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RESEARCH INSTITUTE FOR MARINE FISHERIES

ORSTOM

COMMISSION OF THE EUROPEAN COMMUNITIES

JAVA SEA PELAGIC FISHERY ASSESSMENT PROJECT

(ALA/IN/87/17)

COLLECTED REPRINTS

ON

THE PELFISH COMMUNICATIONS

GIVEN TO THE FOURTH ASIAN FISHERIES FORUM,

16 - 20 OCTOBER 1995, BEIJING

Scientific and Technical Document No. 25

February 1996

FOREWORD

Activities of the Project "Java Sea Pelagic Fishery Assessment" will lead to publication of many kinds of documents :

- Administrative documents.
- Missions reports on land, at sea or abroad.
- Data compilations.
- Technical and scientific reports.
- Articles in research journals with reading panel.

A serie, called "Scientific and Technical Documents" will be published by the Project. The first number was issued in July 1991. That collection with restricted distribution includes all the technical and scientific Project's reports, the semesterial and annual statistics on catch, effort, biological and economical data, and articles concerning with pelagic fishery in the Java Sea. That basic documentation will serve for the final writing of scientific and technical articles proposed to research journals.

February 1996

NOTICE

The scientific and technical documents number 25 of the Java Sea Pelagic Fishery Assessment Project resume the whole of 13 communications presented in Fourth Asian Fisheries Forum which took place in Beijing from 16 to 20 October 1995.

The communications presented herewith are corresponding to the texts proposed to the Forum's Scientific Committee for publishing in the proceedings.

This short publication in Project's scientific and technical documents allows the reader to get know about the 13 communications which cover the whole of Project's scientific activities before the final publication by Forum's Scientific Committee.

The mention of these communications must be done under the following form :

Cotel P., Petit D., 1996. Target strength measurements on three pelagic fishes from the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 5-9.

The presentation order of these 13 communications resume the great themes of the Project as :

- 4 communications in acoustic,
- 5 communications in exploitation,
- 2 communications in economic significance,
- 2 synthesis communications in management.

PEMBERITAHUAN

Dokumen scientifik dan teknik nomor 25 dari Java Sea Pelagic Fishery Assessment Project merupakan ringkasan dari 13 komunikasi yang dipresentasikan di Fourth Asian Fisheries Forum yang berlangsung di Beijing (China) dari tanggal 16 sampai 20 Oktober 1995.

Komunikasi-komunikasi yang dipresentasikan di sini berhubungan dengan teks-teks yang diusulkan ke Panitia Ilmiah Forum untuk dipublikasikan di dalam prosiding Forum.

Publikasi yang singkat pada dokumen scientifik dan teknik proyek ini memungkinkan pembaca untuk memahami ke 13 komunikasi ini yang meliputi keseluruhan kegiatan ilmiah proyek sebelum publikasi akhir oleh Panitia Ilmiah Forum.

Kutipan komunikasi-komunikasi ini harus dibuat sesuai dengan bentuk berikut ini :

Cotel P., Petit D., 1996. Target strength measurements on three pelagic fishes from the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 5-9.

Urutan presentasi dari ke 13 komunikasi tersebut merupakan ringkasan dari tema-tema utama Proyek, yaitu :

- 4 komunikasi mengenai akustik,
- 5 komunikasi mengenai eksploitasi,
- 2 komunikasi mengenai kepentingan ekonomi,
- 2 sintesis komunikasi mengenai manajemen.

Communications lists

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1. Cotel P., Petit D., 1996. Target strength measurements on three pelagic fishes from the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 5-9.
2. Luong N., Petit D., 1996. Vertical distribution and circadian cycle of pelagic fish density in the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 10-14.
3. Nugroho D., Petit D., Cotel P., Luong N., 1996. Pelagic fish shoals in the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 15 - 18.
4. Petit D., Gerlotto F., Petitgas P., 1996. Data stratification and pelagic fish density evaluation in the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 19 - 23.
5. Atmaja S.B., Ecoutin J.M., 1996. Mini purse seine fisheries in North Java coastal waters. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 24 - 27.
6. Nurhakim S., Durand J.R., Potier M., Sadhotomo B., 1996. The state of exploitation of small pelagic fishes by the large and medium purse seine in the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 28 - 33.
7. Petit D., Potier M., 1996. Fishing tactics in the javanese ring net fishery. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 34 - 38.
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11. Roch J., Durand J.R., Sastrawidjaja. 1996. The economic evolution of large seiners in the Java Sea. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 57 - 60.
12. Durand J.R., Petit D., Potier M., Roch J., Widodo J., 1996. Multidisciplinary studies for fishery management. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 61 - 68.
13. Widodo J., Durand J.R., 1996. Management of the small pelagic fisheries of the Java Sea, Indonesia. Fourth Asian Fisheries Forum, Beijing, 16 - 20 October 1995, Java Sea Pelagic Fishery Assessment Project, Sci. and Tech. Doc., 25 : 69 - 72.

TARGET STRENGTH MEASUREMENTS ON THREE PELAGIC FISHES FROM THE JAVA SEA

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Using acoustics for biomass evaluation, the back scattering cross section of species has to be determinated to convert the data into weighted values. During the cruises of EU Project "Java Sea Pelagic Fishery", TS measurements on three pelagic fishes of economic importance : *Decapterus russelli, Selar crumenophthalmus, Rastrelliger kanagurta* were carried out, using a Biosonics dual beam echosounder at 120KHZ. The observations on single or multiple targets in a cage, revealed a large dispersion of the responses, even in the same experiment. These results are discussed and compared with Johannesson's (Anonymous, 1984) in the same area.

Key words : Java Sea, Pelagic fishes, Acoustics, Methodology, Target strength.

Introduction

With the calibration of acoustic equipment, reflection index measuring of live fish constitutes the first stage in the evaluation of abundance. This operation should allow the adjustment of the threshold on the echo voltages which are to be taken into account; it should also allow the calculation of a conversion constant of integrated voltages during prospection of biomass measuring. The following observations were made during the "Java Sea Pelagic Fishery Assessment" Project.

Materials and Method

Three series of measuring have been made during the season when pelagic fish abound in the Java Sea : November 91, October and December 92. The success of these experiments is dependent upon strict environmental conditions : the location has to be deep and sheltered from the wind and currents ; it must moreover be close to a fishing zone. Only two places in the Java Sea were found to be acceptable : Bawean Island and Matasiri Island ; the former, 17 meters depth, in a bay, was the best.

The measurements were made with a dual beam Biosonics echo-sounder (7° narrow and 18° wide circular beams). The acoustic characteristics of the equipment were controlled previously on a standard tungstene ball with a -41dB reflection index. Characteristics and adjustments throughout the measurements can be found in the Table 1.

Table 1. Sounder characteristics

Transmitter Source Level	: 222.54 dB /µPa /m
Narrow beam Receiving Sensitivity	: -173.13 dB/V/µPa
Wide beam Receiving Sensitivity	: -172.17 dB/V/µPa
Pulse Duration : 0.4 ms	
Ping Rate : 3 / second	
Threshold : 100 mV	
TVG : 40 Log R + 2 αR α = 34.7 dB/km R = 125m	

In order to keep the fish in the acoustic beam, the latter is introduced into a conical cage specially built in order not to be disturbed by the reflecting contribution of the lateral surface. The transducer is an integral part of this cage (Fig. 1). In this way the transmitted signal is not attenuated by the net, the cage is sufficiently spacious to permit the movement of the fish and to record the echo without interference. The measurements were taken from three pelagic species, among the most exploited in the Java Sea : *Decapterus russelli, Selar crumenophtalmus* and *Rastrelliger kanagurta*. The three species have a swimbladder. The fish were introduced into the cage in sets of 1, 2, 4 or 6 ; the cage was then submerged. Reverberation measurements were taken both night and day.

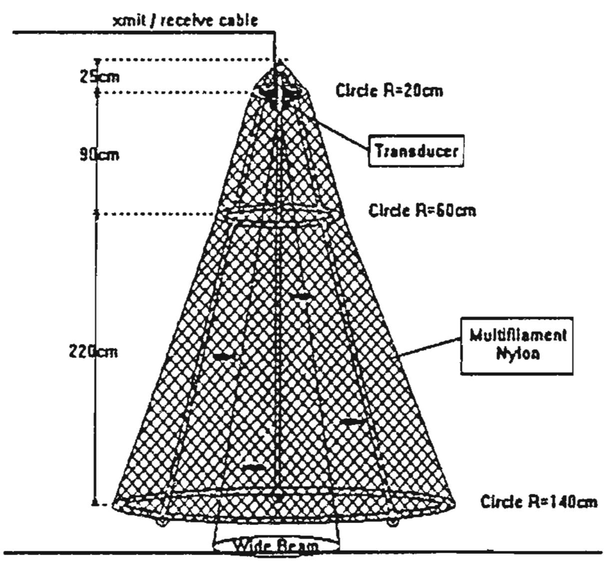

Fig. 1. The live fish calibration cage.

Results

Dispersal of Measurements

The most significant aspect from these experiments is the dispersion of the values that considerably mask the existence of a relation between the reverberation index and the size of targets, on the short interval of length (11 to 17 cm). Figure 2 represents the distribution of Target Strength measurements of *Selar* between 12 cm and 17 cm (fork length) ; the same dispersion can be observed with *Decapterus* and we saw no notable decline in this dispersion according to the number of measurements.

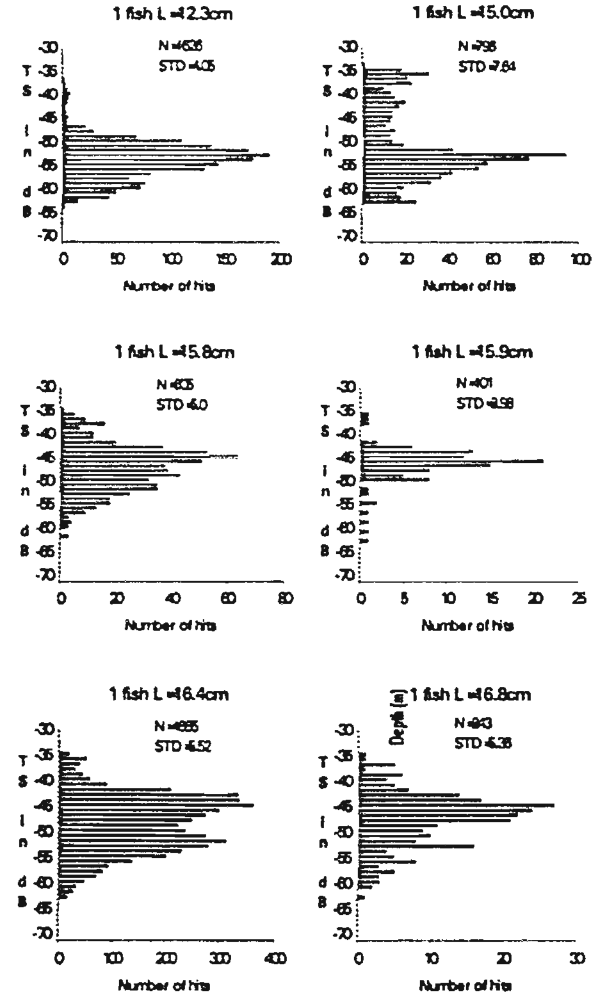

Fig. 2. TS related to the Size.

Figure 3 represents the distribution of Target Strength values of *Decapterus* when one, two or six fish were introduced into the cage. The standard deviation is of the same order as in the first experiment. No notable changes in behaviour were noticed between the observation on one fish and on several : the "group effect" does not seem to influence measurements.

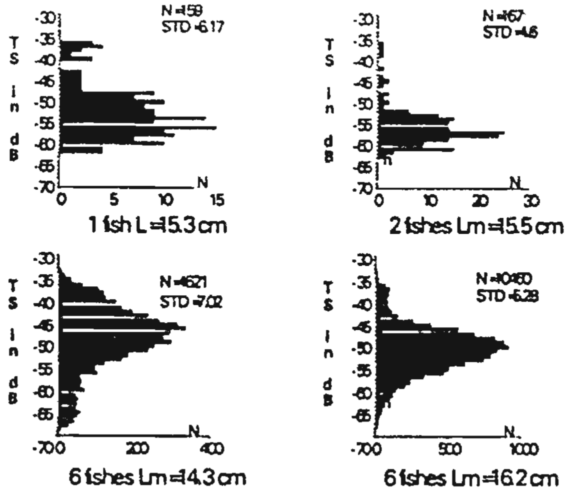

Fig. 3. TS related to the number of fish.

"Swimming Activity" Effects

The influence of the position a fish takes in the sonar beam on its acoustic response is known (Love, 1971 and 1977 ; Nakken and Olsen, 1977). The acoustic response is the strongest laterally. In dorsal detection the reverberation index can vary to more than 10 dB according to the fish tilting (in less than 15°). In classic prospection conditions, such variations can be attributed to different species as well as the inclination of the same species if we do not have simultaneous visual information. Observations carried out on the isolated fish in the cage gives us knowledge about the vertical location and the acoustic response. By using the results of an experiment on *Selar*, we put the reverberation index and the vertical positioning of the fish in relation (Fig. 4a).

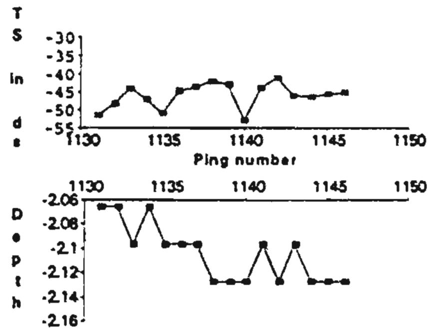

Fig. 4a. TS during low swimming activity.

From ping to ping, the position slightly changes and suggest very low swimming activity. The dispersion of index values is slight as well. On the contrary, in the same series of values, while selecting events where the fish shows a significant vertical movement, the corresponding index values show a strong dispersion (Fig. 4b). Owing to an intense swimming activity, the fish enters the sonar beam in different positions which leads to strong index dispersal.

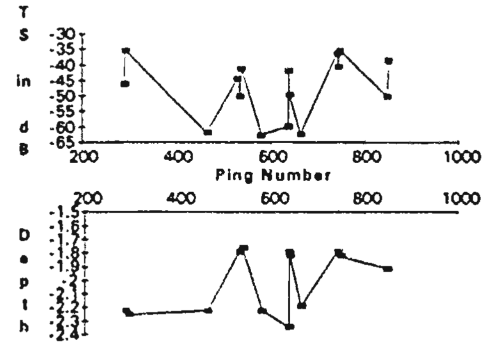

Fig. 4b. TS during high swimming activity.

Influence of External Factors

Under normal acoustic prospection conditions, the influence and effects of disruptive external factors is generally difficult to bring to light. The state of being confined in a cage can in itself have a considerable effect. We assume that since the length of time necessary for measurements is short, this effect is only slightly disruptive[1]. The animal gets used to its environment and the noise.

The effect of light during prospection was noted in some experiments (Levenez *et al.*, 1987 ; Gerlotto *et al.*, 1990) and the authors consider that it tends to polarize the fish more than generate an escape reaction. In the region, light is used to gather the fish together which makes it easier to catch them.

Figure 5 shows the reactions of one group of g. *Selar* to the light. The experiments took place at about 10 PM. In the first experiment a 400 watt lamp attached to the rail, lit the cage which was submerged at about 3 meters. In the second experiment, a 1000 watt lamparo was used. It was placed at 2 m under the cage ; in the third, it was pitch-black.

In the first two experiments, the fish showed from the position they took in the cage, that they tend to avoid the light and that swimming activity is reduced. When darkness is back, the echoes are dispersed in the cage space; swimming activity is increased. Even though the experiment was brief, it shows that light, in provoking a reaction, can bias index measurements.

[1] Unless behaviour is visibly such that measurements can not be taken : permanence out of the acoustic beam or permanently random activity.

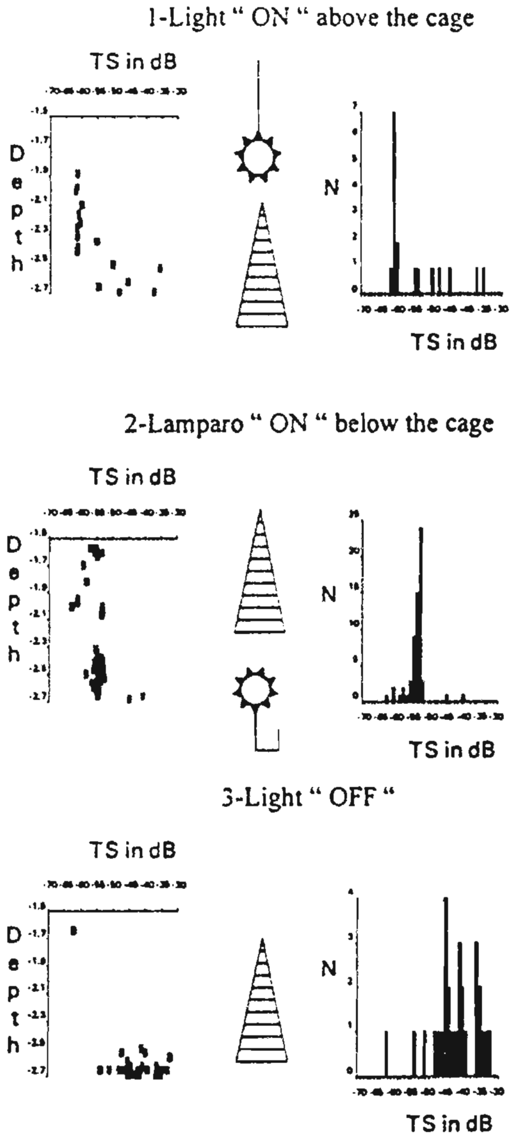

Fig. 5. Light Influence.

Adjusting the Equipment

Reverberation index measures require first that the acoustic characteristics to be known exactly. In the case of dual beam sounder, one part of these controls (source level and receiving sensitivity) is facilitated by the use of a tungstene ball as the standard target. However, the choice of electric level of the signals that are taken into account for index measurements is up to the operator. Use of a threshold that is too high risks suppressing the low reverberation values, truncating the distribution histograms.

Recorded with a 100 mv threshold, certain measurement series were played back with a 300 mv threshold. Table 2 summarizes the results and shows that the elimination of low values has a more or less significant effect according to the average index value and the dispersion. In our experiments, distribution histograms of index values are not shortened in respect of the weak values, it indicates that the chosen threshold (100 mv) was correct, taking into account the acoustic performance of the equipment.

Table 2. Index values related to the Threshold

SPECIES	LENGTH cm	INDEX values Threshold 100mV	Threshold 300mV
	12.5	-47.7 dB	-46.9 dB
	14.2	-47.5 dB	-46.4 dB
	14.3	-44.5 dB	-43.8 dB
Decapterus	15.3	-47.4 dB	-42.3 dB
	15.5	-51.4 dB	-42 dB
	15.7	-48 dB	-45 dB
	16.2	-47.7 dB	-47.1 dB
	12.3	-51.3 dB	-47 dB
	15	-43.6 dB	-39.5 dB
Selar	15.8	-44.2 dB	-42.8 dB
	15.9	-44.7 dB	-43.9 dB
	16.4	-44.9 dB	-42.7 dB
	16.8	-44.4 dB	-42.8 dB

Among the series of observations, we chose, as the most likely, the average reverberation index values in experiments where several animals were present and where the targets showed a fairly homogeneous distribution in the space of the cage.

The average values observed are :

D. russelli : TS = - 47.7 dB (Lf = 16 cm)

S. crumenophtalmus : TS = - 44.9 dB (Lf = 16 cm)

R. kanagurta : TS= -50 dB (Lf = 11 cm) but this value concerns a small number of values.

Conclusion

Reverberation index measurements are necessary for acoustics to define the conversion constant of reverberation measurements on biomass. In the past, these measurements were made on known quantities of fish introduced into a cage. This relatively simple method was not without risk : imprecision about the space really occupied by the fish, handling important quantities, incidence on measurements of minimal occupation space acting by means of behaviour (Foote, 1980a), death, possible multiple reverberations or shadow effect, besides reverberation on the surfaces of the cage of which the importance was only approximated (variable in time).

The development of new equipment (dual beam or split beam) and the computerization of signal data processing have allowed the use of a semi-automatic system of measurement and the development of software data processing. The fact remains, nevertheless that the operator should always take measurements with calibrated equipment.

The behaviour plays a very important role. That is the reason why one try to measure the reverberation index in a natural environment : in this way we attempt to avoid the interference of uncontrollable behavioural reactions produced by confinement in a cage.

Except the remaining exceptional situations, measurements "in situ" without simultaneous visual control cannot guarantee a value corresponding to a particular size known species. According to the catches in the Java Sea, five dominant species live together ; an imprecise knowledge of their geographical habitat and behaviour does not allow us to attribute the measurements to a given species.

On the other hand, in the calculation of the weight conversion constant we tended to use an index value which was close to the maximal response : the latter was considered to be the one produced by the fish in a normal position in the acoustic beam[2]. For a dozen years, one have tried to associate simultaneous orientation measurements of the target (Foote, 1980b) in order to calculate an index according to the most probable directivity of the fish. In situ, these kinds of observations are obviously rare, given the slight chance of encountering favorable conditions and the difficulty of getting the logistics. Very recently, observations on herring (Hamre and Dommasne, 1994) showed that in the reproductive phase, the reverberation index would be more low, in this specific case.

The choice of an index value should then be defined according to the predicated use (Foote, 1987). In our case, we tried to define an index destined for weight evaluations on "classical" prospections. To reduce a possible effect of being confined in a cage or isolated behaviour, it is recommended to increase the observations made up of a large number of measurements, the procedure aims to obtain an average index value corresponding to the most frequent position. Our observations show that optimal response values are found to be far away from the mode or the average, which indicates that the most favorable for a strong echo is not on average the usual position of the fish. In the Java Sea, shoals are not numerous; the fish are scattered. The nycthemeral density variations are strong; they suggest important vertical movements throughout the diurnal cycle. The behaviour observed in the cage, where the fish sustains considerable swimming action, does not seem to contradict the distribution and vertical movements observed in situ.

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[2] Using a great quantity of encaged fish, we tried to make sure that the fish "turned", having then a behaviour close to the one observed in a natural environment while the fish is in shoal.

Until now, the great majority of index measurements concern the species of the North Atlantic stocks with sizes that greatly exceed the tropical pelagic ones. In operating on caged fish (measurements in 20 log function) Johannesson (Anonymous, 1984) has calculated - 45 dB on the same or related, species (*D. russelli* or *D. kuroides*). at the same frequency. Other experiments are still necessary to complete the first results.

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VERTICAL DISTRIBUTION AND CIRCADIAN CYCLE OF PELAGIC FISH DENSITY IN THE JAVA SEA

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Abstract

Analyses of the acoustical data collected during several cruises made in the Java Sea from 1991 to 1994 in the context of the Pelfish project, have facilitated the elaboration of a biological model based on three groups of fish, each having particular distribution characteristics. This paper show how analyze of bathymetric distribution on the same database gives valuable information on fish behavior, and how this method could be used first to define different groups of fishes (in our case to increase the types up to five groups) and second to raise several questions on the determinants of the fish distribution.

Introduction

The Pelfish project, a franco-indonesian cooperation and development project, started in 1991 to answer several issues converging toward the improvement of fisheries management in the Java Sea (Boely, 1991). For this reason, a special attention has been given to the study of fish behavior with 15 acoustic surveys held since 1991 in the Java Sea. The equipment used and the implementation of each cruise, have been previously described (Petit, 1993).

A first analysis of these data, based on a standard methodology (Gerlotto, 1993), has been used during a workshop "AKUSTIKAN I" held in December 1994 in Jakarta. A report mainly focused on the geographical description of the pelagic biomass distribution in the Java Sea has been published (Petit *et al.*, 1995). One of the main results has been the elaboration of a biological model including 3 groups of fish :

- Group 1 coastal type ;
- Group 2 pelagic type, with a relative low density and an homogeneous geographical distribution ;
- Group 3 quite similar as a typical oceanic community, quite dense and performing on the one hand yearly horizontal migrations to the east of the Java Sea during the rainy season (Fig. 1a) and to the center of the Java Sea during the dry season (Fig. 1b) ; and on the other hand daily vertical migration to the surface at night and to the sea bed during the day (Fig. 1c).

In order to validate this biological model, we have processed these data by focusing this time at the bathymetric distribution of the biomass.

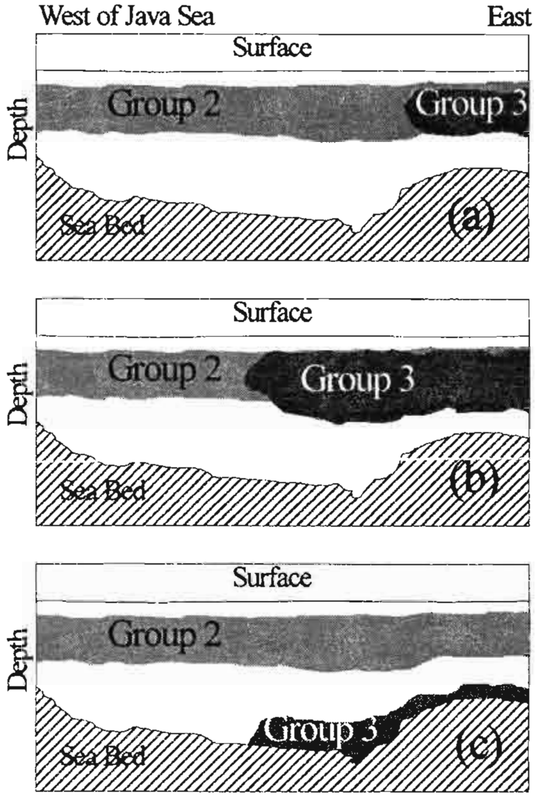


Fig. 1. Bathymetric distribution of the groups 2 and 3 according to a West to East direction in the Java Sea. (a) in February by night; (b) in October by night; (c) in October by day (from Petit *et al.*, 1995).

Methodology

The study concerns the data of the transect : Semarang - Matasiri Island, following Karimunjawa Island, Bawean Island and Masalembo Island (Fig. 2).

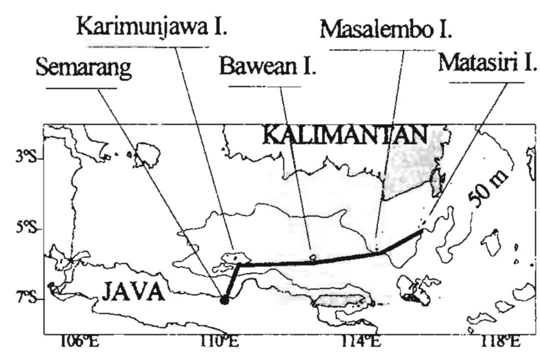


Fig. 2. Geographical location of the transect Semarang - Matasiri I., with the position of the main islands encountered.

This West to East transect which shows high annual biomass variation (according to the results of the workshop "AKUSTIKAN I") seems to be a fruitful axis for studying fish behavior in the Java Sea (Petit *et al.*, 1995). In addition the repetition of this transect during several months (12 measures) facilitates seasonal comparisons.

Each serie includes density values for each nautical mile and each layer of 10m. The data processing has involved the following 4 steps :

1. To facilitate descriptive analyses, we have applied a geostatistical gridding method, also called kriging method (Isaaks and Srivastava, 1989), which calculates by interpolation the relative density values for each node of a net of lines and columns previously chosen.

2. This krigging realized through the use of a professional software (SURFER[1]) allows a graphic representation of the surface corresponding to the densities which minimal value is immediately above a given threshold. This representation use the distance covered in abscissa and the depth in ordinate. Night periods, from 6PM to 5AM (Petit *et al.*, 1995), have been indicated using frame (Fig. 3).

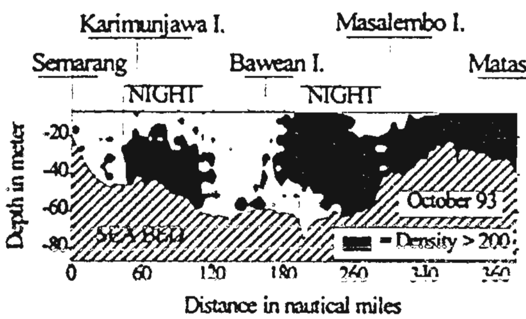


Fig. 3. Example of the representation of the density distribution in relative integration unit (r.i.u.) for a density threshold D=200. Case study : survey October 1993.

3. For each of the 12 data series, several graphics of the density distribution for different thresholds have been realized (D varying from 5 to 500) (Fig. 4).

