B I O D Y N E X

Biology, Dynamics, Exploitation of the Small Pelagic Fishes in the Java Sea

Scientific Editors : M. Potier, S. Nurhakim

BIODYNEX

IN MEMORIAM :

This book is dedicated to the late Dr. Thierry Boely.
Without him the project would not have been implemented.

FOREWORD

M. POTIER, S. NURHAKIM

On earth more than 100 million people depend directly or indirectly on fishery for their subsistence. Artisan fishery contributes to almost half of the 70 million tons of fish consumed by human beings in the world. It needs to be valorized specially in populated countries like Indonesia where aquatic proteins play a key role in maintaining quality food intake among the population.

As shown during the interventions of the representatives of the Indonesian government agencies, in Indonesia marine resources are very important. The country has access to one of the widest maritime area of the planet (5.8 million km^{-2}). If the sustainable resources of these waters are estimated to around 6 million tons, the coastal ones are heavily exploited. The Java Sea is one of the main exploitation zone (700 000 tons/year in 1991 among which 485 000 for small pelagic fishes) (DGF source). Most of the resource is pelagic. Highly instable this resource represents the main income of numerous fishermen which are among the poorest group of the Indonesian population. The northern coast of the Java Island concentrates very active and varied fishing activities which represent a large manpower receptacle for the heavy populated coastal zones. Then, the management of such fisheries becomes urgent in order to avoid their collapse.

The PELFISH project has defined for its frame study the pelagic fisheries in the Java Sea which operate with large purse-seines on the six or seven main pelagic species of the region (*Decapterus spp., Rastrelliger spp., Sardinella spp., Selar spp.*). Its global approach includes biological and dynamic of exploitation research as well as socio-economical and environmental studies.

Mainly due to the fact that biological and dynamic studies have already been implemented prior to the project (BPPL/ORSTOM program 1984-1987) the first phase of the project has been primarily oriented toward the completion of bio-ecology, population dynamics and exploitation fields. A reliable and well documented description of the dynamic evolution since the trawl ban (1980-1981) on the North Java coast is now possible and will serve as reference for the other fields of studies in the project.

The present document concerns the seminar in biology, dynamics and exploitation (**BIODYNEX**) which was conducted in March 1994 and divided in three different but complementary phases:

- March 21-22: classical presentation of the research and debates,
- March 22 : Round table on the global fishery system in the Java Sea mentioning some future management contingencies,
- March 23-25: workshop animated by international experts. Thematic small groups used the software and the data base of the project.

This publication follows the same pattern and consists of three parts:

- The first one includes a presentation of the PELFISH project and the official opening speeches delivered by the different sponsors.
- The second part is composed of the 17 articles presented and discussed during the seminar. They are classified in four themes :

  General frame of the study gives an overview of the environment, the species caught by the seiners fisheries and the place of these last ones in Indonesia.
  Biology presents the first results of the biological studies carried out on the main species.
  Dynamics gathers analytical models applied on some species and an attempt at the modelization of the fisheries with the surplus models.
  Exploitation is approached from an historical point of view, the changes in the fisheries are studied and the debate is enlarged by the presentation of the small seines exploitation along the northern coast of the Java Island and the contributions of the experts invited at this seminar.
- The third part reports the round table talks and the issues developed during the workshop.

While reading this document it should be kept in mind that the seminar has been a success in term of national and regional communication (ninety five per cent of the people we contacted participated to the event, many personalities from Indonesian government structures, research circles and fishery industries as well as scientists from ASEAN countries). The knowledge now available is of solid quality with some chronological data tracking ten to fifteen years of observation which is important in the case of tropical pelagic. Some hypothesis about extending the studied area are to take into account and some on migrating patterns are to verify. But the bioecological and exploitation knowledge allow us to foresee some management scenarios.

ACKNOWLEDGMENTS

The present document reports on the **"BIODYNEX"** seminar, Biology, Dynamic and Exploitation of Javanese purse-seiners fisheries, which was held in Jakarta, Indonesia in March 1994.

This seminar would not have taken place without the help of some governmental agencies and the collaboration of numerous people to whom we wish to express our gratitude:

- The European Union which funds this Research and Development project.
- The French government which financially supported the seminar and allowed its holding.
- The AARD (Agency of Agriculture Research and Development) and the DGF (Directorate General of Fisheries) for their help to get all administrative authorizations and in the search of the seminar location.
- The whole project staff whose constant technical and administrative assistance allowed this event to become a successful forum of scientific communication.
- Mrs. Maxime Gioffredo for her rewriting in English.
- Mr. Budi Iskandar who computerised the figures illustrating the articles.
- Mrs. Anne Andrei for the logistic organization of the seminar, the development, design and editing of the book.

CONTENTS

OPENING CEREMONY 7

PELFISH PROJECT PRESENTATION 11

FRAME STUDY 13

BIOLOGY 67

DYNAMICS 107

EXPLOITATION 169

WORKSHOP AND ROUND TABLE 261

LIST OF ABBREVIATIONS 277

LIST OF AUTHORS 278

LIST OF SEMINAR PARTICIPANTS 279

OPENING CEREMONY

Mr. Vincent De Visscher
DEVELOPMENT COUNSELOR
EUROPEAN UNION REPRESENTATION IN INDONESIA

"It is an honor and a privilege to attend the seminar on behalf of the European Commission. The objective of today's seminar is a very important one : Scientists will share their results with government officials, decision makers and fishermen. Since the Project's goal was to assess the stock of pelagic fish in the Java Sea, we should all be concerned about resources utilization. It has never been an easy task for scientists to describe how different fish species migrate or concentrate. There are so many factors and so many parameters which need to be studied. The rule of thumb based on the experience of the fishermen or the sophisticated echo-radar of the ***Bawal Putih I*** *will most probably not give us accurate indications, some trends and some overall indicators will be the outcome of this important work. This does not mean that, given the limitation in the scope of the Java Sea Pelagic Project, this has no value. To the contrary, vital information will be an incentive for the government to develop a management plan for the fishery sector.*

Actually, there is a vacuum. We are lacking of an overall base line survey for the whole Java Sea: how many fishermen are taping on the resource ? How many boats - large, medium and small- are engaged on a day to day fishing activity ? What is the total of the daily catch from the Java Sea ? How many persons are living out the fishery sector ?

The future of this sector is depending on the sustainable management of this resource. Everybody therefore has interest to safeguard the existing pelagic stock and to refrain jeopardizing it.

The role of the European Union in this Project is to assist the Government and other partners with technical guidance based on solid field data in order to, at least, elaborate an embryo of management plan and strategy to develop the sector in the future.

Ladies and gentlemen,

Allow me to conclude this intervention by expressing my gratitude to the authorities with which we have been maintaining excellent contacts and relationship throughout the implementation of this Project. This is addressed to AARD, RIMF, CRIFI, Department of Fisheries. I would also like to pay a tribute to all other parties involved i.e. scientists, experts, boat owners and fishermen. Without your collaboration, this Project would have been impossible. To all the participants to this seminar, I wish you all the best in your deliberations and exchange of views.

Thank you for your kind attention."

Mr. Pierre Bousquet on behalf of Mr. Marc Pain,
SCIENTIFIC ATTACHÉ
FRENCH EMBASSY

"A general presentation of the Project will be done by specialists in a few moments. I will just, as I was advised to, present the contribution of France to the Project. As you know, France has been supporting strongly the Project since its beginning in 1989.

First, of course, as a member of the European Union.

Second, through ORSTOM. ORSTOM is the French scientific research institute for development through cooperation. It is co-ordinated by the two French Ministries in charge of research and of cooperation. ORSTOM has provided the Project.

Third, the French Ministry of Foreign Affairs contributes to the Project since its start by financing, among others, shorter assistance missions of experts for example fisheries experts from IFREMER (French Institute of Marine Research) or ORSTOM.

The Embassy of France here will continue to help financing seminars - like this one - that will be held in to enable the Project to present its results. This is only the first of three seminars.

Why seminars and workshops ? Because transfer of know-how and transfer of technology are essential objectives of the Project- especially now, in its second part and until its end. We pay a very special attention to technology transfer and development matters, which are down-stream to scientific research.

This is why France has supported the proposition for a consolidation phase of the Project that was presented by the mid-term evaluation mission- and that should enable the Project to reach its objectives in terms of transfer of technology."

Ir. H. Muchtar Abdullah
GENERAL DIRECTOR OF FISHERIES
INDONESIAN GENERAL DIRECTORATE OF FISHERIES

"Indonesia has 5.8 million km^{-2} of total jurisdiction waters and extended exclusive economic zone (E.E.Z.). This waters include 2.8 million km^{-2} of archipelagic waters, 0.3 million km^{-2}. of territorial waters, and 2.7 million km^{-2} of Indonesian E.E.Z.. As an archipelago nation, Indonesia consists of 17 508 islands, and a coastline of 81 000 km, the longest in the world. These natural resources, especially marine resources need to be developed and rationally utilized.

Based upon the available data and information, the potential yield of the marine fisheries resources is estimated to be about 6.7 million tons/year which consist of 4.5 million tons/year *in the Indonesian waters and 2.2 million tons/year in the Indonesian E.E.Z.. These marine fisheries resources counts pelagic fish, demersal, tuna, skipjack, shrimps, coral reef fish, molluscs, sea cucumber and sea weeds. Additionally, about twenty per cent of the total Indonesian coastline can be developed for mariculture with the estimated potential yield of 0.6 million tons/year.*

Up to 1991 only 40% of the total potential yield was used. In 1991 the production of marine capture fisheries was of 2 537 612 tons. The annual average increment was of 4.3% between 1968 and 1991. So far, marine fisheries production has contributed as much as 75% of the national yield, 14.3% coming from the Malacca Strait waters, 22.2% from the Java Sea, 13.4% from West and South Sulawesi. As marine fishery product of mariculture is still at initial stage, more attention is needed for its further development.

Although the potential yield of marine resources has not been fully utilized, the rates of exploitation are not uniformly allotted. Most of the existing exploitations are concentrated in waters close to populated areas such as the North of Java, the Malacca Strait, the Bali Strait as well as West and South Sulawesi. Consequently, marine fisheries resources in those areas have suffered from intensive fishing pressure . In addition to the uneven fishing intensity among the areas, most of the fishing activities are performed in coastal waters. The concentration of fishing in the coastal areas has a close relationship with the structure of the fleet consisting mainly of unpowered boats and small size powered boats.

Besides the uneven exploitation, we can point out other problems, namely, illegal fishing by foreign fleets, fishing with dynamite and poisons, coral mining, pollution of coastal waters due to domestic and industrial waste which threaten fish habitats. Monitoring and control need to be activated along with the strengthening of law enforcement.

The private sector has played an influential role in the development of fish production. Investment on marine fisheries may take forms of domestic (PMDN : Penanaman Modal Dalam Negeri)) or foreign enterprises (PMA : Penanaman Modal Asing). For the domestic ones only 18.2% of the whole investment plans were put into operation, while investment in foreign enterprises was reaching 50%. Those investments not only concern fishing activities but also mariculture, especially sea weeds and culture of pearls. Constraints encountered in fisheries investment are due mainly to the lack of conduciveness climate in supporting capital investment, insufficient detailed and accurate information on potential yield, and limited variation in fisheries enterprises.

Research institutes on fisheries will play a considerable role in offering data and informations needed by the industrial sector to initiate, develop and sustain its businesses. Within the Second Long-term Development (PJP II : Pembangunan Jangka Panjang II), fisheries development will focus on the acceleration of the growth rate through agro-business and agro-industry systems. An integrate development program based on the fisheries resources diversity, geographical variations, and their potential yields should be set up in accordance with the research programs and their results.

That is my message for this seminar. I do hope that its results will be able to support the Indonesian fishery development plans which I have mentioned earlier. I wish the participants all the best for a successful workshop and I thank you very much for your attention."

Dr. Faisal Kasryno
GENERAL DIRECTOR OF A.A.R.D.

"First of all, let me express my sincere gratitude and welcome all of you who are willing to take part in BIODYNEX, a seminar and workshop organized by the Java Sea Pelagic Fishery Assessment Project on "Biology, Population Dynamics and Exploitation of the Java Sea Pelagic Fishery". The number of participants and their level of expertise is indeed revealing the importance of the work that has been achieved.

In response to trawl ban in the Java Sea in early 1980, big purse seine fishery in these waters has developed significantly. Within the last decade the landings increased from 46 000 tons in 1980 to 125 000 tons in 1992, while the fleet increased from 285 to 357 units. On average, big purse seine fishery in the Java Sea contributes as much as 25% of the landings of the North Java coast. Overall, the Java Sea contributes to about 30% of the total annual Indonesian marine catch and fishery in the region plays a significant role in supplying food, job opportunities, and income for the population. On the other hand extensive exploitation has been conducted on the resources since 1980.

It is interesting to notice that the specific objective of the Project is, among other things, to provide an improved knowledge of the biology and status of the offshore pelagic fishery resources on the Java Sea, which will serve as a basis to establishing a management regime allowing a sustainable development :

The biological studies of the Project have been carried out on a number of biological aspects of the dominant pelagic species, especially on their reproduction and growth characteristics. Results in this area will be presented by the counterpart scientists of Research Institute for Marine Fisheries (RIMF).

*Results on the population dynamics studies of "**ikan layang**" scads (Decapterus spp.) and "**banyar**", Indo-Pacific mackerel (Rastrelliger kanagurta) will be delivered by counterpart scientists of the RIMF.*

The third topic of the workshop, exploitation, which focus on the evolution of catch, effort and catch per unit of effort of the fishery, will be presented by an ORSTOM expert and his counterparts.

In addition, a number of scientists of the RIMF will present their results on mini (outboard engine) purse seine fishery which closely interacts with the big purse seine fishery.

All of the results studies will be presented within the first two days of the seminar. The remaining three days will be used to analyze the data which has been collected so far. A number of well-known scientists have been invited to work together and to supervise the workshop. By doing so, some of major outputs on the Project namely institutional strengthening, manpower development and transfer of technology hopefully will be materialized. I do hope that the results of this workshop as well as all the efforts which have been generated by the Project so far will progressively be translated into reality and will help the fishermen in increasing their income and improving their welfare.

If in this workshop, policy makers, experts and potential users will discuss results accumulated during these first half of the Project, it is obviously because of the remarkable cooperation between ORSTOM experts and their counterparts. For this, I would like to express my sincerely appreciation of the two co-directors and the personnel of this Project for the task that has already been accomplished so far.

May I, once again, wish the participants all the best for a very fruitful seminar."

PELFISH PROJECT PRESENTATION

J.R. DURAND, J. WIDODO
PELFISH CO-DIRECTORS

The PELFISH Project which studies the fishing activity in the Java Sea is sponsored by Indonesia (Agency for Agricultural Research and Development, AARD), France (French Research Institute for Development through Cooperation, ORSTOM) and The European Union. Its research is focused on offshore pelagic fisheries (mainly medium and large seiners fisheries) and its main objectives are :

- 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.

To reach these objectives, PELFISH has developed three main fields of activities :

- Resources and exploitation

It refers to fisheries functioning as well as to bioecology or fish populations dynamic. A special attention is paid to fish behavior and biomass estimation through echo-prospecting and integration.

- 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.

- Technological innovations

It is related to nets design and its evolution, the implementation of electronic devices on the fishing boats, the evaluation of the fish quality and the methods of conservation.

ACTUAL STATE OF THE PROJECT

Over a period of 5 to 6 years the contribution of ORSTOM, European Union and the Indonesian government in financial and human resources has demonstrated the importance of the PELFISH project targets. The training of Indonesian fishermen, technicians and scientists is heavily emphasized. However the success of the Project cannot be evaluated only on scientific and technical beats but moreover on its ability to use the information to help local interveners in the fishery.

Owing to its multi-disciplinary and multi-targets approach the PELFISH Project is now able to work with government representatives and boats owners in order to assess in a near future various management hypothesis. This is of most importance because the seiners fishery is in a transitional state. In this kind of "pre-industrial" state hasty innovations may generate too heavy rates of exploitation.

SEMINAR CONTRIBUTION TO THE PROJECT

This first seminar on the knowledge acquired on biology, population dynamics and exploitation allows us to draw some general conclusions.

■ The center of gravity of the whole system seems to be located on the eastern part of the Java Sea and raises questions on the biological links between this part and the western region of the Makassar Strait and of the Flores Sea.

■ It is also noticeable that the seiners exploitation is already well developed and almost certainly will not extend further in the actual technical and economical environment.

■ The complementary studies to be done are well identified. They concern mainly the spatio-temporal variations of the fishing effort, the definition of the geographic boundaries of the stocks, the biological importance of the oriental regions. A lack of information on the environment is also to be noted.

■ The work already accomplished will acquire all its meaning when the socio-economical studies will bring their information on costs, social organization, distribution systems, etc... Only a global approach will allow the Project to find out if the Java Sea fisheries are limited by the resource or the market and, if not, how the situation will develop in time, what are the future possibilities for the large and medium seiners exploitation, what is the level of adaptability of the various parts in the situation, what are the risks linked to the exploitation of variable resources. From the answers to these questions depend the optimal decisions of management. The seminars on acoustics and socioeconomic planned in 1995 will complete this first one and will allow us to have a better view of the situation.

Besides the whole project staff we would like to thank MM. S. Nurhakim and M. Potier who accepted the difficult task of directing the writing, corrections and publication of this book.

