THE PELFISH SURVEYS : OBJECTIVES AND DATA COLLECTION

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ABSTRACT

From 1991 to 1995, twenty acoustic surveys took place in the Java Sea and the surrounding areas in the frame of the PELFISH Project, sponsored by European Union, Indonesia and France. Their aim was to study the distribution, abundance and behaviour of the pelagic fauna, especially on the fishing grounds of the seiners. It needed various operations as environmental measurements, echo-integration, TS measurements, school localization, light attraction and trawl samplings. The scientific equipment and its adjustment, as well as the procedures of data acquisition used, are summarized (acoustic and physical measurements, samplings). The spatial, diurnal and bathymetric distribution of the sampling show that the data collection can give an accurate information for the prospected area. About 500 environmental stations, 1,500 TS stations and 20,000 density measurements give matter to constitute the basic information of a Data Bank which may be consulted at the RIMF BPPL, Jakarta (INDONESIA) or at ORSTOM, Montpellier (FRANCE).

KEYWORDS : acoustics, echo-integration, Java Sea.

ABSTRAK

Dimulai pada tahun 1991 hingga 1995, sejumlah dua puluh kali pelayaran akustik telah dilakukan di perairan laut Jawa dan sekitarnya melalui Proyek PELFISH yang biayai oleh Uni Eropa, Indonesia dan Perancis. Tujuannya adalah untuk mempelajari penyebaran, kelimpahan dan tingkah laku ikan pelagis terutama pada di daerah penangkapan ikan dengan pukat cincin. Hal ini didukung oleh berbagai aspek operasional seperti halnya pengukuran karakteristik lingkungan, echo-integrasi, pengukuran pekiraan ukuran ikan, keberadaan kelompok ikan, pengaruh cahaya serta pengambilan contoh melalui penangkapan dengan trawl dan kapal komersial pada saat survey. Peralatan ilmiah serta pengaturannya, prosedur sistem akuisisi data yang telah digunakan (akustik, pengukuran fisik,serta pengambilan contoh) akan disajikan dalam tulisan ini. Penyebaran secara spasial, diurnal dan kedalaman berdasarkan pengambilan contoh memperlihatkan sejumlah koleksi data yang dapat memberikan informasi secara akurat dan harapan terhadap perikanan pelagis. Sekitar 500 stasion lingkungan, 1,500 stasion pengukuran besaran target, 20,000 unit pengukuran kepadatan sebagai bahan informasi dasar bank data dapat dikonsultasikan pada Balai Penelitian Perikanan Laut, Jakarta (INDONESIA) atau pada ORSTOM di Montpellier (PERANCIS).

KATA KUNCI : akustik, echo-integrasi, Laut Jawa.

The abundance evaluations of Indonesian pelagic fauna, by means of Acoustics, began 25 years ago. The first surveys were carried on by the FAO, with the R/V Lemuru in 1972-1976 (Venema, 1996). The development of investigations had been supported then by various international programs : the Jetindofish Project with the FR/V Jurong in 1979-1981 (Lohmeyer, 1996), the CIDA/FAO Indonesian Fisheries Development Project with the R/V Tenggiri in 1981-1983 (Johannesson, 1984), the Indonesian-Dutch Snellius Expedition in 1984-1985 with the R/V Tiro (Schalk *et al.*, 1990). But on the other side, the Indonesian Research developed its proper investigations with the R/V Bawal Putih I (Merta, 1976; Amin *et al.*, 1981; Uktolseja, 1981), the R/V Tenggiri (Amin and Nugroho, 1990), the R/V Baruna Jaya I (Amin and Nugroho, 1991). In 1985, after a first echo-integration survey in the Java Sea (Boely *et al.*, 1987) and the beginning of a cooperation in Fisheries Biology with the B.P.P.L. in 1987, the PELFISH Project started in 1991. Its aim was the study of the fishing activity of the seiners in the Java Sea. It was sponsored by European Union, Indonesia (the Agency for Agricultural Research and Development, AARD) and France (the French Research Institute for Development through Cooperation, ORSTOM). The researches were focused on offshore pelagic fisheries, with the following objectives : provision of scientific advice for a future management, improvement of the performances of the fishing system, evaluation of the socio-economic impact.