4. Taking into account the previous results (Petit *et al.*, 1995), the study of these graphics evolved to 3 directions :

   - The study of the coastal area ;
   - The study of relatives low densities ;
   - The study of relatives high densities.

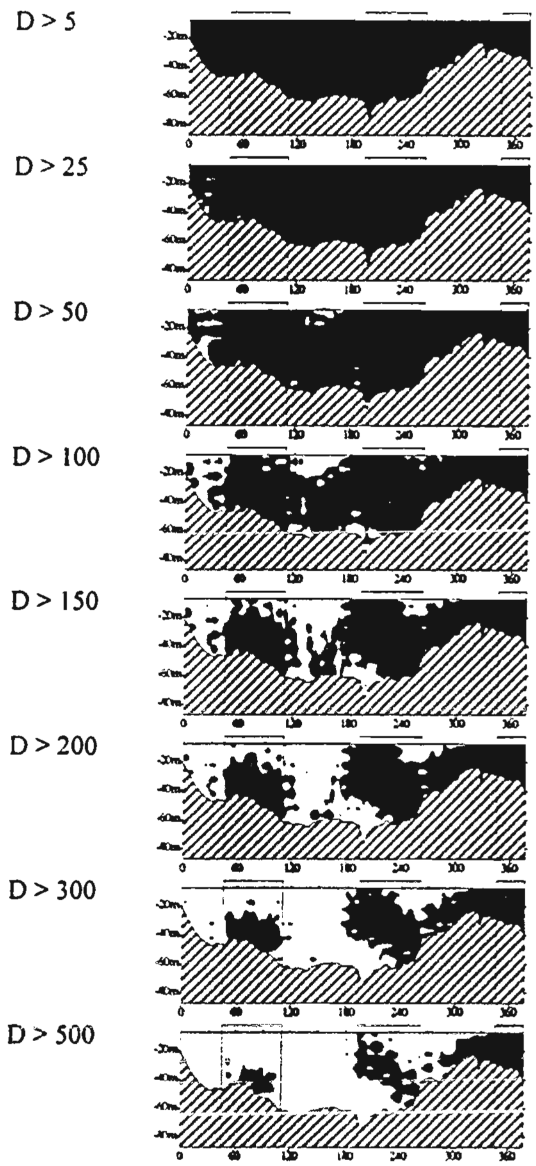


Fig. 4. Density distribution (r.i.u.) for the cruise Semarang - Matasiri Islands, October, 1993.

Results

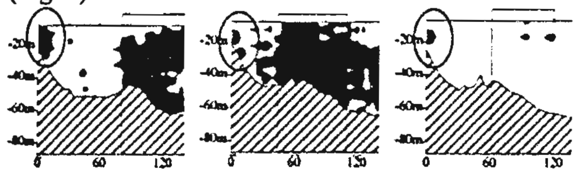
Study of the coastal area

Results obtained during the day in the coastal area (up to 100 nautical miles from the coast), show clearly the existence of a group close to the coast the density of which exceeds 100 r.i.u. (Fig. 5a). This group present its lowest density values in October, 1993 (Fig. 5b) and its highest in February, 1994 (Fig. 5c).

This group uniformly is located at less than 30 nautical miles to the coast by day and 50 nautical miles by night. This distance varies according to the season.

[1] SURFER Version 5.01 for Windows - Surface Mapping System

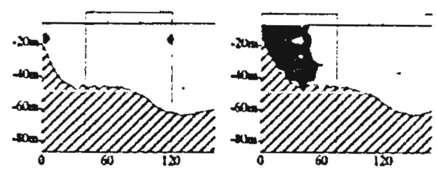
Whenever it is possible to compare day data and night data, day densities are lower than night ones (Fig. 6).



(a) Dec. 92 D > 150 (b) Oct. 93 D > 100 (c) Feb. 94 D > 500

Fig. 5. Coastal group during different period of the year.

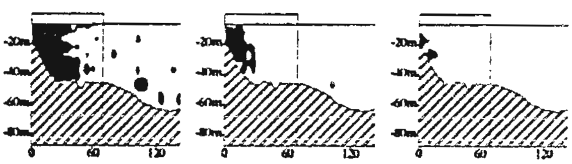
May 92
D >150



Data by : (a) Day (b) Night

Fig. 6. Comparison of density distributions by day and by night in the coastal area, for densities higher than 150 r.i.u. in May, 1992.

Finally, for a given cruise and a given period of the day (day or night) the highest density values for this group are systematically those which are both close to the bottom and to the coastline (Fig. 7).



(a) Jun. 92 D > 50 (b) Jun. 92 D > 200 (c) Jun. 92 D > 500

Fig. 7. Comparison of the coastal biomass for different density threshold values in June 1992.

Synthesis of the coastal group

The coastal group described in the report AKUSTIKAN I (Petit *et al.*, 1995) shows here a relatives high density (more than 100 r.i.u.) with a minimum in October and a maximum in February. This group present higher density by night than by day, which could be explained by a migration behavior from the sea bed to the surface, and from the coast to the open sea. Nevertheless these migrations are limited considering that they concern only the area shallower than 30 meters and within the 50 nautical miles distance to the coast.

Study of the relatively low densities

A group with a minimal density of 10 r.i.u. is homogeneously distributed in the water column, between July and February (Fig. 8). This homogeneous group reaches up to 50 r.i.u. in October 1993.

(a) Dec. 92
D > 10

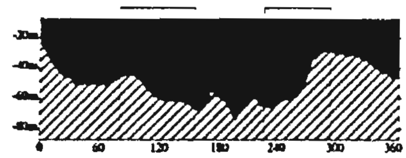


Fig. 8. Distribution of the densities above 10 r.i.u. between July and February.

From March we can observe a limited decline of densities during the day between Bawean and Karimunjawa, except in the area close to the sea bed (Fig. 9a). This low densities area extends in May and stretch out all around Bawean area (Fig. 9b). The average density in this area is lower than 2 r.i.u.. In June the reversed phenomenon occurs and leads to a situation quite similar to that observed in March (Fig. 9c).

(a) Mar 92 D > 10
(b) May 92 D > 10
(c) Jun. 92 D > 10

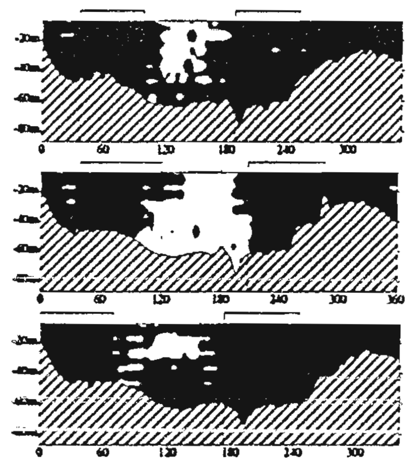


Fig. 9. Distribution of density at least of 10 r.i.u. between March 1992 and June 1992.

Synthesis of the relatives low densities

The group of relatives low densities could correspond to the pelagic group which presents an homogenous horizontal distribution as described in the report AKUSTIKAN I (Petit *et al.*, 1995). Nevertheless it appears that this homogenous distribution only occurs during part of the year, from July to February. During this period there is no clear pattern of vertical or horizontal migrations. In March, this group seems to vanish during the day in the area from Karimunjawa to Masalembo. That phenomena more obvious in May decreases in June.

Study of the relative high density group

Almost non-existent in March (Fig. 10a) high densities higher than 200 r.i.u. appear in May in the Masalembo area (Fig. 10b); then in June between

Bawean and Matasiri (Fig. 10c). From October to December these high densities can be found at night all the way to Karimunjawa (Fig. 10d, e). Then in February these high densities vanish again except on the East of Matasiri, and on the East of Karimunjawa (Fig. 10f).

(a) Mar. 92

(b) May 92

(c) Jun. 92

(d) Oct. 93

(e) Dec. 92

(f) Feb. 94

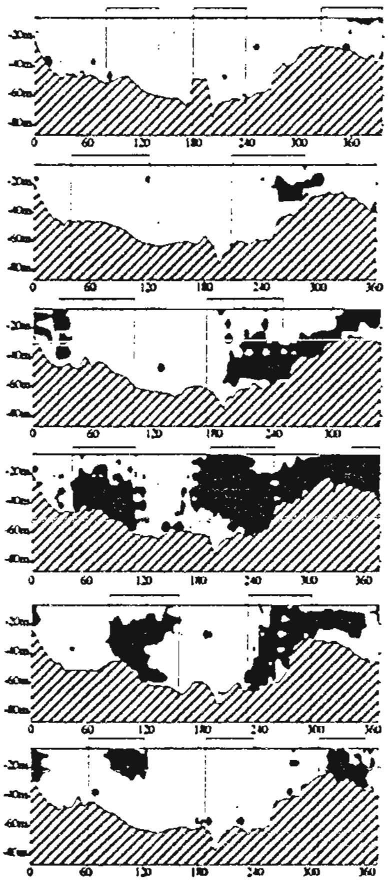
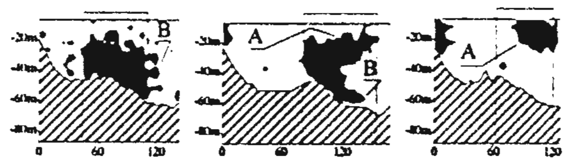


Fig. 10. Comparison of the distribution of the high densities (higher than 200 r.i.u.) during different periods of the year.

The observation of the bathymetric distribution of these high densities allows to distinguish 3 different subgroups :

- during the day observations show the presence of high densities in the shallow water area (Masalembo - Matasiri). These high day densities which could not be found in the area of deep water (Karimunjawa - Bawean) characterize a subgroup living in the East area of the Java Sea up to Masalembo, and which never goes more westward ;
- at night in the deep area we can observe part of the high densities close to the surface and totally away from sea bed (Fig. 11c), while another part of the densities doesn't go up to the surface and stay in contact to the sea bed (Fig. 11a). This difference of bathymetric distribution characterizes 2 subgroups which may coexist during part of the year (Fig. 11b).



(a) Oct. 93 (b) Dec. 92 (c) Feb. 94

Fig. 11. Subgroups in the area from Karimunjawa to Bawean by night : A. group go up to the surface ; B. group staying close to the sea bed (threshold : 200 r.i.u.)

Synthesis of the relative high densities

We can notice a migration of the relative high densities from the East to the Center of the Java Sea. The migration starts at the beginning of May, reaches its maximum between October and December, then disappears in February.

This group seems to be divided in 3 subgroups :

- the first one presents high densities both by day and by night. It is restricted to the shallow area which stretch from Masalembo to Matasiri. It appears in March, and vanishes in February ;
- the second group, not detectable by day, goes up from the sea bed during the night without reaching the surface ; this group appears during June in the shallow water of Masalembo and Matasiri Islands and spreads considerably up to October from there to Karimunjawa Island. Still present in December, it seems to disappear in February except at the East of Matasiri ;
- the third one is not detectable by day. It leaves totally the sea bed at night goes close to the surface. It arrives around June from the east of the Java Sea, stretches to the West until December, and leaves the Java Sea in February except in the area of Karimunjawa.

Conclusion

The large amount of information given by the study of the bathymetric distribution allows to improve or modify the knowledge previously obtained through the study of the geographical density distribution (Petit *et al.*, 1995). The main modification is the division of the oceanic type of the biological model proposed in the report made after the workshop AKUSTIKAN I, in 3 subgroups. Each of them has a different bathymetric distribution and presents a different seasonal variation. Furthermore night phenomena of vertical migration described in the same report could be observed for each of the 3 groups but more or less clearly as it has been previously said.

According to results of this vertical distribution study, we know that fish population of the Java Sea can be divided in 5 groups with particular distributions characteristics (one group of coastal type, one group of pelagic type and 3 groups of oceanic type). The exploitation of these results in parallel with other kinds of observations (experimental catches, species composition in landing sites, evolution of the temperature, salinity and current of the water, ...) should allows us to characterize these groups in term of species, and to understand the determinants of the vertical and horizontal fish distribution.

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PELAGIC FISH SHOALS IN THE JAVA SEA

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Abstract

Two acoustical surveys took place in October 1993 and February 1994, covering the main part of the Java Sea, below 50 m depth. The echointegration process was performed through Biosonics 120 Khz dual beam echosounder. Fish shoals characteristic s and their behavioural aspects were observed. The shoals configuration were extracted from echograms and quantified. This information allows to represent the spatial and bathymetric repartition. An analysis on abundance and distribution of shoals is proposed, as well as their contribution to the global densities and description of their behaviour during the day and night periods.

Keywords : Java Sea, Pelagic fishes, Acoustics, Shoals.

Introduction

The continental shelf of the Java Sea is estimated at 442 000 Km² (Durand and Petit, 1995), with an average depth of 40 m. The environmental conditions are controlled by a monsoon cycle. The total catch of pelagic fish by seiners was estimated at 485 000 tons in 1991, and it is caught in an area representing 7% of the marine territory of Indonesia (Potier and Sadhotomo, 1995).

Previous studies on the state of exploitation by seiners since 1980, have related that the fishing operations take place with aggregation in areas depending of the season (Atmaja and Sadhotomo, 1985 ; Nurhakim *et al.*, 1987 ; Potier and Boely, 1990). To supply informations on the importance of the stock and its availability, the estimation of density by acoustics is applied into a frame work of the Java Sea Pelagic Fishery Assessment Project.

Materials and Method

The data analysis is based on two parallel acoustic surveys carried out in October 1993 and February 1994, during twelve days (Fig. 1). Tha data are collected aboard the stern trwaler R/V Bawal Putih 1, with biological sampling of using with pelagic and bottom trawls. The echointegration was obtained by means of a dual beam 120 Khz echosounder connected to an interface INES MOVIES, for digitalizing, display and echointegration of the signal.

The basic dimensions of shoals (distance from the bottom, height and global relative reverberation) were extracted manually from echograms (which give the progress of integration for each ping and the total value by mile). Data postprocessing was performed throughout OEDIPE and SURFER softwares. As it is difficult to attibuate a criterion of "pelagic or demersal" to the shoals close to the bottom, only the ones situated at more than 5 m from the bottom were taken into account in this study[1]. We selected also the shoals giving a reverberation level more than 50. As the monofrequency systems are unable to discriminate the species, these shoals can not be related to particular species ; nevertheless as Gerlotto (1993) points out, we may consider that aggregations are referred to species having momentaneously the same "acoustical behaviour".

Table 1. The general settings of the equipment

Frequency	: 120 Khz	Pulse duration	: 0.4 m sec
Power	: -3 dB	Ping rate	: 3/sec
Bandwidth	: 5 Khz	Depth range	: 125
TVG	: 20 log	Speed	: 6 knots
Angle trends	: 7° (narrow beam)		
	18° (wide beam)		

The environmental measurements are obtained by vertical profile measurements of temperature and salinity.

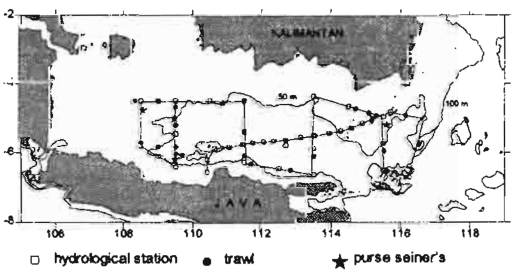


Fig. 1. Survey October 93, acoustic tracks, oceanographic stations and biological samplings.

Results

Hydrological conditions during the surveys

The mean saline conditions observed during the surveys are relative to the seasonal conditions and topographyc. In October, winds and currents bring up the oceanic influence throughout the continental shelf ; the salinities are near 34‰. In February, winds and currents transport waters of low salinity (rains and out flows) from the west and lands ; the mean salinities fall

[1] The shoals, near the bottom, are scarce and uniformaly distributed.

to 32‰ (Durand and Petit, 1995 ; Petit *et al.*, 1995). The more interesting is the spatial location of the maximal between the two seasons : in October, we have a low gradient from west to east (max) ; in February, the gradient tends to be opposite because of the bulk of salted water coming along the coast of Kalimantan where the depth is shallower. Consequently the highest salinities in February are in the south west part of the Java Sea. This is well described in the figure 2, where the mean salinities appear more homogeneous in October than in February. In this later, in the eastern part the salinities grow only along the last transect. Between the two seasons the means temperature vary only of about 1°C.

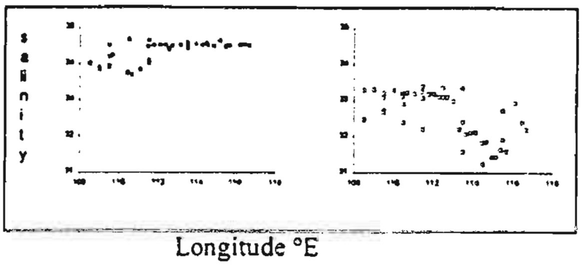


Fig. 2. Longitudinal averaged salinity in October 1993 (left) and February 1994 (right).

Abundance and spatial location of shoals

The total number of shoals recorded in October is 197 and 110 in February. Most of shoal reverberation are low in both seasons. In October, the shoals are distributed almost in the whole area, but the maximum in concentrated in the eastern part aroud the Matisiri and Kangean Island (Fig. 3). This abundance tends to decrease through the west, except in the coastal zone of Java.

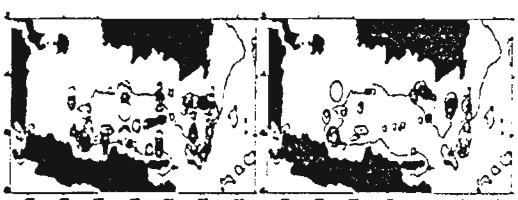


Fig. 3. Geographical distribution of pelagic shoal density in October (left) and February (right).

In February, the bulk of shoals is concentrated along a curve from the north of Kangean Islands, the continental slope and continuing in the shallow waters, north of Masalembo Islands. In the western part, numerous shoals are remaining in the north of the Java Coast.

Between the two situations, the more merged event is the disappearance of shoals in the middle and south eastern part of the Java Sea. The mean number of shoals per mile within nine longitudinal strata is relatively low in both seasons (0.047 to 0.325 in October ; 0.014 to 0.186 in February, Fig. 4).

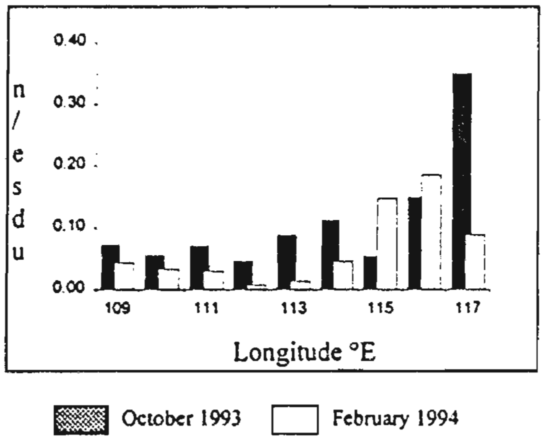


Fig. 4. Longitudinal distribution of averaged number of shoals per ESDU (nmi).

The spatial distribution of reverberation levels.

Between February and October, the mean reverberations levels of shoals are the same : 199.4 (October), 199.8 (February). Taking into account the longitudinal distribution of the number of shoals (Fig. 4), we split the area in two strata ; west and east of 112°E. The histogram of relation reverberation (Fig. 5) shows that a common mode (< 100) appears all over the area. The modes 200-500 stay numerous on south eastern monsoon, in the eastern part ; the last mode (> 1000) is only in the east.

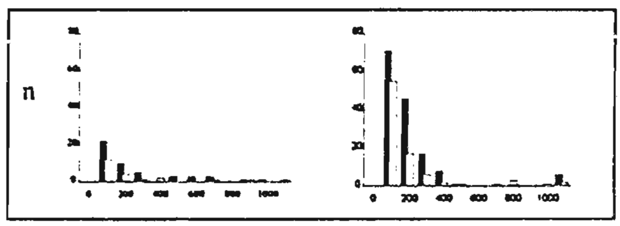


Fig. 5. Frequency histograms of shoal density on both.

Thus, until now, the study of reverberation levels gives limited informations. The mean levels are comparable between two seasons ; the shoals are low reverberating, more numerous in the east during October and February, and almost 40% of the density represent has disappeared.

Vertical distribution and day-night variation

The vertical distribution revealed that the shoals are more dispersed during the south east monsoon : the occupation of the space is better (Fig. 6). The modal vertical location is not the same between the two seasons i.e. 40 m in October, 20 m in February. The global behaviour change also : the shoals tend to stay during the night in October and the mode is going down during day. In February there is no particular change in location between day and night.

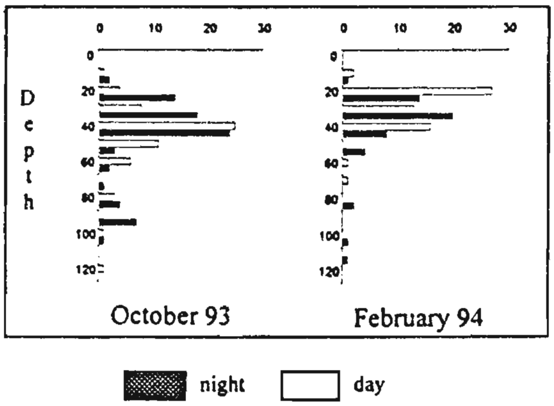


Fig. 6. The number of shoals vs depth.

The more interesting seems that the number of shoals is more important during the night in October, although the pelagic populations are usually scattered by night (Table 2). An evaluation on the mean levels of reverberation shows that the highest reverberation levels appear by day in October when the small ones are found by day and night. In average the situation is inverted : the mean level is highest in February ; the phenomenon could be in relation with the lunar cycle (February : full moon ; October : new moon).

Table 2. Density of shoals by day and by night

	October 93		February 94	
	day	night	day	night
N	76	121	72	38
Minimum	50	50	50	50
Maximum	2474	1527	1151	3177
Mean	262	160	172	253
Variance	162620	41164	51857	300307

Discussion

On his study, various informations have been extracted :

- proportion relatively low of pelagic (or semi pelagic) stock able to aggregate,
- identity of the reverberation mean level of shoals between the seasons,
- big relative abundance of small shoals every where in dry season and more located in wet season,
- occurrence of bigger shoals in depth and in the eastern part in October,
- permanence of shoals in the extreme west part, particularly near the Java Coast,
- difference of behaviour for the global population between the two seasons.

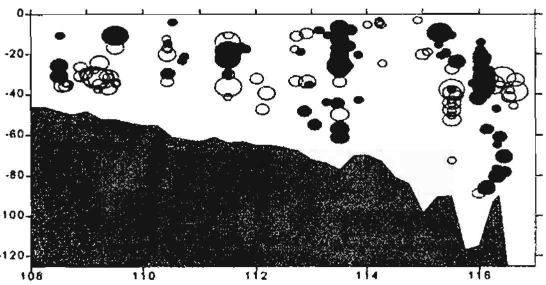
Studies on abundance and distribution of fish through acoustics have been done in the past around Kangean Islands (Barus and Rumeli, 1982) and in the middle part of the Java Sea (Boely and Linting, 1986 ; Boely *et al.*, 1991). During this later cruise, same dispersed small shoals have been indicated. But these surveys were very limited. Since the end of 1970, investigations point out high rates of pelagic fish exploitation in the middle of Java Sea (Sudjastani, 1978). After 1980, an active development of new fishing tactics are followed by the increasing of the total catch (Sadhotomo and Widodo, 1992 ; Potier and Petit, 1995).

Recent investigations suggest the presence of three groups of fish inhabiting the waters of the Java Sea (Petit *et al.*, 1995) : a coastal one, living close to the Java Coast ; a neritic one covering the whole of the continental shelf ; an oceanic one that would have semi demersal behaviour. Eventhough analogy cannot be made totally between global data of density and shoals, we have to consider that the small shoals participate to the group 2, as the bigger from the eastern part, would participate to the group 3.

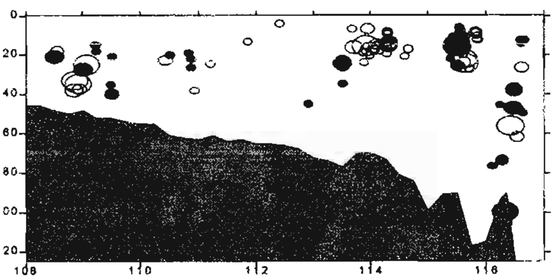
Acoustic evaluation reveals that the mean density fall is 58% by night and 48% by day between October and February. For the aggregated part, the decreasing is 49% and 38%. The migrating population do not belong exclusively to the shoals ; or from an other point of view a important part of the "pelagic" population do not aggregate. Eventhough, with their new tactic (light attraction) the fleet of big seiners are not operating on shoals, the behaviour of the part of pelagic fish staying aggregated by night in October could be in favour for attraction and aggregation.

In February, the percentage of total catch in central Java Sea represents only 9% ; then the most part of big seiners operate in the Makassar Strait (Potier and Sadhotomo, 1995). This seems related to the disappearing of the big densities in the eastern part. But as revealed by the apparent change of behaviour, the catchability could be less favourable : deleted waters in wet season may be more turbid and this can disturb the light attraction. Potier and Boely (1990) and Boely *et al.*, (1991) suggest that the seasonal changes of fishing grounds could be related with the ones of environmental conditions, particularly the salinity. Obviously, the disappearance of shoals in the eastern part (Fig. 7) seems to coincide with the low salinity (less than 33‰, Fig. 2).

Five exploited species live in the Java Sea. *Decapterus macrosoma* represents the bulk of the catch during the dry season in the eastern part. It is sure that this species is migrating out of the continental shelf in wet season. But, does this species participate or not to the shoals ? What are the ecological affinities of the other species ? (*D. russelli, Selar crumenophtalmus, Rastrelliger kanagurta, Ambligaster sirm* and *Sardinella* *gibbosa)*. In wet season, we met the "highest" salinities in the south western part of the Java Sea ; we met also in the same area, relative big densities and shoals. But another group of shoals appear in shallow water, south Kalimantan (29 < S‰ < 31‰). Experimental samplings and further investigations will be necessary for satisfactory interpretation.



October



February

Fig. 7. Longitudinal day and night variability of shoals density (depth in meter).

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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 I 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.

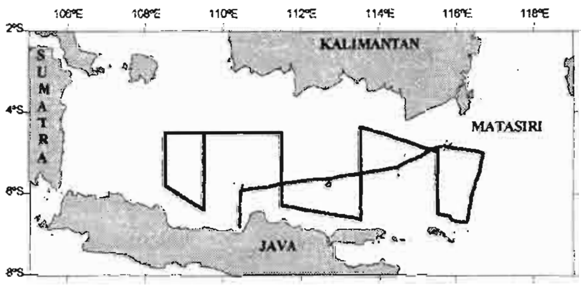

Fig. 1. October 93 and February 94 : echointegration surveys in the Java sea.

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 stable 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.

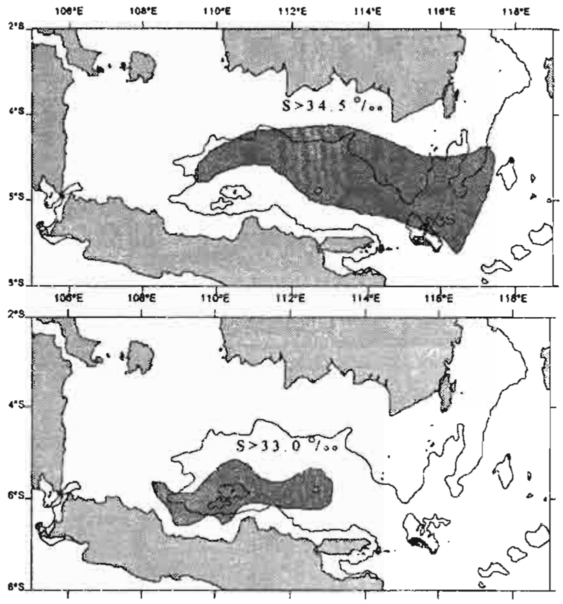

Fig. 2. Location of the mean salinity maxima in October 1993 (up) and February 1994 (down).

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.