FRAME STUDY

THE JAVA SEA ENVIRONMENT
J.R. DURAND, D. PETIT 14

SYSTEMATICS OF THE SMALL PELAGIC FISH SPECIES
J. WIDODO, BURHANUDDIN 39

SEINERS FISHERIES IN INDONESIA
M. POTIER, B. SADHOTOMO 49

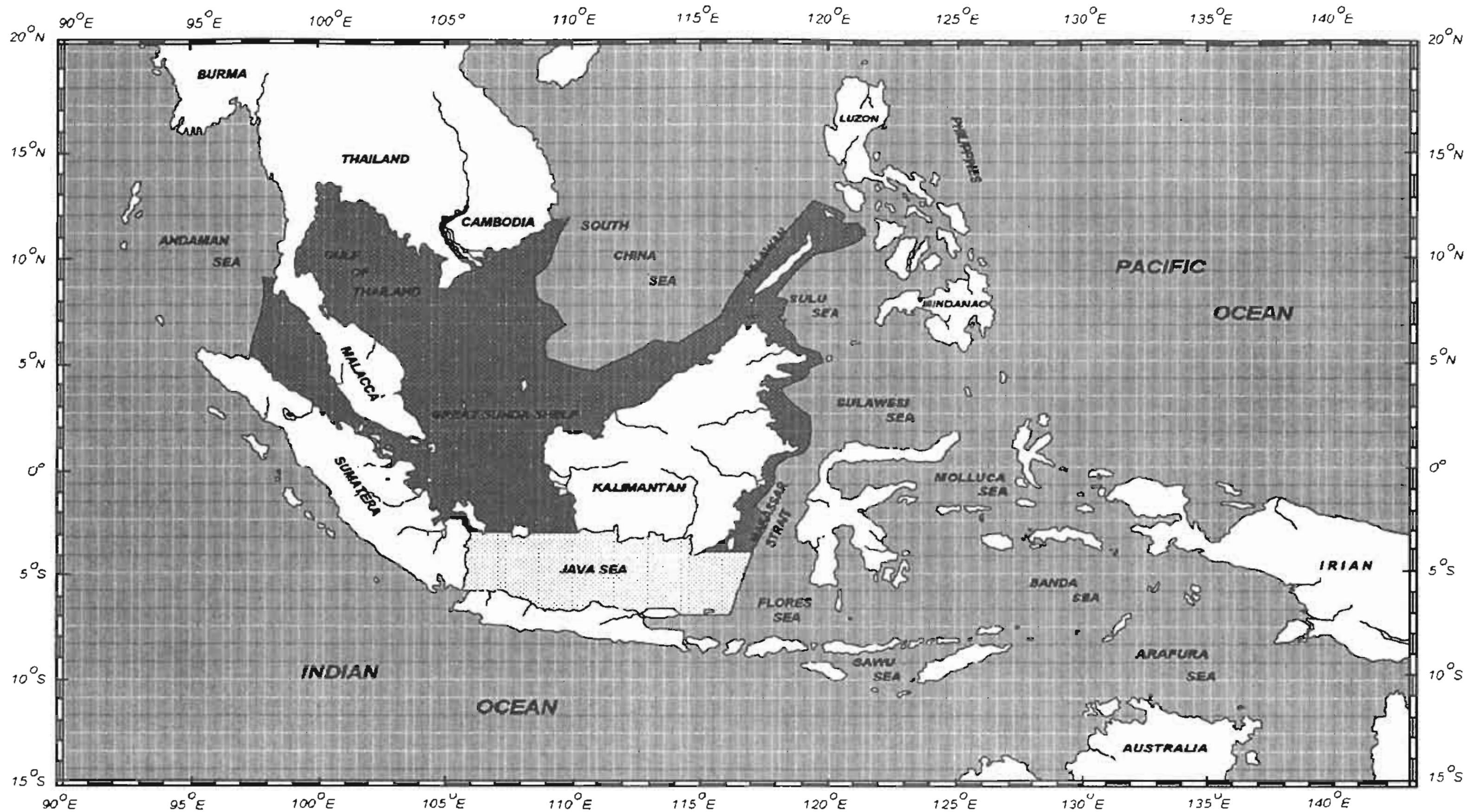


Figure 1

Great Sunda Shelf (<100 m) and Java Sea location

Letak Laut Jawa terhadap Paparan Sunda {<100 m}

THE JAVA SEA ENVIRONMENT

J.R. DURAND, D. PETIT

ABSTRACT

The Java Sea is mainly a continental shelf with an average depth of 40 m and is controlled by the monsoon cycle : eastward current during North-West monsoon, westward current during South-East monsoon.

Surface salinity is the best known parameter and its variations allow to describe the global circulation scheme in the Java Sea region. More in depth studies should be conducted to give a more accurate description which would take into account variability according to water depth, regions and years.

Despite scarce environmental data, hypothesis on the level of productivity and a more oriental definition of the Java Sea pelagic resources system are given in this article.

Laut Jawa adalah dangkalan benua dengan kedalaman rata-rata 40 meter dimana daerah tersebut terutama dipengaruhi oleh siklus muson: arus dari arah Timur pada musim muson Barat daya dan arus dari arah Barat pada musim muson tenggara.

Salinitas permukaan adalah parameter yang sudah banyak diketahui dan variasinya dapat menggambarkan sirkulasi masa air secara menyeluruh di perairan Laut Jawa. Penelitian yang lebih mendalam perlu dilaksanakan untuk memberikan gambaran yang lebih tepat berdasarkan kedalaman, daerah dan tahun.

Didalam makalah ini, meskipun data tentang lingkungan masih kurang, hypotesa pada tingkat produktifitas dapat disajikan bersama-sama dengan definisi sistim sumber daya pelagis pada bagian yang lebih Timur dari Laut Jawa.

INTRODUCTION

A good understanding of the ecosystem 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 in a chain of consequences such as climatic variations and global productivity, importance of recruitment for such species and fish availability for fishermen.

There is a need of knowledge on environment. Studies have been identified by the PELFISH initiators as early as 1990 but such programs on environment or productivity issues requiring specific means and skills could not be conducted. Thus we choose to gather and exploit existing informations. In a further publication we will give the results of the measurements performed during the fifteen **Bawal Putih I** acoustic cruises which happened between December 1991 and March 1994.

These horizontal transects and vertical stations should allow us to give a good description of the temperature and salinity variations during two successive annual cycles. Since global studies are quite old it will constitute an important contribution on environment issues. For now we will mainly refer to works such as Wyrtki's or Veen's, that is to say works which are 30 or 40 years old. Since that time only scarce and partial observations have been made. This paper is also an opportunity to point out the most obvious lacks.

Our contribution is not the first of this type on the Java Sea environment topic. More specifically, we relied on three papers and their, more or less, general description : Potier *et al.* (1989), Potier and Boely (1990), Boely *et al.* (1991).

1. GENERALL LANDMARK

1.1 Physical features

The great Sunda shelf extends from the Gulf of Thailand southward through South China Sea between Malaysia, Sumatra and Kalimantan, and the Java Sea represents its South-eastern part (fig. 1). It is a large and shallow water mass which has been exundated several times during Pleistocene (Emery *et al.*, 1972) when Sumatra, Java and Kalimantan where joined together with the Malacca peninsula.

Morphologically, the Java Sea is roughly rectangular (fig. 2). It is well delimited on three sides materialized by three huge islands : Kalimantan, Sumatra and Java. In its western part, it remains open with the Sunda Strait, between Sumatra and Java, giving way to the Indian Ocean and the Karimata Strait opening northward on the South China Sea. Obviously the eastern boundary has not the same meaning, as it is wide open toward the Flores Sea and the Makassar Strait.

This quick description already gives three essential features of the ecosystem :

- The discharge of continental freshwater is considerable through Kalimantan (mainly) Sumatra and Java rivers. It partly explains the low salinities encountered seasonally (cf. below, 2.1).
- The seasonal exchanges with the South China Sea through the Karimata Strait should not be underestimated, even if we don't follow Hardenberg (1937), who quoted Berlage calculations on the Java Sea being **"swept clear twice a year"**.

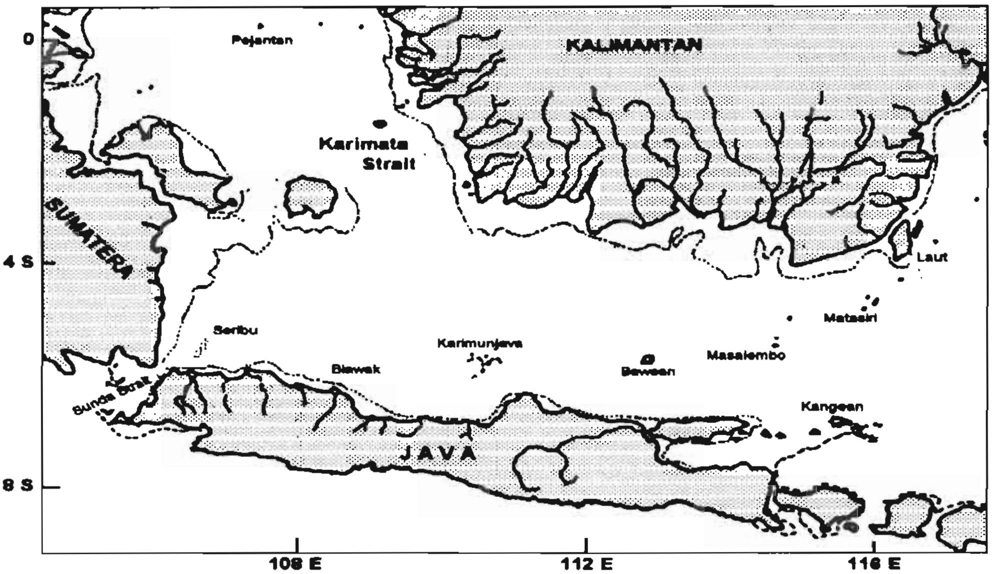


Figure 2a

JAVA SEA SURROUNDINGS AND TOPONOMY

PERAIRAN LAUT JAWA DAN BEBERAPA NAMA PULAU YANG PENTING

..... 20m isobath

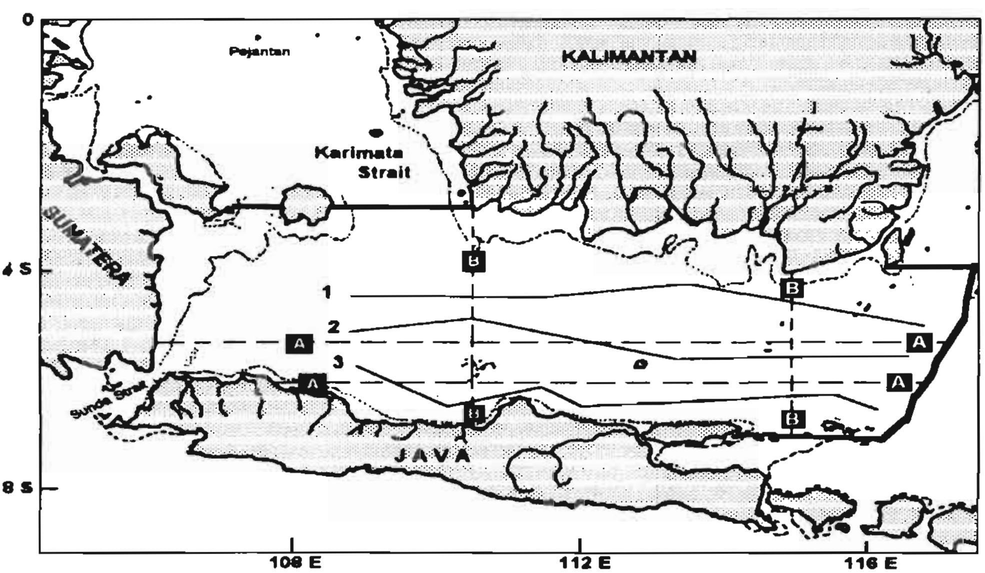


Figure 2b

LIMITS OF THE JAVA SEA AS DEFINED IN THIS ARTICLE

1,2,3 = Position of the transects of vertical profiles salinity

A-A,B-B= Positions of the bathymetric profiles

BATAS LAUT JAWA YANG DIMAKSUD DALAM TULISAN INI

1,2,3 = Posisi dari pada transek dari profil vertical salinitas

A-A,B-B= Posisi dari profil batimetrik

■ The eastern delimitation of the Java Sea raises a main issue : what are the relations with the eastern part of the Indonesian Archipelago ?

From the above description we could give an estimation of the Java Sea total area. We choose to define Java Sea as the area of marine waters -for depth less than 100 meters- delimited by the coasts of Sumatra, Java and Kalimantan, latitude 3° South for the Karimata Strait and 4° South for the Makassar Strait (fig. 2b). Owing to planimetric processing we obtained 442 350 km^{-2}. In fact, one could ask if near the eastern border, the estimation should not include a large part of continental shelf in the Makassar strait (this northern extension represents 57 790 km^{-2} above 100 m deep). In the same way, the southern Bay of Madura (fig. 2a) could be taken into account : 10 000 km^{-2} less than 100 m deep. Even excluding the South China Sea, these few remarks demonstrate that for biologists and ecologists the Java Sea concept is not as clear as it is for geographers. It explains why the Java Sea area is sometimes given with different values from one paper to another.

The average depth of the Java Sea is about 40 m and in longitudinal axis, its bottom is slightly sloping toward East. The maximal depth is found North of the Madura Island (fig. 3a). It is interesting to notice that there is a clear dissymmetry between the coasts of Kalimantan and those of Java, with shallow waters much wider in the northern part than in the southern one (fig. 3b). According to the spatial definition given above, deep waters (i.e. more than 50 m deep) represent 156 000 km^{-2} (about 35% of the total area) whereas the coastal shallow ones, less than 10 m deep, cover 30 300 km^{-2} (nearly 7%).

From West to North-East many islands and/or coral reef lie in the Java Sea (fig. 2a) : Seribu, Biawak, Karimunjava, Bawean, Masalembo, Kangean, Matasiri. Except for the Seribu Islands they all correspond to pelagic fishery zones. According to Emery (1972) the bottom of the Java Sea is -mainly 90%- constituted of a deep dense mud layer. During the **Pechindon** campaign (Boely *et al.*, 1991), large beds of mud mixed with shell and coral debris were detected in the central part and South of Kalimantan. Near the coast, rocky outcrops associated with coral formations are observed.

1.2 Climatology

This general description of main climatic features, important for the understanding of the Java Sea functioning, comes from Potier *et al.* (1989).

The prevailing climate in the Java Sea is a typical monsoon climate marked by a complete reversal of the winds regime. This phenomenon is caused by differences in temperature between the continental and oceanic areas. The rainy monsoon occurs between mid December and March and is characterized by very windy periods with frequent rainfalls lasting for days. The dry monsoon occurs from June to September and is more regular. The climate varies considerably throughout this zone.

■ Winds

These are the essential feature of the climate. From November to February they blow from the North-West with an average intensity of 3 Beaufort. From May to September they blow in a South to South-East direction and are more regular, their force sometimes exceeding 4 Beaufort. During the transitional months they are light and very variable (fig. 4a and 4b). Land breezes may upset the general pattern.

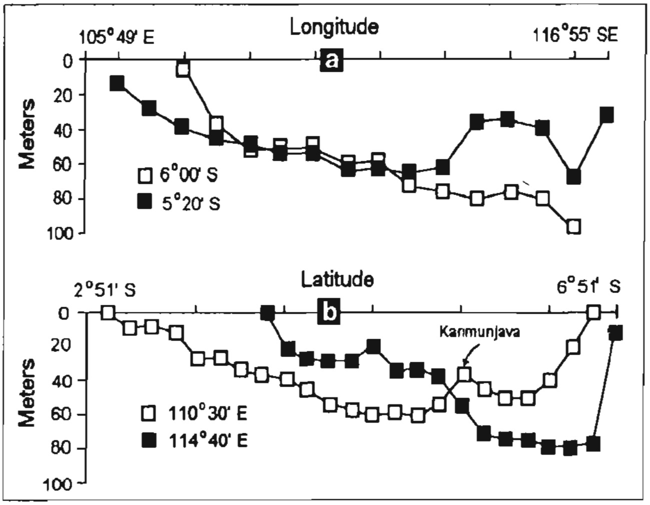


Figure 3a

Longitudinal Java Sea bathymetric profiles

Profil irisan melintang batimetrik di Laut Jawa

Figure 3b

Latitudinal Java Sea bathymetric profiles

Profile location is indicated on fig. 2 b

Profil batimetrik di Laut Jawa

Lokasi profil ditunjukan pada gambar 2b

■ Rainfalls at sea

Rainfalls at sea follow a very peculiar rhythm (fig. 5). The rainy season lasts from December to March reaching its maximum in January and February. The dry season occurs from July to October with a characteristic minimum in September, sometimes less than 50 mm. There is a clearly marked West to East gradient (Wyrtki, 1955), the most abundant rainfalls being observed off the Sumatra and Kalimantan coasts. The average annual rate is 1 880 mm. The relative humidity decreases from February to November. Due to heavy rainfalls during the first two months of the year, it decreases during the transitional months, becoming light when the South-East monsoon sets in.

■ Air temperature

The intensity of the monsoon is indicated by the monthly means. In general, the temperature is lower when the monsoon is more regular and lasts longer. During the North-West monsoon, it comes with increasing rainfalls. The average monthly temperature is 27° C and the daily amplitude is much higher in the transitional months. Maxima are recorded between 12:00 and 16:00, except during the North-West monsoon when the extent of the cloud layer and the abundance of the rain cause many daily variations in temperature. Following a semi-annual rhythm, maxima are reached in the inter-monsoon periods whereas the minima correspond to the monsoon periods (fig. 6).

2. The hydrological parameters : salinity and temperature

From the first investigations of importance by Van Veel (1923), various works and results have been produced. All are agreeing with the description of the average phenomena. More recently, since 1950, information originated from commercial ships (hydrological and meteorological measurements) allowed to establish maps with an average distribution of the parameters by geographic square.

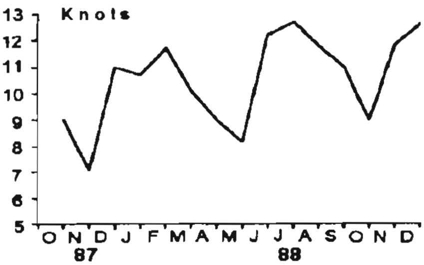


Figure 4a

Average velocity of the winds in the Java sea from October 1987 to December 1988
Kecepatan angin rata-rata di Laut Jawa dari oktober 1987 sampai desember 1988
SHIP data from Potier and Boely, 1990

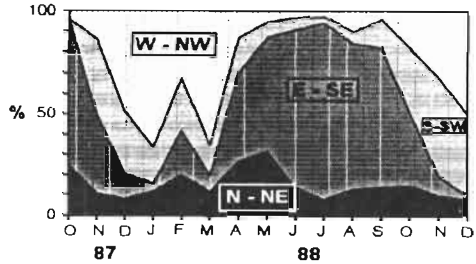


Figure 4b

Monthly distribution of the winds direction in the Java Sea from October 1987 to December 1988
Distribusi bulanan arah angin di Laut Jawa dari oktober 1987 sampai desember 1988
SHIP data from Potier and Boely, 1990

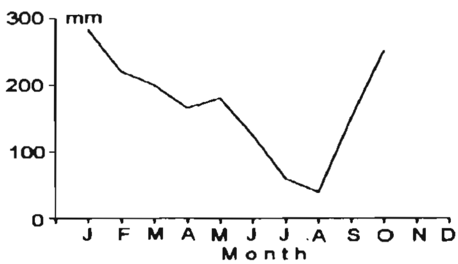


Figure 5

Monthly average rainfall in the Java Sea
Rata-rata curah hujan di laut Jawa
From Wyrtki, 1956

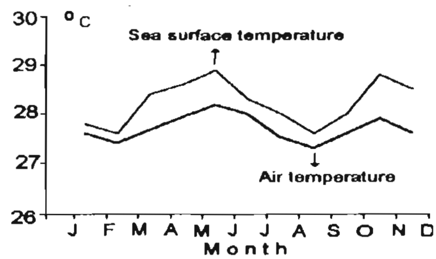


Figure 6

Monthly average air and sea surface temperatures in the Java Sea
Rata-rata bulanan suhu udara dan permukaan air laut di Laut Jawa
SHIP and Wyrtki data, 1956

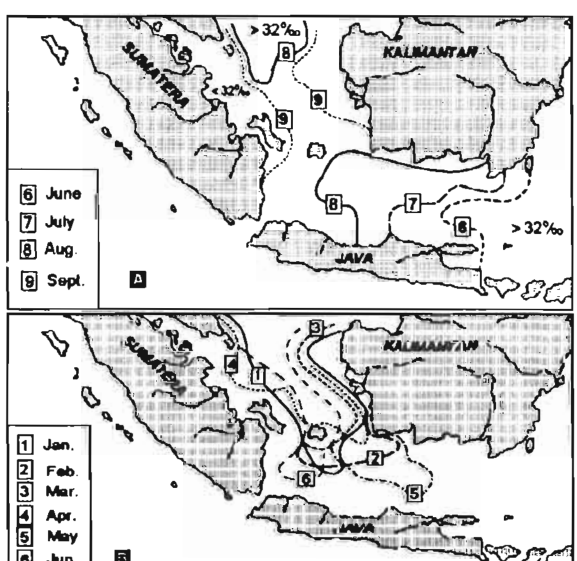
Figure 7

The position of the 32 ‰ isohaline
Gambaran isohalin 32 ‰

***A** : From June to September 1950 showing the advance of high salinity waters from the East*
Dari Juni sampai September 1950 memperlihatkan desakan masa dengan salinitas tinggi dari Timur

***B** : From January to June 1953 showing the position of the tongue of high salinity entering the Java Sea in North West mooson*
Dari Januari sampai Juni 1953 memperlihatkan posisi lidah masa air salinitas tinggi memasuki Laut Jawa pada musim Barat daya

(Wyrtki, 1961)



2.1 Salinity

From the classification established by Wyrtki (1956-1961), we can consider 4 types of waters circulating seasonally in the Java Sea.