Thus, to reach these objectives, PELFISH has developed various fields of activities and among them, studies oriented to the fishery functioning, bioecology and fish population dynamics. In this field, the aspect of the fish behaviour and the biomass estimation throughout the echoprospecting and echo integration were considered to occupy a special attention. Yet, the biomass evaluation by Acoustics is the only method able to supply the necessary information on the condition of the stock and its availability at any time. But, it appears that the method could bring up the more interesting information, especially in the studies on structures, distributions and behaviours

OBJECTIVES OF THE PROJECT AND CONSECUTIVE SCIENTIFIC ACTIVITIES IN ACOUSTICS

The objective, as expressed in the original Work Plan (Boely and Cholik, 1991), was that the Project was aimed "to study and improve the exploitation and the organization of offshore pelagic fisheries in the Java Sea ..." Especially, the Project aimed at promoting the development of offshore pelagic resources in the long term, "throughout a better knowledge on stocks, by suggesting better fishing methods as well as better conservation, handling, transformation, able to optimise the profits..." Translated in scientific terms, the investigation's subjects devoted to the acoustics research can be assembled into two principal terms :

- the study of the distribution and the abundance of the pelagic fish populations,
- the study of their behaviour.

These two studies had to be investigated through the two variables : time and space, in order to take into account the geographic and seasonal variations.

DEFINITION OF A STRATEGY

A strategy of prospecting has to be oriented from the available knowledge. At the beginning of the Project, exist few information : a possible existence of an "island effect" on abundance, observed in the surroundings of the Natuna Islands (Johannesson, 1984) and the necessary influence of a gradient in the west-east environmental characteristics on the pelagic populations in the Java Sea[1]. Especially, the presence of important catches in the North east of the Java Sea (Sadhotomo *et al.*, 1988; Boely *et al.*, 1988).

[1]Not forgetting the information given by the R/V Lemuru surveys made in the Java Sea, but unfortunately, these latter were still in a qualitative aspect.

Admitting that fishermen operate in the most accessible rich sectors for profitability, the orientation of research towards intensive fishing grounds as a priority was justified.

The Java Sea (Fig. 1) has a surface area of some 440,000 km^2 (Durand and Petit, 1995). From Semarang, the port of registry of the research vessel, the vast fishing grounds (Masalembo-Matasiri Islands) are at about 300 nautical miles. Besides, the trawler Bawal Putih I, at the Project's disposal did not present anymore satisfactory capacities -- with an autonomy of twelve days and a speed of 6.5 knots about -- to insure large surveys.

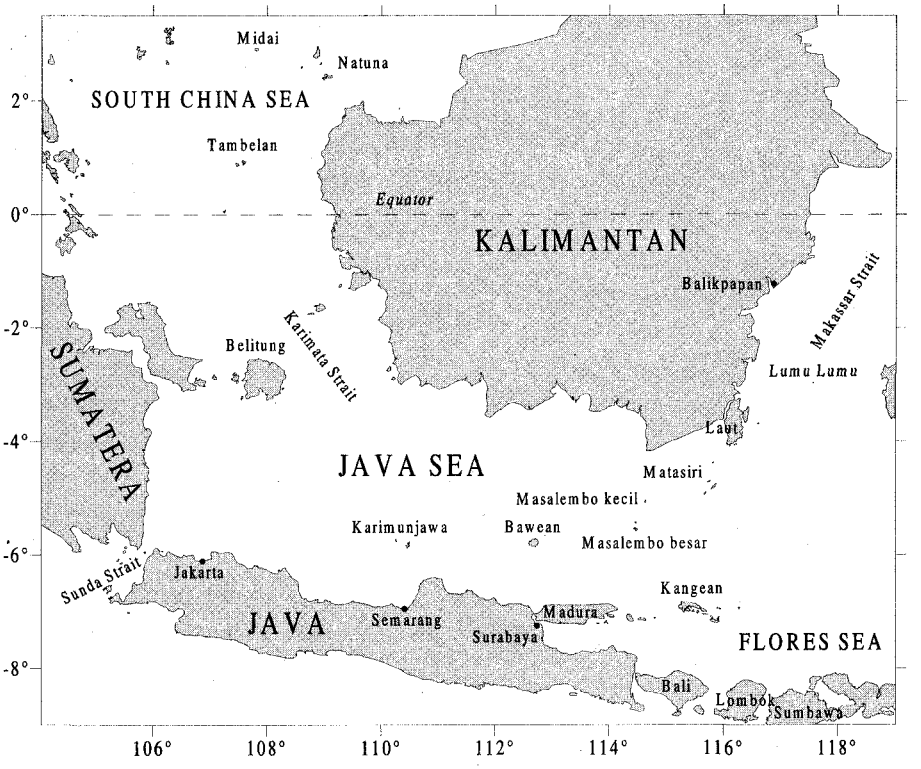

Figure 1 The Java Sea and its surroundings.
Gambar 1 Laut Jawa dan sekitarnya.