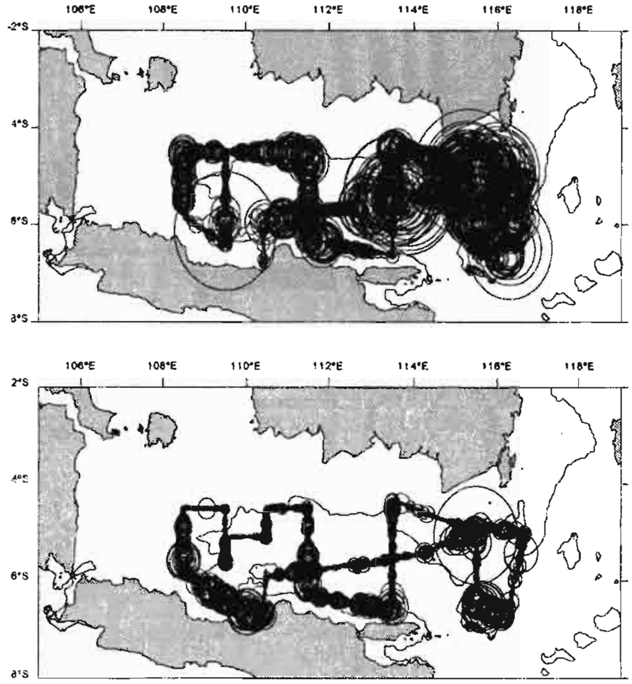

Fig. 3. Relative density of pelagic fish in October 1993 (up) and February 1994 (down).

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).

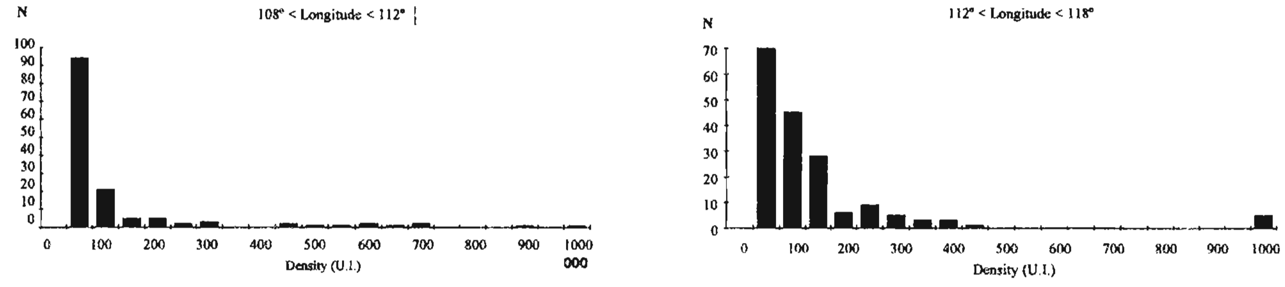

Fig.4. Distribution on both sides of the longitude 112°E of the number (N) of fish schools according to density in October 1993 (survey 34).

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.

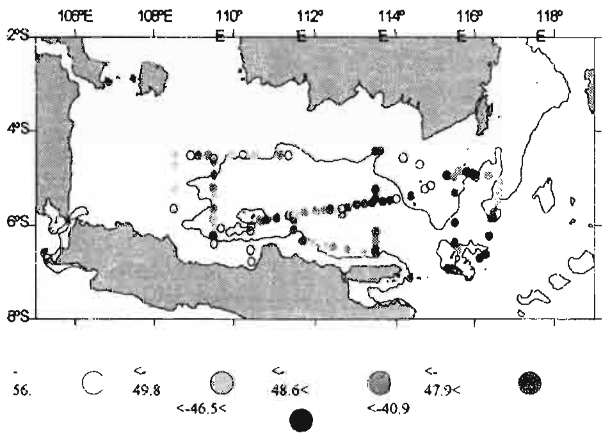

Fig. 5. Repartition of the mean TS values (in dB) in October 1993.

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).

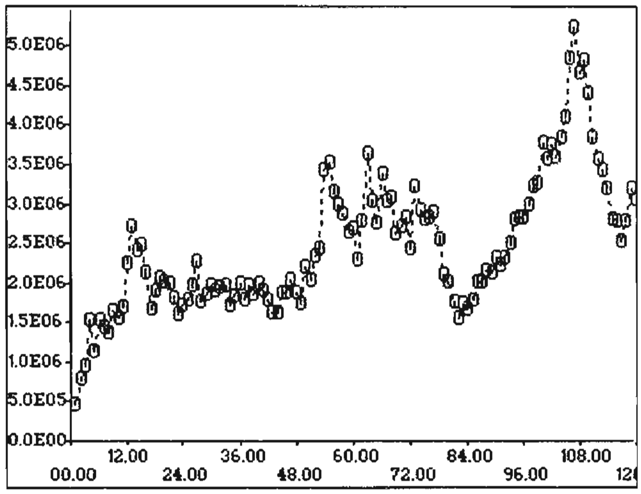

Fig. 6. Variogram on the night densities in October 1993.

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].

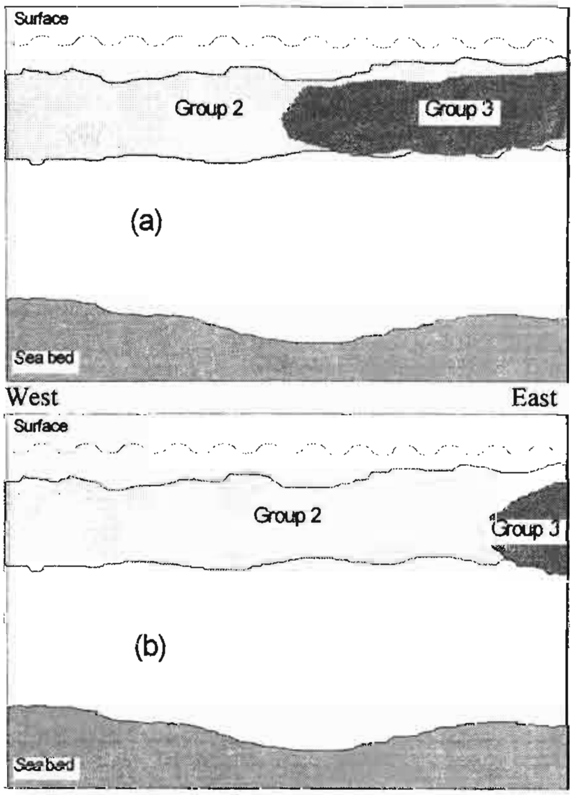

Fig. 7. Group 2 and 3, night annual distribution of pelagic fish from West to East of the Java Sea : (a) October, (b) February.

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.

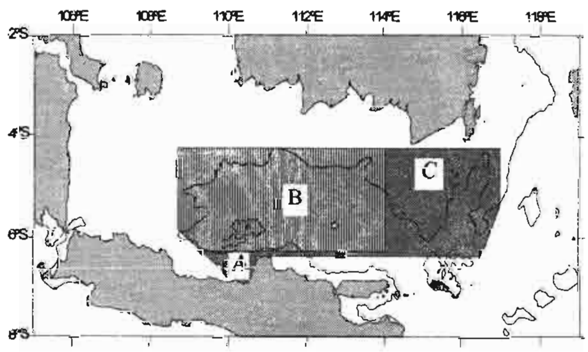

Fig. 8. The 3 strata of the Java sea, following the location of the main fish populations.

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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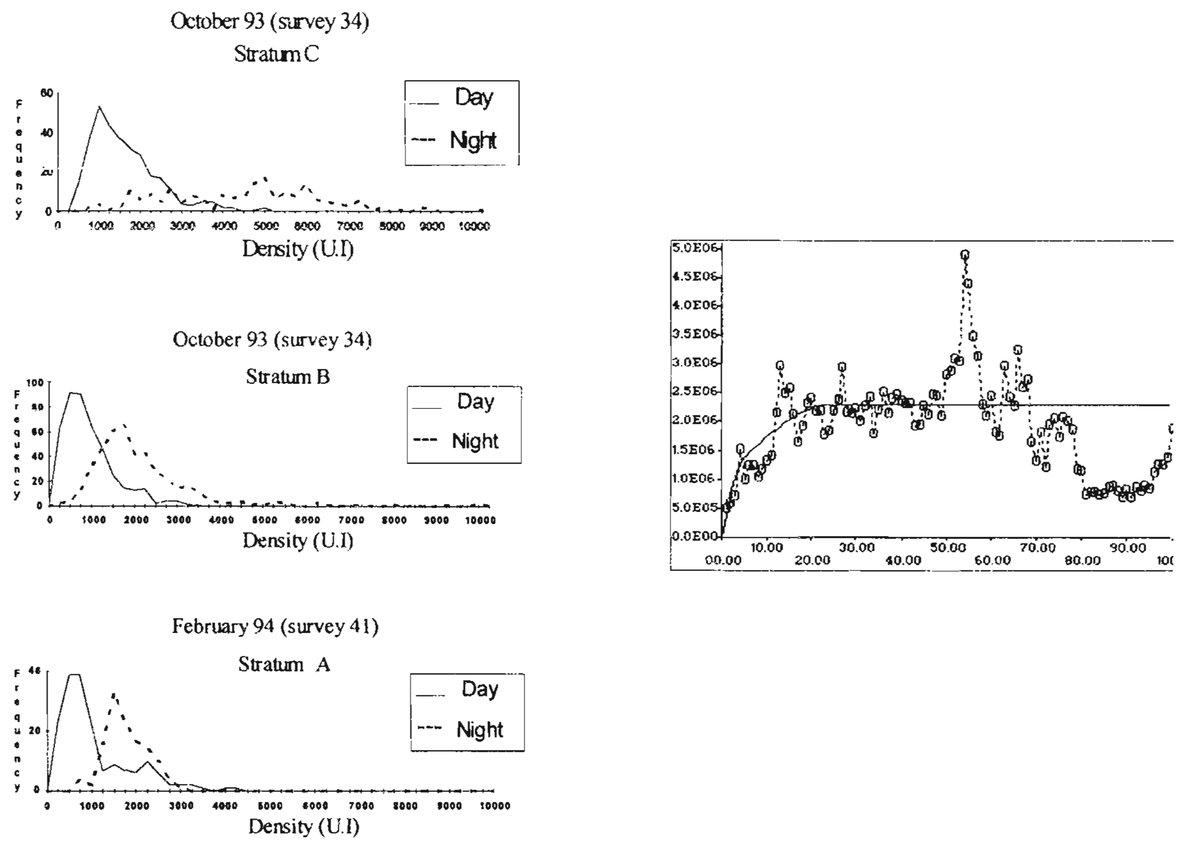

Fig. 9 : After stratification, frequency distribution of densities into the 3 strata and one aspect of variograms (here, for the stratum B, night densities, in October 93).

MINI PURSE SEINE FISHERIES IN NORTH JAVA COASTAL WATERS

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Abstract

The pelagic fish resources of Java Sea have been exploited since long time by many gears. Among which are purse seine, payang net (a kind of Danish seine), gill net and lift net. In particular, three fleets of purse seiners linked to the size of the seine, the boat and the fishing unit, share this resources. This paper presents the development of one of them. The topics discuss the fishing activities and catch composition.

Introduction

The North coast of Java waters is one of the most productive area of fish and a densely populated area in Indonesia. Its coastal line is about 1 100 km include Madura Island. This area is well known with the abundance of scads (*Decapterus russelli* and *D. macrosoma*) and mackerels (*Rastrelliger spp.*) (Martosubroto, 1982). The coastal pelagics resources have been intensively and fully exploited (Sujastani, 1978 ; Nurhakim *et al*, 1995). The gears that have been used to exploit the small pelagic stock are Danish seine, lift net, gill net and purse seine.

Since the trawl was banned in 1980 (Sardjono, 1980), purse seine fishery has had a significant role to support the increase of fish marine production in the Java ; more than 40% of total landing of the North of Java came from this fleet (Potier and Sadhotomo, 1995a). The seiners in the North coast of Java according to size of boat, engine power and their fishing grounds can be grouped into three classes, i.e. big, medium and mini purse seiner. The big and medium seiner have been discussed by Potier and Sadhotomo (1995a, b). The definition of a mini purse seiner (MPS) in this study is a wooden boat of the size ranging from 12 to 17 meters in length, powered with one or two out board engines of 25 - 30 HP, the size of the net is 200 - 250 meters in length and 40-60 meters in depth, the mesh size of bag net is usually 3/4 inch (Yusuf, 1978 ; Subani and Barus, 1988). Their fishing grounds are close to landing base and they go out for 1 to 4 days.

The aims of this study are attempting to give the information concerning the fishing activities and catch composition of mini purse seine in different fishing grounds and to recognize the fishing overlapping grounds scads.

Materials and method

More than fifty landing places are found along the North coast of Java (Fig. 1a). However, for the purpose of this study, we just selected two landing sites, i.e. Pekalongan and Sarang. The previous studies we carried out by Research Institute for Marine Fisheries by applying the procedure of the data collection introduced by Java Sea Pelagic Fishery Assessment Project for big and medium seiners. Collected statistical data are catch composition by commercial category in weight and price by fishing boats.

In Pekalongan, mini purse seine originally came from East Java and generally apply the light fishing without ***rumpon*** (fish aggregating device). Sarang is one the big landing site of mini purse seine where the fishermen usually use typical of ***rumpon***. The fishing of mini purse seine mostly take place in fishing grounds close to the North of Pekalongan and Rembang - Sarang waters that needs steaming time of 2 - 10 hours from landing place (Fig. 1b). The trip duration usually one day or more, most one night fishing.

In Pekalongan, 3 639 landing data were recorded between February and December 1994, and approximately 6 894 from January to December 1994 at Sarang.

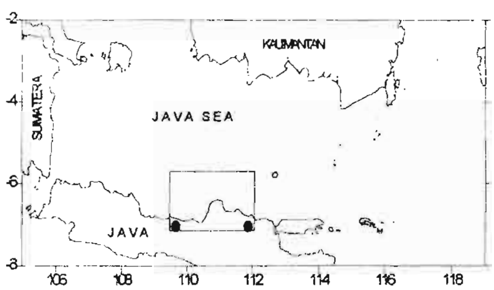

Fig. 1a. Map of fishing ground of mini purse seiners.

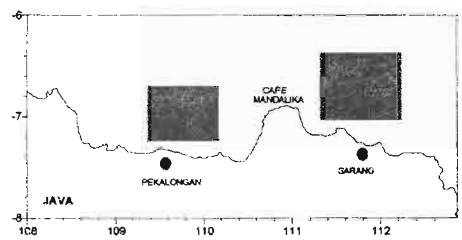

Fig. 1b. Two landing sites were selected for this study.

Results

Effort

The fishing operation of mini purse seine is seem to link with lunar calendar and fishing tactics. The fishing tactic can be classified into three groups :

1) searching and scouting school of fish, 2) light fishing without ***rumpon*** (fish aggregating device), 3) fishing with ***rumpon***. However, the fishermen usually use only one fishing tactic.

Searching and scouting school of fish is fishing tactic catching coastal tunas and mackerels. They are fishing during the day "at sight" when the fish shoals are near the surface. At night, they can catch some mackerels (*R. brachysoma*). The fishermen look for the luminescence coming from the shoals of this species (Potier and Petit, 1995).

The fishing unit of Pekalongan is carried out at night during periods of little or no moon, when the full moon (from 14th to 20th day of lunar calendar) the fishermen are not go to sea (Fig. 2a). In Sarang, the activity of fishing units were observed more regularly all lunar calendar. This is can be as a relation to the fishing tactics (Fig. 2b).

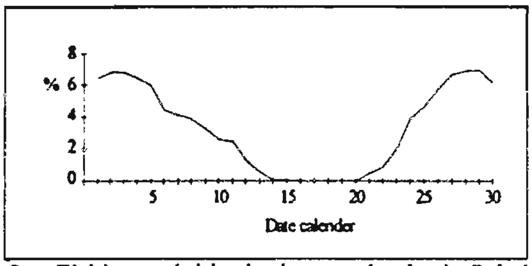

Fig. 2a . Fishing activities by lunar calendar in Pekalongan.

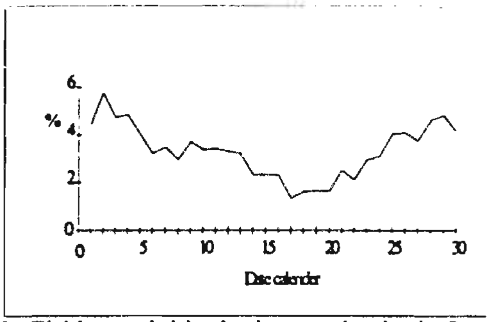

Fig. 2b. Fishing activities by lunar calendar in Sarang.

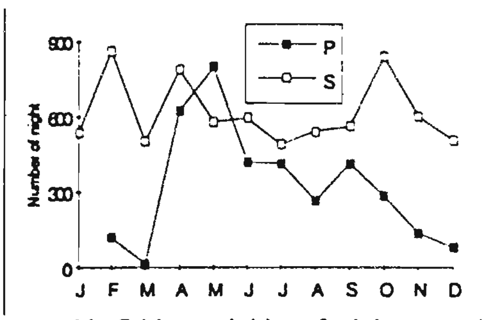

Fig. 3. Monthly fishing activities of mini purse seiners in Pekalongan (P) and Sarang (S).

The monthly number of boats using light fishing without ***rumpon*** showed great variation due to direct influence of monsoon, beside the tendency of fishermen came from East Java usually keep moving from place to place following fish migration. The peak of light fishing occurs from April to May, where as, the number of boats which land are not vary in every month (Fig. 3). Accordingly, fishing with ***rumpon*** is not affected by monsoon. The fishing area of those using ***rumpon*** is sheltered from West monsoon by cape Mandalika.

Catch composition

The main catch of mini purse seine is depicted in Table 1. Scads and indian mackerels (mainly *R. kanagurta*) were absent in catch of mini purse seiners whose fishing ground are close to the North coast of Pekalongan. The scads are the main species caught in Sarang during the northeast monsoon (August-December) almost all the boats catch on scads (*Decapterus spp.*) that reach 85-95 % from total boat landing, while sardines (*Sardinella spp.*) replace scads from March to July (Fig. 4). The CPUE of Sarang grounds was also higher than CPUE of Pekalongan grounds. It can be explained that scads enter the inshore waters close to Sarang in the northeast season and the shoals size much bigger than the others and CPUE as well.

Table 1. Catch composition of mini purse seine from Pekalongan (P) and Sarang (S) in year 1994

Common name	Scientific name	P (%)	S (%)
Scads	*Decapterus spp*	-	41.7
Indian mackerels	*R. kanagurta*	-	18.0
Indian mackerels	*R. brachyoma*	17.4	-
Sardines	*Sardinella spp*	23.8	15.2
Selar	*Selar spp.*	14.9	8.1
Rainbow sardines	*D. acuta*	1.0	
Spanish mackerel	*Scomberomorus spp*	3.1	2.1
Coastal tunas	*Auxis spp.*	10.4	12.9
Black pomfret	*Fornio niger*	5.0	1.0
Hairtail	*Trichiurus spp.*	12.7	
Squid		4.6	
Others		7.1	1.0
Total catch		1579 mt	7427 mt
Catch per night		0.5 mt	1.1 mt

In Pekalongan, catch composition tend to be dominated by coastal pelagic species, coastal tunas, and semi demersal such as hairtail, black pomfret (in this study categories as "others"). Shift of these species caused to alter monthly catch composition (Fig. 5). On other hand, the catch composition of Sarang grounds between August and December was almost similar to those of big and Medium seiner where was operate d in the Java Sea, of which the fleets of big and medium were concentrated (Fig. 6).

The difference of catch composition both fishing grounds are possibly affected by different saline waters, the Pekalongan grounds is more neritic and less saline, bottom sediment is mud, while Sarang grounds is clear waters and high saline, bottom sediment is sand and mud.

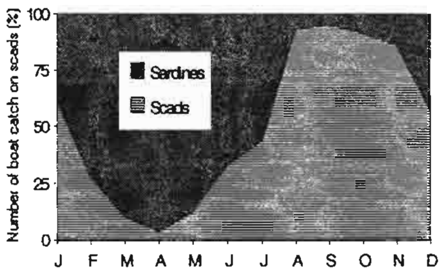

Fig. 4. Monthly percentage of number of boats catch on scads and sardines in Sarang.

In the period 1988-1994, the ratio of dominant small pelagic species to the total catch landed in Pekalonagan (657-1579 mt) between 46 and 56% consist of *S. gibbosa, R. brachysoma* and *Selar spp.* (Table 2). In Sarang, the period 1991-1994, the dominant small pelagic species contributed about 79-82% of total landings of 7433-8757 mt, which consisted of scads (30-53%), indian mackerels (13-21%), *Selar spp* (8- 16%), *Sardinella spp.* (10-18%), respectively (Table 3). Among the mackerels, *R. kanagurta* are captured in great quantity in Sarang, on the other hand *R. brachysoma* is rarely found.

Table 2. Catch composition by year in Pekalongan

Year	Indian mackerel	Sardines	Selar	Coastal tunas	Spanish mackerel	Black pomfret	Hartail
1987	11.0	18.0	19.8	7.1	1.3	9.0	2.3
1988	9.9	32.9	7.3	12.1	2.3	11.3	3.9
1989	8.4	43.1	5.0	6.3	3.7	10.9	2.1
1990	7.2	37.9	10.5	6.8	2.1	5.8	9.2
1991	13.9	19.1	16.6	11.9	3.5	11.7	7.7
1992	6.7	10.0	16.8	12.5	4.5	16.6	1.7
1993	0.6	25.4	24.0	8.8	2.8	8.7	0.1
1994	17.4	23.4	14.9	10.4	3.1	4.5	0.7

Table 3. Catch composition by year in Sarang

Year	Scads	Indian mackerel	Sardines	Selar	Coastal tunas	Spanish mackerel
1991	53.3	13.2	10.5	11.8	7.4	3.6
1992	30.1	20.7	13.5	15.6	9.4	10.6
1993	31.7	18.4	18.6	14.3	12.3	3.5
1994	41.7	17.9	15.2	8.1	12.9	2.1

The scads (*Decapterus spp.*) and mackerels (*R. kanagurta*) live in waters of salinities at least 34 per mil. They are caught during August - December when the oceanic waters enter the Java Sea (Hardenberg, 1938 ; Potier and Sadhotomo, 1995). Beck and Sudradjat (1978) reported that the higher catch rate of coastal species such as *R. brachysoma* and *D. acuta* occurred during the northwest monsoon when the salinity is lower. Hadisubroto (1975) reported that scads predominate the catch of purse seiner operated off the North of Tegal and Karimunjawa island waters during the southeast monsoon period. It appears to be a differential distribution between *R. brachysoma, S. gibbosa* in one hand and *R. kanagurta, Decapterus spp.* on the other hand, the latter being common in off-shore neritic waters. They are generally caught above the shelf where the fleet operating at further distance from land, i.e., higher salinity.

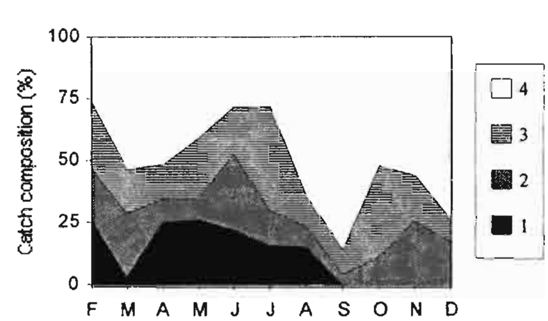

Fig. 5. Catch composition of mini purse seiners in Pekalongan, 1994 (1. *R. brachysoma*, 2. *Selar spp.*, 3. *Sardinella spp.*, 4. others).

Discussion

The hydrographic condition and characteristic of Java Sea are closely associated with the southeast and northwest monsoons. In the southeast monsoon, the high salinity (>34 per mil) enters Java Sea, and when the northwest monsoon, the salinity induced by river discharges and the low salinity waters from the South China Sea (Wyrtki, 1961 ; Durand and Petit, 1995). Additionally, win and rainfall strongly influence on activities of fisheries in the Java Sea (Potier and Boely, 1990). This condition was demonstrated by mini pourse seiners operated in the North coast of Pekalongan, when the peak northeast monsoon (December- February) the fishermen sometime have to stop fishing.

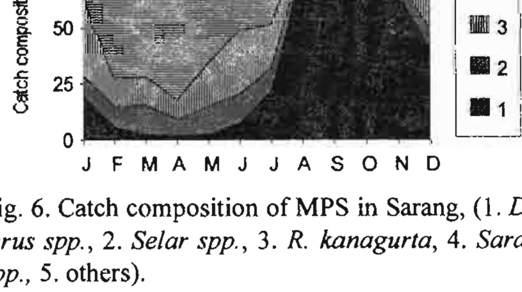

Fig. 6. Catch composition of MPS in Sarang, (1. *Decapterus spp.*, 2. *Selar spp.*, 3. *R. kanagurta*, 4. *Sardinella spp.*, 5. others).

We can notice that fish assemblage between fishing ground of the North coast of Pekalongan and coast of Sarang waters were different distribution pattern. The absence of scads from the North coast of Pekalongan waters indicates that the salinity is lower than coast of sarang waters. The difference of catch composition seems to reflect characteristics of the hydrographic condition rather than fishing tactic. So, the target species of mini purse seiners were varies according to fishing ground and monsoons. However, the scads were is easy caught whose fishermen used fish aggregating device. The dominant species composition caught by mini purse seine fleet depends on monsoon and fishing ground.

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THE STATE OF EXPLOITATION OF SMALL PELAGIC FISHES BY THE LARGE AND MEDIUM PURSE SEINE IN THE JAVA SEA

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Abstract

The small pelagic fisheries in the Java Sea play an important role in fishery development in Indonesia. It is one of the answers to the protein need for the Java numerous population. It represents also a major source of employment and revenue in the coastal communities along the North coast of Java. Through three main flottillas, seining is the main fishing method used and the development of fishing tactics and strategy is still in progress. Consequently the fishing grounds extended to new areas and the landing increased. This paper will describe the evolution of the main parameters of exploitation such as number and power of boats, spatial distribution of effort, total and specific catches as well as the problems of exploitation level and fish quality.

Introduction

The small pelagic fisheries in the Java Sea play an important role in fishery development in Indonesia. Because it could answer the need of animal proteins for the population of Java. Additionally, this activity is a major source of employment and revenue in the coastal communities along the North coast of Java as well as of the South coast of Kalimantan. Consequently a rational management of the natural resources, namely fishery pelagic resources is essential to support national economy, social and nutritional goals.

Since the trawl ban in 1980, pelagic species are the main resources exploited in the Java Sea. Their exploitation by artisanal fisheries is very old and has an important socio-economic impact on the islands bordering that sea. First limited to inshore resources of the North coast of the Java island, the exploitation extended offshore since the implementation of the purse seine.

The purse seine was introduced in the Java Sea in order to have a longer fishing period and a higher catch than with the traditional nets. It spreads out quickly and the seiners were able to extend their exploitation area outside the Java Sea in order to free themselves from the high seasonal fluctuation of the catch occuring there. The exploitation of the resources by the large purse seiners is now twenty years old and during this period many changes occured.

The fishery is a dynamic system which quickly react to internal and external changes. In 1987 smaller seiners coming from the Pekalongan harbour entered the fishery. The geographic distribution of the pelagic species is such that the mini, medium and large seiners are now exploiting same or overlapping populations. This is why in the statistics analysis on large and medium seiners the data collected on other fisheries has also to be taken in to account.

Materials and method

Since 1985 with the beginning of the research cooperation between ORSTOM (France) and RIMF (Indonesia) a sampling scheme for the collect of the data coming from large seiners fishery has been set in the different landing places. The catch and effort are now known by fishing ground and by commercial category.

Since the beginning of the Java Sea Pelagic Fishery Assessment Project the sampling scheme has been improved. Catch is known by species and by fishing ground. Effort data is collected from the fishing port administration of Pekalongan where entries and exits of the seiners are registered. At other landing places the effort estimation is derived from enquiries on board of the Seiners during every landing.

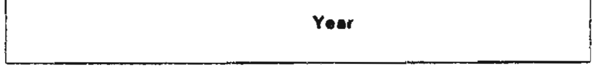

Fig. 1. Evolution of number of seiners belonging to the two main flottillas between 1978 and 1994.

Results

__Fleets__

The large seiners fleet is the oldest to use the seine net in the Java Sea. The number of fishing vessels increased from 1979 until 1985 when the fleet reached 520 units. In 1987 and 1988 the number of large seiners drastically decreased. Despite the construction of many new vessels in the last years the number of seiners, with

372 units in activity in 1994 (Fig. 1) is still far from 1985. This fleet represent 61% of the whole seiners in activity in the province of Central Java.

Medium seiners appeared in 1987 and their number slightly increased until 1991. With new investors, the fleet quickly expanded and reached 238 untis in 1992 and decreased to 201 units in 1994 (Fig. 1).