- The oceanic water masses coming from the Pacific and the Indian oceans. Permanently present in the eastern part of the Indonesian archipelago, they can reach the Java Sea through the Makassar Strait or through the Flores Sea. Their salinity is more than 34‰. All the other waters have been more or less subject to a mixing. They are :
- "mixed" waters between 34‰ - 32‰, mixed waters from the South of the China Sea, or oceanic waters mixed with rainfalls or streaming in the Java Sea.
- "Coastal" waters between 32‰-30‰, like the diluted waters from the South of the China Sea by streaming along the East Sumatra or South Kalimantan borders.
- "River" waters below 30‰ which represent coastal waters more diluted at the mouth of rivers.

In reality, there are only two types of original waters in the Java Sea : one from the West (South of the China Sea) and one from the East, oceanic.

The moving and/or the formation of these types of waters are ruled by the alternative system of the monsoon : the wet monsoon from North-West, the dry monsoon from South-East.

From June to October, the dry monsoon blows from South-East. Rainfalls are scarce and limited. Figure 7A (Wyrtki, 1961) gives the progressive penetration of the oceanic waters into the Java Sea, by means of the retreat of isohaline 32‰. Figures 8a and 8b, from Veen, 1953, represent the progression of high isohalines westward.

From December to March, the wet monsoon blows. The waters from the South China Sea push off the waters in place and enter throughout the Karimata Strait. Figure 7B, from Wyrtki 1961, shows isohaline 32‰ moving toward the East during this season. Owing to rainfalls and river outflows, an intense dilution develops, progresses from the coasts (Sumatra, Kalimantan) then reaches the whole Java Sea. Figures 8c and 8d, Veen 1953, show the increasing dilution whereas the South China Sea waters push is carrying on. In March diluted waters have overrun the Java Sea.

When in June - July the winds from the South-East monsoon blow again, the oceanic waters entering into the Java Sea, push on the diluted waters westward and toward the coasts. So by 107-108°E, we encounter two minima of salinity every year. (fig. 9, from Soeriaatmadja, 1956).

Compared with the oceanic annual variations, the average annual variations of the Java Sea are very large : from 30.8 to 34.3‰ in the eastern part, and from 30.6 to 32.6‰ in its western part, due to important discharges of the rivers (Kalimantan, Sumatra). The average minimum of salinity is near 31.8‰ from January to June, the maximum occurring in September (34‰) (Veen, 1953).

On an average, isohaline 34‰ moving eastward reaches the latitude of Semarang (111°E). Sixty per cent of the area would be covered by the waters from 32 to 34 ‰ all along the year, 15% of which being less than 32‰. Figure 9 (Soeriaatmja, 1956) gives a good illustration of waters permanently tending to be diluted with the western part from 109°E down to 33‰. But from one year to the other, due to important rainfalls, the variations of salinity concerns the maxima more than the minima.

2.2 Inner layers salinities

All the previous observations concern superficial and average measurements, whereas the depth of the Java Sea is about 40 meters. To our knowledge there is almost no deep hydrological measurements from the Java Sea excepted from **"Samudera"** (1956) but referring to the South coast of Kalimantan, and from **"Pechindon"** trips (1985) but located at the longitude of Karimunjava Islands.

During two recent trips in opposite season, some vertical profiles were assessed along three transects, with an automatic sensor profiler SEA BIRD and the average values by meter recorded. These positions are located in figure 2b. The data processing is still in progress but we can present here the first provisional results.

In October (fig. 10a), the North and South profiles show the presence of low dilution from the surface to 25 m depth, West of 111°E in the South, West of 109.30° E in the North. At the surface, isohaline 34‰ is significantly at the latitude of Semarang but further West in the northern part. All the water mass is occupied by waters more than 34.5‰ (maximum 34.7‰) until 113.3° E and even until the western limits of the observations. So at the end of the dry season at least half of the Java Sea waters would have been replaced.

In February-March, the dilution of the waters has already well forwarded but referring to Wyrtki's conclusions (fig. 7) the lowest salinity occurs one month later. At about 90 miles from the coast of Kalimantan (fig. 10b) we detected two zones of important low salinity; at the West, the first may continue throughout the West and represents the input of the low salinity waters from the Karimata strait; at the East, it is the low salinity waters from the complex of Barito rivers (Banjarmasin). In the North profile, the water salinity stands between 31.5 and 32‰ in the East; but they are more salted in depth in the West.

In the median transect, we found the same as in the North one, but the importance of higher salinity waters, in the West, increases. In the South transect, waters mainly have a 33-33.5‰ salinity. From this we observed at the entry of the Java Sea a clear pushing of salted waters near the bottom. In the South-West part, there could be waters more than 33‰, in full wet monsoon. It means that the Java Sea does not represent an homogeneous whole. During the year the northern half reveals high variations in salinity and is euryhaline (variations from 31 to 34.6‰) while the southern half, under permanent oceanic influence, has more limited variations (33-34‰). But we do not really know what is the evolution of the South-West part.

2.3 Temperatures

The following is adopted from Potier *et al.* (1989). The annual fluctuations of the surface temperature are relatively slight and the Java Sea has a great thermal stability with an annual average of 28° C and a gradient situated between 2° and 3° C (fig. 6) Usually during the North-West monsoon the highest temperatures are found in the East (Van Veel, 1923) and the lowest ones in the West along the coasts of Sumatra (influence of rainfalls). During the South-East monsoon this gradient is reversed and highest temperatures are then found in the West. The minima are observed in June-August and December-January (27°C), the maxima being

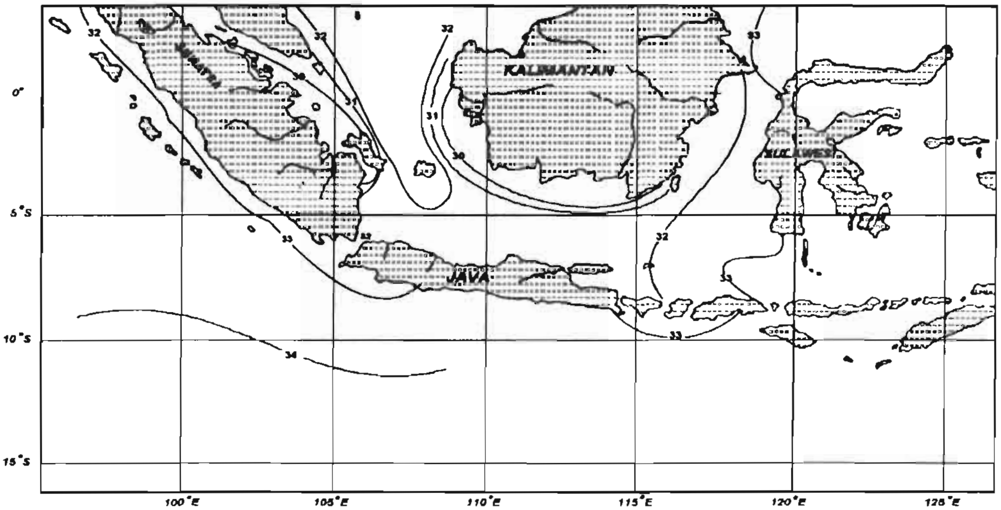


Figure 8a

AVERAGE POSITIONS OF THE ISOHALINES IN MAY (SURFACE SALINITIES)

POSISI RATA-RATA DARI ISOHALIN PADA BULAN MEI (KADAR GARAM PERMUKAAN)

(after Veen, 1953)

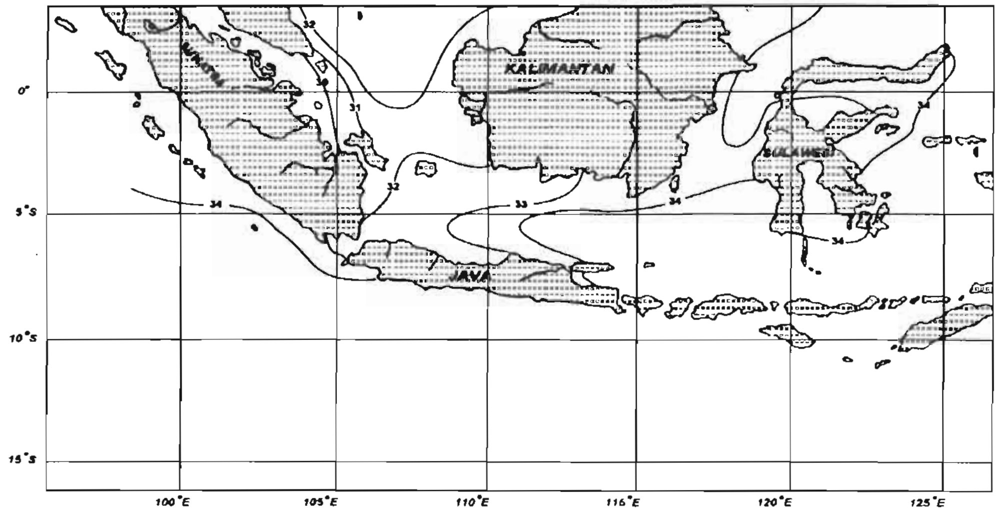


Figure 8b

AVERAGE POSITIONS OF THE ISOHALINES IN SEPTEMBER

POSISI RATA-RATA DARI ISOHALIN PADA BULAN SEPTEMBER

(after Veen, 1953)

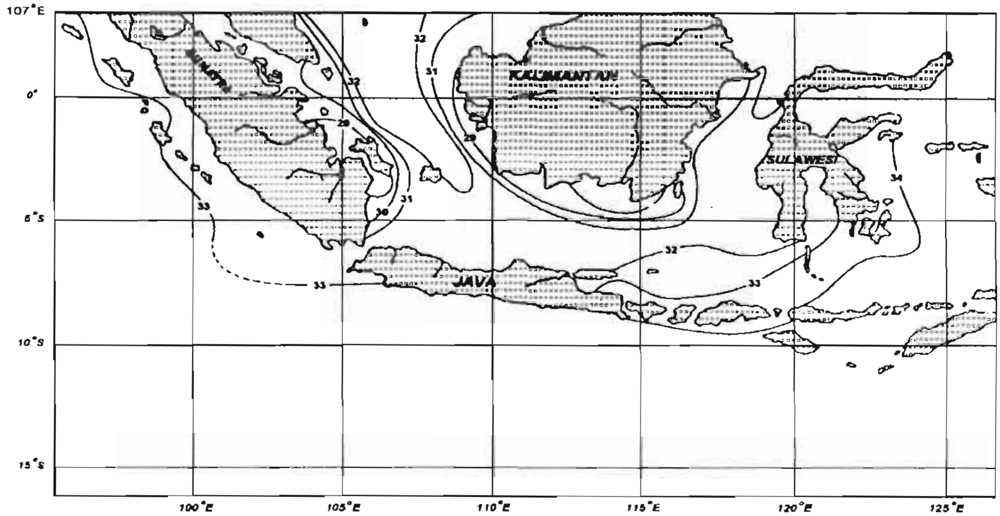


Figure 8c

AVERAGE POSITIONS OF THE ISOHALINES IN JANUARY

POSISI RATA-RATA DARI ISOHALIN PADA BULAN JANUARI

(after Veen, 1953)

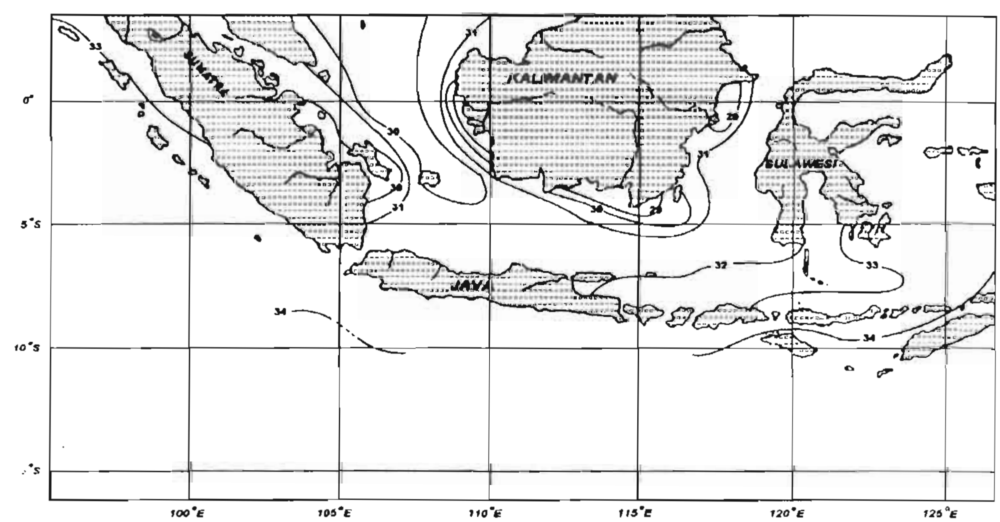


Figure 8d

AVERAGE POSITIONS OF THE ISOHALINES IN MARCH

POSISI RATA-RATA DARI ISOHALIN PADA BULAN MARET

(after Veen, 1953)

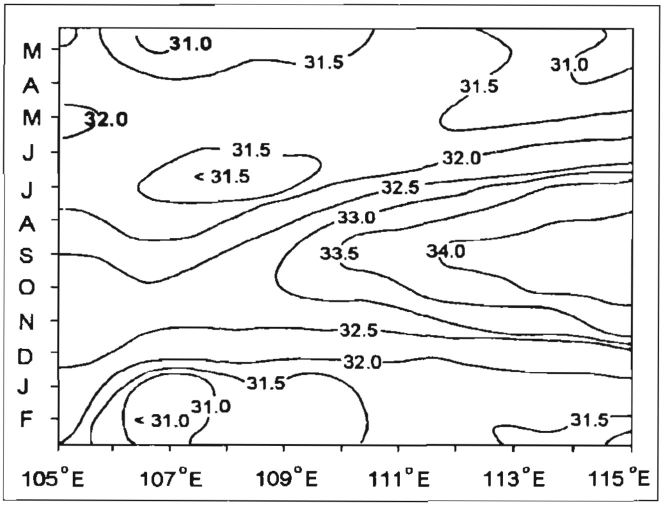


Figure 9

JAVA COAST ALONG THE YEAR EVOLUTION OF THE MEAN SALINITY BETWEEN 5° AND 6° S

EVOLUSI SALINITAS RATA-RATA ANTARA 5° DAN 6° LINTANG SELATAN, DI LAUT JAWA, SEPANJANG TAHUN

(after Soeriaatmadja, 1956)

recorded in April, May and November (30° C) in the inter-monsoon periods. The water mass itself is very homogeneous with slight thermal gradients from 1°C recorded in May 1985 during the **Pechindon** survey to 0,4° C recorded during the **Mutiara IV** campaigns (Losse and Dwippongo, 1977) in July-September. The vertical temperature stratification is not always found but no reverse phenomenon is observed. In the extreme eastern part of the region where depth exceeds 90 m a slight thermocline appears between 30 and 70 m at certain periods of the year (June-July). A study of the data provided by the Gosscompt charts, covering a period from June 1981 to December 1984 confirms these results. The data grouped per 1°15 * 1°15 squares show a noticeable homogeneity in latitude and longitude (fig. 11). The various cruises of the PELFISH Project do not bring further information.

3. THE CIRCULATION SCHEME

The development of a system of currents related to the winds in the Java Sea is favored by the orientation of its basin in relation to the direction the monsoon blows. The settling of the currents is directly in relation with the winds, except on the coasts of Sumatra and Java, where local phenomena related to geography could interfere (Wyrtki, 1961). It seems that these phenomena have not yet been studied (fig. 12) .

3.1 Surface currents

During the South-East monsoon (June-September) the currents flow to the West at low speed (0.5 knot). They reach up 1 knot off Belitung Island. During the North-West monsoon (December-March) the pattern totally reverses and currents flow toward the East (1-2 knot) (fig. 13a).

During the inter monsoon, the current would flow toward the West along the coast of Kalimantan whereas in the whole Java Sea, they would be toward the East. (fig. 13b).

This is the scheme usually accepted, as resulting from the climatic conditions. Nevertheless, as mentioned before, it seems that the phenomena do not always follow the general pattern.