In a first time, the best way to associate the previous requirements and/or hypothesis in the prospecting scheme, was to run a transect from island to island through the intensive fishing zone, repeating the course adopted by the seiners to reach the richest fishing grounds. In this way, we were able to locate precisely the seiners in activity, sample them and compare the abundance in and off the fishing areas. When have been gained ship improvements (main engine, radar, GPS,...) and complemented the scientific equipment (trawls, netsond), more ambitious surveys have been carried out. Thus, the operations of investigation have been composed in two phases : until 1993, took place surveys to study mainly the seasonal variation along transects; from 1993, some large surveys and experiments complementing the precedent observations have been tried. Nevertheless, the short autonomy and the low ability of the trawler to sail have reduced the activities.

THE THEMES OF ACOUSTIC INVESTIGATIONS

Before the beginning of data acquisition in routine, two cruises (November and December 1991) were carried on to adjust the settings and controls of the acoustic equipment.

The domains of studies require different features of prospecting and observation (Simmonds *et al.*, 1992) and, during the Project, the various investigations set about can be gathered into 6 themes.

The description of the seasonal variation was mainly realized by transects from island to island from Semarang to Matasiri, when the weather allowed it. These transects took place 11 times from March 1992 to February 1994, especially in 1992 (Fig. 4).

Various local minisurveys ("mini," by lack of time) from 96 to 360 square miles, complemented the study of the local nycthemeral behaviour and gave information about the local day and night densities. All these minisurveys were located eastwards from Bawean Island (March, May, September, October, November 1992 and December 1993), on the fishing grounds of the Java Sea, except one, in April 1993, in the South China Sea.

Two large surveys covering the maximal area of the Java Sea, were achieved in October 1993 and February 1994. They allowed to have an overview of the density distribution and to evaluate the mean density of the Java Sea during the seasonal situations more or less extreme (Petit *et al.*, 1995).

Three cruises have been performed to describe local areas : in front of Semarang, in the coastal zone (April 1994), in the south eastern part of the Java Sea (May 1995), along the eastern continental slope (return from Lumu-Lumu Island, February 1995).

There were two exploratory surveys out of the Java Sea : a long transect through the fishing grounds in the South China Sea (April 1993) and a survey on the Kalimantan continental shelf in the Makassar Strait (January-February 1995). These two surveys were made when the fleets of seiners move out of the Java Sea for some months.

The last group of observations concerns punctual experiments as light attraction experiments in various places, close to or far from seiners (more than twenty experiments especially in May and November 1993), transects around the Matasiri Island (June 1992), Bawean and Karimunjawa Islands (June 1993), tracks around anchored *rumpon* (Fish Attracting Device, May 1993, November 1993), experiments on light effect during prospecting and some other methodological observations (effect of pulse duration, tilting of paravane).

We have to add to the precedent list the necessary tests of calibration, made at anchor in the Dungos Bay (Bawean I, by 17 m deep), well protected but far from Semarang, and Target Strength measurements on living fish at Bawean and Matasiri Islands (November 1991, October 1992, December 1992; Cotel and Petit, 1996).

Since November 1992, a new radar has allowed to locate the seiners met during the surveys and to study the relation between the fishing tactics and the distribution of the fish density (Potier and Petit, 1995; Petit and Potier, 1996; Potier *et al.*, 1997).

THE COLLECTED DATA

Environmental observations

From May 1992, the R/V Bawal Putih 1 has been equipped with a SEACAT SBE21 surface thermosalinograph and above all, a C.T.D. SEACAT SBE19 Profiler. During all the following surveys, vertical profiles of temperature, salinity and light penetration were executed along the tracks of echo-integration. More than 500 environmental stations were stored and analyzed.