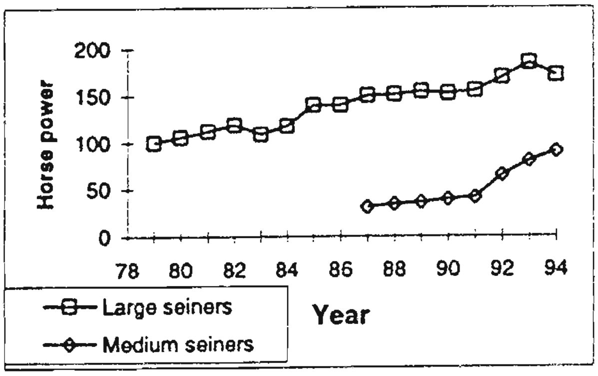

Fig. 2. Evolution of horse powers of purse seiners.

These two well fleets with differing vessels and distinct fishing strategies tend to overlap. Since 1979, size, horse power (Fig. 2) and fish hold capacity have increased. This evolution, linked with a better fishing efficiency, allowed the exploitation located in the traditional Javanese fishing ground to extend to the eastern part of the Java Sea, to the Makassar Strait and to the South China Sea. In 1992, we can describe three segments exploiting different fishing grounds in the fishery :

- the first one which exploits the traditional fishing ground of the Javanese fishermen consist of the old medium seiners (16-18 meters) ;
- the second one whose fishing grounds extend from the Karimunjava Islands to Matasirih is made of old large seiners built before 1985 and a new generation of medium seiners ;
- the last one which mainly exploits the eastern part of the Java Sea, the Makassar Strait and the South China Sea consist of the newest large seiners built since 1985.

Catches

The small pelagic species in the Java Sea are mostly caught by large and medium purse seines. Their landings show great variations. But since 1979 the catch increased four times reaching 157 000 tons in 1994 (Fig. 3).

The Javanese seiners catch around thirty pelagic and semi-pelagic species. Eleven of these species account to 90% of the landing. According to official statistics, these eleven species are gathered in five statistical categories. In the different landing places the names of these categories are replaced by local names related to species and size.

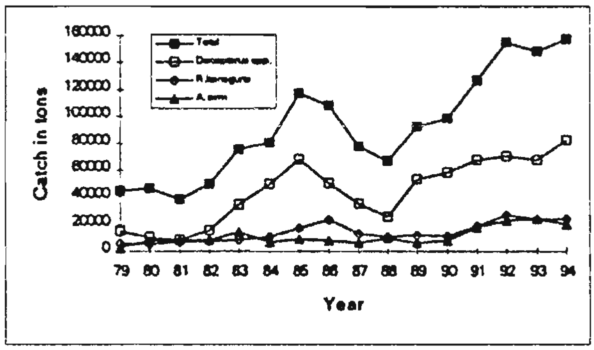

Fig. 3. Evolution of the total and main species catches for the last sixteen years (excluding China Sea).

Two species of ***layang*** scads (*Decapterus russelli* and *Decapterus macrosoma*) are caught by the seiners. The catch shows high fluctuations with two production peak in 1985 and 1991-1994 (Fig. 3). Since 1993, every year, they account at least for 50% of the total catch and form the bulk of the catch in each fishing ground. The total landings of the seiners fishery is highly related to the fluctuation of the scad landings (Fig. 3). As the fishing grounds move eastward, the catch of the species shows different trends. The landing of *D. russelli* decrease while those of *D. macrosoma* increase. In 1992, *D. macrosoma* was dominant in landings. Due to different fishing areas, the exploitation of the two fleets do not focus on the same species. Medium seiners mainly catch *D. russelli*.

Most ***banyar*** mackerels represented in the large and medium seiners catch are *Rastrelliger kanagurta*, while *Rastrelliger brachysoma* being accidentally present in the landings. The evolution of *R. kanagurta* catch shows the same trend as for the scads with high fluctuations and a production peak in 1986 (Fig. 3) when 23 000 tons were landed. Most part of the catch comes from the eastern part of the Java Sea and the Makassar Strait.

The landing of ***siro*** *Amblygaster sirm* was relatively more important between 1979 and 1993 : it could represent up to 20% of the seiners catch. From 1983 and until 1988 the landing decreased a lot before increasing again from 1991 (Fig. 3). The bulk of the catch is made in the Makassar Strait. It is mainly caught by the large seiners and accounts for a small part in the medium seiners landing.

Landing of ***tanjan*** (*Sardinella gibbosa, Sardinella fimbriata* and *Sardinella lemuru*) shows regular fluctuation. These fishes are not the target species of the seiners fleet. They are caught by the large seiners as well as the medium seiners. In 1992 the landing sharply increased. The major part of the catch is made in the Java Sea in May-June.

The ***bentong*** big-eye scad (*Selar crumenophthalmus*) is caught in small quantity by the large and medium seiners. Since 1979, the landing tends to decrease slighly. The bulk of the catch is made in the Java Sea. Certain years, some important catch occurs in the South China Sea.

The other species account for 6 to 8% of the total catch. They are accidentally caught and among others consist of ***Japuh*** (*Dusumeria acuta*), ***bawal hitam*** (*Formio niger*) and small coastal tunas as *Auxis spp.*

Landings show a high seasonal trend which is more or less related to the monsoons (Potier and Boely, 1990), it shows two peaks, a minor one in March-April, a maximum in September-November (Potier and Sadhotomo, 1995). The decrease of landing in December-January is highly related to the North-West winds which blow at that season and prevent the fishing vessels to go at sea. During the peak fishing season (September-December) most of the catch is made in the Java Sea, while from January to March-April it is made in the Makassar Strait. As the waters of low salinity extend eastward and reach their maximum of extension in May-June, the bulk of the catch is made in the South China Sea.

Based on sun ray plot analysis, the yearly catch and the CPUE trends, Potier and Sadhotomo (1995) mentioned that there are three groups species which correspond to three different types of populations among the seiners catch :

- oceanic population : *D. macrosoma, A. sirm, R. kanagurta*. They live near the continental shelf edge. They are found in waters where salinity is more than 34‰. They are caught when the oceanic waters enter the Java Sea from August to November ;
- neritic populations : *D. russelli*. They live on the continental shelf in waters with salinities between 32-34‰. They are caught along the year by the seiners ;
- coastal group : *S. crumenophthalmus, S. gibbosa*. They are found near the coast and live in waters with high fluctuations of salinity. They are found along the year in small quantity in the seiners catch.

<u>Effort</u>

Expressed in number of trips (Fig. 4) the effort has decreased continously since 1979 ; consequently the average number of days at sea per trip increased from 6 in 1979 to 25 in 1994 (Fig. 5). It can be related to the extension of the fishery, the growing distance between harbours to the fishing ground and the use of larger vessels which stay longer at sea.

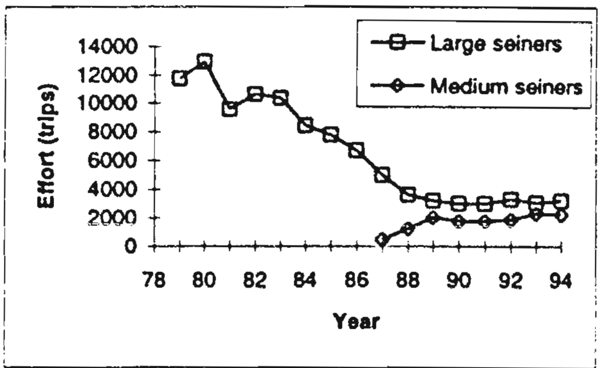

Fig. 4. Evolution of the effort of large and medium seiners between 1978 and 1994.

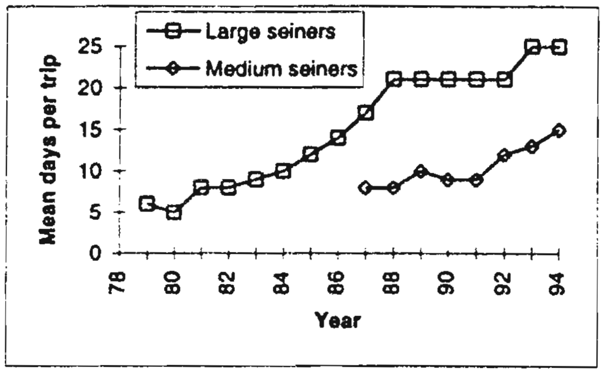

Fig. 5. Number of mean day by trip between 1978 and 1994.

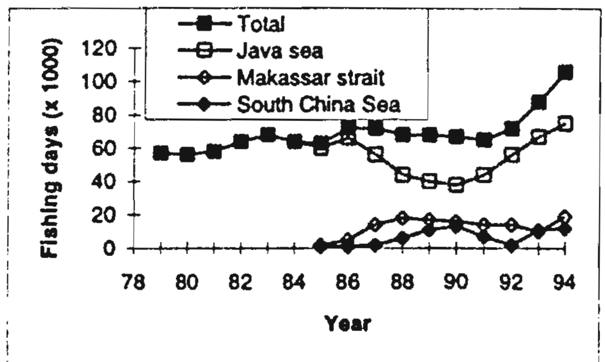

Fig. 6. Evolution of fishing days of three main fishing places between 1978 and 1994.

Most part of the effort comes from the large seiners vessels and is spent in the Java Sea (50 to 70%), the rest is spent in the Makassar Straits and in South China Sea (Fig. 6). The effort is highly seasonal and related to environmental and human factors. When the winds are stronger than 20 knots the vessels are not able to go at sea, this situation occurs mainly during the first months of the year when the North west monsoon is well established. During these months, floods on the North coat of Java Island can entirely stop the activity of the seiners because the landing places are flooded. The effort is high inside second part of the year from August to November. Medium seiners deploy their whole effort in the Java Sea, while large seiners share it among the whole fishery space, including Makassar Strait and South China Sea.

Catch per Unit Effort

Values of the CPUE show a 50% decrease from 1985 to 1987 (Tab. 1 and fig. 7) when the catch rate of the large seiners was 1 ton per fishing day. Since 1988, it increased by step and in 1992 is slightly higher than in 1985 reaching 2.4 tons/fishing day. The catch rate of the medium seiners after three years of stagnation increase since 1989.

The fluctuation of CPUE in the large seiners fishery are seasonal with a maximum peak at the end of the year and a minimum one in May-June. In the medium seiners fishery there is only one annual peak during September-November. The evolution of CPUE differs among the fishing areas. The Makassar Strait and the Java Sea have a similar evolution with higher values in the Makassar strait. In the South China Sea, CPUE fluctuates a lot.

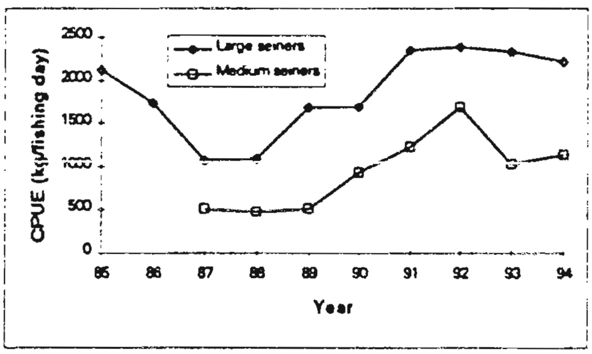

Fig. 7. Catch per unit effort : average yearly values for large and medium seiners (kg/fishing day).

Fishing strategies and tactics

Before 1992, the trip strategy was to choose one fishing ground and to spend all the fishing days in this zone. Since then, some technical changes have appeared. All fishing vessels are now equiped with radio and the strategy is to prospect two or three fishing zones during one trip. The strategy which was an individual one. But even now the aim is to be at sea during the new moon when the catch is believed to be higher.

Because of the fish behaviour and of the vessels they use, the fishing tactic of the Javanese fishermen consist of concentrating the fish by mean of Fish Aggregating Devices (FAD) and lamps. During the first development stage of this fishery the FAD had the main role in aggregating the fish. Since 1988 lamps have replaced the FAD in this function. The number of set by night will vary from one in full moon to two in new moon. Seiners are not randomly distributed in the fishing ground.

Level of exploitation

The pelagic fishes in the Java Sea consist of several species being exploited by various fishing gears, and we are still considering that only part of the stocks captured, the real configuration of the pelagic stocks is can not exactly be defined yet. However, based on recent developments of fishing activities in the whole area, the level of exploitation could be near the maximum.

By assuming that a big part of the stock is being exploited by the large Purse Seine in the Java Sea, the previous studies (Widodo, 1995 ; Nurhakim, 1995) demonstrated that the level of exploitation of *D. russelli*, *D. macrosoma* and *R. kanagurta* have been closed to the optimum level.

Management and Regulation

The mesh size regulation and zonation were issued by the government. The minimum allowable mesh size is 1 inch, and the repartition of fishing zones is defined according to the gross tonage of the fishing boats. The paths of the fishing zones are defined as 0-3 miles, 3-5 miles, 5-7 miles and more than 7 miles from the coast line respectively.

In fact the mesh size used in the fishery never follow the government regulation, while fishing zone of the purse seiners tend to be more further than 7 nm except during the season of certain species (*R. brachysoma*) when the mini seiners tend to catch in near the coast. Eventhough, in some area the mini seiners always operate close to the coastal line such as in Madura and Sunda Straits.

Actually the fishermen tend to avoid the small size of fish during the first recruitment and the use of mesh size 0.5 inch is more intended to prevent the fish entangle on the net.

Since the recruiment occurs in certain period, closed season regulation might be more efficient, with a support of relevant deep biological study.

It seems that the fishermen unconciously regulate by themselves the effort exerted upon the resources. The large purse seiners tend to reduce their fishing activity in the Java Sea by shifting the fishing ground to the South China Sea and never fish in other areas beyond the Java Sea which are presumed to be the natural migratory grounds of the same exploited stocks.

Conclusion

The exploitation of small pelagic in the Java Sea is related to the season and the availability of the fishes is linked to the monsoon regime. The large seiners extend their fishing ground to the South China Sea in order to avoid the lower disponibility of fish during in the Java Sea.

Although the structure of the stocks has not been recognized yet, we believe that the scheme of exploitation of the seiners fleet is related with multispecies stocks repartition the multi stocks. The effort exerted by these fisheries exclusively concentrates on part of the stocks living in the Java Sea.

It seems that the level of exploitation of the small pelagic species in the Java Sea is near to optimum level. However, regarding oceanic stocks, the fishing pressure is lower as their geographic distribution exceeds the fishing boundaries of the seiners fisheries.

The changes of fishing tactics and strategies along side with improving in and equipments vessels characteristics should be followed in order to monitor the development of fishing effort of small pelagic fishes in the Java Sea and ajacent waters.

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Table I : Evolution of the effort (fishing days) and the CPUE (kg/fishing day) of large and medium seiners fleet since 1985

Effort	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Large	56282	62052	70345	56087	50086	51256	46384	52889	53150	57964
Medium			2873	8157	16915	12569	14136	17539	24412	27187
Total	56282	62052	73218	64244	67001	63825	60500	70428	77562	85151
CPUE										
Large	2120	1742	1077	1097	1683	1697	2350	2367	2328	2216
Medium			512	477	511	939	1226	1688	1034	1134

FISHING TACTICS IN THE JAVANESE RING NET FISHERY

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Abstract

The Javanese fishermen use Fish Aggregating Devices (FAD) and light to concentrate fish before catching it. Since years, the FAD were used as the main attractors and the light as an help for fishing. Today, the situation reversed and light is the main attractor. This evolution induces some changes in the fishing tactics. Formerly, the vessels stayed along their trip on the same fishing ground, now they can prospect more than one fishing ground by trip. On the fishing ground, the seiners are not randomly distributed and the concentration of the vessels show a high structuration.

Key words : Java Sea, Fishing tactics, fishing devices.

Introduction

The fishermen want to catch the fish in the most efficient way in order to maximize the time they spend at sea and raise their profit. To achieve this goal, they are willing to quickly adopt new technologies. The introduction of the ring net in the Java Sea was a technological improvement which allowed the Javanese fishermen to fish all along the year and to have a higher catch compared with the catch of traditional nets such as "payang".

Fishermen rely on their knowledge on environment and of the fish behavior. Then they apply it to the fishing tactics. They are a set of coordinate actions made by the fishermen on the fishing grounds in order to catch the fish.

Results

Fishing Tactics

Traditionally the Indonesian fishermen used the FADs or "*rumpon*" to catch fish. Around 1950, the use of light (paraffin pressure lamps) spreads. All the ring net fisheries in Indonesia use these tools widespread in the South-East Asia. In the ring net fishery of the Java Sea, lamps and rafts are combined. The fishing operation takes place at night (Potier *et al.*, 1992) after aggregation of the fish.

Traditional fishing tactic

The tactic used by the Javanese fishermen can be resumed in two phases : the mooring of the rafts and the fishing operation itself.

Mooring of the rafts

To moor the rafts the fishermen look for the color and the transparency of the water. A good fishing ground should be with transparent and deep-blue colored waters. The catch of fish with lines around old rafts or the observation of shoals at the surface just before dusk are also good indicators.

Until 1988, the ring netters used to moor around 12 rafts on the same fishing ground. Now, the number decreases to four or five rafts, moored several nautical miles apart. They are laid according to compass bearings the first one used as a starting point, and marked with distinguishing flags to identify the parent vessel. The rafts remain there for several fishing trips (two to three months) until they deteriorate.

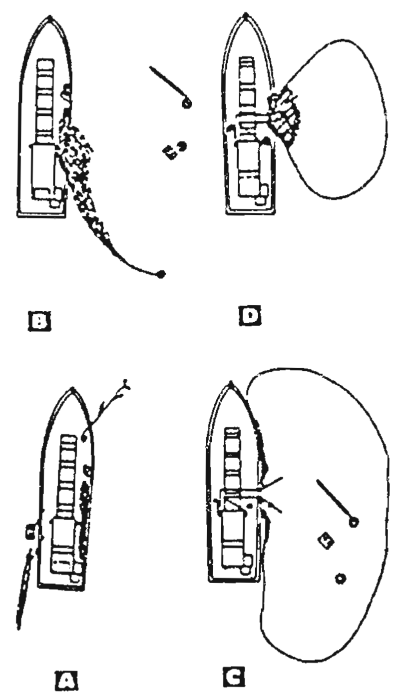

Fig. 1. Different phases of a ring net set.

Fishing operation

Choice of the "*rumpon*" : it starts in the afternoon when the vessels inspect the rafts. Every time lines are laid on, the raft in which the catch is the best or around which shoals have been seen is chosen. Before anchoring close to the raft, the vessel moves to find the best position according to the current and to the wind. The raft is secured with a rope remaining 10 to 20 m. behind the stern of the vessel. As soon as mooring is done, before dusk (17h15-17h45), lamps are turned on and their supporting framework lowered to the horizontal so that they shine down into the sea.

Hauling the *rumpon* : the setting starts by hauling the raft (Fig. 1a) which is put on board with the ballast. The upper part of the line, around 18m, is laid on and placed along the hull. Paraffin pressure lamps are placed on floats in the water. Every 2 minutes the vessels lights are gradually turned off.

Setting : the vessel weighs anchor and moves away from the raft. It moves around the raft following the informations given by the *juru arus* (current master) about the current direction and the fish position.

Starting leeward, the net is shot over the stern (Fig. 1b) while one fisherman in the water, with an inflated inner tube, holds on to a bamboo pole attached to the floating line and acts as a marker buoy. In order to be seen in the dark he carries an electric torch. The net is shot in a circle at full speed, the bamboo pole and the floating line are picked up at the bow. The boat is kept leeward from the net so that it does not drift into it. The setting operation is very fast, 3 minutes for the shooting, 15 minutes for the purse line hauling (Fig. 1c) and 35 minutes to form the bag (Fig. 1d).

Most of the time one set will take place during the night, but around the new moon (two or three days before and after) when the fish concentrates easily under the lights two sets will be done (Boely *et al.*, 1988). Most of the settings are conducted between 3 a.m. and 5 a.m. (Fig. 2).

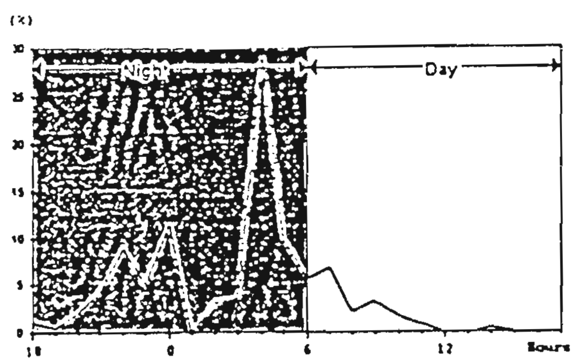

Fig. 2. Distribution of the ring net sets (%) according to the daytime.

Evolution of the traditional tactic

Light fishing

Since 1987, the use of auxiliary generators has widely replaced the paraffin pressure lamps formerly used in the Javanese ring net fishery, most of the vessels carrying 12-36 lamps of 200-1000 watts. First using mercury lamps, some are now using enclosed halogen floodlights.

Today, the light initializes the concentration and the raft only helps to the aggregation and the setting. The traditional roles of these tools have been inverted (Fig. 3). Fish search is still done late afternoon. When the fishing master estimates an area good, he stops the boat. The light are turned on before dusk. Two rafts called *tendak* are moored at the stern and the bow of the boat respectively. Before setting, they are hauled on board. The upper part of the one placed at the stern is moored again and the setting occurs in the same way as before.

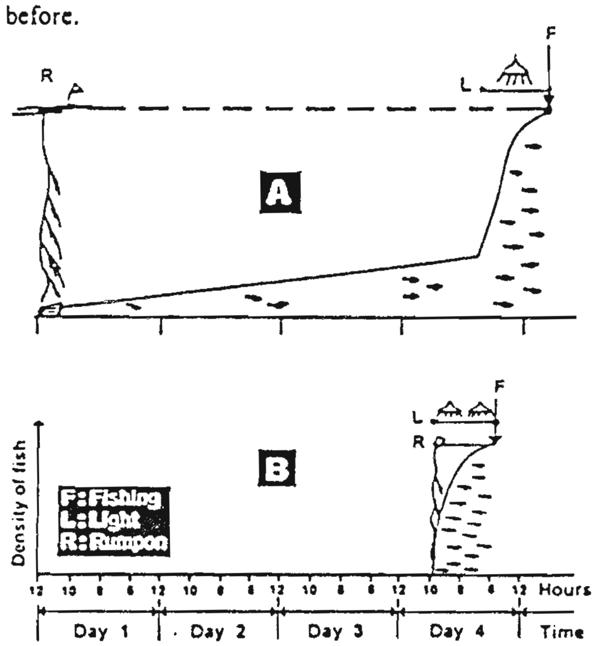

Fig. 3. Phases of fish attraction. Old (A) and new (B) fishing tactics.

Pack fishing

Whenever fishermen go at sea they try to find the fishing area where fish is most abundant. To achieve this aim radio communication is very helpful. Today, the fishing vessels adopt a "pack" strategy. They can track the fish in several fishing grounds during a trip. The distribution of the fishing vessels in the fishing area is highly related to this strategic change.

To illustrate these changes, some visual and radar observations made during acoustic cruises in the fishing grounds add to the information collected during inquiries on the field. The survey of these distributions consisted of the following method. The cruises made on Bawal Putih I covered the fishing grounds of the Javanese ring netters. At night, when the fishing vessels are grouped their spotting is easy. According to the size of the clusters they can be detected 30-35 nautical miles away. When the distance between these clusters and the Bawal Putih I is less than 15 nautical miles, the position of each fishing vessel is noted with the help of the radar.

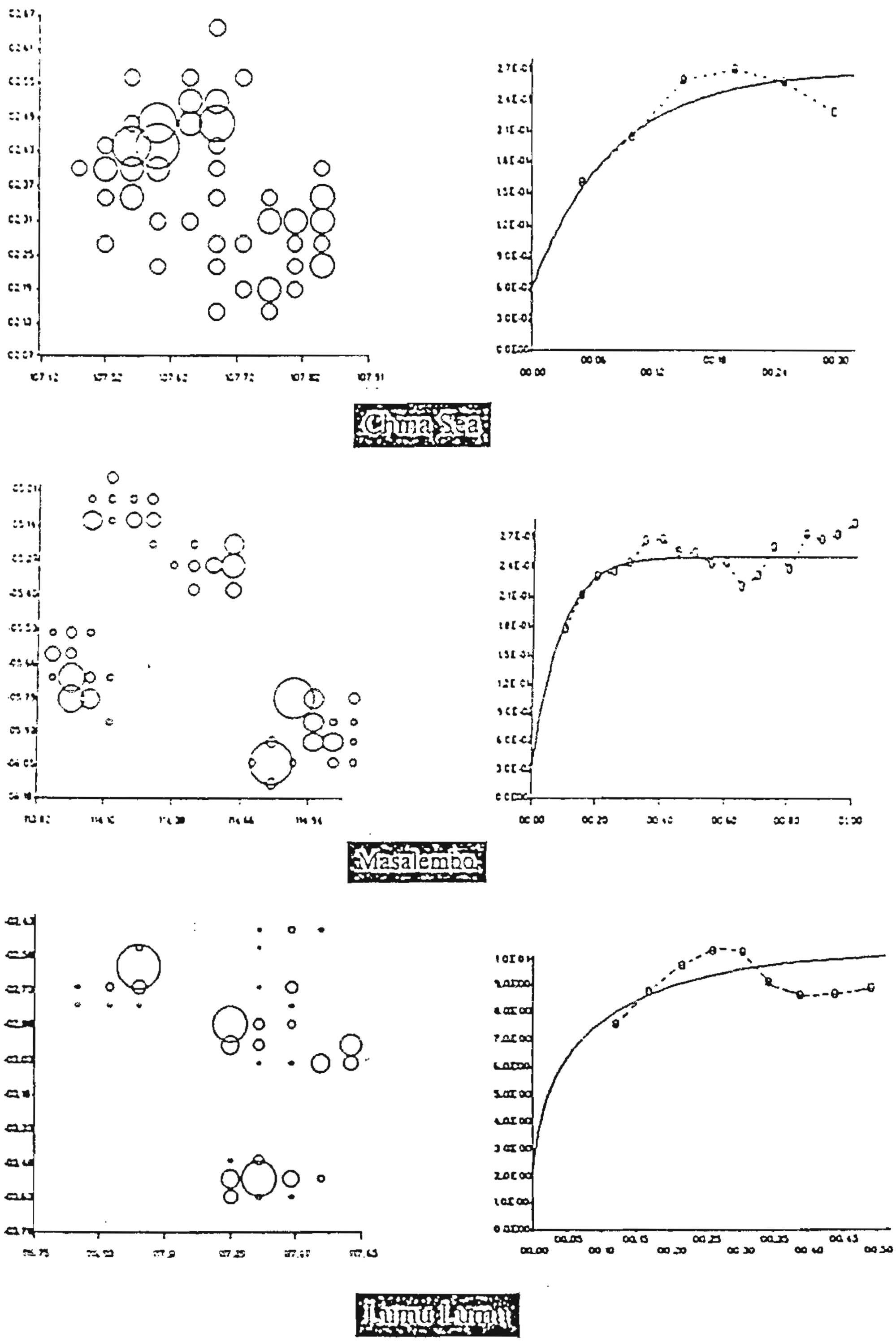

Fig. 4. Vessels clusters and associated variograms.

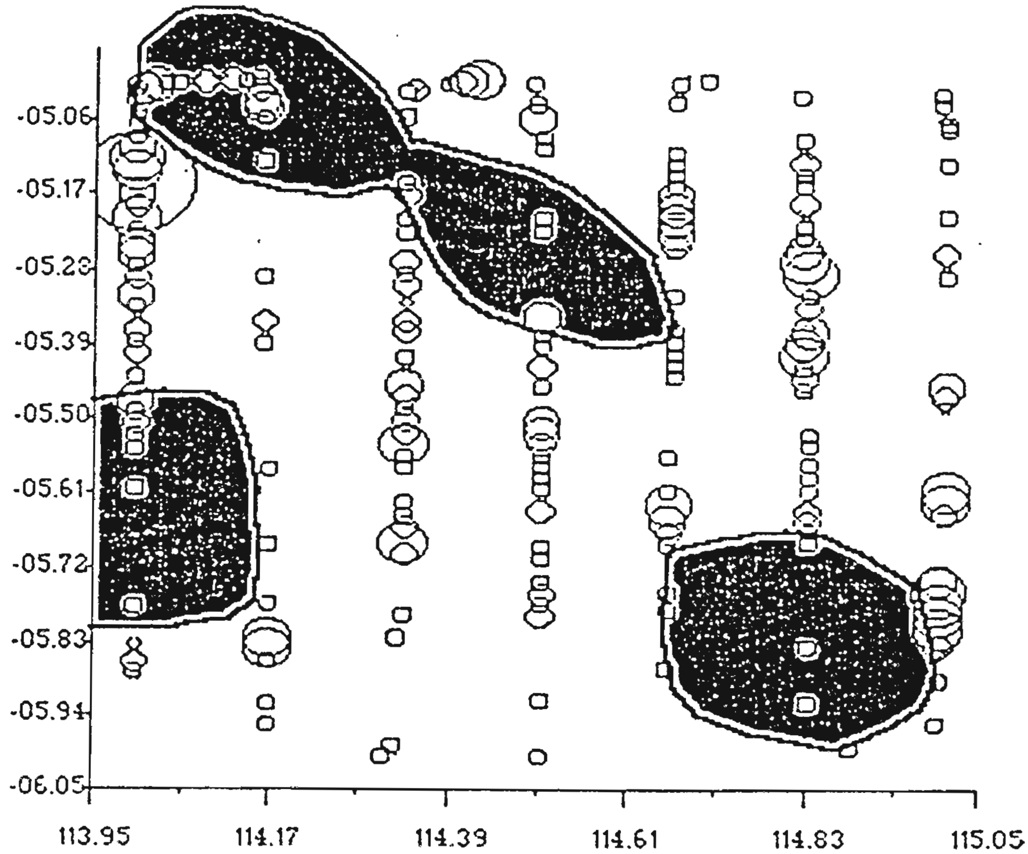

Fig. 5. Position of vessels clusters and schools of fish around Masalembo Island October 1992.