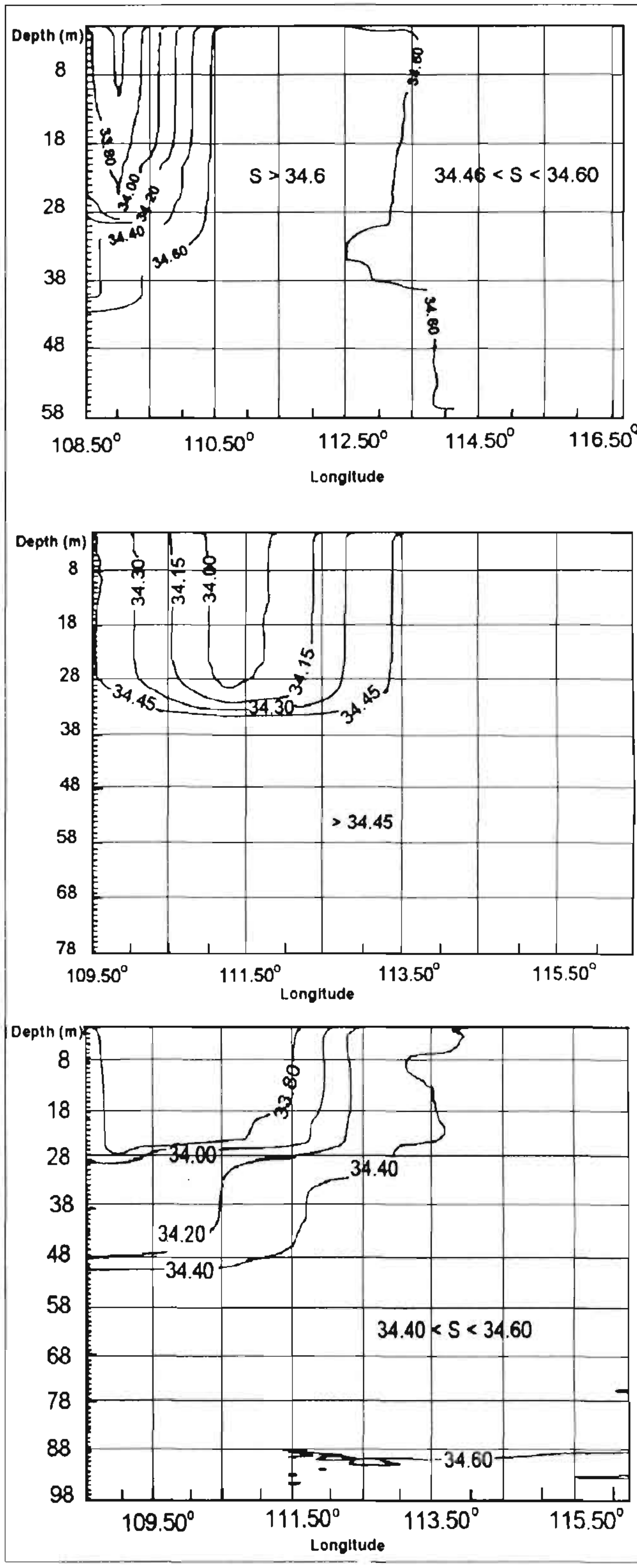
Figure 10a

JAVA SEA : W-E VERTICAL PROFILES OF SALINITY IN OCTOBER 1993

(position of transects in fig.2)

PROFIL VERTICAL SALINITAS DARI BARAT KE TIMUR PADA BULAN OKTOBER 1993 DI LAUT JAWA

(posisi transek pada gambar 2)



In the North
Pada bagian Utara

In the middle
Pada bagian Tengah

in the South
Pada bagian Selatan

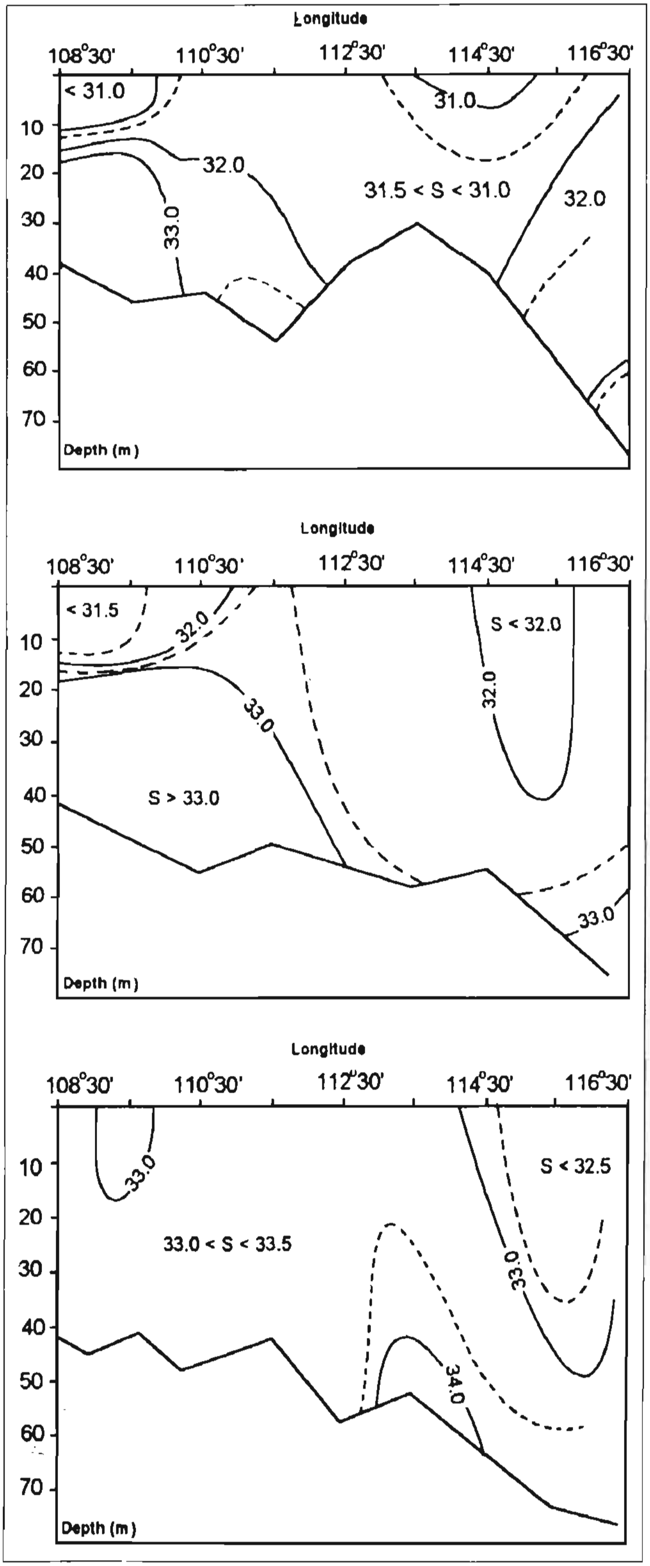
Figure 10b

JAVA SEA :
W-E VERTICAL PROFILES OF SALINITY IN FEBRUARY 1994

Position of transects in Fig. 2

PROFIL VERTICAL SALINITAS DARI BARAT KE TIMUR PADA BULAN FEBRUARI 1994 DI LAUT JAWA

Posisi transek pada gambar 2



In the North
Pada bagian Utara

In the middle
Pada bagian Tengah

In the South
Pada bagian Selatan

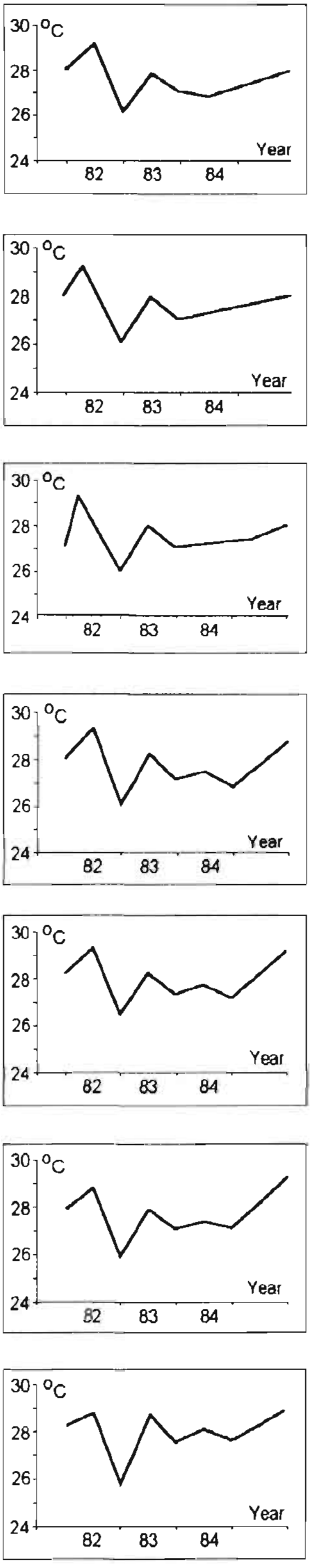


Figure 11

EVOLUTION OF THE SURFACE TEMPERATURE FROM JUNE 81 TO JUNE 85 IN THE JAVA SEA

EVOLUSI TEMPERATUR PERMUKAAN AIR LAUT DARI JUNI 1981 SAMPAI JUNI 1985 DI LAUT JAWA

(Gosscompt data), after Potier et al. (1989)

But to which extent? In February 1994 in the North-West of the Java Island (25 miles from the coast) in full West monsoon we met a superficial current toward the North-West. On the other hand, some people think that, during the inter-season the land winds can play an important role.

3.2 Inner layer currents

All the previous observations concern superficial and average measurements. Whereas the Java Sea is about 40 m deep, its whole East facade is open to influences from the Flores Sea, even if in the North-East bathymetry is less than 40 m in the South of Kalimantan.

As far as we know, no measurements of sub-superficial currents have been made in the Java Sea. Wyrtki (1961) considered that owing to depth of these shallow waters and to the winds steady at every season, the surface currents have to concern the whole water mass with the same celerity. But isohaline maps may contradict this early conclusion. The two groups of profiles we present (fig. 10a and 10b) clearly show that the system of underwater current do not entirely follow the superficial ones.

In October, the underwater currents clearly flow from the East but apparently their celerity seems higher in the North and the South where the salinity reaches the maximum values. Horizontal profiles at 10, 30, 40 m show that the current is entering from the North-East. But the most interesting are the vertical profiles from February (fig. 10b). That point out the quasi permanence of an underwater current from East during the wet season. Otherwise, how could we explain the permanence of salted waters along the coast of Java although the northern part is submitted to a heavy dilution ? Thus during the wet season, there could be in the Java Sea a system of current similar to an anti-estuary circulation. And what about the South China current in the wet season ? Various vertical profiles made in April 1993 are presented in figure 14. When, in March, were found 33-

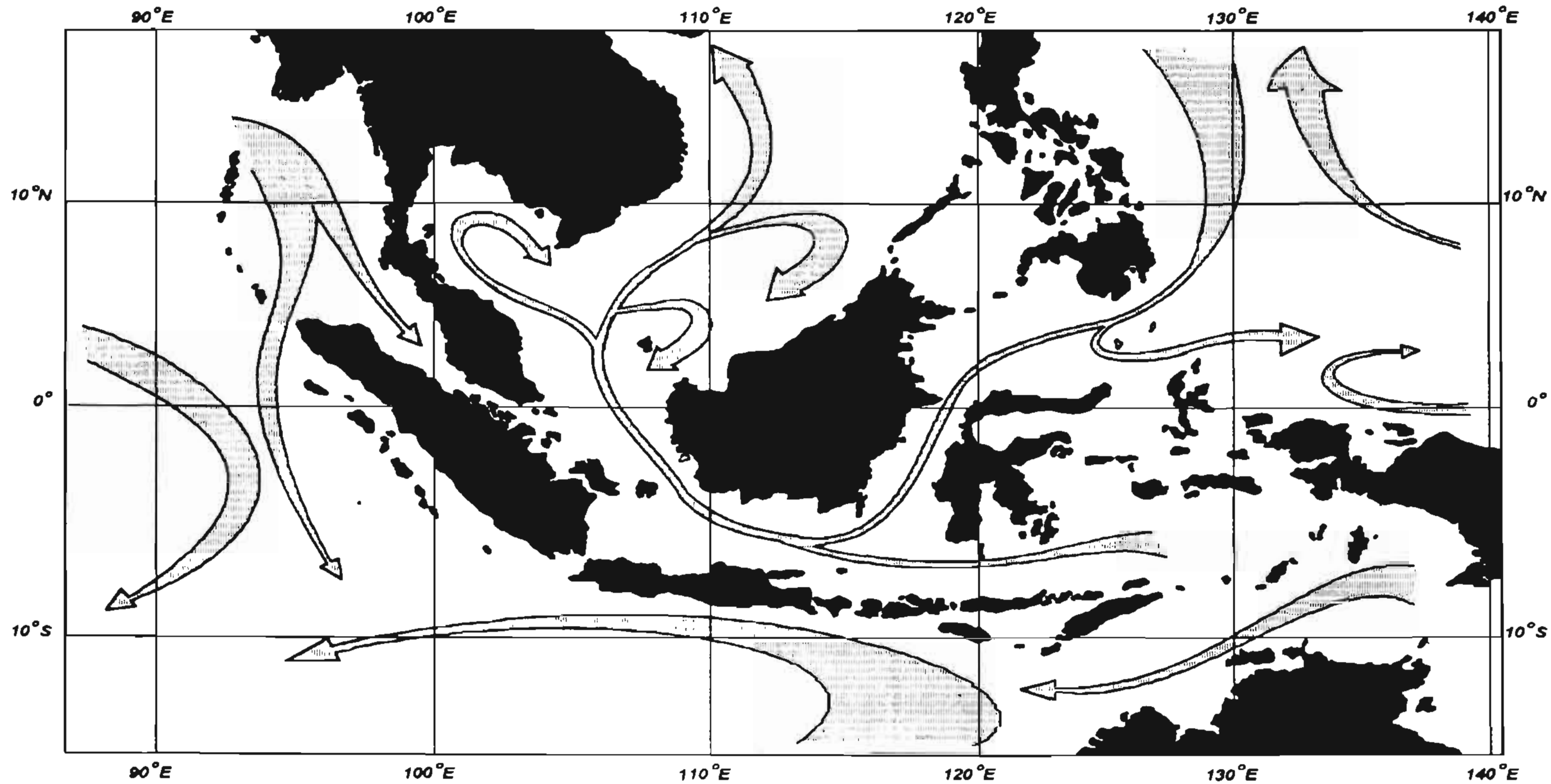


Figure 12

SURFACE CURRENTS IN SOUTH ASIA IN AUGUST

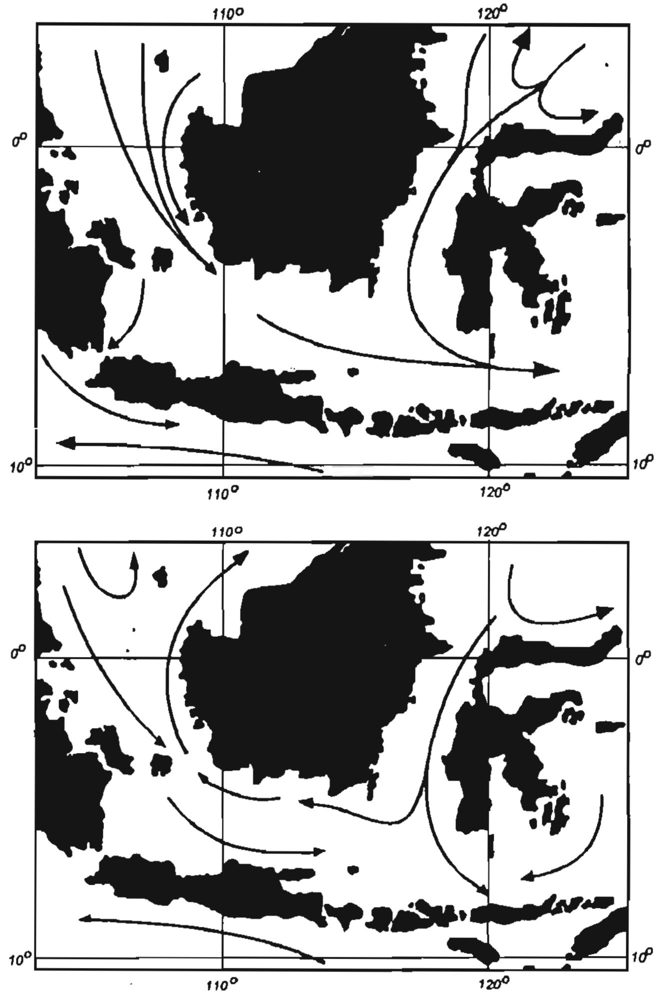
ARUS PERMUKAAN DI ASIA SELATAN PADA BULAN AGUSTUS

(From Wyrtki 1961)

Figure 13

SURFACE CURRENTS IN THE JAVA SEA

ARUS PERMUKAAN DI LAUT JAWA



a: February
Pada bulan Februari

b: October
Pada bulan Oktober

(after Wyrtki, 1961)

35.5‰ waters in the South-West part of the Java Sea, we also found them along a transect toward the Karimata Strait. During the second part of the wet season, it seems that there is no hyaline separation between South-West and Karimata Strait inner layer waters.

4. PRODUCTION AND RESOURCES

As far as we know, there has never been any comprehensive study about the productivity of Indonesian marine waters. The data is scarce and was mostly collected years ago. A special mention should be made for the **Pechindon** trip which gave a complete description for the whole layer in the central Java Sea for May 1985 (Boely *et al.*,1991).

4.1 Oxygen and nutrients

During the **Pechindon** trip (May 1985) oxygen measurements have been performed from

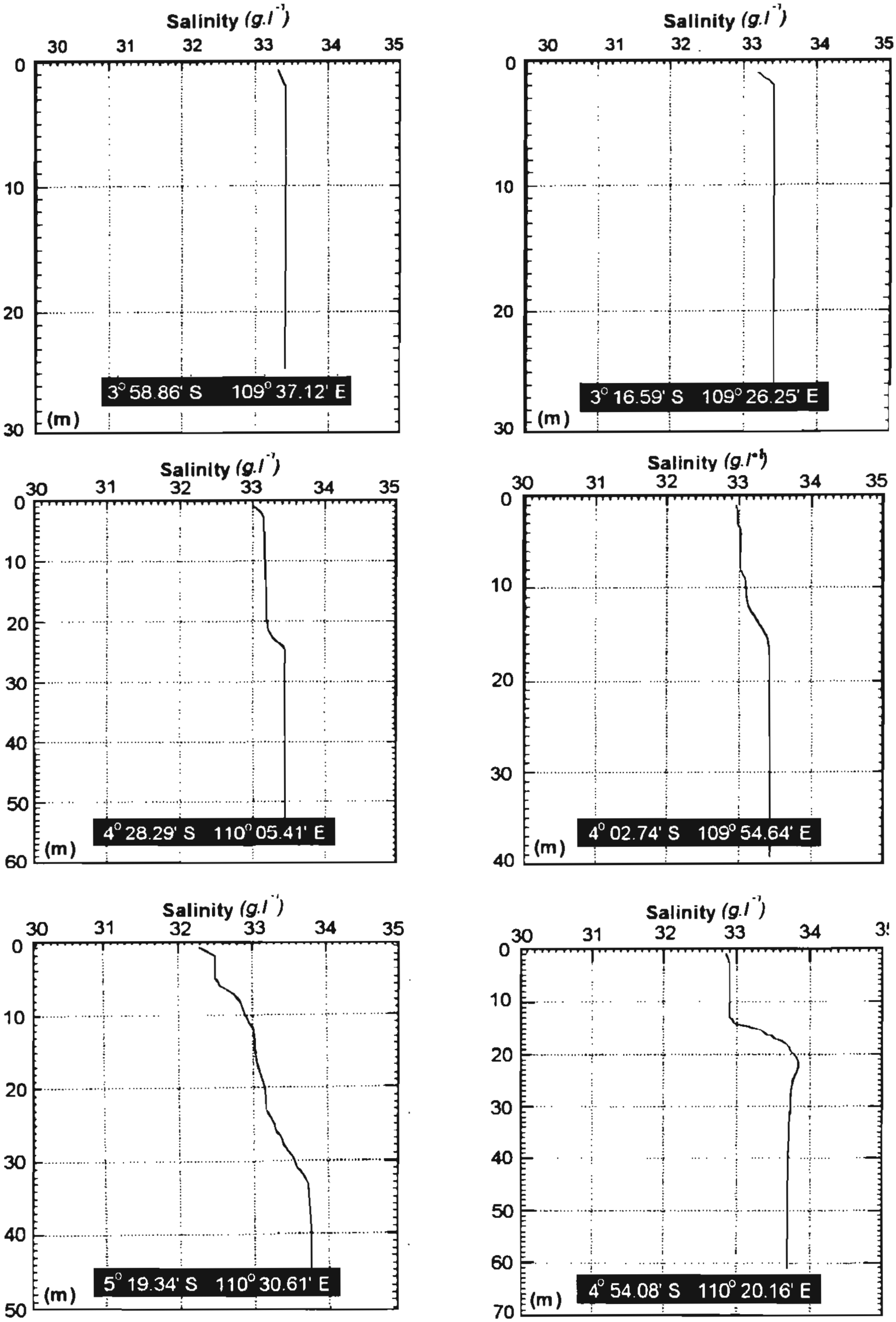


Figure 14

FROM THE JAVA SEA DOWN, TOWARD THE KARIMATA STRAIT, HALINES PROFILES IN APRIL 1993

PROFIL SALINITAS BULAN APRIL 1993, DARI LAUT JAWA MENUJU SELAT KARIMATA surface to bottom in 21 stations. They are distributed from the Karimata Strait and the South Kalimantan coast to the North Java coast in waters at least 20 m deep. All measurements gave high O_2 values: everywhere near the bottom O_2 was more than 4 ml/l and we may conclude that the whole water mass is well oxygenated (fig. 15a). at least at this time of the year. The only other measurements we found concern a few stations located from the Karimata strait to South eastern Kalimantan and performed by the **Samudera** in January 1956. All O_2 measures were high near the bottom : from 4.5 to 4.7 ml/l.