Biological samplings

Tentative to rig the R/V Bawal Putih 1 with a seine in February 1993 did not give full success by inadequation of the ship. Besides, the aggregations met in the Java Sea, scarce and small, did not allow the opportunity to sample effectively the pelagic fish. From April 1993, a pelagic trawl (vertical opening 10 m), equipped with a Furuno CN8 netsond without cable and a bottom trawl (vertical opening 4 m) has been used. The abundance of the catches, except for bottom fish, stayed very poor and low significant.

Thus, when it was possible, the samples were the seiners met along the tracks. The species were determined and measured on board (weight and fork length).

Some other catches, made with trammel nets upon the bottom or near the surface were experimented with some success during the light attraction stations (November 1993), thanks to the presence on board of the Captain Guegen. But, due to the big dispersion of the pelagic fish and its escape, the whole of the cruises suffered of undersampling, and during the light attractions, when fish were well aggregated, the operational conditions did not allow us the sampling which needed the partnership of another ship.

Acoustic data

The diagram (Fig. 2) gives the representation of the scientific installation on board. Two sets of data were acquired with a Model 102 Dual Beam echo-sounder (BioSonics Inc.) working with a 120 kHz frequency. It was equipped with a paravane, towed aside the board and immersed at 1.5 or 2 meters deep. This type of equipment, semiportable, therefore more adaptable, made the various operations easier (prospecting, stationary stations and especially the calibrations) and storing the equipment in good condition, at land as well.

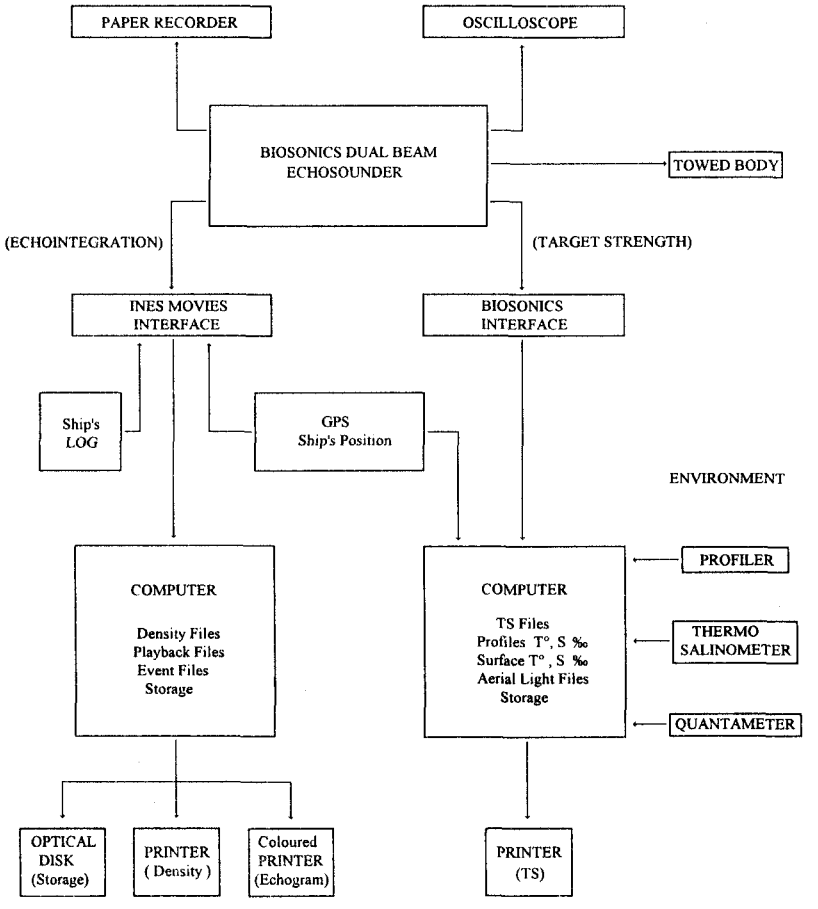

Figure 2 **Block diagram of the main equipment and data acquisition aboard the R\V Bawal Putih I.**

Gambar 2 **Diagram blok peralatan dan akuisisi data pada K.M. Bawal Putih I.**

Density measurements

They are automatically computed by means of an Ines-Movies system (Diner, 1991). The Ines interface is connected to the 10 kHz detected output (20Log function) of the echo-sounder and to a Ben log which measures the speed and to a computer. This latter gets the location given by a GPS.