In October 1992, large clusters of ring netters were observed around the Masalembo and Keramian Islands, in April 1993 South of the Midai Island (South China Sea) and in January-February 1995 in the Makassar Strait. The movements of these clusters were observed during several days. Such clusters consisted of 36 vessels in October, 79 vessels in April and 50 vessels in January-February. They make up patches of 20 to 30 nautical miles in surface (Fig. 4a, 4b, 4c). The number of light spots echoed by the radar control allow us to confirm that most of the observed vessels were in fishing operation. In such clusters, the average distance between the ring netters is 1.4 nautical miles and the maximal 4 nautical miles. Sometimes, they are less than half a nautical mile apart.

A study of these clusters based on geostatistics show that the fishing vessels are not randomly distributed in a fishing area (Fig. 4d, 4e, 4f). When we compare in a fishing zone the distribution of the vessels with that of fish schools (Fig. 5) we record that in the area where are the vessels the fish schools are few. It can mean the vessels are able to aggregate most of the surrounding biomass acting as a pump towards this last one. Using this tactic they tend to exploit a fishing ground to its maximum level even if the fishing zone is not located over area where the fish abundance is the highest.

The vessels being not far from each other this tactic can lead to a competition among them to attract the fish. We can observe an increase in the average light power among the vessels which can confirm that hypothesis.

Conclusion

The use of rafts and lights in a fisheries sets the question of their presence and their utility. In the case of the Javanese ring net fishery several interpretations can be given :

first, the ring netters are not able to fish at "sight" shoals seen at the surface because of their low speed ;

second, shoals are small and not numerous, the fish being scattered in the water column.

In both cases, it has to be aggregated and fixed before being fished. This is a problem of resource availability. The fluctuation of the number of rafts in an area can also reflects the fish accessibility. More numerous are the rafts less is the fish accessibility and *vice versa*. The evolution of the tactics since 1987 sets the two aspects of the question. In a first approach the increasing use of electric lamps could be a way to increase the fish vulnerability because there would be a better aggregation around the boat. In a second approach, the replacement of rafts by light could be linked to a change in the fish accessibility since 1990-1991. Changes in tactic often happen when the fisheries have to face difficulties as stagnation or decrease of the catch.

In the actual state of the technology the ring net fishery of the Java Sea exploit all the space available. As the knowledge of the Javanese fishermen about environment and fish behavior is quite good, the fishing tactics are efficient. The fishing pressure is high on the prospected fishing grounds. A new evolution will be only possible with changesat high costnot only leading changes in the fishing tactics but also in economic and commercial ones.

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TRENDS IN THE SCAD FISHERY OF THE JAVA SEA

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Abstract

Since long time ago, the small pelagics are exploited along the north coast of Java Island by two fisheries, one which exploit coastal species, and the other one which exploit mainly the scads (*Decapterus spp.*). Until the seventies, these fish were caught with Danish seines "(Payang)" carried by large canoes "(Mayang)". Due to the vessels and the fishing gear used, the fishing season was short and the fishing grounds were located not far from the shore. In 1970's, the introduction of a new net and new type of vessel allowed the extension of the fishing season and of the fishing grounds. The landings show a high seasonality related to the monsoon, phenomenon which seems common to many pelagic fisheries in the Asian region.

Key words: Java Sea, Trends, Scads.

Introduction

The scads are widely spread in the Indonesian waters and are of important significance, primarily to the fisheries in the Java Sea. Two species are found in that sea (*Decapterus russelli, Decapterus macrosoma*) and they form the bulk of the pelagics catch. There are species cannot live in waters of salinity less than 32 %. They are exploited by artisanal and small scale fisheries in fishing grounds located more than 20 nautical miles off the coast. According to Hardenberg (1937) two or three populations of scads occur in the Java Sea (Fig. 1). The first one which comes from the Indian Ocean through the Sunda Strait inhabits the western part of the Java Sea and do not overthrow the Thousands Islands. The second, the most important, inhabits the eastern part of the Java Sea and, according to the season, can be found until the Biawak Islands. The third would come from The South China Sea through the Karimata Strait and enter the Java Sea during the North-West monsoon. The presence of this latter in the Java Sea is not certain. The scad fishery exploit mainly the population living in the eastern part of the Java Sea. In the recent years the exploitation of the South China Sea population by the purse seiners based in the Central Java province started.

Results

Historical Trend

Before the second world war the scads were caught with ***payang*** net carried on board large canoes called ***mayang***. These vessels of 12 m long and 3 m width could not stay for a long time at sea. The trips were short, often one day fishing, and the rough weather prevailing during some months do not allow them to go at sea along the year. In the 1950's, the development of the fishery led to the motorization of the fishing vessels (Hardenberg, 1950) and the fishing pressure over the coastal fishing grounds drastically increased.

The fishings grounds were restricted to a small belt along the northern coast of the Java Island located between 20 to 30 nautical miles from the shore. In order to overcome these constraints some owners from Batang, a small fishing place located in the Central Java province, introduced the seine net in Indonesia. After a rather long test, the commercial exploitation started in 1973. This new fishing technic allowed bigger catch than traditional gear (Table 1) and longer fishing times. In 1975, these nets were put on board vessels derived of the trawlers operating in the Java Sea. Along the northern coast of Java, the fishermen adopted very quickly the seine net. Until 1980, the purse seiners exploited the traditional fishing grounds of the Javanese fishermen. In 1980-1981, with the trawl ban, numerous trawlers were transformed into purse seiners. The fishery expanded as these vessels extended the fishing zone eastward and their number increased. In 1985-86, they overpass the boundaries of the Java Sea and began to exploit the Makassar Strait and the southern part of the South China Sea (Fig. 2). The landings which were 10,000 tons in 1970 reached 110,000 tons in 1992.

During the first years of the exploitation the East Java province was the center of the exploitation and the Madura Island, Pasuruan and Rembang villages the main landing places of the fishery. With the apparition and the development of the seine net fleet the bulk of the landings moved in the Central Java province (Fig. 3a) where are located the main landing places (Pekalongan, Juwana). In 1992, 74% of the scads catch was landed in that province.

The exploitation of the seine net fleet based in the Central Java province is an artisanal one with vessels of 30 m long and 8 m width. They can stay at sea until 40 days and land until 100 tons per trip. They exploit the main part of the Java Sea, the Makassar strait and the indonesian part of the South China Sea.

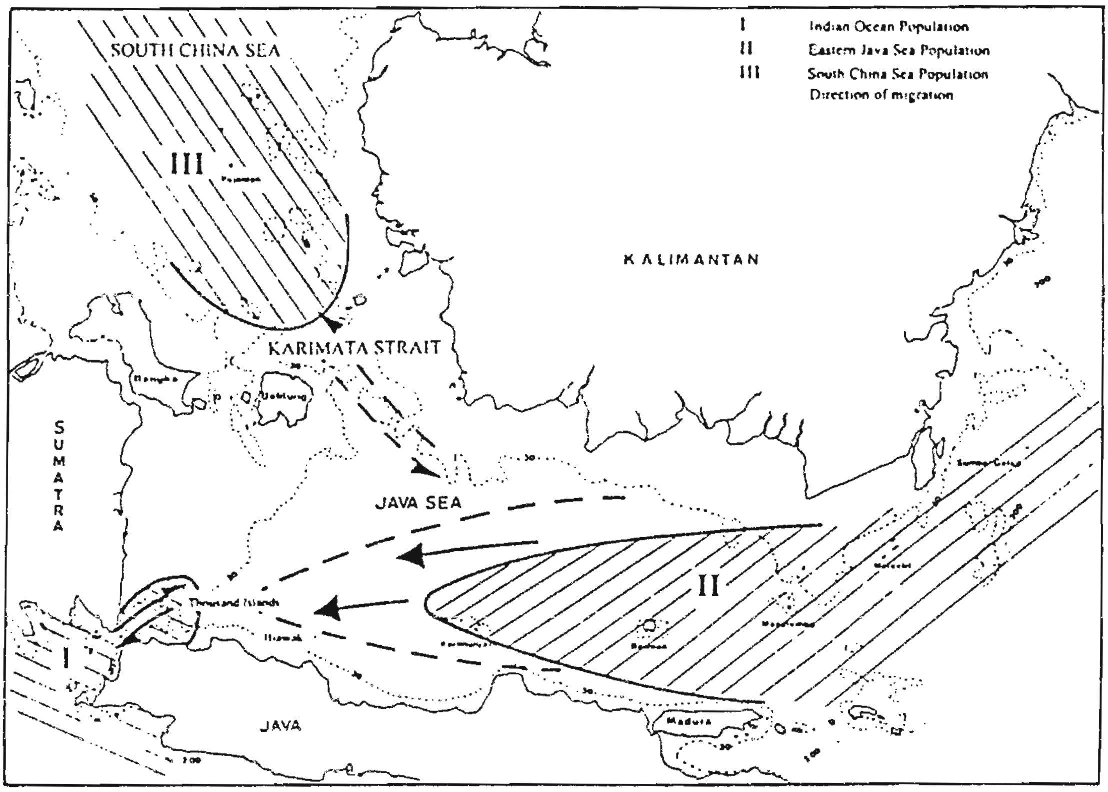


Fig. 1. Hardenberg's hypothesis (1937) on the scads populations of the Java Sea.

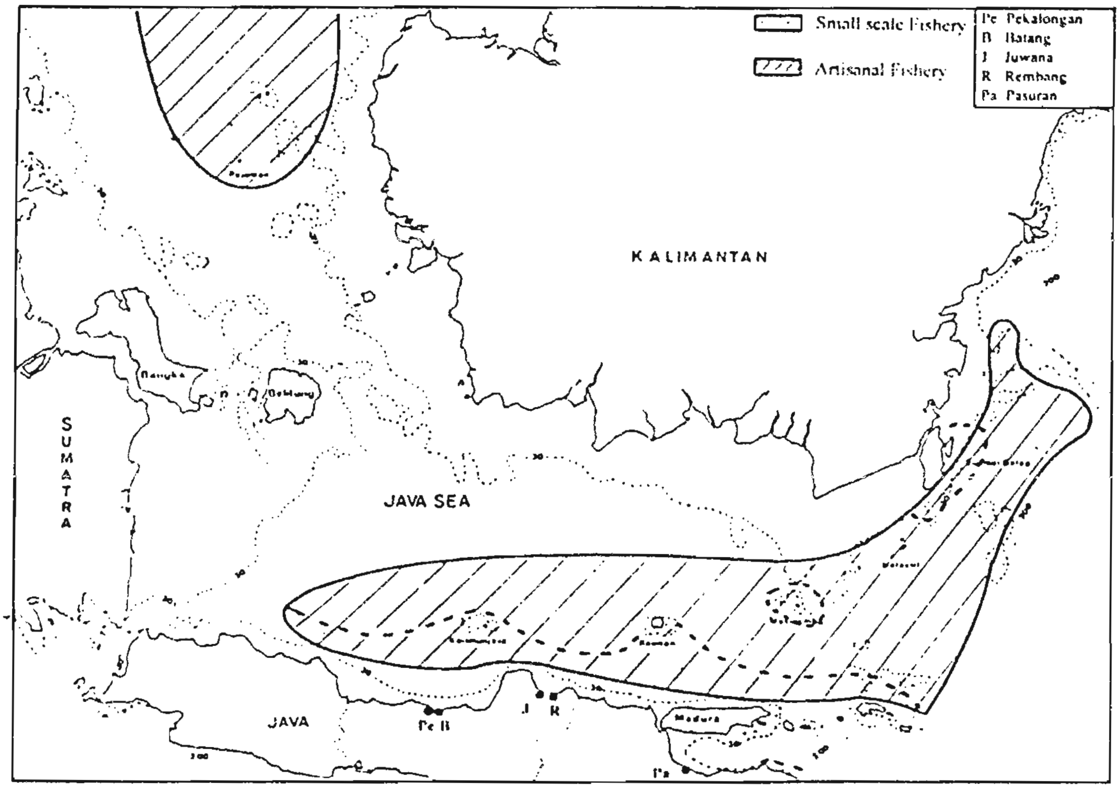


Fig. 2. Fishing grounds of the artisanal and small scale fleets in the scads fishery of the Java Sea.

Table 1. Evolution of the scads (tons) landings by fleet and by province from 1967 to 1992.

	FLEETS			PROVINCES		
Year	Artisanal	Small Scale	Total	West	Central	East
1967		8,300	8,300		3,200	5,100
1968		9,600	9,600		3,700	5,900
1969		11,300	11,300	100	4,200	7,000
1970		10,000	10,000	100	3,300	6,600
1971		12,800	12,800	300	4,500	8,000
1972		13,800	13,800	200	5,000	8,600
1973	500	16,200	16,700	400	10,000	6,300
1974	2,000	16,300	18,300	400	11,100	6,800
1975	4,200	21,600	25,800	500	12,800	12,500
1976	12,700	21,000	33,700	500	17,500	15,700
1977	15,900	22,500	38,800	600	20,900	17,300
1978	15,700	25,500	41,200	800	22,000	18,400
1979	18,400	29,300	47,700	1,000	26,600	20,100
1980	15,200	30,500	45,700	1,400	23,400	20,900
1981	12,000	17,600	29,600	600	17,000	12,000
1982	19,700	18,600	38,300	1,000	23,700	13,600
1983	39,900	30,800	70,700	2,200	46,000	22,500
1984	53,800	31,800	85,600	1,300	62,000	22,300
1985	74,800	35,200	110,000	3,300	83,100	23,600
1986	52,100	48,600	100,700	3,500	63,200	34,000
1987	37,000	26,900	63,900	3,800	36,900	23,200
1988	27,300	24,400	51,700	3,200	27,300	21,200
1989	55,300	29,100	84,400	3,900	55,300	25,200
1990	60,100	31,600	91,700	3,900	60,100	27,700
1991	69,200	37,900	107,100	4,500	74,600	28,000
1992	72,300	40,000	112,300	3,500	82,700	26,100

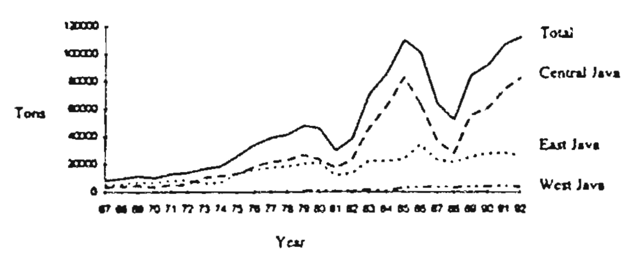


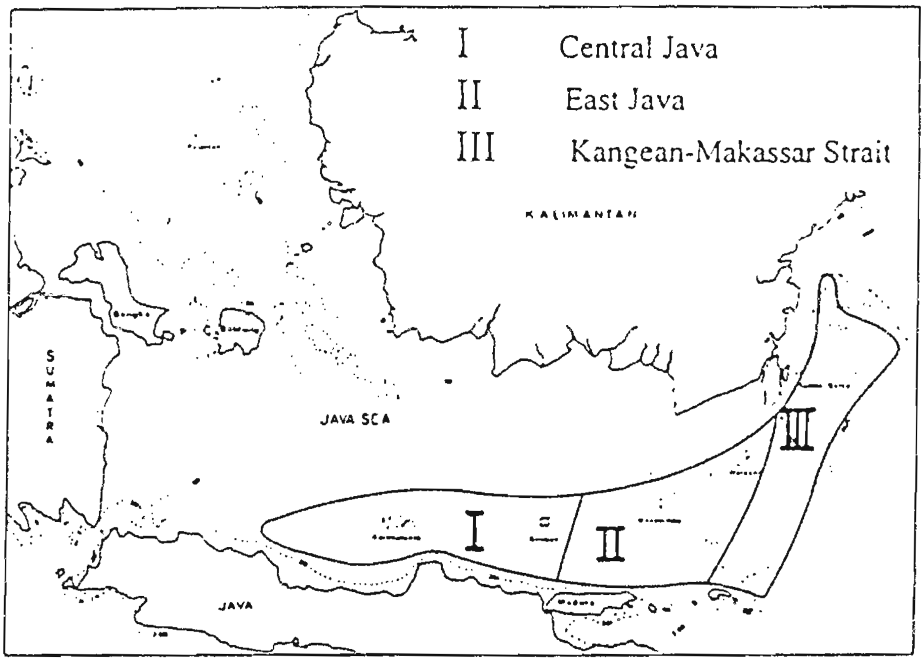
Fig. 3. Evolution of the scads catch in the Java Sea.

The small scale fishery is, for the most part, still based in the East Java province. Even if small ring nets have replaced the payang on board the vessels the exploitation remains traditional with small vessels going at sea for one or two nights and prospecting coastal waters. In 1992, the artisanal fleet accounts for 65% of the scads landings (Fig. 3b).

Table 2. Repartition (percentage) of the scads landings in 1967, 1986, 1992.

	1967	1986	1992
D. macrosoma	12	32	64
D. russelli	88	68	36

Before the apparition of the purse seiners, *Decapterus russelli* formed the main part of the landings. As the exploitation move eastward the part of *Decapterus macrosoma* increased (Fig. 4, Tab. 2). In 1991, this



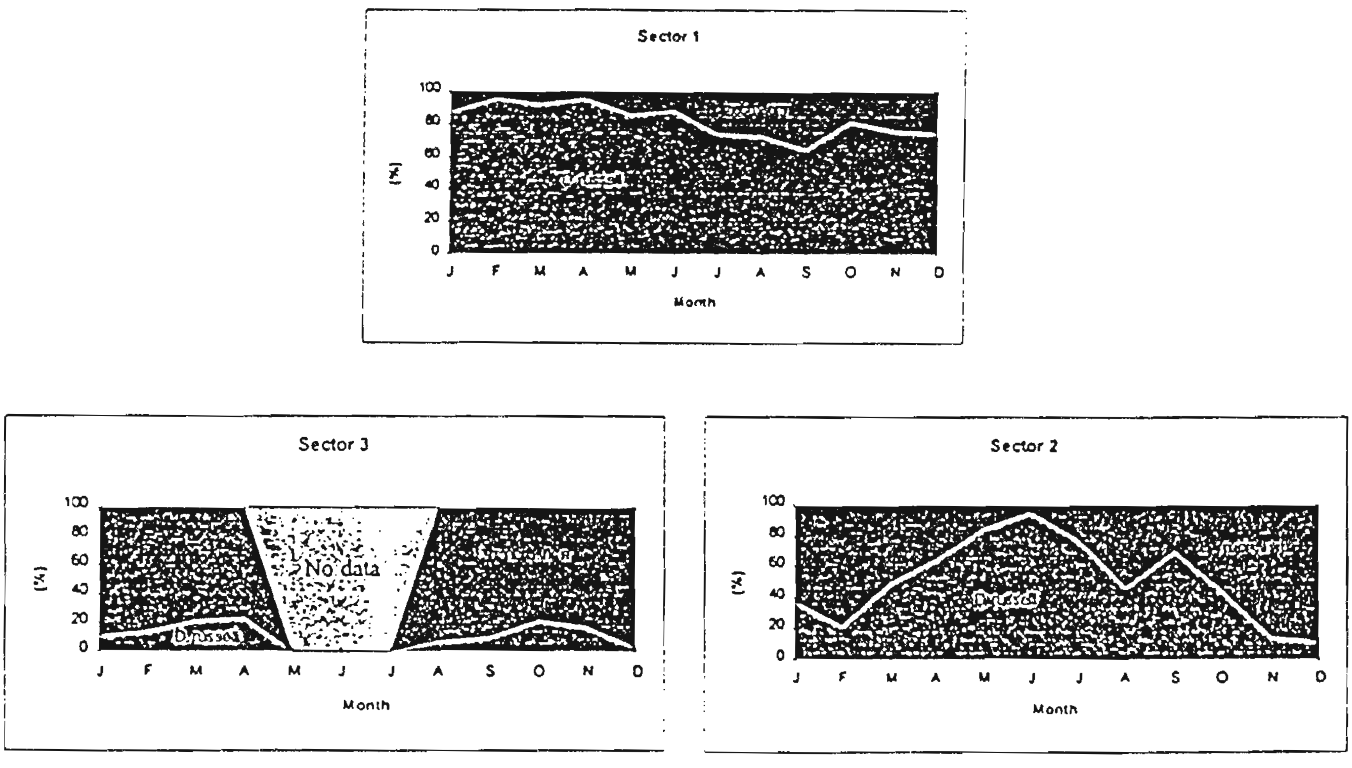


Fig. 4. Specific repartition of the Scads landings according to the fishing sector.

species became the main one in the landings. A seems due to different ecological needs among the two species, *Decapterus russelli* being more neritic with ecological needs (salinity tolerance) less strict than *Decapterus macrosoma*. The distribution area of *Decapterus russelli* (Fig. 5a) is more centered on the Java Sea where this species would be present along the year, at least in its eastern part. *Decapterus macrosoma*, more stenohaline, has oceanic habits and its distribution area would be centered on the Flores Sea (Fig. 5b), its presence in the Java Sea being influenced by hydrological factors.

Hardenberg (1937) noticed that the bulk of the catch consists of juveniles and immature fish. It is obvious at least for *D. russelli* where 60% of the landings are made of young fish, this proportion being of 50% for *D. macrosoma* (Fig. 6 ; Potier and Sadhotomo, 1995). The lamps and rafts used in the fishery which alter the behavior of the fish seem the main factors explaining this result. Generally, the juveniles and immature fish are easily attracted by a light source staying near the sea surface and closer of that source than the adults ones (Ben Yami ., 1976). During the setting the larger fish which stay farther of the light source and in more deeper layer avoid more easily the net. Tiews *et al.*, (1970) show that *Decapterus* species develop different behaviour at different stages of their life, being epipelagic during their juvenile phase and bentho-demersal at the adult age. In the Javanese fishery the adults would leave the fishing grounds for deeper waters and they would not be accessible to the seine nets and *payang*.

Seasonal Trend

When the exploitation was limited to the inshore waters of the North coast of the Java Island Van Kampen (1922) and Soemarto (1960) already noticed that, every year, two peaks of production are observed a minor one in February-March and a maximum one in July-September. Presently, the exploitation covers the most part of the Java Sea but the yearly cycle of production remains the same. It is closely related to the monsoon cycle (Fig. 7) and varies in phase with it.

The monsoon induces the cycle of the exploitation by its two main components, the wind and the rainfalls. They act on the exploitation at two levels :
- the fishing pressure. The fishing vessels cannot go at sea as soon as the winds exceed 15 knots ;
- the availability of the resource. The wind and the rainfalls are responsible of the movements of the water masses in the Java Sea. During the South-East monsoon (May to September), the scads populations follow the advance of the oceanic waters coming from the Flores Sea and the Makassar strait in the Java Sea and the catch increase. During the North-West monsoon they retreat with these waters, the catch decreasing (Potier and Boely, 1990).

This trend can be observed in other pelagics fishery located in region where blows the monsoon. It is the case of *Sardinella lemuru* in the Bali strait (Merta, 1992) and of the scads fishery in the Philippines waters (Fig. 8).

Conclusion

After a long stagnation of the scads catch due to the use of limited technical means, the introduction of a new net and new vessel increased a lot the catch of the scads in the Java Sea. These modifications of the exploitation induce some changes in the specific repartition of the catch and among the artisanal and small scale fleets. These last years, some local conflicts between artisanal and small scale fishermen for the share of the resource arose.

The exploitation concerns species which seem spawn once during its life time (Widodo, 1988 ; Tiews *et al.*, 1970). The actual fishing technics limit the exploitation to the shelf seas and to the catch of the young part of the stocks. The artisanal and small scale fleets prospect all the space they can exploit and the knowledge the Javanese fishermen have about the environment and fish behavior is quite good. The fishing pressure is high and new innovation which can increase the efficiency of the vessels will alter the fragile equilibrium of the fishery.

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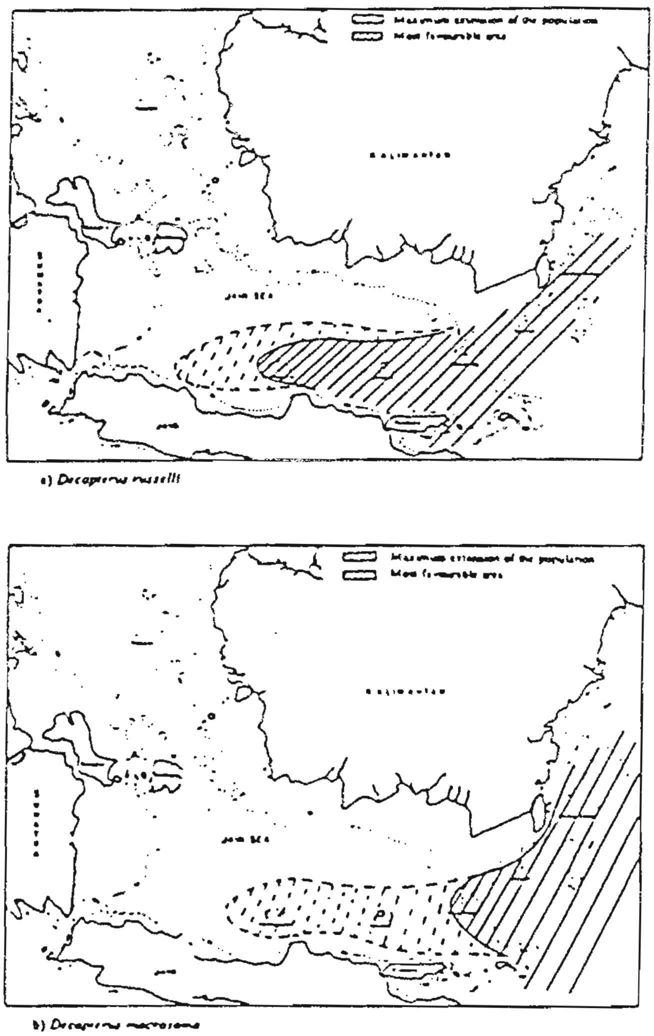

Fig. 5. Distribution area of the scads populations of the East Java Sea.

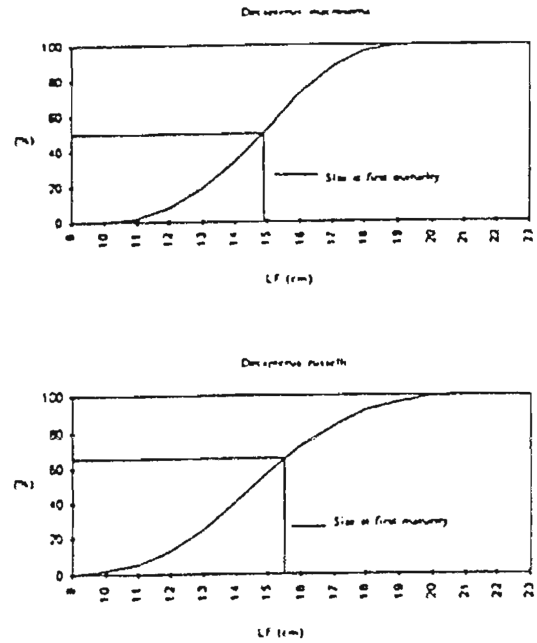

Fig. 6. Catch cumulative curve for the two species of scads caught by the ring nets in the Java Sea.