The seasonal distribution of nutrients in the Java Sea is quite unknown. In his paper about the Makassar Strait productivity, Ilahude (1978) wrote that "**the influence of the Java Sea waters in the productivity of the region is also strong [It brings] high phosphate, high nitrate and high silicate...**" We could not find the origin of such an assertion. On the other hand, during their May 1985 trip, Boely *et al.* did not find very significative concentrations of PO_4 or NO_2-NO_3, the only exception being for nitrates in transect III near the bottom (fig. 15b). Doty *et al.* conclusion (1963) seems to remain valuable : "**quantitative determination of such fertilizer salts as nitrates, phosphates and silicates should be added to the biological measurements**".

4.2 Chlorophyll a

Few papers give a first idea about a primary production : Doty *et al.* 1963 (November 1957 stations in the Malacca Strait, South China Sea and western part of the Java Sea) Soegiarto and Nontji, 1966; Nontji, 1972 (two cruises in September-October 1964 and March-April 1965 in the Java Sea); Boely *et al.* 1991 (May 1985 cruise in the Central Java Sea). According to Nontji the main values were approximately similar during the two cruises -that is to say at the end of the South-East and North-West monsoons - with 0.18 and 0.19 mg/m3 chl.a. Values higher than 0.2 mg/m3 were found along the South coast of Kalimantan during the two cruises with highest values recorded off the Barito river: 0.62 mg/m3 in March-April and 0.85 mg/m3 in September-October.

Pechindon results in June 1989 show the same range of values generally low (between 0.2 and 0.3 with two surfaces exception, towards Kalimantan again and East of the Karimunjava Islands (fig. 2a)). It is interesting to notice that intermediate waters may present a maximum toward 20 m (fig. 15c) which could be correlated with a vertical salinity gradient. On the whole, chlorophyll surface contents were 3 to 4 times lower than in the deeper layers measurements.

4.3 Primary productivity

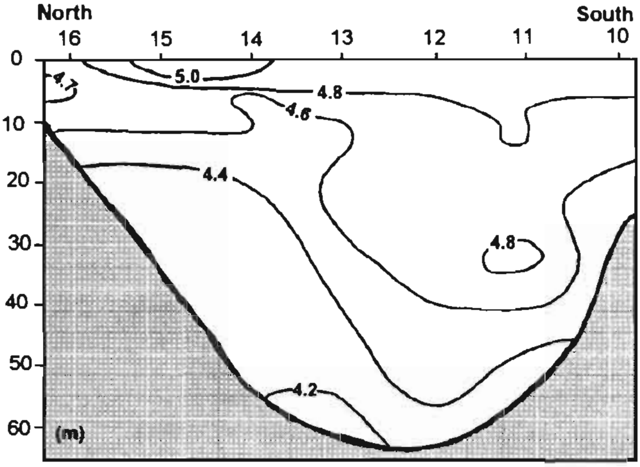
Some values of productivity are given by Doty *et al.* (1963) and Soegiarto and Nontji (1966). According to these authors the productivity measurements showed higher values during the East monsoon than during the West monsoon for open waters. In November 1957, in the western part of the Java Sea "**productiveness less than 0.2g/C/dy/m^2 characterizes the region**". The same authors gave a clear demonstration of the "**land mass effect**" for the Malacca Strait and West Kalimantan. This positive effect of run off water has also been demonstrated in the South Kalimantan Barito river.

Figure 15

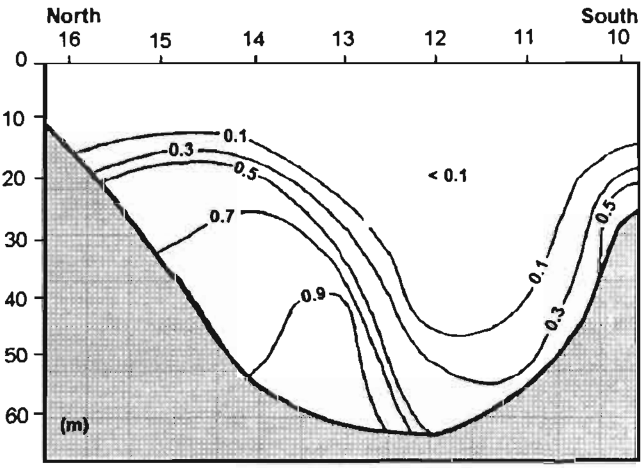
NORTH-SOUTH CROSS SECTION ALONG 111° EAST

IRISAN UTARA SELATAN PADA 111° BUJUR TIMUR

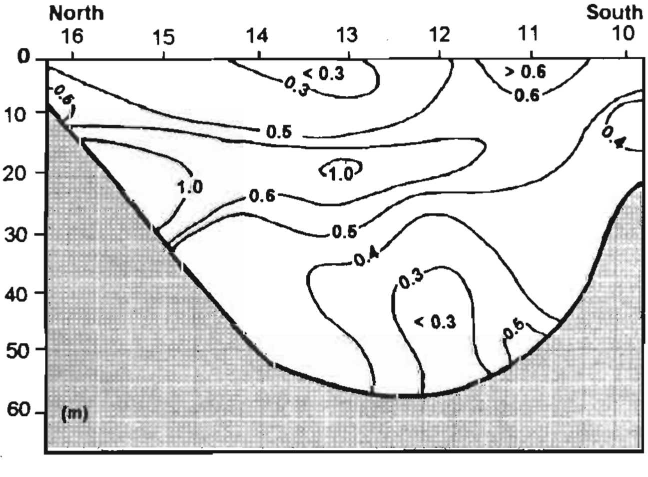
From Boely et al. 1991 : June1985, Pechindon cruise



Oxygen (ml/l)
Oksigen (ml/l)



Nitrates and Nitrites (µatg/l)
Nitrat dan Nitrit (µatg/l)



Chlorophyll a (µatg/l)
Chlorofyl a (µatg/l)

According to Nontji (1977) : **"the enrichment effect of the river was clearly seen at the three stations located near the river mouth, the further from the mouth the less the chlorophyll values were, i.e. 0.62, 0.42 and 0.23 mg/m^3. The same proved to be true for the productivity values (measurements following Doty & Oguri, 1958) i.e. 6.92, 3.01 and 1.83 mgC/hr/m^3."**

Doty *et al.* quoted Steeman-Nielsen and Aabye-Jensen (1957) who made some productivity measurements during the **Galathea** trip (1959-1952) : **"all their stations in relatively shallow waters of the Indo-Malay area yielded high rates of production, i.e. between 0.24 and 1.08 g/C/dy/m^2"**. From their results and the above quotation they concluded that **"the shallow Indonesian waters are as productive of organic waters as the most productive waters elsewhere in the tropics."**

Further investigations are needed to get a better evaluation of the primary productivity in the Java Sea in order to be more specific about this general conclusion. On the whole, even if measurements are scarce and made thirty years ago, the land mass effect is obvious and gives a noticeable enrichment during the whole year. Furthermore during the South-East monsoon there could be an enrichment through expelled waters, South-West of Sulawesi (Ilahude, 1978).

4.4 Fish Production

Fish yields in the Java Sea could give us another way to answer the question about productivity level in this shallow marine system. Obviously, when fish production (at least non harvested i.e. total catches) is high, the ecosystem productivity is high too. Marten and Polovina (1982) have carried out a very global study on fish yields from various tropical ecosystems. In comparative terms they noticed that " fin-fish catch from lakes, reservoirs, rivers, continental shelves and coral reefs fall in approximately the same range as model values in a range of 3 to 6 tons/km^{-2}/year."

For the Java Sea we used figures given from Potier and Sadhotomo who gave the main marine statistics for Indonesia and for the Java Sea in 1991 (General Directorate of Fishery). The total fish production is assumed to be 700 000 tons of which 485 000 were pelagic and 215 000 demersal fish. Related to the Java Sea area as quoted above, it means that the yields for pelagic fishery should be around 1.1 ton/km^{-2}/year and the demersal yield around 0.5 ton/km^{-2}/year.

This total average value, 1.6 ton/km^{-2}/year lays far below the estimated general range given above. Of course the method used to get this 3 to 6 ton average range could be questioned as neither MSY values nor primary productivity values seem highly reliable. Another point is the choice of area values for pelagic fishery. Lately the rate of exploitation should be taken into account. On the whole the exploitation pressure seems fairly high for coastal stocks (with some over-exploitation cases). For the offshore fisheries, demersal resources are probably under-exploited and pelagic resources fully exploited. In order to correct the previous estimation, a global sustained value could be around 2 tons/km^{-2}/year. It would mean -with all usual precautions- that the open waters productivity would not be very high. Anyway, it also means that we actually need further global studies on productivity.

CONCLUSION

From this short presentation on environmental issues it appears that in this field the acquired knowledge is noticeable but not accurate enough to answer the main questions regarding the functioning of this ecosystem.

The general climatic scheme is quite clear, at least concerning the Java Sea and the monsoons regime. Winds are seasonally reversing and so are the currents in the Java Sea : westward flow during the South-East monsoon, eastward during the North-West monsoon. Water salinity seems to be the most important parameter to be studied because it is convenient to show the evolution of water masses and because its variations have great ecological consequences.

Nevertheless it should be underlined that most hypothesis and demonstrations are relying on surface observations generally extended to the whole layer. We think that a possible gradient should be taken into account (*cf.* for example salinity section on fig. 10). Also we think that the circulation model could be more precisely described than it has been until now : dissymmetry from North to South, coastal countercurrents, specific behavior of most western water-masses.

At the time being we are not able to give a liable rough estimation of the renewal rate of water-masses and of their variations through space and seasons. The general importance of fresh waters impacts through rain at sea and outer inflows is well demonstrated. It has a major impact on salinity and on productivity through the river outputs of organic and minerals materials. It seems that Kalimantan plays a first role from that point of view, with fresh waters pouring from West and South during the North-West monsoon. With liable data it should be possible to make a quantitative estimation of fresh waters coming in the Java Sea; it supposes to search for hydrological and meteorological data around the Java Sea.

Even if we could have made a more precise description of an average hydro-climatic functioning scheme, it would not have been sufficient as inter-annual variability should also be assessed. For the time being, we are able to identify two sources of variability: regional modulations of the monsoon regime bring about variabilities on winds and sea currents, and on rainfall. From another point of view, the intrusion of oceanic waters during the South-East monsoon could be more or less directly related to El Nino southern oscillation (ENSO) in the Pacific waters. Quinn *et al.* (1978) demonstrated that unusually heavy precipitation in the coastal and western equatorial Pacific and Indonesian droughts were closely associated with El Nino type of events.

There is no need stressing on the major consequences for biology and ecology : spatial heterogeneity, vertical gradients and inter-seasonal variabilities determine productiveness, species recruitment, fish availability. It is quite obvious that management of pelagic resources refers to more accurate exploitation data but also to a better understanding of the functioning and time series data on climate and environment (cf. Freon and Saila 's contributions to this seminar).

Eventually, it remains difficult to give an evaluation of the Java Sea productivity. According to scarce and old data, we tend to think that the "specific productivity is not very high itself but is compensated by "external" inputs such as river flows and Flores Sea waters. At the present time, it is more an hypothesis than a proved demonstration.

A few conclusions may be drawn from this provisional presentation on the Java Sea environmental issues :

- There are still many interrogations but it becomes more and more obvious that the geographical frame of the Java Sea should be reconsidered for Pelagic resources and offshore fisheries. We are led to a more oriental conception of the system including seasonally the Makassar Strait waters and the East Kalimantan shelf, and excluding - maybe - the most western part, near Sumatra. This conception is confirmed through several contributions in this seminar about fishery and echo-prospecting results which should be presented in a further Projects's meeting.

- The inter-annual variability should be measured on a permanent routine basis. Whether it should be done through marine parameters measurements and/or through indirect climatic indications still has to be established. Remote sensing means could be very useful. In any case a better resources management and more prospective modeling are at stake.

- The available information on the Java Sea environment is noticeable and entire sets of data are still unused or not fully exploited : for example, the inter-annual salinity variability from 1940 to 1960; used winds and rains historic data; rivers discharge. But nevertheless, some specific programs on environment issues should be carried out in order to clearly assess the productivity and to understand the functioning of the Java Sea.

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SYSTEMATICS OF THE SMALL PELAGIC FISH SPECIES

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ABSTRACT

As part of the western Pacific region which has a greater diversity of species than the eastern Pacific or the Atlantic regions, the Java Sea has a wide variety of different taxonomic groups. Among the fish fauna of the small pelagics there are three families of Elopiformes, i.e., Elopidae, Megalopidae and Albulidae, and three families of Clupeiformes, i.e., Clupeidae, Engraulidae and Chirocentridae. Two families of Perciformes, i.e., Carangidae and Scombridae, are abundant in the Java Sea. The geographical distribution of the fish is mostly restricted to the tropical Indo-Pacific waters, i.e. between the 23° N and mid-Australia on each of its coast.

The distribution of the main small pelagic fish of the Java Sea is mainly restricted in the coastal waters and over the continental shelves. The fish are comprised of a variety of taxonomic groups which belong to several orders, i.e., herring-like fish of Elopiformes and Clupeiformes and perch-like fish of Perciformes.

Elopiformes sometimes enter brackish waters, while Clupeiformes are often truly coastal fish with high tolerance of low salinities, though not all of them are euryhaline. Most of the Perciformes live over continental shelves and in coastal waters.

Sebagai bagian dari wilayah Pasifik Barat yang mempunyai lebih besar keanekaragaman species dari pada Pasifik Timur.Laut Jawa mempunyai banyak jenis dari kelompok

taksonomi yang berbeda. Pada fauna ikan dari kelompok pelagis kecil terdapat tiga famili Elopiformes yaitu, Elopidae, Megalopidae dan Albulidae, dan tiga famili Clupeiformes yaitu, Clupeidae, Engraulidae dan Chirocentridae. Dua famili dari Perciformes yaitu, Carangidae dan Scombridae banyak terdapat di Laut Jawa. Penyebaran geografi ikan-ikan adalah terbatas pada perairan tropis Indo-Pacific, yaitu antara 23^o Lintang Utara dan kedua pantai pertengahan Australia.

Penyebaran dari ikan-ikan pelagis kecil yang penting di Laut Jawa terutama terbatas pada perairan pantai sampai paparan benua. Ikan-ikan terdiri dari bermacam-macam kelompok taksonomi yang termasuk dalam beberapa ordo, yaitu "herring like fish" dari Elopiformes dan Clupeiformes dan "perch-like fish" dari Perciformes.

Kadang-kadang Elopiformes memasuki perairan payau, sedangkan Clupeiformes sering benar-benar merupakan ikan-ikan pantai dengan toleransi yang tinggi terhadap salinitas yang rendah, walaupun tidak seluruhnya bersifat euryhalin. Sebagian besar dari Perciformes dapat diketemukan pada paparan benua dan perairan pantai.

INTRODUCTION

In general, the geographical distribution of small pelagic fish of the Java Sea is restricted to the tropical Indo-Pacific waters. Bond (1979) illustrates the region as those bordered by 20º C isotherm both to the North and South. The northern boundary is depressed South to the Hainan in the West, raises North to Taiwan and runs across the Pacific at about 23º N. The southern boundary extends from mid-Australia on each coast to near the coast of South America.

In fact, the western Pacific waters have a greater diversity of species than the eastern Pacific ones. Consequently, as part of the western Pacific region the Java Sea has a huge number of fish species both in marine and inland waters.

There is a sufficient wealth and diversity of pelagic fish in the Java Sea, and important fisheries such as purse seine, encircling net, Danish seine, beach seine, lift net and gill net are based upon them. The fisheries are driven by a local demand of fish products, i.e. fresh/ iced, dry/salted, ***"pindang"*** boiled salted, and smoked to supply the local food market in Sumatra, Kalimantan and chiefly in Java.

The habitats of small pelagic species are more restricted to the coastal waters and over the continental shelves of the Java Sea. As part of the western Pacific region which has a greater diversity of species than the eastern one, the Java Sea pelagic fisheries are based on a variety of different taxonomic groups of pan-tropical distribution.

The Java Sea small pelagic fish can be classified into several orders, i.e., herring-like Elopiformes and Clupeiformes, generally found over coastal waters and continental shelves, then perch-like Perciformes mostly carangids jacks and trevallies, and finally the scombroids mackerels which are of continental shelves.

One of the characteristics of the Java Sea fish fauna is its abundance of clupeoids and scombroids that are bentho-pelagic and are therefore frequently caught in demersal trawls (Saeger *et al.*, 1976; Widodo, 1976).

In addition to more important and familiar herring-like genera, e.g., *Sardinella* and *Amblygaster*, there are, in the Java Sea, some others quite different in morphology and ecology from those more typical forms. Among the six families of herring-like fishes found in the Java Sea, three of them belong to Elopiformes, i.e., tenpounders, *Elopidae*; tarpons, *Megalopidae*; and ladyfishes, *Albulidae*. The other three families belong to Clupeiformes, i.e., the predatory wolf-herring, *Chirocentridae*, sardines, shads, gizzard shads, *Clupeidae*, and anchovies, *Engraulidae*.

The species belonging to each family, local/common names, English vernacular names, their geographical distribution and behavior (most of them based on Fisher and Whitehead, 1974, otherwise stated) are listed as follows :

Elopids

■ Elopidae

Elops machnata (tenpounder), inhabits coastal waters, pelagic species. Geographical distribution : Red Sea, Gulf of Aden, Gulf of Oman, Zanzibar, coast of India, S. Africa, Indonesia, China, Japan, possibly to Hawaii.

■ Megalopidae

Megalops cyprinoides ("**bulan-bulan**", Indo-Pacific tarpon), inhabits coastal waters. Two species of megalops occur in the Indo-Pacific and Atlantic, respectively. Geographical distribution : East African coast, Indian coast, Indonesia, the Philippines and Australia.

■ Albulidae

There are two species of *Albula*, one ubiquitous and the other one restricted to the central American region of the Pacific and Atlantic oceans (Longhurst and Pauly, 1987). *Albula vulpes* ("**bandeng cururot** ", ladyfish), inhabits continental shelves, pelagic species. Geographical distribution : Red Sea, Gulf of Aden, elsewhere in all tropical seas.

Clupeids

■ Chirocentridae

Chirocentrus dorab ("**golok-golok**", Dorab wolf-herring), inhabits coastal waters, pelagic species. Geographically, *C. dorab* occurs only in the Indo-Pacific region from South Africa to the Red Sea and from Japan to New Zealand.

■ Clupeidae

Anodontostoma chacunda ("**selanget**", Chacunda gizzard shad), inhabits coastal waters, pelagic species. Geographical distribution : Persian Gulf, Indian Ocean to Indonesia, the Philippines, Melanesia.

Dussumieria acuta ("**japuh** ", rainbow sardine), inhabits coastal waters, pelagic species, in schools. Geographically distributed throughout most of the northern part of West Indo-Pacific, to northern tip of Australia, westward to East Africa and Madagascar and northward to Foochow.