In the interface, the signal of the echo-sounder is adjusted in voltage, amplified, digitized (7.5 kHz frequency) and squared. Thanks to a set of adjusting menus, the software MOVIES assumes the echo integration by distance, here the nautical mile, for echoes higher than a threshold and manages the input-outputs, from the GPS and the keyboarding, to the printers and the file storage. The integration range is from 2 m deep to the bottom, by layers of selected thickness (10 layers related to the surface, 4 related to the bottom).

During the surveys, the same sets of adjustments were generally used and were recorded in the stored files. Nevertheless, due to the low level of the detection, the threshold was a little more accurately adjusted during the cruise of December 1992, passing from 42 mV_{rms} to 33 mV_{rms} (echo-sounder output) for the following surveys.

Some measurements of density by surface have been used for the data processing in the PELFISH results (but the measurements of density by volume, or volume back scattering strength, are also available in the files). The mode of conversion of these data in weight is presented in another paper (Petit and Cotel, 1997).

At the end of an echo-integration track, the operator can have a set of information :

- a colour echogram,
- a listing of echo-integration data by nautical mile,
- a digitized signal data file, for playback,
- an echo-integration file,
- and a file recalling all events keyboarded during the track.

Due to the volume of information, the digitized data files need the use of a large storage system and along the PELFISH surveys, an optical disk storage was used for this purpose. All the information collected will be used to validate the data. The corrections of files are assumed by means of a specific software, OEDIPE (Masse and Cadiou, 1994) that allows also, among other functions, the configuration of data files in a format suitable with classical data processing software (Excel, Lotus, Surfer, Eva).

The Target Strength (or TS) measurements

Because the echo-integration goes on all along the tracks, another computer was used during the surveys. It allowed all other data acquisitions, as environmental data (by temporary connection to the Profiler or to the thermosalinograph) and especially the TS measurements by continuous connection with the echo-sounder (output 40Log function, Fig. 2). These measurements took place along the tracks, when the detection appeared abundant throughout the echo-integration monitor and/or at interval of three hours systematically. As for echo-integration, the data acquisition is realized by means of a signal processing board -- ESP (Echo Signal Processing) main board, housed in the computer. The echo-sounder output is interfaced with this ESP main board via the Signal Conditioning Pod (SCP), which also contains BNC outputs so that certain signals can be independently monitored. To perform the data processing, the user simply runs the appropriate BioSonics program. Although both softwares -- echo-integration (ESP-EI) and Target Strength measurements (ESP-DB) -- are available, only the ESP-DB program has been used for estimating fish Target Strength. This software also uses interactive menus, which permit a rapid and convenient entry of all processing parameters and multiple functions can be displayed on the screen. Individual TS measurements can be made by stratum, up to 100, from 1.2 m deep to the bottom. Each stratum can have its own size, voltage threshold, etc. They can be either surface-locked (numbered downward from the water surface) or bottom-locked (numbered upward from the bottom).

The data files, usually about 10,000 echoes for each observation, stored with the acquisition settings, can be used to perform the frequency distribution and vertical locations of the individual Target Strengths. Most of all, they are used to process the TS values in order to obtain average values then input as a factor in the final expression of echo-integration for biomass evaluation.

REPRESENTATIVENESS OF THE PELFISH ACOUSTIC SAMPLING.

Before the presentation of the results, we will try to give, from the lot of sparse data, a synthetic view about the sampling distribution. It is important to estimate the level of representativeness of sampling in relation to the geographic and seasonal environment studied. The geographic limits of the Java Sea used here are the ones defined previously (Durand and Petit, 1995) : in the north-western part, south of 3° S; in the north-eastern, south of 4° S, and the continental slope (100-200 m depth) on the eastern border.

The seasonal distribution of the surveys

In Java Sea, the dry season is the richest one for the landings and it was understandable that this active period of fishing might have been also oversampled. The monthly distribution of surveys (Fig. 3) shows a lack of sampling during 3 consecutive months. There are 2 reasons for that : the meteorological conditions and, crudely, the lack of manpower in the acoustics team. The first part of the dry monsoon has relative strong winds, not very favourable to surveys with a ship that is slow and pitching (the same circumstances explain the lack of survey during January). On the other hand, because of administrative holidays, the low number of acoustic team made impossible the survey programming at this period.