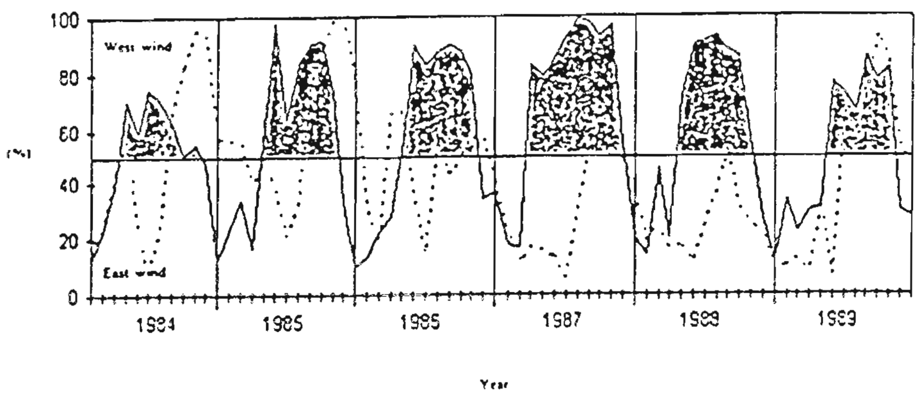

Fig. 7. Monsoon cycle (wind direction) and landings of scads in the Java Sea from 1984 to 1989.

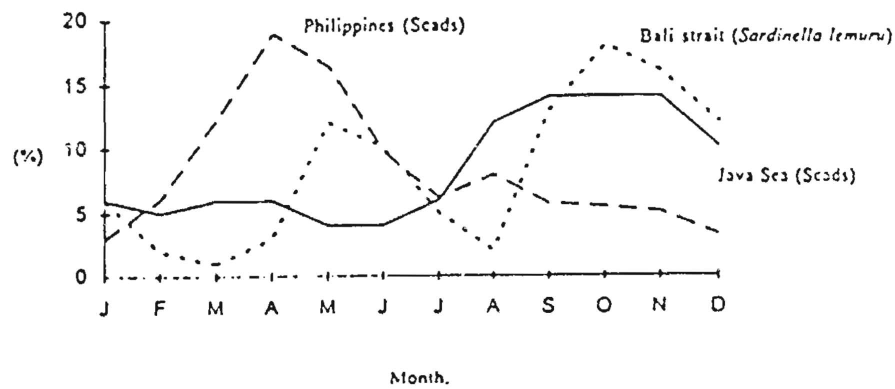

Fig. 8. Production cycle in different fisheries from the Asian region.

HETEROGENITY OF MINI PURSE SEINE NET FLEET IN JAVA SEA

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Abstract

The exploitation of the Java Sea small pelagic resources is performed mainly through three types of purse seine fleets which are broadly distinguished according to the size of the boat. The smallest boats, that is to say from 12 to 18 m total length, belong to the mini seiners fleet. They are not able to fish very far off shore but, on the other hand they move frequently along the Java North Coast. Recent census demonstrated the importance number of this fleet with approximately 1 600 fishing units. From the different recent censuses and a specific inquiry about the technical characteristics of these units, it is possible to discriminate this group between difference fishing fleets corresponding to the specific fishing strategies with specific innovations.

Key words : Java Sea, Mini seiners, Fishing strategies.

Introduction

The exploitation of the Java Sea small pelagic resources is performed mainly through three types of purse seine fleets which are broadly distinguished according to the size of the boat. During the first synthesis about these fleets, made in 1994 (Potier M. and S. Nurhakim, 1995), it appears that the fleet constituted by the smallest vessels using purse seine, take great part in the total pelagic fish catch made by the whole of the purse seines fishing units (Potier M. and B. Sadhotomo, 1995). Approximately, 30% of the pelagic fish landing issued from the Java sea are realised by this specific fleet (Potier M. and B. Sadhotomo, 1995). This article describe the first results obtained about this fleet, mainly showing that this whole of fishing units is not an homogeneous group but that it is made of different sets with different fishing strategies. This approach complete the work presented in this forum by Atmaja and Ecoutin (1995).

Materials and Method

Two different approaches are used to describe the mini purse seine fleet : first, the result of different censuses made in 1994 and 1995 as part of the PELFISH program ; second, an analysis of different technical specification of the vessel using mini purse seine.

The result of two censuses are used in this study, made in March and June 1995. During these censuses, some informations about the equipment of the unit are recorded : type of the vessel, geographical origin, type of engine, fish hold, light,... All informations easily to record during a census. During these censuses, more than fifty places are visited on the North Java coast between Sunda Strait ant Bali Strait (Fig. 1). Approximately 1 600 units using the mini ring seine are counted.

About the analysis of characteristic of vessel, the data are issued from twelve villages of Central Java and East Java but this table do not respect the equilibration of the sampling places issued of the different census.

Each questionnaire is focused on nine clusters of data :

- identification of the boat : landing place, vessel name, vessel origin, type and condition,
- stem shape : side and upper views,
- stern shape : side, upper views and upper view of the deck,
- fish storage,
- superstructure,
- observation of fish schooling,
- motorization : main engine position, type, number and shaft installation,
- lamps : type of light, electric generator,
- capstan : position of capstan engine.

In addition to these informations, some aspects of the boat's history and of the fishing strategy of the unit are collected.

For this last analysis, all the treatments involve the method of factorial correspondence analysis, so called reciprocal averaging. The initial data file contains 56 units which are described by 21 variables. After the elimination of defective items, this final active data file has only 20 variables which are divided into 49 disjunctive variables.

Results and Discussion

I. Presentation of the main types of vessel

There are 5 basic types of mini seiners along the North Java Coast. These types are called locally ***Kranjl***, ***Bulu***, ***Dadap***, ***Sopek*** and ***Payang***. The three first types are boats which stern has wings. The two others have their stem and stern pointed and streamlined. Coupled with the development of mini seiners fisheries, they have subsequently developed and being modified.

Kranji type originally comes from Kranji, a small village in the North Coast of East Java.

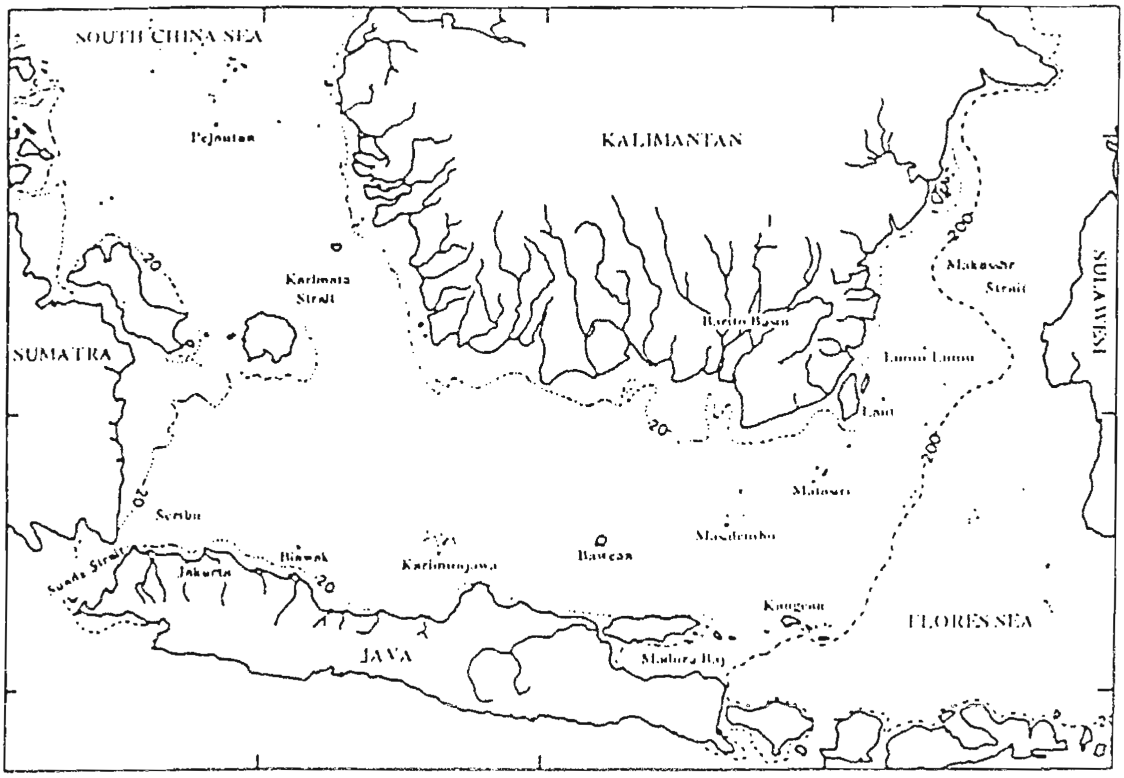


Fig. 1. The geographical environment of the Java Sea.

In 1970's, the fishermen from this village have operated mini purse seine in which their vessel type was built by indigenous boat builders. Coupled with the migration of fishermen, this vessel type spread to other places in the East Java and North Madura.

Bulu type was initially built in Bulu, a border village in East Java. Subsequently, it spread and being built in different villages of Central Java and South Madura. In the later area, most of fishermen were modified the stern part and superstructure of their vessels. During the different censuses of 1995, there was found other types of mini seiner vessels which the hull shape of the vessels was similar with Bulu type. They are provided by deckhouse, inboard engine which eventually linked with capstan, full decked stern. It seems that they were modification type of Bulu.

Dadap type has an appearance closely to the *Kranji* type. The difference lies on the vessel construction, ratio of the main dimension and fishing aids. The vessel construction provided by insulated fish hold, hull planking more neatly and strongly tied to the close frames. The ratio of length to breadth is smaller than *Kranji* type. It means that of the same length, the vessels of *Dadap* type are wider than *Kranji* type. These vessels provided by mercury and halogen lamps for fishing aids and an electric generator which usually linked with capstan engine.

Sopek and payang types were commonly used in the Javanese small scale fisheries ; however, the vessels size of both types which used for purse seiners were larger than the boats used for other fishing techniques. Hull shape of these vessels was pointed stern.

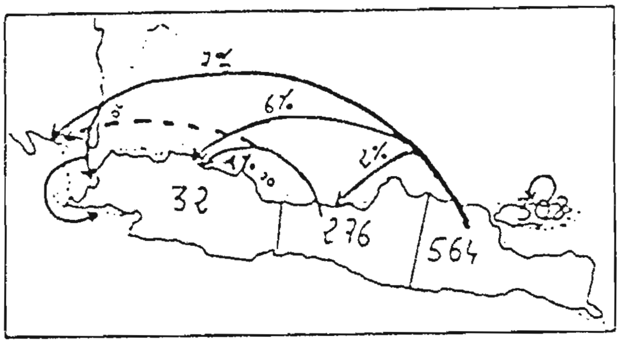
II Geographical Distribution : the result of census

During the censuses of March and June 1995, the geographical distribution of the vessel types was recorded (Fig. 2 and 3).

According to the results of the figure 2, it seems that it has not great difference between the two censuses : more than 1.660 units in March against approximately 1.600 in June

It has to be noted that the number of vessel types existing in each area will always change due to some of them were the migrated vessels. Migration of mini seiner fleet closely related to their fishing strategies. Potier and Petit (1995) explained that during July-December period the mini seiners remain in the vicinity of their registration places. From January to April, the mini seiners of East Java Province move to the Madura Strait or to the Western part of the Java Island in order to avoid the rough condition of the Java Sea. These units laund their catches in some harbours of these last area where some units were recorded during the whole of the year.

Census of March 1995



Census of June 1995

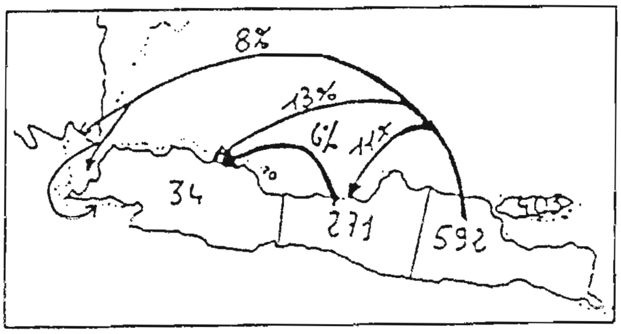
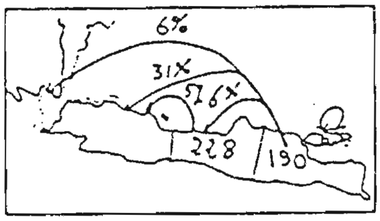
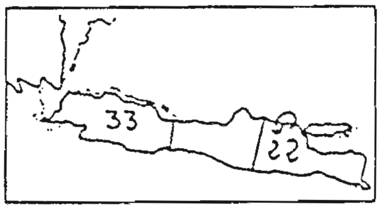


Fig. 2. Repartition of the fishing units in function of their origin with indication of pourcentage of migration between each main geographical zone.

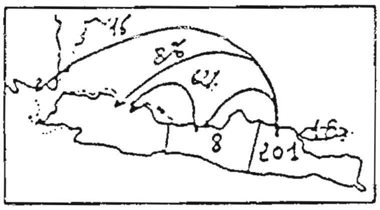
Type BULU



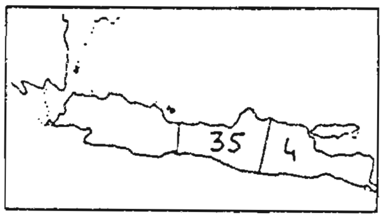
Type DADAP



Type KRANJI



Type SOPEK



Type PAYANG

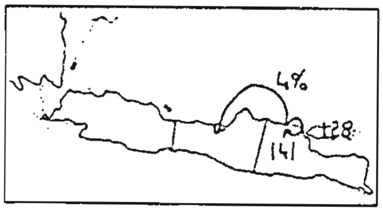


Fig. 3. Repartition by type of vessels in function of their origin with indication of pourcentage of migration.

III Fleet dynamic in relation with the characteristic of the vessel type

III.A Result of the study on the characteristics of the vessel

Many treatments are realized on the different files derived from the initial data set. The difference reflects the number of variables used, this number varying between 15 and 20. Successive analysis explain well over one half of the inertia of the data with the three first axis. On the whole, these successive analysis present the same results with three groups of boats which are markedly differentiated.

• 1st group (presented in term of declining statistical significance) : situated near the first axis issued from the analysis (Fig. 4). It coresponds to the fleet of the ten units observed in a same village, namely units having their origin from this village (Mayangan, East Java). The fleet is composed by :

- boats with a axial main engine linked with the capstan. This main engine is mainly an inboard engine,

- the stern on these boats is square on upper view, always decked and these vessel have a permanent superstructure.

This « vessel type » is usually unknown or not named by the fishermen.

* 2nd group : situated on the fourth quarter of the graph issued from the analysis (Fig. 4), it is composed by the *payang* and the *sopek*. This group is completment opposite of the first group along the first axis.

These are units with a streamlined stem and an engine in starboard position ; without superstructure, these units have always an observation point constituted by a real observation chair.

Stem and stern of the three *payang* are also streamlined with a rounded shape. The shape of two *sopek* is right.

This fleet is formed by all the boat with streamlined and pointed « etraves ».

* 3rd group : the group, situated on the positive side of the third axis (Fig. 4), comprises by three boats which represent all the *Dadap* vessels originally from Dadap.

Four characteristics are dominant and exclusive : presence of all kinds of lamps with petromax, mercury and galaxy, requiring a generator linked with the capstan engine ; these units have also insulated fish holds. Taken jointly, these characteristics describe a fleet which appears have a higher level of technological complexity.

To conclude this analysis, the first axis contrast units with two streamlined « etraves » from the fleet formed by boats without structures well-known in the case of mini purse seine fleet. The second axis seems describe the contraste between fleets searching fish school and fleets attracting the fish with light. Finally, the third axis is describing the level of technology.

III.B Relations between the fishing tactis and characteristis of the vessels

Mini seiners fleet along the Java North Coast carried out various fishing tactics adapted to the target species and referred to the geographical areas. There were 3 kinds of fishing tactics employed :

- fishing with light,
- fishing with light and Fish Aggregating Devices, locally called rumpon (FADs),
- fishing by hunting.

Fishing with light

Most of the mini seiners fleet utilized paraffin pressure lamps (petromax) to aggregate fish. This tactic is locally called *ngobor*. The fishermen usually stay only 1 day at sea. That were why most of the mini seiners vessels are not to be provided by insulated fish hold.

The mini seiners fishermen convinced that the higher intensity of lamps the more fish can be aggregated. Consequently, the recent development showed that mini seiner fleet from Dadap have replaced paraffin pressure lamps by mercury and halogen lamps for aggregating fish, with small electric generator as a power supply. The results of different censuses confirm that.

Fishing with light and FADs (*rumpon*)

Lamps and FADs (*rumpon*) were combined to aggregate fish. Construction of *rumpon* consist of raft, coconut leafs as an attractant, and anchor. These parts were connected by ropes and setted in the water column. Paraffin pressure lamps (petromax) were used as light source. In fishing operation, paraffin pressure lamps were setted and illuminating around the rumpon.

This fishing tactic was carried out by fishermen from Rembang (Central Java) and Blimbing (East Java). Rembang's fishermen performed this tactic during period of March-May with the target species of scads and sardines. While the Blimbing's fishermen held in period of July-October, when they occupied the fishing ground off East Java waters with the target species of scads.

By this tactic, the fishermen generally stay at sea 3 days and over. For Rembang's fishermen, staying along their rumpon they entrust their catch to "sell on behalf of" through the other vessels which were going back to the fish landing. This manner means to avoid fish spoiled due to their vessels not to be provided by insulated fish hold. The Blimbing's fishermen brought insulated fish box in their fleets when they went to fish for staying more than 3 days at sea or during migration.

Fishing by hunting

Fishing by hunting of fish schoals was performed in the day time or in the night through observing phosporus light in the sea surface caused by fish schooling movement (Potier and Petit, 1995). The observer sit on the chair at upper part of mast to observe fish schoals and their swimming direction, mainly in Madura Strait.

In connection with this tactic, the mini seiners of *Dadap* type, *Kranji* type, and mainly *payang* type from Kraksaan (Probolinggo, East Java) were provided by observation chair in the upper part of mast, either simple chair (for *Dadap* and *Kranji* types) or real chair (for *payang* type).

The fishermen from Probolinggo and Situbondo (East Java), which used mini seiners of payang type more often performed this tactic where locally called *gurahan*. In Kranji (East Java) this tactic called *borahan*, which was taken place during October-December with the target species of small tunas and mackerels. In Dadap (West Java), it called ***gurah*** which was performed during March-April with the target species of mackerels.

Conclusion

These two descriptions (census and migration, analysis of characteristics of the vessel) linked with the description of daily tactics, seem indicate that the mini purse seine fleet are not really an homogeneous fleet and it is possible to describe inside five groups :

- the first is composed by the boats centering their searching of fish shoal with a point of observation (issued from analysis of characteristics and fishing tactic),
- the second is formed by the units which search the fish with a higher level of technological complexity (analysis of characteristics and census),
- the third correspond with the fleet which give greater place to catch the fish near the village of the origin of the fishermen : it is the case of the units from Mayangan, but others villages show the same comportment (analysis of characteristics and census),
- between the fourth and the fifth groups, the difference depends of the capability of migration ; the fleet using ***rumpon*** usually against the fleet moving seasonally to search the fish. This aspect will be described by the communication of Atmaja and Ecoutin (1995) in this forum.

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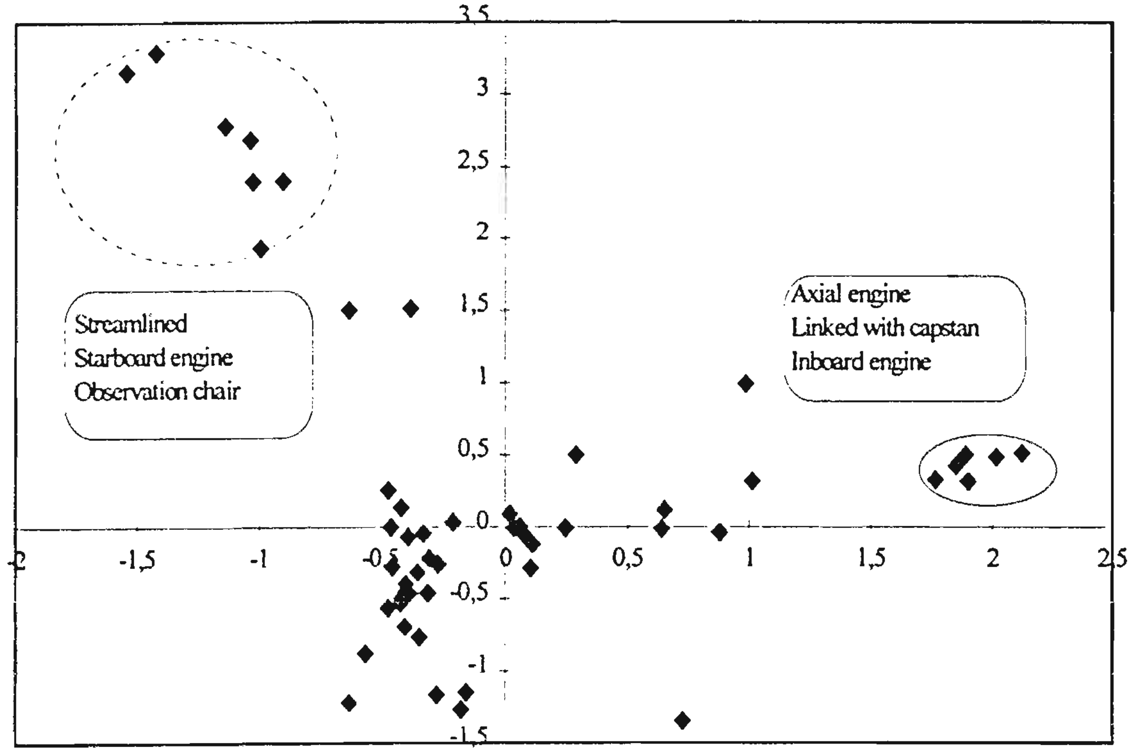
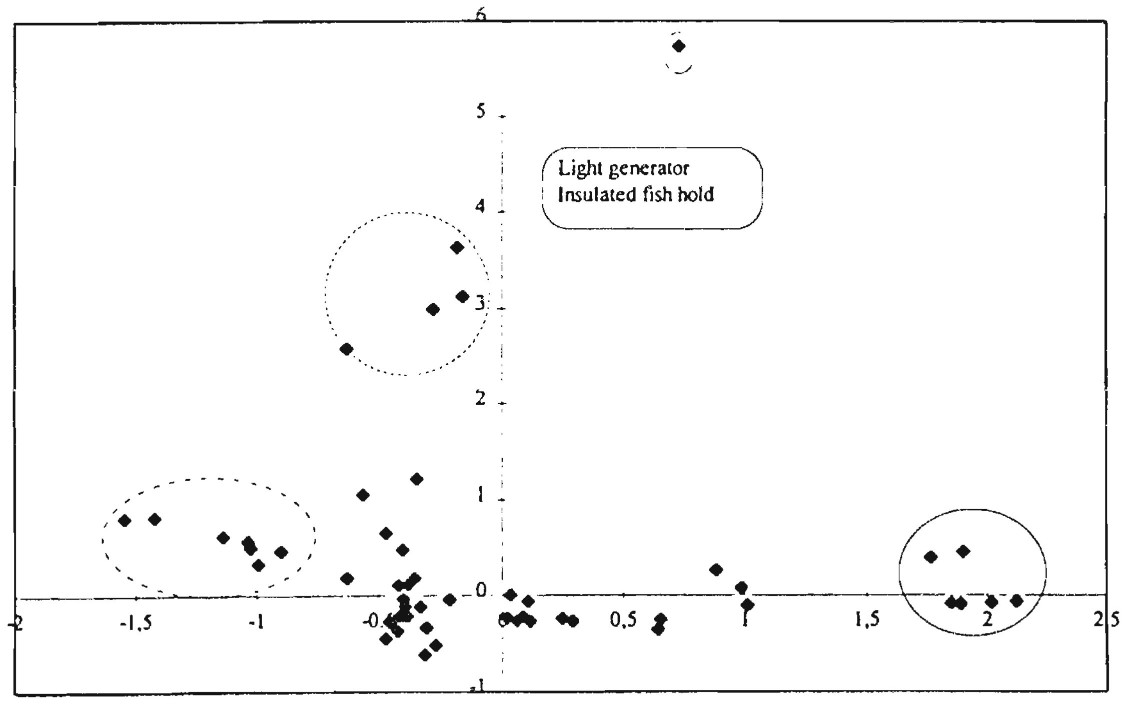


A- Diagram axis I-axis II



B- Diagram axis I-axis III

Fig. 4. Presentation of the results of the statistical analysis of the characteristics of the vessel

THE LARGE SEINERS OF THE JAVA SEA : FISHERMEN INCOMES

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Abstract

Fishermen incomes in Java Sea large seiners fleet have been analyzed through enquiries made in different harbours of North Java Coast : Tegal, Pekalongan and Juwana. First, the various components of the income by the crew of the large purse-seiners of the Java Sea are presented. In a second step, we assess the level of this income, taking into account the social context in which it is earned. Notably, the mode of sharing between owners and fishermen. Its relation to the distribution of the earnings of other workers in the surrounding agricultural milieu is briefly presented for discussion.

Key words ; Java sea, large seiners, fishermen income.

Introduction

The trawl ban of 1980 (Chong and Hutagalung, 1992) has facilitated the development of purse seiners that are concentrated in Tegal, Pekalongan, and Juwana, the three major harbors of the Java Sea. In 1992, 360 units have landed 125,000 tons of pelagic fish (half of it *layang*[1]) for a value of roughly 80 milliards rupiah corresponding to an average price of 640 rupiah per kilogram. Translated in terms of the fishermen income (20% of the value of the catch, with an average of 35 men by boat), these result means an appromative basic income of 1,300,000 rupiah per capita.

The launching of an increasing number of larger units is most likely to transform the social and economic profile of this sector of production. Using this change as a backdrop, the paper identifies first the distinct components of individual earnings, before specifying the additional sources of income generated by subsidiary jobs. In the last part, a first approximation of the income distribution, of its central tendancies and of its variability is sketched while these three dimensions are placed in a larger context.

Methodology

The present article is based on four types of data :

- official statistics (Indonesian statistics : Directorat General of Fisheries, Central Bureau of Statistics) ;
- results of a 1994 survey concerning 155 fishermen and their families residing in three villages of the coastal area of Central Java ;
- the boat accounts of a few entrepreneurs who have accepted to lend them for research purposes ;
- interviews of key actors in this particular sector.

Results

Individual Incomes

In the absence of recent fieldwork, little is known about the income of individual crew members. Further, the analysis is improperly focused on the outcome of the "sharing system" alone, even though this is but one single component of individual income.

In addition, because of the wide range of the distribution, analyses that are based exclusively on central tendancies are not valid. The large variance of earnings results from the uncertainties that surround the whole activity and from systematic differences in the output of individual boats, including the case of units belonging to the same class : large, medium and small purse seiners (Potier and Petit, 1995). Last, contrasts in the status assigned to crew members in function of their skills and their duties, ashore as well as aboard, contribue also to accentuate disparities in individual incomes.

• The components of the fishing income

The model accounting for this income fits all major gears found in Indonesia, whether seines, gill nets or long lines.Yet, the traditional model is modified by the emergence of new patterns, at least in the case of purse seiners fisheries. Individual earnings include the following components :

- The sharing system

The net results of a boat, that is, the product of sales minus current expenditures, are shared on a fifty-fifty basis between boats'owners and their crews. The actual sums earned by the crew represent currently between 15 and 30 per cent of each boat's gross income.

Whenever the catch is minimal, employers give their fishermen an advance they will reimburse later on.Thus, crew members enjoy a kind of guaranteed minimal wage, which limits proportionately the risks they are obliged to face.

Relationships between the value of the boat's production and the individual earnings are illuminated by the following factors :

a) the value of the catch.

As running costs remain relatively constant across trips, individual incomes are primarily influenced by the value of the catch. Data derived from the

[1] *Layang* includes *Decapterus russelli* and *Decapterus macrosoma*.

accounts of individual boats highlight the regularities that characterize such an influence. First, the range of incomes observed for the successive trips made by a single boat during one year is significantly wider in the case of boats with a more limited capacity. Yet, although incomes are contingent on seasonal variations, both the greater range of the trips undertaken by large purse seiners and the high quality of theirs managers and their crew reduce the effect of these variations (table 1).

