly comparable : the eastern area has been explored even though the effect of desalinization has not yet attained its maximum in the Java Sea, as it is the case in May for the exploration of the western part.

However, and even though the observations are still very fragmented, it seems that general characteristics can be extracted from this description, which allow to better understand the system of the Java Sea in its wholeness by integrating to those observations the local and seasonal particularities.

Till now the role of the bathymetry on the distribution of abundance and its relation with behavioural situations have not been much studied. Programmed for analyzing the environment in the fishing zones of seiners, the different surveys have been planned for prospecting the deepest sectors (and also the most monotonous) of the Java Sea. The survey of April 1994 in the Semarang area clearly reveals the existence of a nycthemeral migrating behaviour related to some bathymetric levels. But moving towards the East or the West from that bay, there is a similarity of situation which leads us to consider that the phenomenon is not local. The variations of nycthemeral density ratio, in the noted different sectors prospected, summarize well the behavioural differences and their consequence on the daily variations of abundance. In all that area, under direct continental influence, as soon as the bathymetry becomes deeper than approximately 50 m, the maxima of abundance are linked to the nocturnal vertical movements; the sub-superficial waters are the richest and during the nocturnal phase every layer of water is enriched by a semipelagic fauna. More to the open sea towards the East (February 1994, February 1995), the nocturnal effect becomes lower and the maximum of abundance remains near the bottom.

At the longitude of Semarang, the very coastal domain -- bottom less than 25 m -- has been prospected in February 1995. That strip of less than 10 miles, appears relatively poorer than the near open sea, at least by day, with a multitude of small schools, low reverberating. But in the coastal border of Sumatra, the same type of bottom represents an extension of more than 60 miles; it has been prospected by day and night; it appears very poor with a population remaining pelagic by day and night.

During those 3 surveys, there is a certain analogy in the characteristics and localization of the shoals; it is the presence of numerous small schools, low reverberating; these schools predominate in the coastal border, while the more reverberating shoals tend to be found in the more important depths. Particularly from East to West, the vertical localization of aggregations changes : in the East, they generally remain in the superficial half of the water mass; from Semarang to the West, they are deeper; their density decreases from East to West[1], all like the global abundance (Fig. 13).

[1] The number of aggregation by mile decreases : 0.4 in the east of Semarang, 0.3 in the bay, 0.2 in the west Java and only 0.1 alongside of Sumatra.

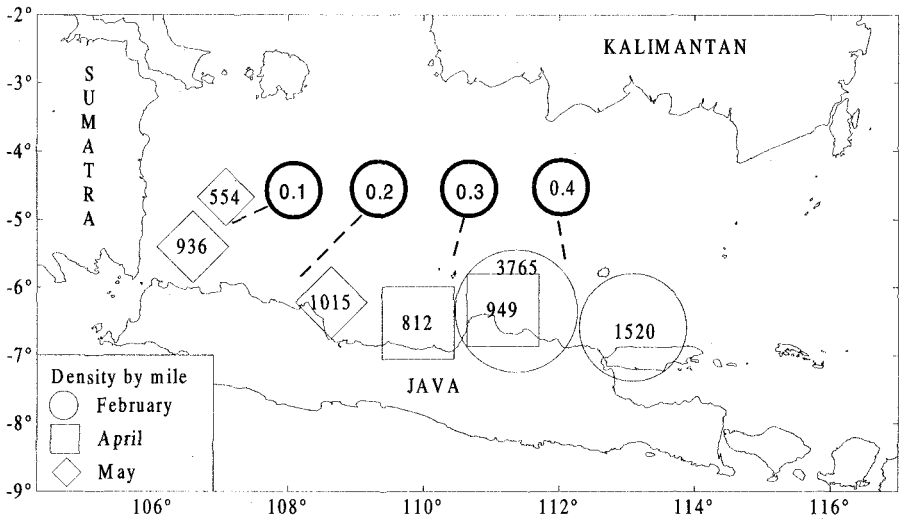

Figure 13 **Mean nycthemeral relative densities between February and May; in black circles, the number of shoals by mile in the 4 sectors : Sumatra, West Java, Semarang sector and East Java.**

Gambar 13 **Rataan « nycthemeral » kepadatan relatif pada Februari dan Mei; lingkaran hitam adalah jumlah kelompok ikan per mil pada 4 sub area : Sumatra, Bagian Barat Jawa, Semarang dan Bagian Timur Jawa.**

Nevertheless, those general characteristics come from observations which were realized during different months and they integrate a seasonal evolution that might have attenuated the similarities or, on the contrary, accentuated the general tendencies, like the impoverishment from the East to the West, including the local and seasonal particularities. The existence of rich pelagic and semipelagic populations in the zone of the Semarang-Karimunjawa Islands, probably can be linked with the seasonal persistence of water with higher salinity in February; the presence of new pelagic population in front of the Sunda Strait, original by the importance of aggregations and by their behaviour reminds us that the Java Sea is an open domain which suffers and takes advantage from seasonal migrating flux.

It remains to confront those results with biological knowledge about the group of species, also with the comprehension of the dynamic mechanisms of the area as they appear in the follow-up of previous analysis. Among the commercial species the most abundant caught by seiners, there is one more semipelagic : *Decapterus russelli.* As a target species, it seems to have greatly contributed to the development of the present fishing technique with light attraction. It is likely that this latter contributes for a great part in the abundance detected in the bottoms of 25 to 50 m along Java. So, in wet season, that species would occupy, for the most important part, a bathymetric stratum, perhaps in relation with the environmental tolerances and trophic requirements : the supplies in nutriments are then essentially continental. The most coastal border, subject to seasonal desalinization would be occupied by a fauna with pelagic dominance and more adapted. The mackerel *Rastrelliger spp.* and certain sardines belong to that fauna.

In a tentative of modelization, the previous works concerning 2 large surveys (October 1993 and February 1994) have come to define 3 strata of associated populations (Petit *et al.,* 1995) : the first, oceanic, does not concern the domains studied here (except probably the Sunda Strait and the extreme East of Java). According to the season; the second stratum, neritic, occupies the major part of the Java Sea. The third, the coastal stratum, had not be sampled correctly; but strong seasonal desalinization justified its existence along the coast.

The behavioural study, moreover, had enabled to recognize 2 different populations : one pelagic, ubiquitous and another one semipelagic responsible of high densities in the dry season. This latter is following a longitudinal movement according to the seasons.

Besides the fact the study of those 3 surveys globally corroborates the previous hypothesis, it also brings out some interesting precision in the domain of ecology as well as in the seasonal migrating movements. The coastal stratum occupies, at least in front of Java, a very restricted surface (fifteen miles maximum). The important extension of shallow waters in front of Sumatra, inhabited by this stratum, seems to contribute to the impoverishment of the West Java Sea. What about the South of Kalimantan where the zone of shallow depth is also large? In wet season, this zone is less occupied by semipelagic populations. At last, it was assumed that the populations migrate to the East, at the beginning of the wet season. It appears, from the high densities met in front of Semarang, that one part, sedentary, makes a migration to the South to stay in some favourable bathymetric sectors.

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DISCUSSION

(Chairman Dr. PASARIBU)

Dr. EDDI AMIN

Q : - Usually, we use the values of density for stock assessment. I would like to know how you convert the value of Target Strength to fish density. Did you use the results of fish calibration or common formulas ?

A : - Tomorrow, we will have another communication about the conversion of relative density values to absolute biomass with many restrictions. To have this information, we made experiments in cage, and we measured the Target Strength of three species. We selected the best data to calculate our constant of conversion. We will see that also tomorrow.

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