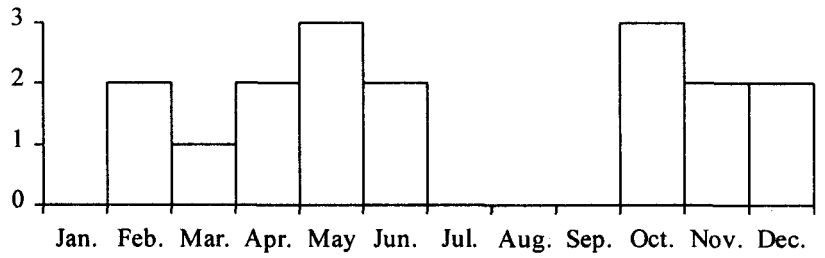

Figure 3 Seasonal distribution of the PELFISH surveys.
Gambar 3 Survey akustik PELFISH menurut musim.

The consequence is not so dramatic because the marine season being put back with regard to the climatic one, the "dry marine season" takes place in October-November. In fact, the difficulty to extract a seasonal follow-on in the PELFISH data is more the consequence of the observation dispersal, five years ago. The extreme situations were known, but the follow-on between them was less easy due to the high interannual deviations.

The distribution of samples in the nycthemeral cycle

To take into account the distribution of sampling between the diurnal and nocturnal phases is important. The PELFISH surveys, that have been covered without large interruptions show the behavioural difference of populations between the two phases. So, the coverage by day or by night, could only give the half of the information, as well as it could not put in a prominent position the specific presence of a nocturnal dense fauna. A precise counting of the day or night sampling has not been achieved but one can consider that the proportions are approximately similar. On the other hand, very few transects were repeated by day and by night, that gives the day and night comparison less accurate, but as it will see elsewhere (Petit *et al.*, 1995; Petit *et al.*, this book), the structural analysis shows that,

regionally, the dimensions of these structures are more or less homogeneous and give permission to the partition of the Java Sea in 3 strata where the day and night comparisons are reliable.

One can only regret that the more frequent route Semarang-Matasiri Islands has been run with the same diurnal schedule, but the departure from the harbour and its entry are difficult by night.

The spatial distribution of sampling

Figure 4 represents, more or less, all the echo-integration routes made along the PELFISH Project, in the Java Sea. One can see, at once, that the surveys are denser in the eastern part. It is the consequence of the Project orientation, aimed in priority to study the seiners and therefore, their operating zones. The coverage is not at all homogeneous (Fig. 5). In the East of 108° E, there was only one survey (May 1995), and the northern part of 4° S has not been prospected.

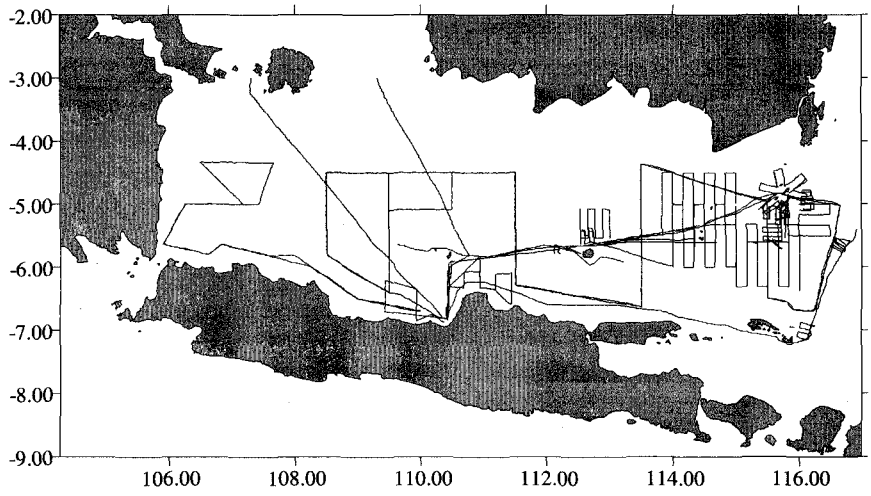

Figure 4 **Tracks of the PELFISH acoustic surveys in the Java Sea.**
Gambar 4 **Jalur survey akustik yang dilakukan PELFISH di Laut Jawa.**