Table 1 : Range of sharing's income of fishermen for medium and large purse seiners

Type of boats	Value of boat's catches minimum-maximum	Sharing's income of fishermen minimum-maximum	Period
Medium purse-seiners (4 boats)			
1	1 - 5	1 - 7	1993 - 1994
2	1 - 12	1 - 18	
3	1 - 9	1 - 20	
4	1 - 5	1 - 9	
Large purse-seiners (12 boats)			
1	1 - 3	1 - 9	1994
2	1 - 2	1 - 3	
3	1-1.4	1 - 1.7	
4	1 - 3	1 - 4	
5	1 - 4	1 - 4	
6	1 - 1.5	1 - 2	
7	1 - 1.3	1 - 3	
8	1 - 2	1 - 3	
9	1 - 3	1 - 5	
10	1 - 2	1 - 8	
11	1 - 4	1 - 5	
12	1 - 4	1 - 7	

The differential results of boats within a same class confirm more qualitative observations which suggest that the best crews are often assigned to the most productive units, especially the large purse seiners of the new generation (35 meters with holds having a full capacity of about 100 tons).

There is a very good positive correlation between the value of individual boats' catches and the income of their fishermen (an example is given on the figure 1). It invalidates assertions according to which the standard of life of crew members is somehow independent of their boat's production. Indeed, they all have a vested interest in contributing to the boat's output rather than in fishing on their own.

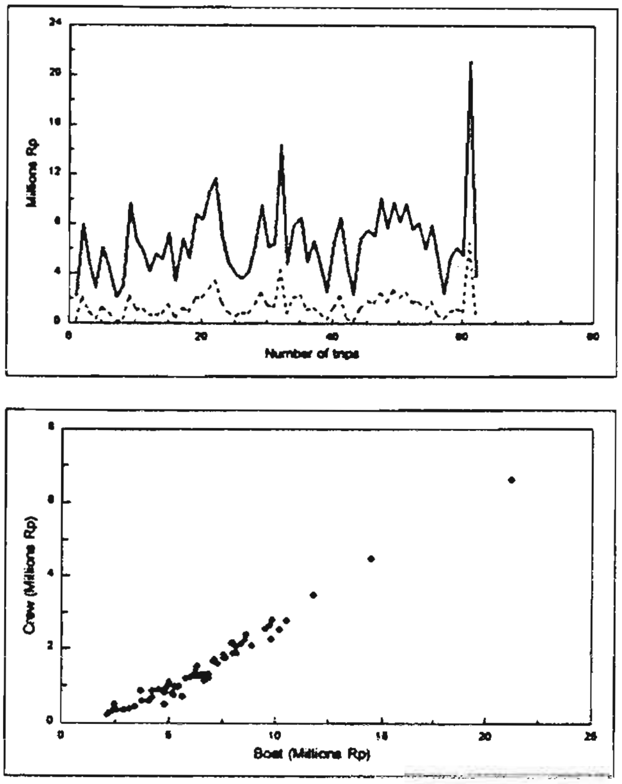

Fig. 1 : Example of incomes for given purse seiner. Top : boat's ("Lelang bersih", TPI, dark line) and crew's (broken line) incomes ; Bottom : regression of crew income vs boat income (r^2=0.93).

b) skills and duties of the crew.

Traditional models continue to account for the actual distribution of shares. Skippers (***nakhoda***) receive three or four shares as a reward for their numerous duties. Chief motorists are entitled to a slightly smaller number of shares. Finally, skilled workers (***Juru arus, Juru rumpon, Juru lampu*** etc.) get a little more than unskilled sailors (*ABK*)[2] who receive only one single share.

c) the status of entrepreneurs and the professionalization of managers

Forming at first a homogeneous class, boat owners come from distinct socio-cultural horizons. Often "ethnic chinese"[3], the owners of larger fleets who benefit usually from the support of financial holdings, adapt fast to the new scenery.They minimize their risks by diversifying the gears they use (purse seiners, gill nets and long lines), by engaging in activities related to fisheries or to other sectors, by attracting the most

[2] ABK (indonesian) : *anak buah kapal.*

[3] The term, as used in the Indonesian census, refers to all individuals with Chinese ascendants, regardless of the amount of time spent in Indonesia. In certain cases, families with this "label" have been settled in Indonesia over hundred years.

qualified workers, and by adopting technological innovations concerning navigational and lighting devices, the quality of holds, etc.

The future of small and medium sized businesses, usually Indonesian owned, remains uncertain. Some of these owners originate from within, after having been initially simple crewmen. Others have accumulated their capital by being successful in another sector. In so far as some of them lack the appropriate technical knowledge, they are assisted by a former skipper who manages their fleet.

There remains a composite group of newcomers. Operating *in absentia*, they are keen to get their own share of the benefits accruing to the purse seiners fishery. Yet, their results are so erratic that it is difficult to make long term predictions about their survival.

In short, there is a growing differentiation of these owners. The situation provides individual crewmen with new opportunities for higher incomes, it generates also new uncertainties.

- Personal fishing

Both tradition and current conditions of fishing in the Java Sea (notably the amount of time necessary for concentrating schools) give crewmen free time to fish on their own. With the exception of skippers and chief motorists, they are allowed to use lines to catch highly valued species that they sell on their own. In Juwana, Pekalongan and Tegal, 64 per cent of ABKs use this opportunity to obtain an additional income which represents about 26 per cent of their overall earnings. Personal fishing is most frequent on smaller boats, due to the way they operate.

- Participation in profits

The traditional model of remuneration includes a variety of incentives contingent on the overall results of the trips. The ***lawuhan*** of the Javanese, or the ***lauk pauk*** of the Indonesian, that is the dish served to accompany rice, represents about 2 per cent of gross results. However, it is not disbursed whenever results remain below a minimal threshold. Even though it figures on the books of boat owners, its payment often fosters tensions with their crewmen. Some owners only pay the total amount in cash, particularly those who are the most productive. An productivity based incentive. Whenever the gross result of the boat exceeds a critical threshold (15 million rupiah for a large purse seiners), some owners offer their crew a premium representing one per cent of each additional million of rupiah obtained. Advances and gifts. A boat owner must comply with obligations stemming from the traditions specific to fishermen's communities. Thus, he must enable crewmen and their families to survive periods of under-production and compensate them for the lack of social insurance programs. In effect, this array of gifts in cash or in material goods (ranging from the *sate* or barbecue offered to all fishermen at the end of each successful trip to the financing of domestic and community ceremonials) aim at gaining the loyalty of the crew.

- The KUD related savings

Cooperatives, called KUD ***(Koperasi Unit Desa)***, play a critical role in the fishery.They manage auction places, and saving programs for the fishermen themselves, that are financed by 2 per cent of the taxes levied on the auction places turnovers. For example, the KUD of Pekalongan manages half of the results of the entire area. Altogether, the saving fund of this KUD reached one milliard rupiah in 1993, representing roughly 500,000 per capita for the fishermen of the city. Yet, fishermen belonging to KUD may encounter difficulties in cashing the benefits owed to them, due to various forms of mismanagement.

- The incentives specific to skippers

Skippers enjoy a special status. In addition to the various earnings already identified, they are entitled to an incentive representing roughly 5 per cent of the gross results of their boats. This additional earning may exceed 10 millions rupiah per year. As a result, many skippers are part of the local elite, their daily expenses being almost three times greater than those of their crew at large.

In short, this particular group enjoys many opportunities for upward social mobility. Usually between 30 and 40 years of age, they often act as intermediaries between their owners and their crews. The currently high purse seiners growth rate enables them to enhance proportionately their bargaining power, and, for example, to manipulate the date of departure of their boats in order to negotiate a better financial deal for them as well as for the crew.

• Income of subsidiary occupations

Working on large seiners is a full time occupation. In 1993, their crews spent an average of 200 days per year at sea. Yet, during the low season or even between two trips, those fishermen who work in a rural environment can assist relatives growing rice or farming shrimps. Even though their participation remains modest, it represents a sometimes significant additional source of income. Thus, 15 per cent of the fishermen interviewed were engaged in an activity other than fishing, which brought them an additional income of 32,600 rupiah that year.

Table 2 : yearly average per capita income of purse seiners fishermen (thousand rupiah)

sources (1)	skill levels	shares	personal fishing	incentives	total	
					estimated by number of trips	self reported
	unskilled crew member (ABK)					
a		640	140	520	1300	1000
b		865	na	na	na	
c		1030	na	480	1500	
	chief motorist					
a		1010		650	1660	2000
	skipper					
a		1830		5880	7710	7500
c		3760		14400	18260	

(1) source a : survey of 155 fishermen, embarked in 1993 on 56 boats, averaging length 27 meters.
source b : accounts of three medium purse seine (20 meters long), over a total of 52 trips in 1993.
source c : accounts of twelve large purse seine (30-37 meters long), over a total of 115 terips in 1994.

• Characteristics of the income distribution of purse seine fishermen (table 2).

The combined reading of the results of auctions - in relation to the fishermen population, the owners accounts and the fishermen survey - facilitates a first approximation of the central tendancies and the variations of the income distributions of the purse seiners fisheries.

To conclude, the data show :
- the large range of disparities between as well as within occupational categories, including among ABK themselves. This range should get even wider as a result of shifts in the existing hierarchy of owners ;
- the instability of incomes throughout the year.

Yet, the paternalistic behavior of fleet owners reduces the severity of the risks incurred by their crews ; so do persisting forms of solidarity within this community, from cooperating at sea to assisting fishermen families in case of emergency.

Familial income

It is also important to identify the variety of structures of fishermen households and to assess the characteristics of their gainfully employed members. Some households benefit from the presence of several crewmen, others from the variety of jobs held by their residents, notably by women.

The diversity of individual contributions to the welfare of the entire domestic groups confirms the javanese exceptional advantages, notably those coming from :
- the co-existence in coastal areas of a variety of rural activities ranging from the culture of rice to aquaculture or the processing of sea salt, as well as of urban activities stemming from the development of large cities ;
- the high density and the ensuing development of a huge market ;
- the creation of sea related jobs with a low capital component in which most inputs have a local origin ;
- the high value added to the products of fisheries.

Conclusion

Javanese purse seiners fisheries are characterized by the following features:

- the coexistence of traditional and modern patterns and the ensuing growing differentiation of individual strategies both among crewmen and entrepreneurs ;
- the increased differentiation of fishermen' incomes in terms of skills and occupational roles ;
- the marked instability of fishermen income ;
- the accentuation of disparities between the over time variations in the income generated at the boat level as a whole and the earnings of individual fishermen, even though this differentiation is masked by the sustained rhythm of the current growth.

In short, the emerging dimensions of the purse seiners fishery (table 3) do indeed facilitate both the upward social mobility of the current generation of fishermen and the higher participation of their children in educational institutions.

Table 3 : yearly average per capita income : fishermen and other (thousand rupiah)

	Yearly income		year
	Indonesia	Java	
All population			
Gross National Product	1524		1993
Gross Regional Domestic Product		1045(1)	1992
National Income	1335		1993
Fisherman of L.P.S.			
Unskilled crew member		1000-1500	1993-1994
Javanese farmer(2)			1992
paddy		909	
maize		487	
cassava		837	
sweet potatoes		913	
peanuts		807	
soya beans		659	
Synthetic assessment		500-900	

(1) Province of central Java only.
(2) Farmer cultivating one hectare : net income.
(value of production at farm gate minus costs of production)
(Source : Statistical year book of Indonesia, Project PELFISH)

On the negative side, this development has not been accompanied by a more equitable sharing of the profits. As of yet, fishermen do not enjoyfully either the benefits of their cooperatives. Finally, there is a lack of collective investments, notably for ensuring the safety of crews at sea or the protection of their health both at sea and ashore. All the indicators suggest that it is possible to improve the welfare of fishermen without jeopardizing the social balance of the community at large.

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THE ECONOMIC EVOLUTION OF LARGE SEINERS IN THE JAVA SEA

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Abstract

The Java Sea large seiners fleet has undergone a marked growth, as a consequence of the interdiction of trawling in 1980. In this study, we describe the profile of the economic change undergone by this fleet and we analyze the implications of the new wave of investments started at the beginning of the current decade. The launching of a large number of large seiners should have a significant impact on the fisheries social environment, at the owners level as well as the wage earning fishermen level.

Key words : Java sea, economic evolution, seiners.

Introduction

After the decision to ban trawling in the Java Sea in 1980 (Chong and Hutagalung, 1987), which was adopted to end conflicts over fishing along coastal waters, purse-seiners fisheries have experienced a remarkable growth. Many trawlers have been converted in purse seiners, this type of net becoming the prevailing gear used to catch the small pelagic species of the Java Sea, notably the *layang* (*Decapterus russelli, D. macrosoma)*.

The fleet of purse seiners can be divided into two groups[1], in function of their respective size (Potier and Sadhotomo, 1995). The small purse seiners. prevail in the province of East Java and the largest ones are based in Tegal, Pekalongan and Juwana, the three major harbors of the province of Central Java.

The analysis will be initially focused on the relative place occupied by the fleet of the purse seiners of the Java Sea, before seeking a meaningful interpretation of its dynamics.

Methodology

The analysis is derived from statistics collected by public authorities (Fishery statistics of Indonesia, Fishery yearbook statistics of the province of Central Java and Statistical yearbooks of Indonesia). It is also based on fieldwork undertaken between 1993 and today, notably through interviews with boat owners, fishermen or officials of the province of Central Java, and on the evaluation of the boats'accounts provided by selected owners for research purpose.

Results

The relative importance of the purse seine fishery of the Java Sea

In 1991, the fisheries of the Java Sea caught one third of the national harvest, and this, both for all species and for pelagic species alone (table 1). Yet, the productivity of Javanese seiners was significantly higher than that of other Indonesian fisheries.

Table 1 : Production (tons) of all fish species and of pelagic species only (1991)

	Java sea	Indonesia	% Java sea
All species	700,000	2,200,000	32
Pelagic species	485,000	1,450,000	33
Purse seiners	190,000	440,000	43

(Source: Potier and Sadhotomo, 1995)

However, results vary in function of the types of boats used, since the production ranges from one to seven and a half between small and large purse seiners based in the province of Central Java their respective average catches being 36 and 270 tons in 1991 (table 2).

Table 2 : Catch of fishes by small and large purse seiners in the Java sea (1991)

Purse seiners	Number of gears	Catch (tons)	Catch rate (ton/year/gear)
Small	1760	63200	36
Large	470	126900	270

(Source: Potier and Sadhotomo, 1995)

The value of the catch, derived from the current average auction price of 600 rupiah per kilo for the major species traded (mackerels, scads, trevallies and sardinellas), can be estimated in the following terms, in 1991 (Potier and Nurhakim, 1995 and our own estimations) :

- purse seiners fleet of the Java Sea : 114 milliards rupiah ;
- small purse seiners : 22 milions rupiah, per unit ;
- large purse seiners : 162 millions rupiah, per unit.

[1] The small purse seiners have a length ranging from 12 to 18 meters, a crew ranging from 15 to 20 men, with a carrying capacity between 1 and 2 tons. Large and medium purse seiners have a length ranging from 20 to 38 meters, a crew of 30 to 45 men, with a fishhold capacity ranging from 50 to 100 tons.

Translated exclusively in terms of the earnings (20% of the value of the boat's catch) to the sharing system, these results mean an approximative basic income of 260,000 rupiah for the individual crew members of small purse seiners and of 930,000 rupiah for the larger ones. This is to be compared with the per capita income of 1,048,000 rupiah for the indonesian population at large in 1991, and more relevant with the net income of 966,000 rupiah for a javanese farmer, cultivating one hectare of paddy (Statistical yearbook of Indonesia, 1994).

The population of full time purse seine fishermen in the Java Sea by using the average of 35 men for the larger units, and 17 men for the smaller ones can be estimated at 45,000 individuals, 14,000 manning the large purse seiners and 31,000 working on the small units.

The period 1988-1994 has been characterized by a steady decline of the average price of fish per kilogram[2]. Despite this decline, estimated in constant prices (figures 1a and 1b), there has been a significant raise of the income earned by both fishermen and boat owners. The increase in scale of the production (figure 1c) accounts for these two simultaneous and opposite phenomena (table 3). Yet, it is also significant to pay attention to seasonal variations which indeed highlight the economic risk faced by the fisheries of the Java Sea.

Table 3 : The growth of total catch by the large (total length ≥ 25 m) purse seiners of Central Java

Year	Number of boats	Total catch		Catch per unit	
		Tons	Index	Tons	Index
1987	495	75700	100	153	100
1988	413	61500	81	149	97
1989	355	83500	110	235	154
1990	338	86800	115	257	168
1191	326	109000	144	334	218
1992	360	125300	166	348	227
1993	378	123700	163	327	214
1994	379	128400	170	339	222

• Number of purse seiners registered which achieved at least one trip during that year. (Source: Pelfish, statistical collection)

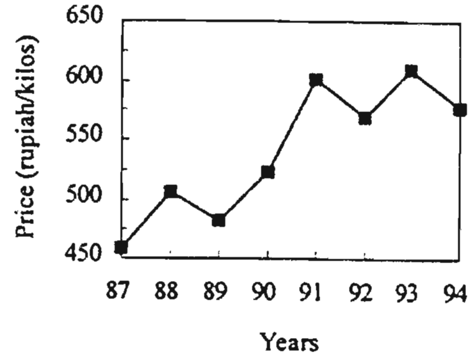

Fig. 1a. PEKALONGAN : Average current price of the pelagic species.

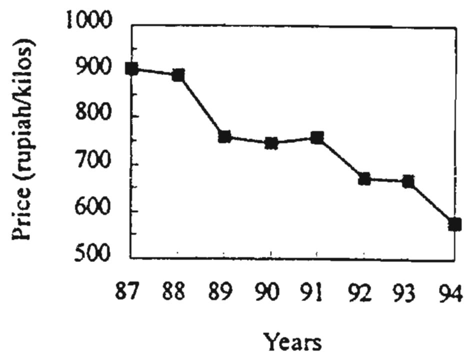

Fig. 1b. PEKALONGAN : Average constant price of the pelagic species.

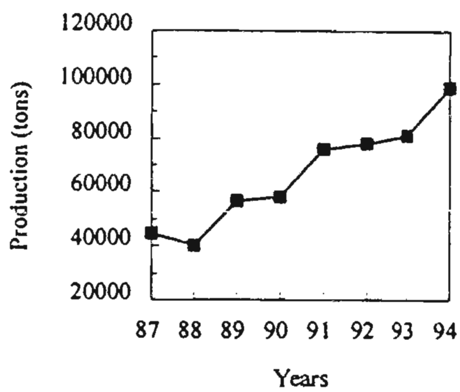

Fig. 1c. PEKALONGAN : Production of the major species (layang, banyar, lemuru, bentong, juwi, tongkol).

[2] Current prices are deflated by the consumer price index (at December 1994 constant prices) for food in Semarang, the capital of the province of Central Java.

Interpretation of the profile of the growth of purse seine fisheries in the Java Sea

The most significant features of the changes undergone by the fleet since 1980 are the following (table 4) :

• The period is characterized by the soaring volume of catches as well as by the soaring number of boats launched.

The results of the large purse seiners based in Tegal, Pekalongan and Juwana, show this strong growth pattern.

Table 4 : Production of the large purse seiners alone, for the three main harbors, from 1980 to 1994

	1980		1989		1994	
	Units	Tons	Units	Tons	Units	Tons
Tegal	57	9.100	55	12.600	36	17.500
Pekalongan	222	24.300	234	48.200	279	70.200
Juwana			37	22.200	55	55.000

(Source : Pelfish, statistical collection)

• The sharp growth of the volume of catches can be explained by the improved productivity of boats, which has tripled during the past fifteen years, from 120 to 339 tons per unit and per year. In addition, the creation of a modern fishing port in Juwana has facilitated the eastward shift of the fishing sites used by large purse seiners.

• The first years of the current decade constitute a turning point. The increase in scale, typical of the preceding period, opens the way to even heavier investments and to the adoption of a number of technological innovations by the leading boat owners. Thus, 500 millions rupiah are devoted to the construction of a new vintage of large purse seiners. Added to the adoption of modern navigational aids and fishing gears or to the attraction of the most qualified fishermen, this whole set of changes represents an accumulation of capital and of knowledge which transforms drastically the profile of this branch of activity. These qualitative and quantitative changes modify relations not only between owners and crews, but also relations within each one of these two groups.

Yet, discontinuities in the growth rate of the volume of catches represent warnings of the enhanced risks associated with the race toward ever larger production units. Between 1986 and 1989, drops in the volume of ***layang*** had been compensated for by increases in the tonnages of other, albeit, less valued such as the ***lemuru***.

Meanwhile, even though the dynamics at work have facilitated the opening of new jobs and the rising of standards of life among all the categories of people involved in fisheries, the likelihood of a stagnation or even of a reversal in the growth rate is looming large.

The more recent years (1992-1994) are characterized by a variety of technological and social evolutions. Those boat owners who participate in larger holdings, diversify their activities, and display a variety of managerial skills should adjust best to the new opportunities and constraints. The same dynamics, and notably the race to ever larger units, jeopardize nevertheless the chances of survival of the owners of a few medium and smaller boats, since they do not enjoy adequate financial and human resources to resist the ensuing pressures.

Conclusions

The whole period may be characterized by the shift of an artisanal type of activity, initially managed by fishermen owning their own means of production, to a more capitalist system of production managed by investors, who are endowed with significant financial resources.

Using the trends highlighted here, it is possible to draw several hypotheses as to the future. First, the fact that the conjuncture remains favorable so far, has generated sufficient profits to maintain a payback period which ranges from two to four years. The high returns obtained accentuate competition and increase the risks that the leading owners are willing to take. At the same time, one can suspect that these owners anticipate more or less consciously the intervention of several mechanisms limiting access to the activity.

This scenario is neither certain nor exclusive. To start with, a number of owners have already started to divert some of their resources toward other subsectors and, for example, by investing in boats specializing in the catch of oceanic tunas. Their "upward" move would leave a sufficient leeway to facilitate the sharing of the ensuing opportunities, either through agreements among surviving operators, or as a result of a decision imposed by public authorities.

Meanwhile, all the actors diversify their risks by using various types of gears (seines, but also gill nets and long lines). Since the stock of demersal species offers a high added value and remains less exploited, it looks as if there are still opportunities for modernizing fisheries without jeopardizing the social balance of the communities involved.

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MULTIDISCIPLINARY STUDIES FOR FISHERY MANAGEMENT
Case Study : Java Sea Pelagic Fisheries

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Abstract

The Java Sea Pelagic Fishery Project has begun in 1991 and will end mid 1996. It was initially focused on main small pelagic species exploitation by large seiners in the open waters of Java sea and the transformation and commercialization of the catches. This paper will give a brief review of the main results obtained in various fields involved : environment, acoustic, bioecology, exploitation, sociology, economics and technology. It will discuss the need of multidisciplinary approach for such fisheries and the interest for research, development and management.

Key words : Java Sea, Seiners, Pelagic Fisheries, Socio Economics.

Introduction

Through this title we want to emphasize the need for knowledge in various fields - mainly biological sciences and social science - when studying natural aquatic resources exploitation. Multidisciplinarity as defined here means that all disciplines aims to analyze and understand the same object. It means too that they have at least some common constraints, time and space scales and observation units.

On a global basis the world fisheries are not in good condition (Garcia and Newton, in press) and " the new Ocean Regime has been a major breakthrough [but] a decade after .... the state of world fisheries has not improved decisively" (Troadec, 1995). In this context the case of Indonesia Exclusive Economic Zone is a very interesting one : it is one of the widest on earth with approximatively 5.8 millions km². Variety of resources - small pelagics, tuna, demersal fishes as well as shrimps - implies variety of fisheries from small scale to semi-industrial ones with various exploitation pressures (for a general presentation of Indonesia marine fisheries see Bailey *et al.*, 1987)

Among Indonesia fisheries, Java Sea fisheries show very specific features : fairly high global production, coastal and open water fisheries, small scale and semi-industrial, quick evolution and proximity of the large Java market with some 100 millions people.

We chose to focus on seiner fisheries in open waters for various reasons and hypothesis :

- the evolution seemed very dynamic, owing mainly at first to the shift to seiners after the ban trawl which took place in early eighties ;
- a priori there did not seem to have much interaction between open water small pelagic stocks and coastal exploitation ;
- apparent feasibility of the study through landings mainly done in two harbours - Pekalongan and Juwana - and existence of a statistical basis for these landings ;
- last, but not least, the first priority of large tonnages caught and relatively low prices.

Given this frame, the ultimate objectives could be summarized as below :

- the provision of scientific advice for the future management of this fishery ;
- the improvement of the performance of this fishing system in terms of catch, conservation and distribution ;
- the evaluation of the socio-economic impact of potential management measures and technical improvement ;
- the enhancement of fishermen's income.

We will make below (see discussion) comments on the definition of these objectives which were for some of them contradictory and subjectives.

The PELFISH project was built upon the cooperation between three main partners : Indonesia through the Agency for Agricultural Research and Development (AARD), France through Research Institute of Development through Cooperation (ORSTOM), European Union (Directorate General 1, external affairs). After a period of six years on the whole it will end in July 1996.

Materials and Method

<u>Resources and Exploitation</u>

It refers to fisheries functioning as well as to bioecology or fish populations dynamic. A special attention is paid to the fish behavior and biomass estimation through echo-prospecting and integration. Data has been taken every month in the two main harbours for the main biological parameters (catch composition, length, reproduction .....). The catch statistics were exhaustive, through harbour authorities and specific project inquiries. A first synthesis of these results has been given in a Seminar held near Jakarta during March 1994. The proceedings had been edited in 1995 (Potier and Nurhakim, Ed.).

Fig. 1. Great Sunda Shelf (<100 m) and Java Sea localisation.

The specificity of acoustic studies required specific tools and methods : disposal of dedicated equipment and oceanographic vessel. The R.V. Bawal Putih has been performing 16 cruises from late 1991 to early 1994. One will find more detail in Petit *et al.*, (1995), proceedings of the Workshop "Akustikan 1". A more global synthesis will be given in January 1996 during the "Akustikan 2" Seminar.

Socio-Economic Studies

They evaluate production costs, fish prices, incomes in the fishing sector and downstream. The research also targets the fishermen conditions of work, the role of women in the production and the respective weight of the formal and informal sectors. Fisheries socio-economics lack of previous studies and data. It was nearly a virgin field at the start of the Project. Various papers were nevertheless dealing with prospects on management and fishermen societies on North Java Coast. Obviously they were too often built on ancient data and/on hyphotesis. We hope that the Project will bring some facts and help - ever if a lot is still to be done - progress in analysis and advance in these matters. A tentative review will be given in December 1995 during the Seminar "SOSEKIMA" (Socio-Economics, Innovation and Management).

Technological Innovations

This field mainly deals with seines design and its evolution, the implementation of electronic devices on the fishing boats, the evaluation of the fish quality and the methods of conservation. For more information see Durand (1994) and Durand and Gueguen (1995) ; the main question being : should technological innovations and evolution be encouraged ?

Results

A fair understanding of the ecosystems functioning is necessary to conduct a wise management of renewable living resources. It means that, beyond the description of an average scheme, we should take into account the variabilities which occur at every level, from climatic variations and primary productivity to species recruitment and fish availability for fishermen.

The need for concomitant data on environment is obvious and the corresponding studies have been identified, but such programs require specific means and skills and could not be conducted in the frame of the present project. Our only solution was to extrapolate ancient results - mainly gathered before World War Two - and to use scarce and scattered recent data (Durand and Petit, 1995). A more specific utilisation was done also for relations between climatic factors and seine fishing (Potier and Boely, 1990). In addition we performed salinities and temperatures measurements during acoustic cruises in Java Sea, from 1991 to 1994 (Petit *et al.*, 1995).

We refer to the above publications for more detailed description on environmental issues and will only recall here the most important points :

* The Java Sea represents the South-eastern end of the Great Sunda Shelf which extends from the Gulf of Thailand southwards through South China Sea (Fig. 1).
* Morphologically, it is well delimited on three sides , namely Sumatra, Java and Kalimantan islands. The eastern boundary is wide open towards deep Indonesia seas (Fig. 2) .
* This collection of waters is huge - about 450 000 square kilometers - and shallow : the average depth is about 40 m with its bottom sloping from west to east, 20 to 100 meters.
* The general climatic scheme is clear. Winds are seasonally reversing and so are the currents in the Java Sea : westward flow during the South-East monsoon (dry season), eastward during the North-West monsoon (rainy season).
* The general importance of freshwater impacts through rivers discharge and rain at sea is well demonstrated.
* The interannual variability of the system is mainly explained through the changing balance of oceanic eastern waters with coastal and neritic waters from Java Sea.

One will find more detailed results in the twelve other communications given to this Forum and referenced in our bibliography. We will give below general conclusions.

Bioecology

Seine fisheries in open waters mainly catch six pelagic species : *Decapterus russelli* and *D. macrosoma* (scads), *Selar crumenophthalmus* (big eye scad), *Rastrelliger kanagurta* (pacific mackerel), *Sardinella gibbosa* (sardine) and *Amblygaster sirm* (spotted sardine). The fish caught are mostly immature or in recovery stage : the length at first maturity is close to the average length at first spawning (Atmaja *et al.*, 1995). Most of the fish seem to reach sexual maturity from April to June, at the end of the rainy monsoon.