Hilsa kelee (Kelee shad), inhabits coastal waters, pelagic species, not abundant. Geographical distribution : Persian Gulf, Gulf of Aden, western Indo-Pacific region from Natal (South Africa) to Burma and Thailand.

H. macrura ("***terubuk***", longtail shad), inhabits coastal waters, estuaries and rivers, pelagic species. Restrictively distributed in Indonesia and Malaysia.

H. toli (toli shad), inhabits coastal waters, estuaries and rivers, pelagic species. Geographically distributed throughout the coasts of India, Indo-Australian Archipelago and northward to Hong Kong or Taiwan.

Ilisha pristigastroides (Java ilisha), inhabits estuaries and rivers, pelagic species. Restrictively distributed throughout Java, Sumatra, Singapore and Borneo.

I. elongata (elongate ilisha), inhabits coastal waters, pelagic species, not abundant. Geographically distributed throughout Burma to New Guinea, westward to the eastern coast of India, and northward to Japan.

I. melastoma (Indian ilisha), inhabits coastal waters, not abundant. Restrictively distributed along the coast of India, Penang, North Java coast and Hong Kong, westward to Persian Gulf.

I. megaloptera (bigeye ilisha), inhabits coastal waters, not abundant. Geographically distributed throughout the southern part of the China Sea, the coasts of India to New Guinea.

Nematalosa nasus (Bloch's gizzard-shad), inhabits coastal waters, pelagic species. Geographically distributed throughout the northern part of the West Indo-Pacific waters northward to Hong Kong.

Opisthopterus tardoore (Tardoore), inhabits coastal waters, not abundant, pelagic species. Geographically distributed throughout the coasts of India to New Guinea, northward to Hong Kong.

Pellona ditchela (Indian pellona), inhabits coastal waters, pelagic species. Geographically distributed throughout the northern part of West Indo-Pacific down to the northern tip of Australia, westward to East Africa and northward to Taiwan.

S. fimbriata ("***tembang/tanjan***", fringescale sardinella), inhabits coastal waters, pelagic species. Geographically distributed from the Red Sea and the East African coast in the West, to the Philippines and Taiwan in the East; it extends from the southern coasts of Asia to the southern boundary of Indonesia.

S. melanura (blacktip sardinella), inhabits coastal waters, pelagic species. Widely distributed throughout the tropical Indo-Pacific waters, ranging from Mozambique along the Asiatic coasts and Indonesia to Taiwan, the Philippines and Queensland (Australia).

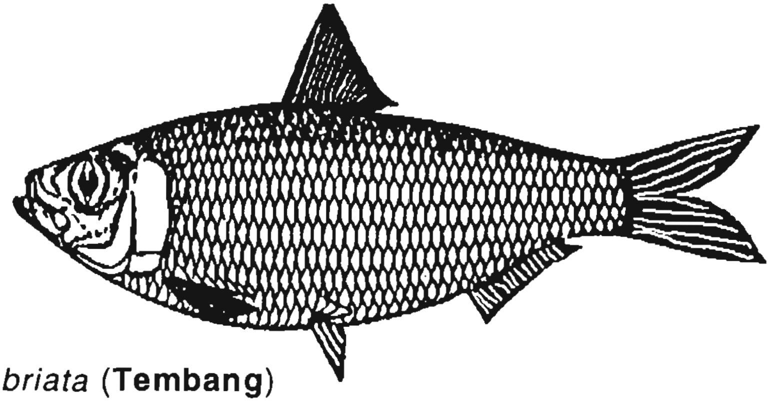
S. albella (white sardinella), inhabits coastal waters, pelagic species. Geographical distribution : throughout the western part of West Indo-Pacific, down South to the northern tip of Australia, westward to East Africa, and northward to Taiwan.

S. brachysoma ("***tembang/tanjan***", deepbody sardinella), inhabits coastal waters, pelagic species. Geographical distribution : eastern coast of India, Indonesia, and Hong Kong.

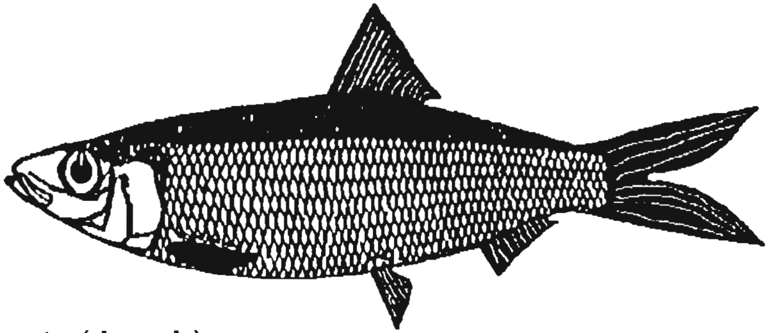
S. gibbosa ("***tembang/tanjan***", goldstripe sardinella), inhabits coastal waters, pelagic species. Geographical distribution : Taiwan in the North, East Africa in the West, the tip of northern Australia in the South and New Guinea in the East.

Amblygaster sirm ("***siro***", spotted sardinella), inhabits coastal waters, pelagic species. Geographical distribution : the Red Sea, the coast of India, Taiwan, Samoa Island, the northern tip of Australia, and the Arabian Sea.

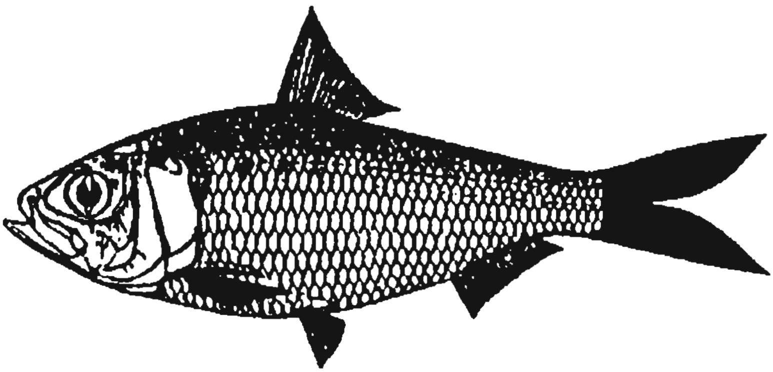
A. leiogaster (smoothbelly sardinella), inhabits coastal waters, pelagic species. Geographical distribution, northern part of Indo-Pacific, westward East Africa, northward to Taiwan and southward to northern tip of Australia.



Sardinella fimbriata (**Tembang**)



Dussumieria acuta (**Japuh**)



Hilsa kelee (**Terubuk**)

Coilia macrognathus (bigmouth grenadier anchovy), inhabits coastal waters, bentho-pelagic species.

C. dussumieri (gold-spotted grenadier anchovy), inhabits coastal waters, pelagic species.

Setipinna taty (hairfin anchovy), inhabits coastal waters, and estuaries, bentho-pelagic species.

S. melanochir (dusky anchovy), inhabits coastal waters, and estuaries, bentho-pelagic species.

Stolephorus heterolobus ("***teri***", shorthead anchovy), from East Africa through the Indo-Australian Archipelago to Bhinawa southward to Queensland.

S. buccaneeri ("***teri***", Buccaneer anchovy), from East Africa through the Indo-Australian Archipelago to Japan and Hawaii.

S. bataviensis ("***teri***", Batavian anchovy), India, Sri Lanka, Thailand, Malaysia, Indonesia, the Philippines and Papua New Guinea.

S. tri ("***teri***", spined anchovy), India, Burma, Thailand, Malaysia, and Indonesia.

S. indicus ("***teri***", Indian anchovy), from East Africa through Indonesia to Samoa and southward to Queensland, Australia.

S. commersonii (Commerson's anchovy), inhabits coastal waters, pelagic species.

Thrissina baelama (Baelama anchovy), inhabits coastal waters, bentho-pelagic species.

Thryssa mystax (moustached thryssa), inhabits coastal waters, bentho-pelagic species.

T. setirostris ("***bulu ayam***", longjaw thryssa), inhabits coastal waters, bentho-pelagic species.

T. hamiltonni (Hamilton's thryssa), inhabits coastal bentho-pelagic species, occuring in large schools.

Most anchovies and thryssas are distributed throughout the northern part of the West Indo-Pacific down South to the tip of Australia, westward to East Africa and eastward to Samoa.

2. CARANGOIDS

A great variety of genera of the Perciformes family of Carangidae occurs over continental shelves and in coastal waters. Scads, jacks, and trevallies are prominent feature of the pelagic ecosystem throughout the Java Sea. Among the species found in the Java Sea, their habitat distribution and behavior are listed as follows (based on Fischer and Whitehead, 1974).

Scomberoides commersonianus ("***talang-talang***", talang queenfish), inhabits coastal waters restricted to neritic waters near continental shelves, bentho-pelagic species.

Trachinotus blochii (snubnose pampano), inhabits shallow coastal areas, coral and rocky waters, bentho-pelagic species.

Ulua mentalis (cale-cale trevally), inhabits shallow coastal areas, bentho-pelagic species.

Seriolina nigrofasciata (black-banded trevally), inhabits coastal areas, bentho-pelagic species.

Selaroides leptolepis ("**selar kuning** ", yellowstripe trevally), inhabits shallow coastal areas, bentho-pelagic species.

Selar crumenophthalmus ("**bentong**", bigeye scad), inhabits coastal areas down to 80 m, bentho-pelagic species.

S. boops (oxeye scad), inhabits coastal areas, coral and rocky reefs, bentho-pelagic species.

Megalaspis cordyla ("**tetengkek** ", hardtail scad), inhabits coastal waters down to 60 m, pelagic species.

Gnathanodon speciosus (golden toothless trevally), inhabits shallow coastal waters, and coral and rocky reefs, bentho-pelagic species.

Decapterus russelli ("**layang biasa** ", Russell's scad), inhabits coastal waters, and continental shelves, pelagic species.

D. macrosoma ("**layang deles**", layang scads), continental shelves, pelagic species.

Caranx tille (tille jack), inhabits shallow waters of coral and rocky reefs, bentho-pelagic species.

C. sexfasciatus (dusky jack), inhabits shallow waters of coral and rocky reefs, bentho-pelagic species.

C. melampygus (bluefin jack), inhabits coral and rocky reefs, bentho-pelagic species.

C. ignobilis (yellowfin jack), inhabits coral and rocky reefs, bentho-pelagic species.

Carangoides malabaricus (Malabar cavalla), inhabits coastal waters and coral and rocky reefs, bentho-pelagic species.

C. ciliaris (longfin cavala), inhabits shallow coastal waters and coral and rocky reefs, bentho-pelagic species.

C. chrysophrys (longnose cavala), inhabits shallow coastal waters down to 60 m, bentho-pelagic species.

Atropus atropus (kuweh trevally), inhabits coastal waters, bentho-pelagic species.

Alepes melanoptera (blackfin crevalle), inhabits coastal waters, bentho-pelagic species.

A. djeddaba (djeddaba crevalle), inhabits coastal waters, bentho-pelagic species.

Alectis indicus (threadfin trevally), inhabits coastal waters, bentho-pelagic species.

The zoogeography of the carangid species in the Java Sea is throughout most warm coastal waters of the West Indo-Pacific waters.

3. SCOMBROIDS

Scombroids mackerels, seerfish and some genera of small tuna occur throughout the waters of the Java Sea. *Rastrelliger* is among the dominant catch of small pelagic fish along with scads and sardines. Geographically, *Rastrelliger* occurs throughout the western Indo-Pacific, westward to the Red Sea, northward to Japan, eastward to Fiji Islands, and southward to Australia but its southern coasts. Within this area three species occur : *R. brachysoma* occupies the Andaman Sea, Thailand, Indonesia, the Philippines to Fiji Islands, *R. kanagurta* has a wide distribution through the western Indo-Pacific waters and a third species *R. faughni* is known from Malaysia, Indonesia, the Philippines and Taiwan.

Rastrelliger brachysoma ("**kembung**", short-bodied mackerel), in some general areas of the western Pacific as *R.faughni* but extending to East Fiji.

R. kanagurta ("**banyar** ", Indian mackerel), throughout Indo-Pacific. From Taiwan, the Philippines, Samoa, and Australia in the East throughout the Indian Ocean to Madagascar and the Red Sea.

R. faugni (island mackerel), Matsui, Taiwan, the Philippines, Indonesia.

Scomber australasicus (slimy mackerel), in the western Pacific from Japan to southern Australia to the Hawaiian Islands and across to the eastern Pacific barrier to Socorro Islands of Mexico.

A few larger species, Spanish mackerels or seerfish (*Scomberomorus*) are also widely spread in the Java Sea. They consist of three species namely :

Scomberomorus commerson ("**tenggiri** ", narrow-barred Spanish mackerels), inhabits coastal waters, pelagic species.

S. guttatus ("**tenggiri papan** ", spotted Spanish mackerel), inhabits coastal waters, pelagic species.

S. lineolatus (streaked seerfish), inhabits estuaries and coastal waters, pelagic species.

Some larger species of scombroids species belonging to those of tuna and widely occuring in the Java Sea, are as follows :

Euthynnus affinis ("**tongkol komo** ", eastern little tuna), throughout Indo-Pacific.

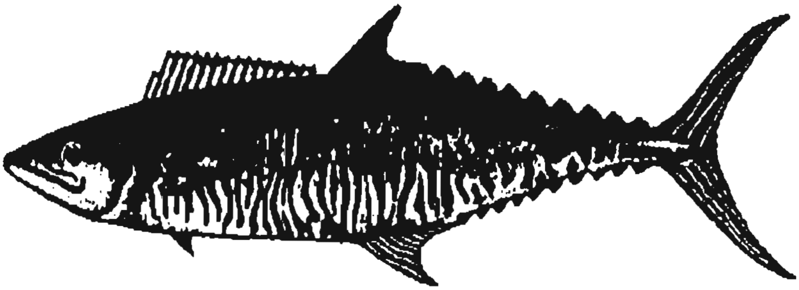
Auxis thazard ("**tongkol krai** ", frigate mackerel), inhabits coastal waters, pelagic species.

Thunnus tonggol ("**tongkol abu-abu** ", long tail tuna), of the Indo-West Pacific, Japan to the Australian Archipelago to Somalia and the Red Sea.

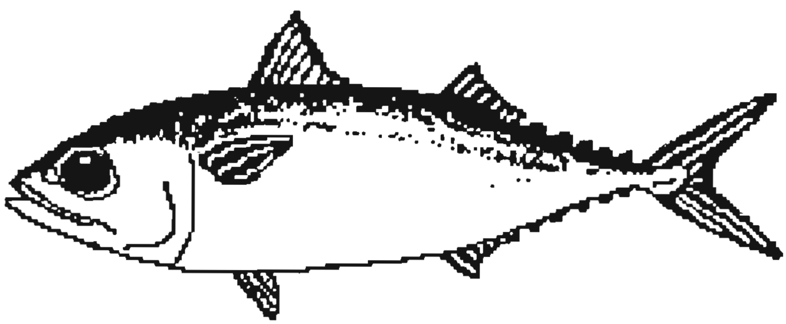
The geographical distribution of these species is mostly in the northern part of the West Indo-Pacific region, down southward to the tropical coasts of Australia, westward to East and South Africa, northward to the sea of Japan, and eastward to Hawaii. It is appropriate to notice here the occurrence of other predatory fish on continental shelves of the Java Sea which may have some significance, especially in the coastal fisheries, e.g. the "**alu-alu** ", barracudas, *Sphyraena*, i.e. *S. jello* and *S. obtusata*.

4. SYSTEMATIC

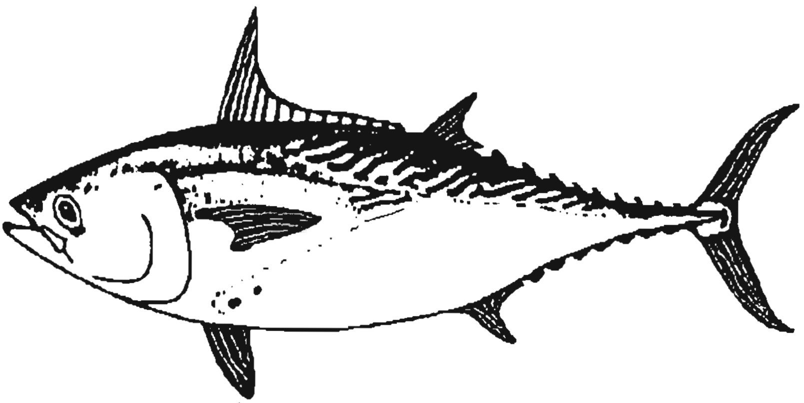
The dominant small pelagic fish of the Java Sea belong to the class Osteichthyes, or Teleostomi, bony fishes, which are commonly divided into three subclasses, namely Dipnoi, Crossopterigii and Actinopterigii. Further, Actinopterigii have often been divided into Chondrostei, Holostei and Teleostei. Teleostei is the typical well-known bony fishes from



Scomberomorus commerson (**Tenggiri Papan**)



Rastrelliger brachysoma (**Kembung**)

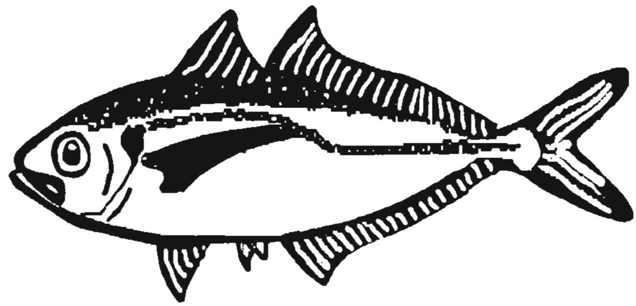


Euthynnus affinis (**Tongkol**)

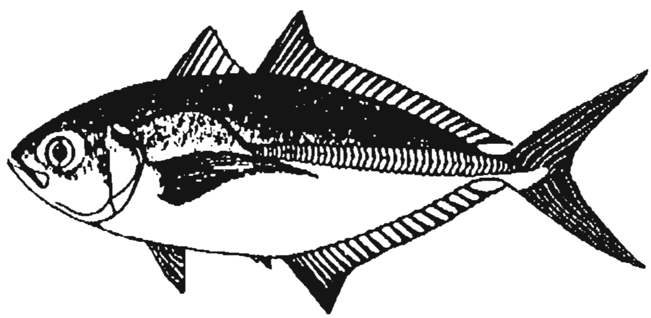
herring to perches and consists of orders Elopiformes, Clupeiformes, and Perciformes. Order Elopiformes includes two suborders, namely Elopoidei and Albuloidei. The first suborder, Elopoidei, contains the tarpons, ladyfish of the family Elopidae, while the second suborder, Albuloidei contains the family Albulidae.

Order Clupeiformes contains two suborders, one of which is Clupeoidei, to which the family of Clupeidae belongs.

Order Perciformes contains several suborders, among them are Scombroidei and Carangoidei of which the families of Scombridae and Carangidae are among the respective members.