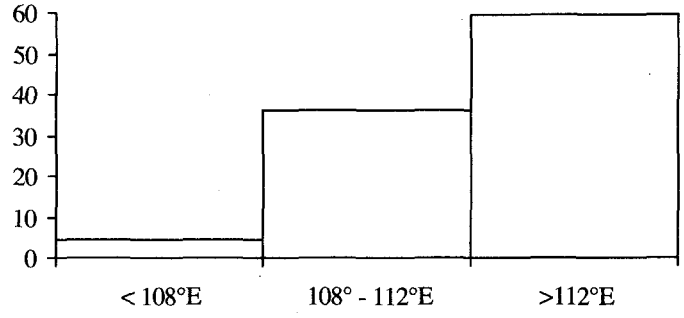

Figure 5 **Localization of integration samples related to their geographic location.**
Gambar 5 **Frekuensi jumlah pengamatan akustik berdasarkan lokasi.**

Though this sampling strategy would have been questioned during the Akustikan I workshop, this latter happens to be justified throughout the fish overdispersion pointed out, at least, in dry season. It was logical, in a first approach, to intensify the investigations in the eastern part. Thus, the observations and evaluations made will concern only the covered areas and other prospecting will be useful in the North and also in the South-East to extend the current conclusions. On this subject, the latter zone of 20,000 km^2, more or less, could allow a fishing ground extension, if the classic gears could be adapted to the local conditions (depth more than 60 m, currents). For the moment, the depths more than 55 m seem

to be relatively underexploited, but as it will be seen below, they represent more than 25% of the Java Sea and quite the half area of the actual fishing ground.

Sampling and bathymetry

All the continental shelves present a zonation of their fauna related to the interaction between the continental factors and the bathymetry (particularly the light penetration and the pressure effect). The Javanese basin does not elude the rule, with the freshwater and alluvia brought in the surrounds and the oceanic water entry on its eastern border.

To analyze the bathymetric distribution of sampling relative to the respective areas of the Java Sea, the data distribution given by Pauly *et al.*, (1996)[2] was used. Figure 6 shows a good enough concordance between the two distributions. Only the stratum 10-20 m depth, extensive in the northern and western parts has been undersampled. But, these places are the domain of fishing customs, quite specific and the presence of many dead gears makes difficult the prospection with a large ship.

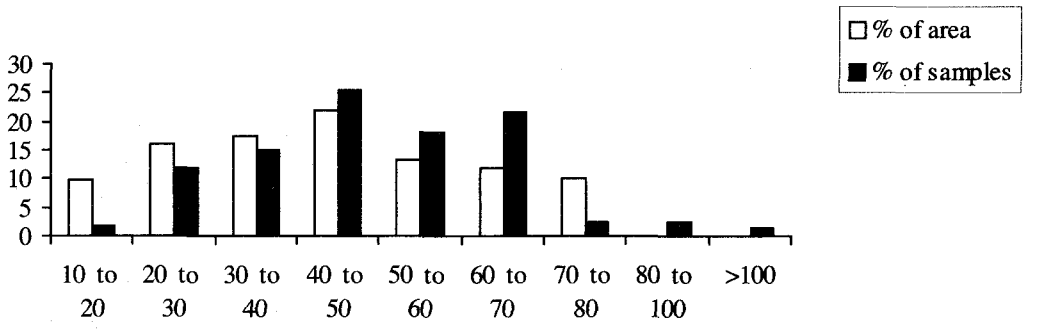

Figure 6 **Localization of all integration samples related to the bathymetric areas.**
Gambar 6 **Daerah pemgambilan contoh echo-integrasi menurut kedalaman.**

CONCLUSION

Until recently, there was not much information about the richness of the Javanese pelagic fauna and its behaviour (as well as about the seasonal oceanographic conditions), even if the pelagic fish catch has an important economic role (Potier and Sadhotomo, 1995; Roch *et al.*, 1996). The acoustics surveys of the PELFISH Project tried to make up lost time. These surveys were based on precise objectives, which aimed at complementing the information collected by the dynamicians and biologists operating directly from the exploitation, not to bring up an overall census of the Java Sea pelagic fauna.