From preliminary observations of growth parameters, it appears that most of the catch consist of young fishes (Suwarso *et al.*, 1995). As a rough estimation, we could say that the average age of fish caught is less than one year.

An exploratory scheme has been given for recruitment and migration (Sadhotomo and Potier, 1995) mainly from reproduction data and catch frequency lengths. The general average length increase from West to East. Obviously, the spatial distributions of sizes are related to hydrographic conditions and three type of life cycles are distinguished : oceanic, coastal and neretic.

Acoustics

The utilization of acoustic tools in Java Sea must be related to this special context. In most cases echointegration has been used to have first - and very approximative - estimations of global pelagic biomasses. It was performed generally on very large scales and these very approximatives estimations were nevertheless very useful as they apply to newly exploited resources. This is obviously not the case in Java Sea open waters as all fishing grounds have been prospected now. The possible "average optimal production" - in other words sustainable - should be more easily and better estimated through bioecological results and exploitation data, rather than by means of biomass evaluation. Our interest for acoustics studies was focused on other topics like small scale variabilities, fish behaviour, fishermen tactics... in the frame of this multidisciplinary study.

From this last point of view, the preliminary results (Petit *et al.*, 1995 ; Luong and Petit, in press) give valuable information on the functioning of the system.

- They confirm the surdispersion of small pelagic fishes and the relative low occurrence of shoals. This result has to be related with the need for concentrating fish tactics. Setting of the nets takes place at night and the concentration is rather slow.
- They give a first stratification for biomass in Java Sea which fits well with what we know about fisheries dynamics.
- They give very useful information on vertical distribution and circadian cycle; these results would not have been obtained without the input of echoprospections.
- They demonstrate the seasonal variability of biomass which explains the shifting of seiners to South China Sea fishing grounds at the end of the wet monsoon.
- They show that there is a strong correlation between biomass densities and salinities in confirmation of bioecological hypothesis.

Exploitation

The evolution of small pelagic seiners fisheries can be summarized through the extension of fishing grounds, the fishing vessels and the dynamics of catches.

Before 1985, the fishing grounds were restricted to the central part of Java Sea (Fig. 2). Then there was a first great extension towards eastern waters, with a concentration of the fishing effort in the vicinity of the main islands. At that time the totality of Java Sea open waters have been explored by big and medium seiners, the only wide parts ignored being shallow waters in West Java Sea and near South Kalimantan. Nevertheless, another extension occurred from 1988 onwards with extension to East Kalimantan waters in Makassar Strait on one hand and Indonesia South China Sea waters on the other (Fig. 2). This last move has two meanings : all the fishing grounds suitable for seiners in Java Sea are exploited and, furthermore, the exploitation of South China Sea small pelagic stocks - which must be seen as a distinct system - gives a seasonal surplus production to seiners companies during bad fishing season in Java Sea. Pekalongan and Juwana (Fig. 2) are the two main harbours for small pelagic fish.

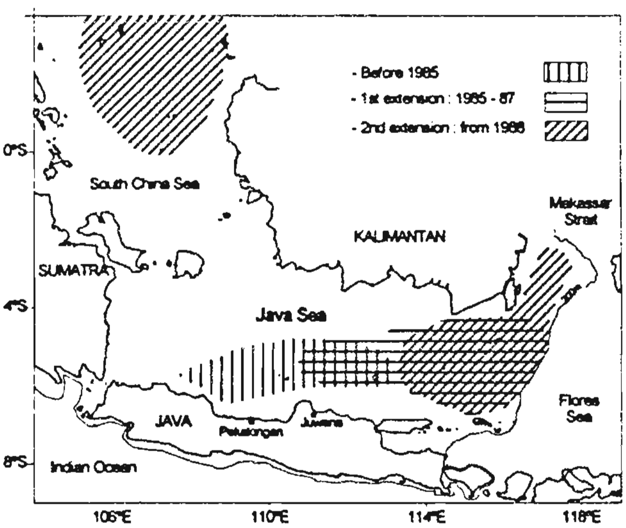

Fig. 2. Historical trends in seiners fishery.

This extension of the fishing grounds has brought about very significant changes in the vessels characteristics (Potier and Sadhotomo, 1995). Initially, the seiners were 20 to 22 meters long, with on an average 120 HP engines and 20 to 30 tons fish holds capacity. At the time being, there has been an evolution towards bigger vessels, able to perform longer cruises towards South China Sea and Makassar Strait but there was also a diversification with the rising up of a new small vessels fleet, the so-called "mini-seiners". Nowadays we have schematically three flotillas :

* large seiners : from 30 to 36 meters, engine power more than 250 HP and fish holds capacities up to 120 tons ; he cruises last 4 to 5 weeks and they fish mainly in the eastern part of Java Sea, Makassar Strait and South China Sea ;

- medium seiners : from 20 to 25 meters, 100 to 250 HP, 30 to 50 tons fish capacity ; they exploit mainly the traditional fishing grounds inside Java Sea (Fig. 2) ;
- miniseiners : 12 to 18 meters, fishing in North Java coastal waters (see Wijopriono *et al.*, in press).

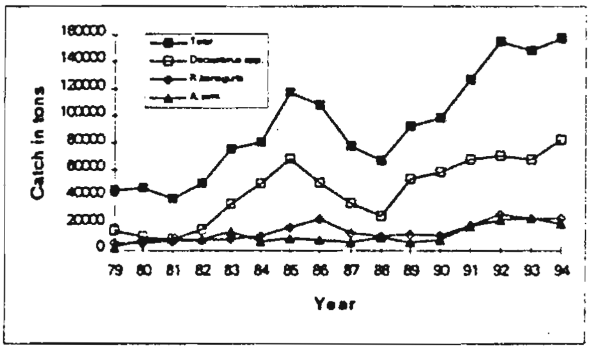

Fig. 3. Evolution of the total and main species catches for the last sixteen years (excluding China Sea).

This diversification and the trend for bigger boats has not been accompanied by noticeable improvements in equipments, but for radio which has spread widely in the early nineties. Only a few vessels have GPS. Fish finders are quite unknown. The vessels speed is low - 7 to 8 knots - owing to under motorization. The fish quality remains generally insufficient, owing to bad insulation of fish holds, bad handling of fish and excessive duration of cruises.

The evolution of the main parameters of exploitation has been given in several papers (among others, see Potier and Sadhotomo, 1995 and Nurhakim *et al.*, in press). On figure 3, we summarize the evolution of the total catch and main species. On Figure 4, we give the evolution of the total number of boats from 1978, year which could be taken as the beginning of the seiners fishery development. During the first ten years, the number of boats has steadily increased : 9 % per year. Then there was a sharp decrease from 1987 to 1991, this negative evolution (- 5 % per year) is related with the decrease in catches from 1985 to 1988, before the last extension of the fishing grounds. In the recent years, the number of seiners has reached the previous maximum level about 580 vessels in 1987. It does not mean that the fishing effort has not increased. On the contrary, it can be said that there has been an increase in total fishing effort, owing to arrival of big seiners and new fishing tactics and strategies (Potier and Petit, in press), but a clear evaluation of this augmentation has still to be made.

From 1988 to 1994, the total catch has increased from 67 000 to nearly 170 000 tons excluding South China Sea. It means that the catch per unit effort has raised significantly (Fig. 5) : more than two times for big seiners and three times for medium ones between 1988 and 1992 (Potier and Sadhotomo, 1995).

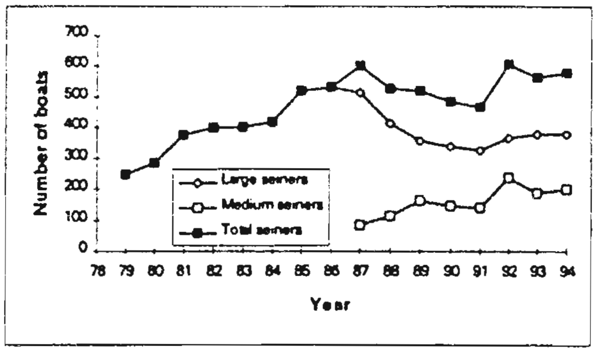

Fig. 4. Evolution of number of seiners belonging to the two main flottillas.

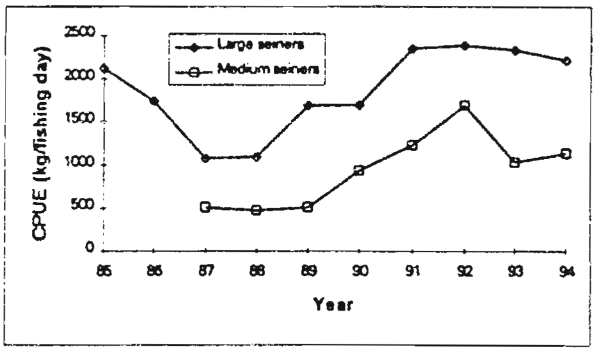

Fig. 5. Catch per unit effort : average yearly values for large and medium seiners (kg/fishing day).

Socioeconomics

The field of fisheries socioeconomics had never been really studied in depth before. There are of course general statistic data and some papers dealing with general economic prospects but corresponding more or less to expertise reports than to research works. From this point of view, Mac Elroy's publication (1991) is quite interesting as it was backed on previous data, the most recent being 1988-1989.

When comparing with other exploitation in the world fisheries, there seem to be a very specific characteristic in the use of fish caught. All fish caught are landed and nearly all fish landed are sold for human consumption, whereas the fish quality is often mean or bad. It means that, at the time being, the demand is not a limiting constraint. Even with small pelagic catches rising sharply in recent years, the market is far from being saturated. These proteins remain relatively cheap, and within the huge population of Java, there are still important groups of consumers, at least along the North coast and in the large javanese towns.

The first project's studies focused on producers, widely speaking : fishermen and owners (Roch *et al.*, in press ; Roch and Sastrawidjaja, in press). These preliminary results show that for fishermen the average incomes are not so low. For the deck hand fishermen they reach around 1 million Rupiah/year ; 1.5 to 2 millions for the chief motorist, and up to 7 or 8 millions for the skippers. These figures are higher than average rural incomes and some skippers are able to invest in small scale fisheries like bottom gillnets.

As far as investments are investigated, it is confirmed that the turn over rate has been very high during recent years, with a paying off in 2 or 3 years. It seems that this very profitable situation is changing, and that the paying off nowadays is next to 4 years. We are still far from rentability threshold, but margins are narrowing, due to higher investments in bigger boats, to higher costs for functioning whereas catch per unit effort are not growing as quickly as they use to do in recent years and fish prices have been decreasing in constant value.

We lack of real data on employment on seiners, but the companies seem to meet some difficulties in recruitment of fishermen. On one hand it appears that the deck hand fishermen prefer often get embarkment on tuna liners. They get better incomes, with a granted salary, whereas on seiners their income depends on the sharing system. They are replaced by countrymen without any skills in fishing, looking for seasonal jobs. On the other hand it is more and more difficult to find valuable skippers : they are not so numerous and are able to get more money in tuna fisheries.

Preliminary synthesis.

The geomorphological concept of Java Sea has been useful but it does not fit any more with the system which supports the medium and big seiners exploitation. On one hand, it is more and more clearer now that, globally speaking, the bioecological links with South China Sea should not be overestimated. Some exchanges exist, as stated by Hardenberg (1938), but it would mainly imply coastal species. In the same order of idea, there are seasonal exchanges through the Sunda Strait, but they have real influence only on the South-West waters of Java Sea. On the other hand, the influence of oceanic waters through the wide and deep eastern opening - even if it is modulated owing to interannual climatic variability - is much more important. It can be said now that, for some of the small pelagic species, the Flores Sea till South-Sulawesi and Makassar Strait up to Banda Sea are parts of the system.

This emphasis given to the eastern part is demonstrated also when one considers the exploitation data. The bulk of the catch comes now from the surroundings of the islands situated north of East Java and Madura and south of South-East Kalimantan (Fig. 2). This eastern shift has reached the East-Kalimantan fishing grounds and explains the growing importance of Juwana and, on another scale and for various reasons of Brondong East Java harbour.

Owing to acoustic studies, the biomass repartition seems to be scattered and fish overdispersed. It could explain why the fishing occurs mainly at night and why the operations of concentration using light are quite long, enabling generally only one set, sometimes two, during the night. It seems to be a natural constraint limiting fishing effort.

The prospection of fishery grounds seem to have reached its maximum extension : the whole continental shelf in the eastern part of Java Sea and northward in the Makassar Strait. The western-part of Java Sea does not seem to have a rich future for seiners : shallow waters, bottom often muddy or rocky and occurrence of small pelagic fishes rather poor.

At least from the knowledge we have now on this fishery, the management issue seems now relatively clear, at least if we stay with the same technological context and existing limitations on fishing effort. Still, the fish quality will be a problem owing to the duration of the cruises, the poor handling on-board, the use of polluted water in harbours and the waiting of seiners in Pekalongan and Juwana for several days before landing.

Conclusion

We begin now to understand the functioning of the system which is represented by small pelagic stocks in Java Sea open waters, their exploitation by seiners fisheries and distribution and commercialization through North Coast harbours.

There seem to have some safeguards to surexploitation :

a) Globally speaking, the combination of different life cycles for the main target species mean that their vulnerability is only partial, coastal and neritic species being protected in shallow waters (but their catches by small scale fisheries is not well known) and oceanic species being out of reach, at least for their adult components in eastern waters.

This major safeguard on biomass availability is not the only one. We have also safeguards on the size of vessel and on the individual effort.

b) Two natural limits to the size of the vessels : on the one hand, coastal waters along Java Coast are shallow and the harbours are built round river estuaries in Central Java. The draught is low and already bigger seiners have problem to enter the harbour when coming back from fishing cruise. On the other hand, the traditional building with one piece wood keels does not seem able to adapt to bigger boats. From this two points of view, it would seem sensible to limit the size of the seiners. It seems that a maximum length round 30 meters - that is to say about 120 tons - would be quite interesting.

c). Owing to environment characteristics and fish behaviour, the fishermen have to concentrate fish during a few hours (with aggregating device and/or light) and therefore they are not able to give many seine hauls during one night. Even if they improve nets and lights it means that the individual effort for a given boat should not rise very much.

In such a context managing level of catches through regulations on maximum size of vessels (hence size of seine and unit fishing effort) and number of vessels would be efficient. It could be combined with outputs management through individual TAC as the landings occur (90%) in two harbours (Widodo and Durand, in press).

Nevertheless it should be kept in mind that managing the quality is also a priority issue as well from economic point of view - the prices reflecting more or less the quality - as from the sociological ones as it would improve nutritive and sanitary standards.

At the end of this very short presentation of our multidisciplinary results we have to point out strong and weak points of our studies, in the sight of the management objectives which could better be analyzed as definition of biological constraints and social objectives.

Classically fisheries biologists focus on population dynamics and exploitation and their major interconnection with social sciences occurs at the end of the production process with landings in harbours and the economist then takes in charge the quantitative and qualitative issues through transformation and commercialization channels. From this point of view we think that the objectives have been reached.

Nevertheless we still find weaknesses in our knowledge, from two points of view, at least. The functioning of the ecosystem has been guessed through ancient data and very partial recent ones ; the inter annual variability issue should be analyzed and an index could be developed, accounting both for local variability and large scale variability (ENSO). In the social sciences field - but for innovation, adaptive processes and women part in fisheries - the sociological knowledge is very low as well for recent history, social life, employment.

In brief, the aquatic resources management need more ecological and socio anthropological interest.

Finally, the Project brought new questions, mainly outside its initial scope.

At the small pelagic stocks level : more should be known about areas which could be important bioecological ones for some of the species caught : west Java Sea and South Kalimantan waters for neritic and coastal species, North of Makassar Strait, Sulawesi and may be further eastward for oceanic species : understanding the Java Sea open waters small pelagic fisheries means studying also Java Sea coastal waters and links with adjacent water bodies.

But it is not really satisfactory to deal with small pelagic only. Along our way, it became more and more obvious that strong interactions are found between fisheries, between fisheries products and with other next economic fields (aquaculture, transport ....). Even more the coastal waters present a specific landscape with high competition on coastal resources, changes of the environment through human behaviour (infrastructures, pollutions ...). We will conclude that the next step should be a systemic approach of Java Sea aquatic resources exploitation. Such an approach will have to deal with complexity and imply involvement of co-management process (see for example, Quensière, 1993 and Wilson *et al.*, 1994). Thus the future should combine classical numerical knowledge and more modern approaches taking into account complexity linked to multispecific populations.

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MANAGEMENT OF THE SMALL PELAGIC FISHERIES OF THE JAVA SEA, INDONESIA

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Abstract

Inside the Java Sea pelagic fisheries are caught through a broad variety of fishing gears, both in coastal as well as in open waters. Nevertheless the bulk of the catch comes from seiners fleets. A brief review is presented of some of the measures taken to manage the small pelagic fishery. Modifications might be carried out in the process of taking management decisions in advanced countries to take into account the various constraints to management in Indonesia, *inter alia* : limited scientific research, lack of effective control, poor implementation and enforcement. Should these constraints and requirements be overcame then there would be optimistic prospects for successful fishery management.

Introduction

The hydrographic pattern of the Java Sea is predominantly influenced by the prevailing monsoon winds which create substantial seasonal changes in direction and strength of the currents, water salinity, and primary productivity of the waters in question (Wyrtki, 1961 ; Weber, 1976 ; Durand and Petit, 1995).

The principal groups of small pelagic fish of the Java sea are those of carangids (scads, *Decapterus russelli, D. macrosoma* ; trevallies, *Selar crumenophthalmus, Selaroides leptolepis*), clupeids (Sardinella, *Sardinella brachysoma, S. fimbriata, S. gibbosa, Amblygaster sirm* ; anchovies, *Stolephorus spp.)* and scombrids (mackerels, *Rastrelliger brachysoma, R. kanagurta*). Scattered shoaling stocks of these species are found along the entire of north Java coast and offshore as well, i.e., from the middle part of the Java Sea through eastern part of the waters to Makassar Strait.

The small pelagic fisheries in the Java Sea could schematically be divided into two main categories, first, the inshore "mini" purse seiners using outboard engine wooden vessels between 10 to 18 m length, and other minor fishing gears such as ***lampara***, ***payang*** (Danish seine), gill net and liftnet; secondly, offshore small/medium and big purse seiners employing wooden vessel of 15 to 20 m and 18 to 30 m in length, respectively. A number of seine nets (e.g., ***lampara***) for anchovies fishery have been intensively used especially in the inshore waters of east Java north coast since recently.

The small pelagic species is of particular importance to food security in Java since these species, which constitute a vital source of animal protein, are the type of fish commonly consumed by principally those of the lower income strata. Generally, the small pelagic fisheries supply the local market with fresh or traditional processed fish (i.e., dried salted, boiled salted and smoked).

Economically the pelagic fisheries of the Java Sea play a significant role as source of income of the fishers and revenues of local government as well. Additionally they also provide foreign exchange earnings mainly in the sense that they may reduce the import of fishery products, besides from the export of salted fish. While from social viewpoint the fisheries are vital to employment and job opportunities that provided by fishing, processing, marketing, and distribution activities.

In fact, the small pelagic fish resources of the Java Sea have been harvested intensively (Widodo, 1988 ; McElroy, 1991 ; Nurhakim, 1995 ; Durand and Widodo, 1995). In 1992 about 500 000 ton with ex-vessel value of over $ 275 million was yielded. Taking into account the importance in biological, social, and economic roles, it will be of great interest to see what effective management regimes are recommended to ensure their long-term sustainable development.

Materials and Method

Materials

The on-going collection on the data of biology, exploitation (catch and effort data), economic and social aspects of fishing communities and fishing fleets have been conducted by PELFISH Project of the Research Institute for Marine Fisheries (RIMF), Jakarta, Indonesia since 1991 and afterward.

Those data will then comprehensively analyzed and reviewed in order to design a sound management strategies for the resources concerned. More comprehensive results will be presented in the PELFISH Project's seminar on socio-economic, innovation and management that will be conducted in Semarang, Indonesia in December 1995.

Method

In managing fisheries, the managers along with those of fishermen and biologists, should set up harvest strategies use for the fisheries. The strategies should takes into account the biological conditions of the stock, and the economic, social and political conditions of the fisheries as well.

There are several harvest strategies in fisheries management that are currently used in many fisheries, namely those of stock-size dependent strategies, periodic harvest strategies, sex-specific strategies, size-limit strategies, economics and harvest strategies, and strategies that include uncertainty (Hilborn and Walters, 1992).

To implement the strategies in the field a set of tactical tools generally used in various fisheries can be listed as gear restrictions, season lengths, gear limitations, effort limitations, annual catch quotas and size limitations.

A fishery may employ more than one of the above alternative tactics. The choice of tools for implementing a certain harvest strategy is very dependent upon the nature of the fishery which requires specific local knowledge.

Results

Fundamentally, the purpose of the fisheries management is to ensure sustainable production over time from the fish populations, through regulatory and enhancement actions which promote economic and social welfare of the fishers communities and industries that use the production.

In general the objectives of the fisheries management can be classified into three groups : (i) maintenance or restoration of the resource, (ii)elimination and reduction of conflicts and (iii)improvement of the economic performance of the fishery (Gulland, 1988).

For the time being, promotion of the fishermen welfare and revenues, support to production growth, increase the foreign exchange earnings and government revenues, and resource conservation rank high in the agendas of the fisheries administrators of the Government of Indonesia.

Among the harvest strategies commonly used in various fisheries stated by Hilborn and Walters (1992), it is very likely that the stock-size-dependent strategy is the one seems potentially effective to achieve the management objectives of the small pelagic fishery in the Java Sea. Harvest strategies which depend on stock size may take the forms of constant-stock-size strategy, constant-exploitation strategy or constatnt-catch strategy. It seems that the constant-exploitation strategy is the most applicable one.

To implement this strategy, a set of tactics can be devised. First, gear restrictions (in terms of net length, vessel size or vessel capacity, engine power, and light power used as FAD) and gear limitations (in terms of number of vessels). Secondly, an annual catch quota especially for the entire small/medium and big purse seiner fleet.

It is possible that such the two tactics can be made to work, particularly for the small/medium and big purse seiners, given the limited number of ports involved, namely Pekalongan and Juwana, where a number of 70% of the vessels are based and 90% of the catch are landed (Potier and Sadhotomo 1995). On the other hand the application of these tactics on inshore small scale fisheries will face operational difficulties that associated with the diversities of fishing operations, dispersion of landings sites and distribution channels.

Eventhough the history to date of enforcement of fishery regulations, including vessel limitation, in the Java Sea is not encouraging, however, that is no justification for not trying again to introduce a limited entry scheme, after trawl banning, this time for purse seiners limitation. The large socio-economic benefits to the wider economy of substantially reducing the risk of stock collapse must surely outweigh the relatively low enforcement costs involved.

Discussion

In the small pelagic fisheries of the Java Sea, quantitative controls may be exerted either on outputs (e.g., catch quotas), on inputs (e.g. catching capacities, number of vessels, number of fishermen) or on stock or biomass. One critical shortcoming of catch quotas is that, for maximizing their values, fishermen have advantage in discarding lower-value species and sizes. This "high-sortin" behavior tend to be particularly marked in the multispecies fisheries. Catches can be considerably more difficult to control that boats or fishers. Those will be particularly severe in pelagic fisheries such as of the Java Sea which presenting the following features : (i) multispecies, multigear, and small scale fisheries with many landing sites and concealed marketing circuit, significant of autoconsumption, etc., and (ii) limited enforcement and surveillance capacities.

Under such circumstances, control on inputs can be the best option. Most suitable input controls are those which apply to variables that contribute most significantly to the fishing power of boats, i.e., (i) the engine power, (ii) the size of net and the power of light as FADs, though the control of gear actually in operation may rise particular difficulties, (iii) the number of fishermen onboard since the purse seiners have been manually operated.

Control on the number of vessels may be accomplished by taxes or license fees, while control on size and capacity of vessels would naturally performed, since the major fish harbors (namely Pekalongan and Juwana) are so shallow that no vessels beyond a certain size able to enter.

Since there are lack of alternative employment opportunities outside the fishery, for whatever reasons, management involving the retirement of participants in the current fishery is unjustified and probably non-enforceable.

Controls on fishing time (days at sea), on the distribution of fishing operations (closed areas or seasons), on the elimination of destructive types of technology (e.g., used of superlight), and so forth, can be useful as complementary measures (to improve working conditions, or for protecting particular vulnerable portions of the stock). The measures have the major advantages that they are relatively easy to be enforced, however, they have only a partial and, therefore time-limited effect on the control of fishing capacities and fishing rate.

So far the Government of Indonesia has set up a mesh size regulation but it is difficult to enforce since the ***nakhoda*** (seiner skipper) wants to avoid gilling fish by using bigger mesh size. Besides, as far as the fishermen dealing with light fishing which harvest a mixed catch, a smaller mesh size will present only minor problems.

In general, the advantages and drawbacks of input controls are as the mirror image of output controls. On the other hand, major limitation of stock or biomass controls rests in the applicability.

Management system are made up of different rules, mechanisms, and structures assembled in a coherent fashion. The number of effective management systems - i.e., of combinations of basic institutions that work - is limited : e.g., open access, TURF (territorial use right in fisheries), limited entry, co-management, tax or fixed price system, individual transferable quotas (ITQs), etc. ITQs, for example, imply that on adequate resource property regime has been adopted and consist of individual quantitative fishing rights expressed on inputs that are usually allocated through a market mechanism.

One of the essential aspects of fisheries management is control over access to the resources. This requires some form of rights to exclude potential fishermen from entering the fishery. Christy (1987) points out that the rights of exclusion can be related to the number of vessels (a license limit scheme); to share of the yields (a fisherman quota scheme); or to areas of the sea (TURF). Or it can be a right to extract revenues from the fishery which serves to control access indirectly by excluding those who are unwilling to pay the tax or fee. Exclusively rights can be exercised by national, regional, or local governments, by a community or by a group of fishermen. Clearly fisheries could be managed if our knowledge of fish population dynamics was improved.

In countries of fisheries where management has been directed explicitly to the regulation on access, overcapacities have been reduced, economic performances and, in several instances, fish stocks have improved.

Control by catch quota is only useful if the quota needed to achieve a given objective can be accurately determined.

Within most fisheries policies, social objectives have hitherto been unstated, non-specific or unprioritised. The policies have, in effect, been driven by conservation and economically oriented goals. In fact there are a number of socio-economic problems related to the potential development of the Java Sea pelagic fisheries. Methods of maximizing social benefits and methods for preventing over capitalization are important subjects for future study.

In the most fisheries the greatest potential economic benefits in the long term come from reducing the total costs of fishing; this commonly be done by restricting access in some way or other (common property and open access). A modified design of the traditional net has been introduces by Dremiere and George (1991) which able to reduce up to 25 to 35% of the cost. In general one forth of the total investment for a set of purse seine is spent for the net. The costs of enforcement should be taken into account.

Most of the coastal countries have revised their legislation to control the activity of foreign fleets operating in their EEZs in order to provide rooms for their domestic fishing fleets to exploit the resources. In Indonesia this also should be taken into account in anticipating the development of purse seiner fleet in the Java Sea which always increasing both qualitatively as well as quantitatively. In addition, there is an increasing tendency for the purse seiner owners in Pekalongan to expand their business into tuna fishing in high seas.

As far as the tendency of increasing number of new vessels still takes place, an overall approach to pelagic fisheries of the Java Sea should be oriented toward adaptive management with suggestions for any moderate increase in fishing effort which should be carefully monitored and evaluated prior to attempting another increment. That is, if, after reassessment of the results of the recommended increase in fishing effort, there is still scope for further development, only then should this be implemented. To incorporate social, economic and resource oriented goals into management procedure, this increment should be based on a risk averse decision. It is preferable to err on the conservative side given the potentially negative social and economic impacts of over capitalization.

Although some form of fish surveillance and enforcement is clearly required, successful fisheries management will not occur if the participants do not generally agree to follow the rules and regulations (e.g., licensing and quota systems) with attention to problem of compliance, their impacts on the group structure of organization of industry, and their wider social impacts on the areas that depend on the fishery.

Conclusion

Interdisciplinary approach to fisheries management and fish science in addition to fish biology and fish population dynamics is needed, for example sociology, anthropology and economics.

Those data will then be analyzed and reviewed in order to design a sound management strategies for the resources concerned. A more comprehensive results will be presented in the PELFISH Project's seminar on socio-economic, innovation and management that will be conducted in Semarang, Indonesia in December 1995.

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