Selaroides leptolepis
(Selar Gontor)



Alepes djeddaba
(Selar)

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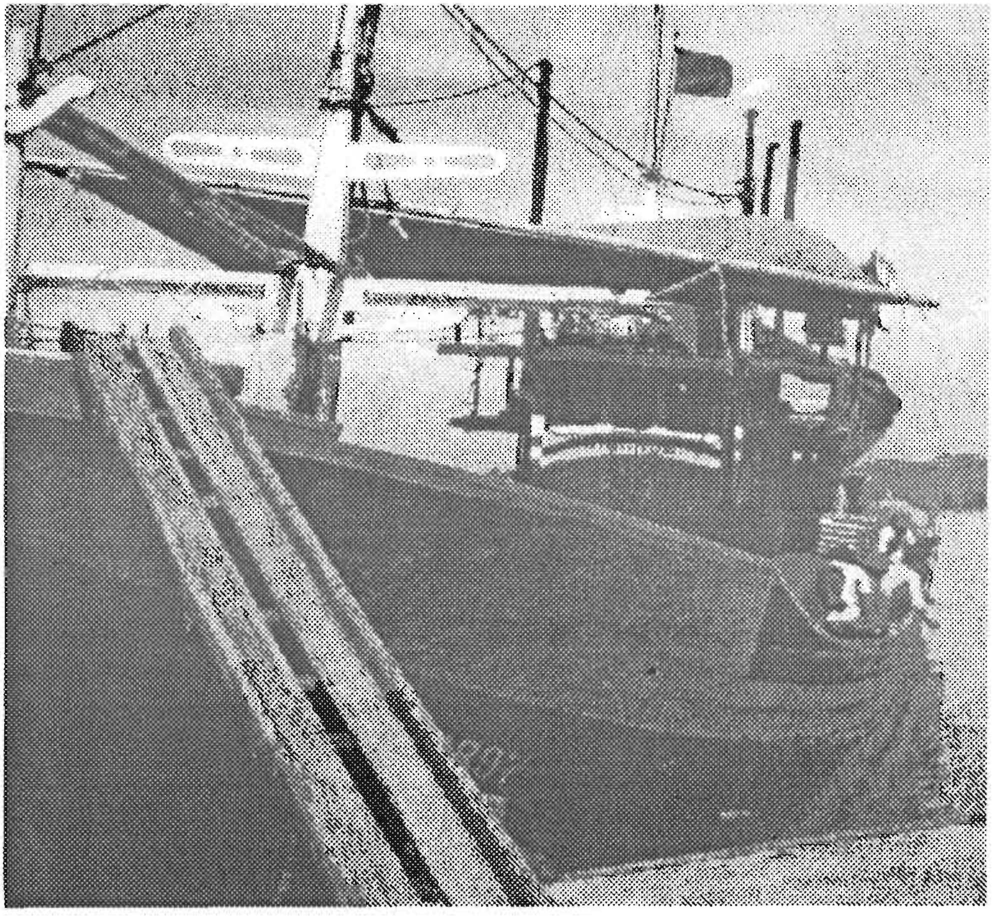
SEINERS FISHERIES IN INDONESIA

LARGE SEINER AT LANDING HARBOR

KAPAL PUKAT CINCIN BESAR DI TEMPAT PENDARATAN



M. POTIER, B. SADHOTOMO

ABSTRACT

The study is based on the 1991 national statistics published by the Directorate General of Fisheries. The reliability of this data varies according to the Indonesian provinces. Accurate data only exists for the province of Central Java. Nevertheless, it can give a profile of the present situation of the Fisheries in Indonesia.

The Indonesian fish production was 2 200 000 tons in 1991. The Java Sea with 7% of the main territory accounts for 32% of this production. Among the 760 000 tons of fish caught in that area, 485 000 tons consists of pelagic fish. Most of the landing is of small pelagics caught by the seines fisheries. The purse seines fisheries account for 40% of the total landing.

They are mainly found along the northern coast of the Java Island. Introduced in 1968 in Indonesia at the Batang harbor in the province of Central Java, the purse seine quickly widespread and is now found in almost all Indonesian provinces. Its catch is higher and its fishing season longer than those of the traditional seine nets used by the small-scale fisheries and it tends to replace them.

Mostly based on the exploited pelagic resources, shape of the coast, presence of rivers, and extension of shallow waters, on cultural, historical habits and economical factors (investors, landings facilities, potential market) , three types of fisheries can be defined :

- The mini seiners fisheries which are dispatched along the northern coast of the Java Island (mainly in the province of East Java) and in the province of South Kalimantan. During short trips they search for species with high value and sell locally.
- The medium seiners fishery is exclusively found at the Pekalongan harbor in the province of Central Java. Their trips last between 6 and 15 days. They only sell fresh fish under auction for the Javanese market.
- The large seiners fishery is concentrated in the province of Central Java in three centers, Tegal, Pekalongan-Batang and Juwana-Rembang. Their trips last up to 40 days and they sell fresh and salted fish for the national market.

Vessels, fishing grounds and fishing tactics vary among these fisheries according to target species and fish market.

Telaah ini dibuat berdasarkan buku statistik nasional tahun 1991 yang diterbitkan oleh Direktorat Jendral Perikanan. Data yang disajikan berdasarkan propinsi ini kurang lebih dapat dipercaya. Informasi yang lebih tepat hanya didapatkan di Propinsi Jawa Tengah. Walaupun demikian data tersebut dapat memberikan suatu gambaran situasi perikanan di Indonesia dewasa ini.

Produksi ikan di Indonesia adalah 2 200 000 ton pada tahun 1991. Laut Jawa yang mempunyai luas 7% dari luas perairan Indonesia menyumbangkan 32% dari total produksi. Diantara 760 000 ton ikan yang tertangkap di daerah tersebut sebesar 485 000 ton terdiri dari ikan-ikan pelagis. Jenis-jenis ikan utama yang didaratkan adalah ikan pelagis kecil yang tertangkap oleh pukat, dimana pukat cincin sendiri memberikan kontribusi sebanyak 40% dari total yang didaratkan.

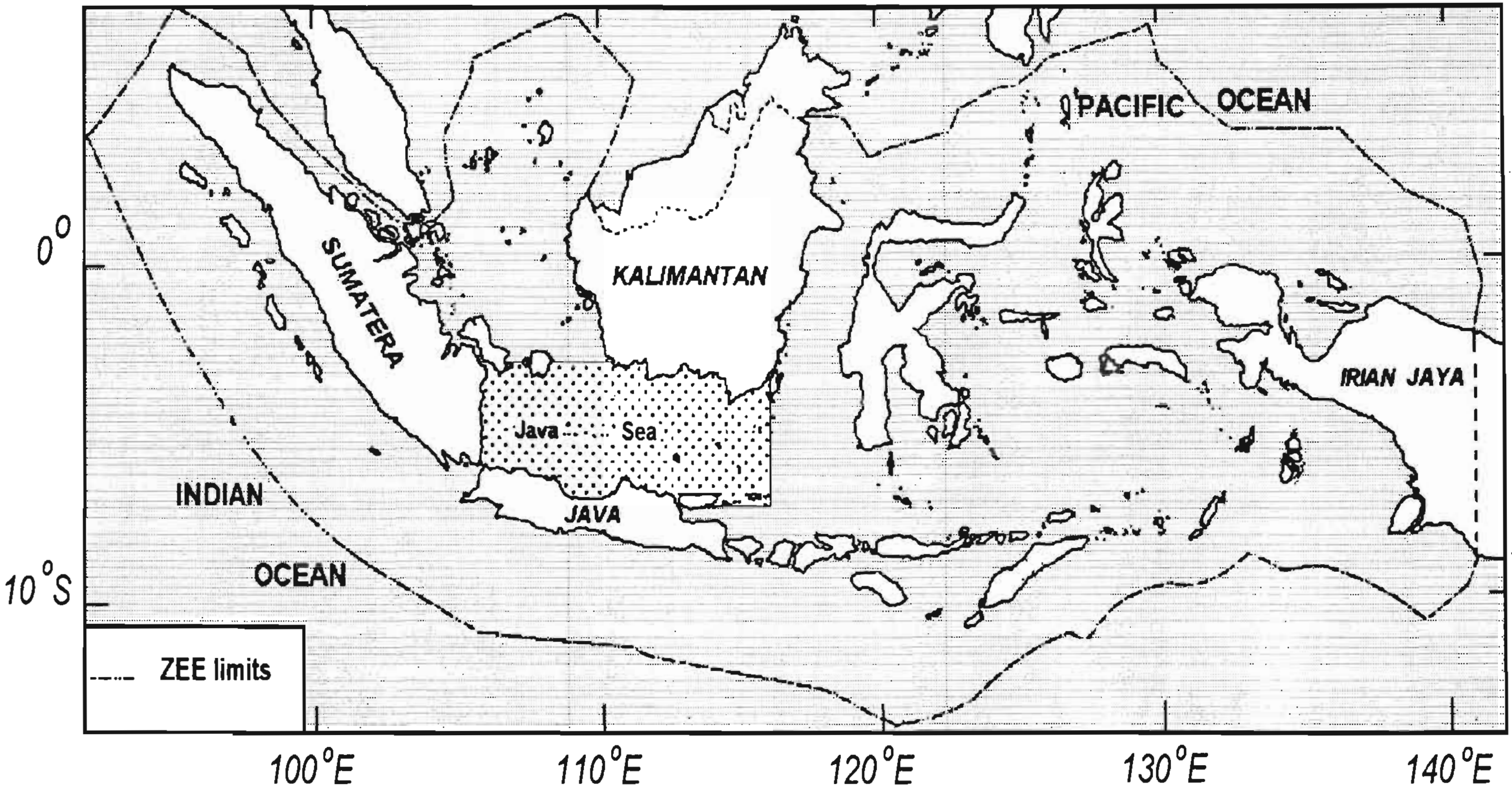


Figure 1

INDONESIAN E E.Z. WATERS AND GEOGRAPHIC LOCATION OF THE JAVA SEA

PERAIRAN Z.E.E. INDONESIA DAN LOKASI GEOGRAFI LAUT JAWA

Pukat cincin terutama terdapat sepanjang pantai Utara Jawa. Sejak diperkenalkan pada tahun 1968 ke Indonesia di Batang, Jawa Tengah, alat tangkap tersebut tersebar dengan cepat dan sekarang dapat diketemukan di seluruh propinsi di Indonesia. Dibandingkan dengan pukat tradisional yang dipergunakan oleh perikanan skala kecil, hasil tangkapan pukat cincin adalah lebih baik dan musim penangkapannyapun lebih lama.

Berdasarkan sumberdaya pelagis yang dipanen, bentuk geografi fisik {letak sumgai dan pantai} dan geografi manusia {permodalan, tempat pendaratan dan pasar yang potensial}, maka bentuk perikanan pukat cincin dapat dibedakan menjadi tiga jenis:

- *Perikanan pukat cincin mini, tersebar sepanjang pantai Utara Jawa {terutama Propinsi Jawa Timur} dan Propinsi Kalimantan Selatan {sekitar Pulau Laut}. Dengan waktu penangkapan yang relatif pendek mereka mencari jenis-jenis ikan yang mempunyai nilai komersial tinggi dan dipasarkan secara lokal.*
- *Perikanan pukat cincin sedang; terdapat hanya di pelabuhan Pekalongan, propinsi Jawa Tengah. Waktu penangkapan berlangsung antara 6 sampai 15 hari. Hasil tangkapan dijual secara segar di pelelangan untuk dipasarkan di dalam propinsi Jawa Tengah atau propinsi lainnya di Jawa.*
- *Perikanan pukat cincin besar; terpusat di Propinsi Jawa Tengah yaitu, Tegal, Pekalongan, Batang dan Juwana-Rembang. Waktu penangkapan dapat mencapai 40 hari. Hasil tangkapan dijual secara segar atau asin dan dipasarkan sampai keluar Jawa.*

Kapal penangkap, daerah dan cara penangkapan adalah berbeda pada setiap jenis perikanan pukat cincin, tergantung dari jenis ikan yang dituju dan permintaan pasar.

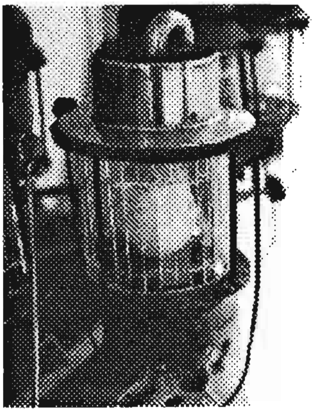
INTRODUCTION

The Republic of Indonesia covers a vast archipelagic area consisting of more than 17 000 islands stretching on about 5 000 km from East to West and about 2 000 km from North to South. With the establishing of the 200 miles Exclusive Economic Zone (E.E.Z.), the total area of marine waters under Indonesian jurisdiction is about 5.8 million km^{-2} with an E.E.Z. area of 2.7 million km^{-2} (fig. 1).

The archipelagic area, in particular, includes highly productive waters due to :

- A diversified underwater topography consisting of thousands islands, shelves, banks, basins and trenches providing excellent breeding and feeding places for a wide range of marine species;
- An area of shallow shelf (less than 200 m deep) totaling approximately 775 000 km^{-2} adjacent to deeply depressed sea-beds;
- Various ocean currents caused by monsoon winds and oceanic sea flows, which cause upwellings between and around the islands;
- An inflow of fertile fresh water from numerous rivers which drain densely forested lands and flow through highly populated islands.

Pressure lamps used to concentrate the fish
Lampu tekan pompa yang digunakan untuk memikat ikan



Hauling of the net
Jaring pukat cicin sedang diangkat

In this area some regions have been exploited since a long time while some are still almost virgins.

The fishery sector occupies an important place in the economy of the islands. Above all, it is a protein resource, even if the fish consumption per capita (14 kg/year) is low compared to other countries. In 1991, the marine production was estimated to 2 500 000 tons (tab. I). The production of fish was around 2 200 000 tons, 1 400 000 of which were pelagics. The fishery sector employs 1 600 000 people which represents 3% of the Indonesian manpower.

Statistics used in this article comes from the Directorate General of Fisheries and from the Project for the large and medium seiners fisheries. Established by province and following the sampling scheme set by Yamamoto in 1976, they are reliable only in the province of Central Java. Elsewhere, as the sampling scheme was not updated since 1976, changes in the fisheries are not taken into account and data are obviously biased. Nevertheless, they can give an approximate picture of the fishing sector in Indonesia. Data is presented up to 1991 because at the time of the article more recent data was not available.

1. FRAME OF THE STUDY

The Java Sea is the eastern part of the Sunda shelf which spreads from the gulf of Thailand to the South-eastern part of Kalimantan (Indonesian part of Borneo) (Emery *et al.*, 1972). It is a huge continental shelf with an average depth of 50 m which covers an area of 360 000 km^{-2}. Westward it connects to the South China Sea through the Karimata Strait and eastward it is widely open to the Flores Sea. The Java Sea is surrounded by the three biggest islands of the archipelago which gathers 80% of the Indonesian population, 60% on the Java Island alone.

Representing only 7% of the marine territory of Indonesia the Java Island accounts for 32% of the Indonesian marine production (tab. I) and 33% of the pelagic catches. Two types of fisheries, small scale and artisanal fisheries coexist to exploit the resources. They are concentrated on the North coast of Java where more than 68% of fishing devices are found and 65% of catch are landed (fig. 2).

Table I

MAIN MARINE STATISTICS FOR INDONESIA AND THE JAVA SEA IN 1991
STATISTIK PERIKANAN LAUT DI INDONESIA DAN LAUT JAWA TAHUN 1991

(Source : Directorate General of Fisheries)

	1991	TOTAL INDONESIA	TOTAL JAVA SEA	RATIO JS/TI
Tons	**Marin production**	**2 500 000**	**765 000**	**31**
	Total fish	**2 200 000**	**700 000**	**32**
	Pelagic fish	**1 450 000**	**485 000**	**33**
Pelagic catch per group of species (tons)	Layang	210 000	110 000	52
	Selar	96 000	40 000	42
	Tembang	137 000	70 000	51
	Lemuru	145 000	39 000	27
	Teri	135 000	46 000	34
	Kembung	144 000	59 000	41
	Tenggiri	64 000	23 000	36
	Tongkol	150 000	41 000	27
	Cakalang	133 000	4 000	3
	Tunas	78 000	1 000	1
	Others	158 000	53 000	33
Fishing devices (number of units)	Total number	535 000	115 000	21
	Danish seine	18 000	9 300	52
	Bottom seine	3 900	700	18
	Beach seine	10 500	1 200	11
	Purse seine	6 100	2 200	36
Catch by seines (tons)	Danish seine	206 000	112 600	55
	Bottom seine	26 000	13 900	53
	Beach seine	103 000	23 000	22
	Purse seine	440 000	190 000	43

The equivalent English names of the Indonesian terms used in the table are given in annex I
Nama Indonesia dari ikan ikan yang tercantum dalam Tabel 1 disajikan pada Lampiran I

The resource has been exploited since a long time by coastal small scale fisheries which use a large variety of fishing gears. The distribution of fishing devices is mostly regional. It depends on cultural habits, sea bed configuration and constitution, and coastline shape. Javanese fishermen mainly use seines, those of Sumatra and Kalimantan gill nets and lift nets (tab. II and fig. 3). This distribution is reflected by the geographic distribution of catches (fig. 4). Gill nets and lift nets production represents more than 60% in Sumatra and Kalimantan, while purse seines and traditional seines production makes up 61% of the Javanese catches. Among the 490 000 tons of pelagic fish caught in the Java Sea, 42% is made by the purse seiners fisheries. With an average of 90 tons/year, their catch rate is high compared to other fishing gears. This value greatly differs according to the fisheries. The catch rate of the large seiners based in the province of Central Java reaches 270 tons/year/fishing gear, while the small seiners catch amounts to 36 tons/year (fig. 5).