Developed towards the stock evaluation, the acoustics techniques are capable to give information about size composition of the global resource as well as its distribution in relation with the environmental conditions provided that these latter are studied simultaneously. The quick analysis developed above shows that the sampling in its whole, was adjusted to the objectives and allows to provide a relatively good description on the main aspects of the seasonal evolution and related behavioural changes. Of course, the information collected is still inadequate and needs to be complemented by new prospecting, especially on the critical seasonal intervals, with large and consecutive surveys (January-February; May-June; September-October). This could be undertaken only with an efficient ship of 35 m length about, moving at 8-10 knots speed and about 20 days of real autonomy.

[2] In our evaluation,we excluded the area of 0-10 m depth and we noticed that the given eastern surfaces correspond to the ones until the continental shelf.

Thanks to new implemented technologies, the scientific information collected allowed to create a Data Bank for more than 500 environmental stations, about 1,500 stations of TS and 20,000 miles of density measurements. The "know-how" to use this Data Bank and its content has been presented in a previous paper (Petit *et al.*, 1997).

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DISCUSSION

(Chairman Dr. PASARIBU)

Mr. MUNANDAR

Q : - I have two questions. The first one is about the gridding. From the cruises in 1992 until now, you have made arbitrary trips that look like gridded linear courses. Should not it have been better to integrate data from rectangular grids or triangular grids ? The second one is : why did you use the INES MOVIES echo-integration system while you used the BioSonics equipment to measure Target Strength ?

A : - When the prospecting operations began, we had to define them according to the knowledge we already had on the environment and the fishing grounds; that is to say : first, to prospect these fishing grounds and second, to analyze their gradients. Wealso had to test the ship's performances.

It is obvious that large surveys with close transects would have been more profitable; but this was impossible. Thus, we have varied the objectives and the prospecting mode as well according to the surveys, because the study themes were numerous, e.g. assessment, distribution, behaviour related to the environment and the traditional fishing tactics. We have, therefore, performed one routine transect, surveys as large as possible regarding to the autonomy of the vessel, mini surveys and light attraction experiments.

To answer the second question, while the BioSonics system was giving satisfaction about the quality of the equipment and the measures of Target Strength, the INES MOVIES system was superior for the storage, the data processing and the printing of echograms. Moreover, the BioSonics system could not assume both echo-integration and Target Strength measurements in the same time, in a single computer.

Dr. Marchal comments : "It is not possible to perform in the mean time echo-integration process and Target Strength measurement with the BioSonics system. You have to choose between echo-integration mode and Target Strength mode. Of course, if you have two BioSonics Echo Signal Processing interfaces, you can perform both of them, but you have to buy a second interface system. Besides, I think performances are better with this configuration."

Dr. NURZALI

Q : - Why the concentration of cruises is higher in the eastern part of the Java Sea than in the western part or in the South China Sea ?

A : - The South China Sea was not the aim of the Project. We focused on the eastern part of the Java Sea because this part is the richest one. We have mainly prospected around Matasiri islands because they are the principal fishing grounds. Concerning the western part of the Java Sea, based on the assumption that if there were no many fishermen there, the reason might be the poverty of fish and we delayed the prospecting of this area. It was an a-priori, and therefore, we decided to survey in order to verify our former assumption. We made only one survey, in May 1995, which confirmed our supposition that the density values we met were the lowest ones found in the Java Sea.

Dr. Gerlotto comments : "I would like to make some comments on this matter because, of course, it is the most serious point we have to deal with on acoustic surveys. Surveying has two objectives : one is ecological and would require the description of the area; the other one is to measure the actual density within the Java sea. For density measurements, we need two kinds of data : one is the mean value and the second one is the precision of this mean value. Usually, it is very universal that both mean and variance depend on the highest values. If you have not a good sampling on the high value data, it may lead to big mistake on the data; but if you have a bad sampling on very low densities, it is not so dramatic, as far as

the mean density is concerned. According to this, it was, therefore, a good strategy to focus a large part of the allocated effort on high density areas.

Now, talking about ecological surveys, it is different. Obviously, it might have been extremely interesting to have a complete survey of the whole Java Sea, with regular parallel transects. I remember, during Akustikan 1, we had a discussion with you, Mr Chairman, on the strategy of sampling for ecology. It is true that we need this kind of survey, but I guess, my colleagues didn't have the choice. The first constraint was the time allocated to survey. The question was the key question. Maybe the right answer is to say : we decide to focus more on density and precision measurements than on complete ecological surveys."

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