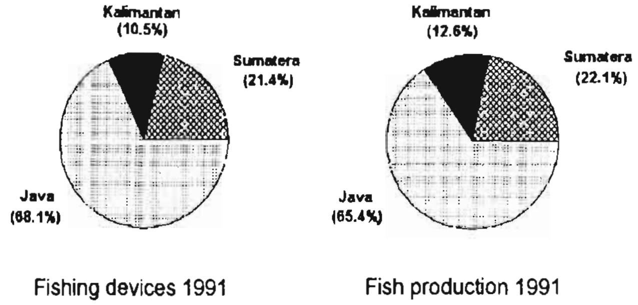
Table II

MAIN CHARACTERISTICS OF MARINE STATISTICS IN THE JAVA SEA IN 1991
KARAKTERISTIK UTAMA DARI STATISTIK PERIKANAN LAUT DI LAUT JAWA TAHUN 1991
(Source : Directorate General of Fisheries)

FISHING GEARS (N.UNITS)	SUMATRA	KALIMANTAN	JAVA	TOTAL
Danish seine	1 500	800	7 000	9 300
Bottom seine			700	7 000
Beach seine	310	560	330	1 200
Small purse seine		200	1 560	1 760
Lines	6 900	2 500	12 900	22 300
Gill nets	4 700	3 800	39 600	48 100
Lift nets	7 600	2 500	4 500	14 600
Large purse seines			470	470
Total	**21 010**	**10 360**	**67 060**	**98 430**
CATCH (TONS)				
Danish seine	25 300	14 100	73 200	112 600
Bottom seine			13 900	13 900
Beach seine	5 600	7 900	9 500	23 000
Small purse seine		6 700	56 500	63 200
Lines	25100	8 000	26 000	59 100
Gill nets	52 900	38 700	130 400	222 000
Lift nets	45 900	12 800	22 400	81 100
Large purse seines			126 900	126 900
Total	**154 800**	**88 200**	**458 800**	**701 800**
CATCH RATE (TON/YEAR/GEAR)				
Danish seine	17	18	10	12
Bottom seine			20	20
Beach seine	18	14	29	19
Small purse seine		34	36	36
Lines	4	3	2	3
Gill nets	11	10	3	5
Lift nets	6	5	5	5
Large purse seines			270	270

Figure 2

Fishing devices and fish production dispatching in the Java Sea
Distribusi penangkapan dan produksi di Laut Jawa berdasarkan pulau-pulau yang membatasinya



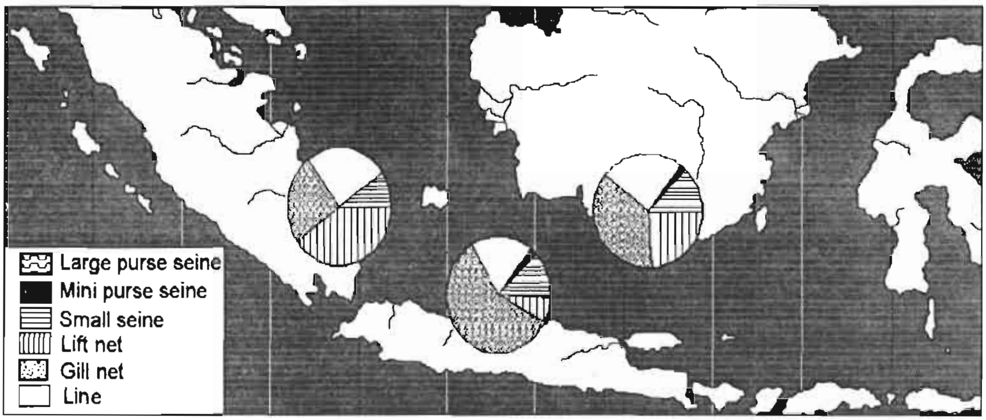


Figure 3

Fishing gear dispatching in the three islands bordering the Java Sea
Distribusi penangkapan berdasarkan alat tangkap pada tiga pulau yang membatasi Laut Jawa (1991)

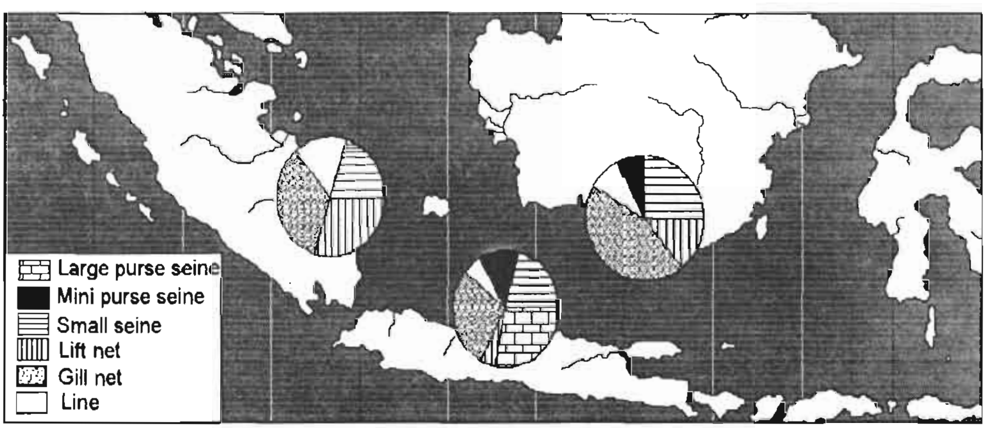


Figure 4

Fish production according tp the fishing devices in the three islands bordering the Java Sea
Produksi ikan berdasarkan alat tangkap pada tiga pulau yang membatasi Laut Jawa (1991)

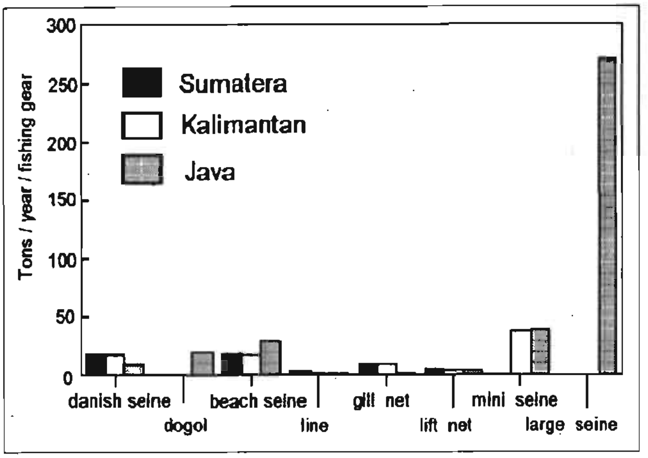


Figure 5

Catch rate of the various fishing gear in the three islands bordering the Java Sea

Laju tangkap dari beberapa alat yang berbeda pada tiga pulau yang membatasi Laut Jawa

(1991)

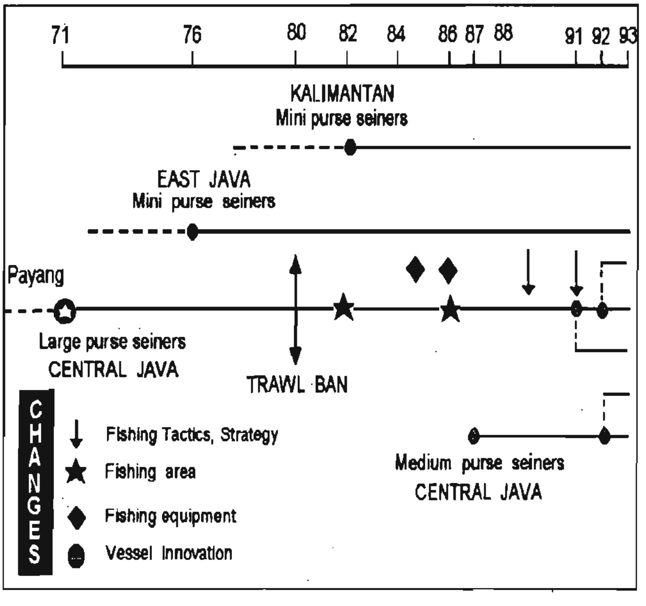


Figure 6

Historical development of the purse-seine fisheries in the Java Sea

Sejarah perkembangan perikanan pukat cincin di Laut Jawa

2. Development of the Seiners Fisheries

Since the beginning of the XXst century, the encircling nets "***lampara***" and Danish seines "***payang***" are used around fish aggregating devices or "***rumpons***". Due to the influence of the monsoon, the catch rate of these devices is low and the fishing period short. The development of the fisheries led to the motorization of the fishing vessels. The fishing pressure over the coastal stocks drastically increased.

In 1968, in order to overcome these constraints some fishery owners from Batang, a small fishing port located in Central Java, introduced the purse seine in Indonesia. At first, a seine imported from Japan by the Lembaga Penelitian Perikanan Laut was put on a small fishing boat usually fishing with "***payang***". After a rather long test, the size of the gear was adapted to local conditions and a commercial exploitation started mid-1973 with three vessels.

This new fishing technic allowed bigger catches than traditional gear and longer fishing times. This explains why purse seine exploitation spreads very quickly along the northern coast of Java.

Around 1975, in Central Java, a new type of fishing vessel derived from trawlers operating there was adopted by the fishery. In 1980, the flotilla was constituted of 250 vessels. Until 1980 the exploitation was limited to the onshore waters of the Java Island, traditional fishing grounds for the Javanese fishermen. In 1980-1981, with the trawl ban, numerous trawlers were transformed into purse seiners. The fishery expanded very quickly as these vessels extended their fishing zone eastward and their number increased. In 1985-86 they overpassed the boundaries of the Java Sea and began to exploit the Makassar Strait and the southern part of the South China Sea (fig. 6). At the time being, the purse seine is found in almost every province of Indonesia and the trend to replace traditional seine nets by purse seine in small scale fisheries is strong. The North coast of Java still represents the main Indonesian area for the seiners exploitation with 42% of the fishing vessels and 31% of the landings (tab. III).

Table III

PROVINCIAL REPARTITION OF LANDINGS AND NUMBER OF PURSE SEINERS VESSELS IN THE INDONESIAN ARCHIPELAGO IN 1991.

PENYEBARAN HASIL TANGKAPAN DAN JUMLAH KAPAL PUKAT CINCIN BERDASARKAN PROPINSI DI INDONESIA TAHUN 1991

(Source : Directorate General of Fisheries)

In this table production and number of purse seiners are gathered by province and by main Island. The figures given for Bali Island are erroneous. The catch by device is high in Irian Jaya as some industrial tunas purse seiners operate there. The last third lines give informations about the three main purse seine fisheries in Indonesia

PROVINCE	CATCH	NUMBER OF UNITS	CATCH/UNIT
Aceh	19 700	499	39.4
North Sumatra	57 700	632	91.2
Riau	900	59	15.2
Jambi			
West Sumatra	5 200	29	179.3
Bengkulu			
South Sumatra			
Lampung			
Sumatra	**83 500**	**1 219**	**68.4**
West Java	5 500	42	130.9
DKI Jakarta	2 700	158	17
Central Java	137 000	704	194.6
East Java	74000	1 656	44.6
Java	**219 200**	**2 560**	**85.6**
West Kalimantan	1 300	12	108.3
Central Kalimantan		64	
South Kalimantan	6 700	132	50.7
East Kalimantan	1 000	128	7.8
Kalimantan	**9 000**	**336**	**26.7**
North Sulawesi	11 900	356	33.4
Central Sulawesi	9 000	76	118.4
South Sulawesi	27 400	653	42
South-East Sul.	1 700	12	141.7
Sulawesi	**50 000**	**1 097**	**45.6**
Bali	28 400	70	
W.Nusatenggara	8 000	163	49
E.Nusatenggara	7 700	170	45.3
East Timor		2	
Maluku	18 600	425	43.8
Irian Jaya	17 300	11	1 572.7
TOTAL	**441 700**	**6 053**	**73**
Java large Seiners	126 900	468	271.1
Malaka Strait	51 700	782	66.1
Bali Strait	25 000	355	70.4

3. TYPOLOGY OF THE JAVANESE SEINERS FISHERIES

Large pelagic resources are found in the eastern part of the Java Sea, while in the western part these resources seem to be more limited. Therefore purse seines fisheries are found in the provinces of Central and East Java, and in South Kalimantan where the conditions required for such a development are fulfilled. At least three types of purse seiners fisheries coexist in the Java Sea. Their typology is based on geography, human behavior and availability of large fish resources. These factors determine the presence and the evolution of the fisheries.

The cultural and historical habits linked with the economical ones determine the type of fisheries (small scale, artisanal) which exists (tab. IV). In the three islands surrounding the Java Sea, some places have a long maritime tradition (Palembang in Sumatra, Banten, Pekalongan, Tuban in Java), but, unlike in Java which is densely populated, in Sumatra and in Kalimantan, there is no hinterland where marine products can be easily sold. Big investors primarily involved in trawling are found in the Central Java fishery sector. After the trawl ban, they invested in purse-seining and favored the expansion of the fishery which became artisanal. In East Java where such investors are not found the purse-seine fishery is still done on a small scale.

Geography determines the type and the size of the vessels and consequently the size of the gear used by the different fisheries. Around the islands bordering the Java Sea, shallow waters extend far from the coastline and in order to land, large vessels have to find landing places located at the mouth of the rivers. There are large rivers in Sumatra, Kalimantan and in the province of Central Java. Most Javanese rivers have a ria. In East Java where the rivers are scarce and small, the vessels have to land on the beach. Due to these physical conditions, the Javanese vessels have a flat bottom and present shallow draught.

Table IV

SYNTHESIS OF THE FACTORS AFFECTING THE EMERGENCE OF THE SEINERS FISHERIES IN THE THREE ISLANDS BORDERING THE JAVA SEA

SYNTESA DARI FAKTOR-FAKTOR YANG MEMPENGARUHI KEBERADAAN PERIKANAN PUKAT CINCIN PADA TIGA PULAU YANG MEMBATASI LAUT JAWA

(- negative impact, + positive impact)

		Sumatra	Kalimantan	Java		
		South	South	West	Central	East
Fish resources		-	+	-	+	+
Geography	rivers	+	+	+	+	-
	coastline	-	+	+	+	+
Cultural habits	tradition	+	-	+	+	+
Econom. factors	investor	-	-	-	+	-
	market	-	-	+	+	+
Results		No	small	small	large	small

The seines previously used were of **"lampara"** and Danish **"payang"** types (fig. 7a and 7b). The present type of seine derived from the old ones. It consists of two trapezoidal and symmetrical wings, flanking a central bunt where fish is concentrated before broiled on board. Because of this shape, the nets have to be hauled on board simultaneously from both wings (fig. 8). It is a ring net rather than a purse-seine one (fig. 9).

The differences between the two types of nets are :

■ Ring net :	■ Purse-seine :
Central bunt	Bunt at one side
purse line in two pieces	purse line in one piece
hauling from the two sides	hauling from one side

In the fisheries the general scheme of the net is the same. It only differs by the size from 300 m for the smallest ones to 600 m for the largest ones.

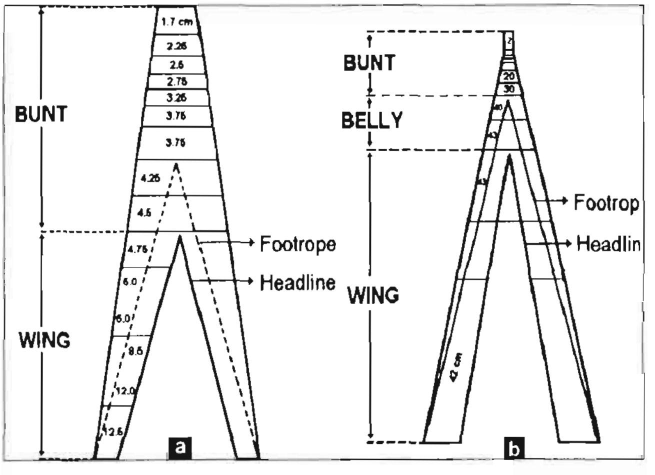


Figure 7

Design of the traditional seine nets in Indonesia

a) Danish seine(from Unar 1968)

b) Encercling net (from Subani and Barus 1988)

Rancangan pukat tradisional di Indonesia

a) Payang

b) Lampara

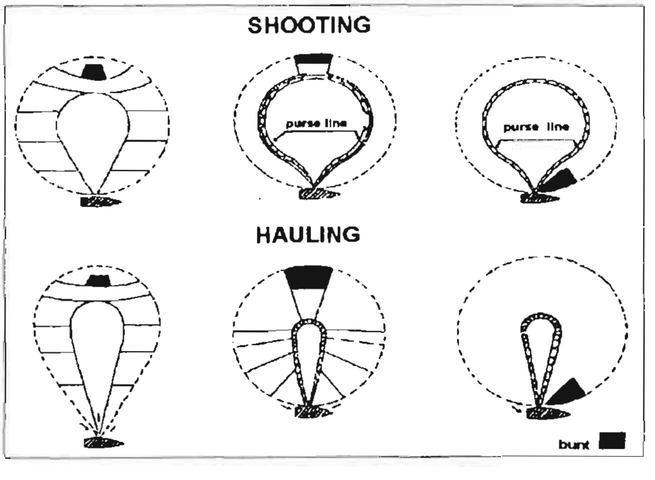


Figure 8

Main types of surrounding nets and their manoeuvre

Jenis utama dari jaring lingkar dan cara pengoperasiannya.

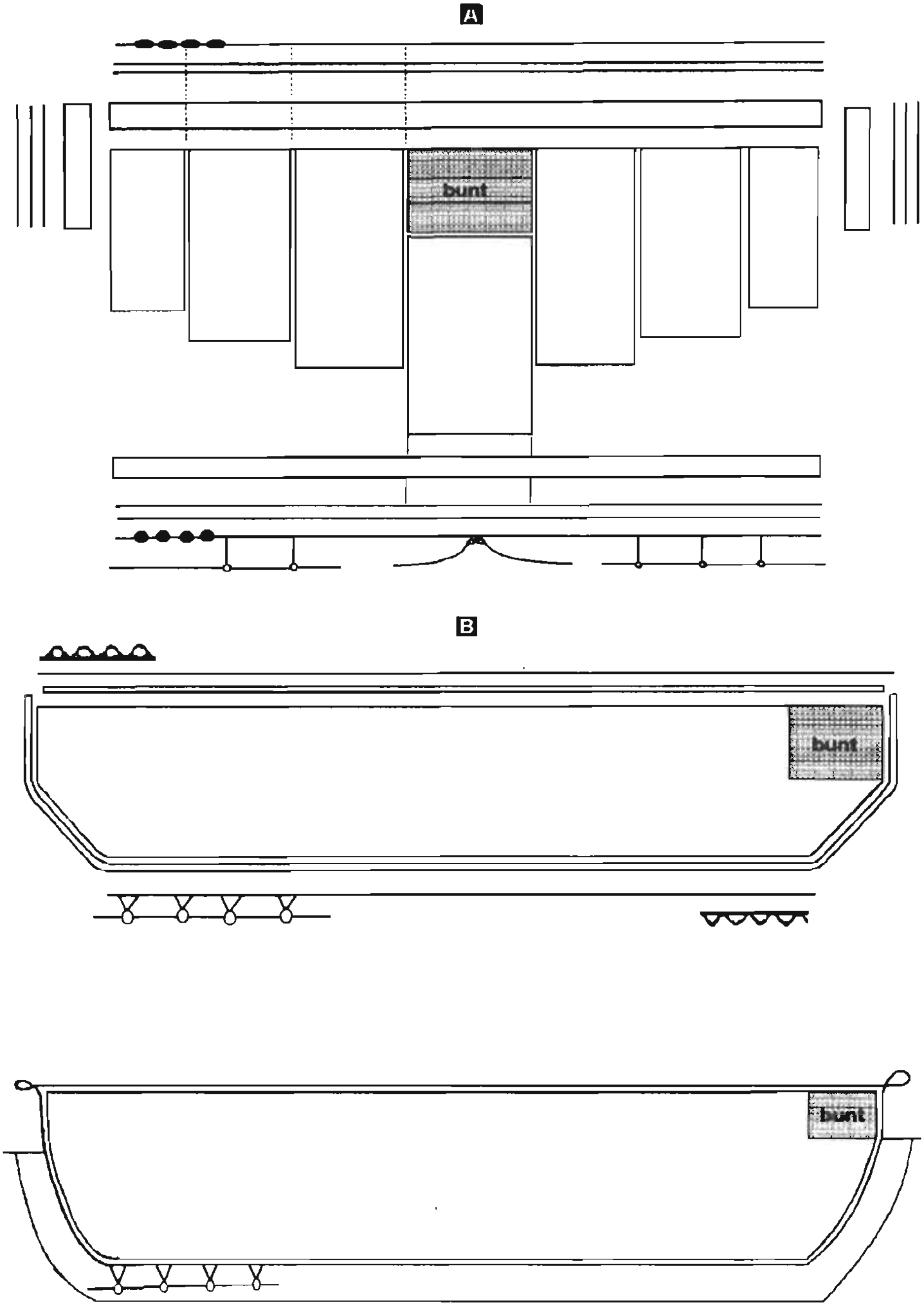


Figure 9

Design of a ringnet used in the Java Sea (A) and a Purse-seine net used in artisanal fisheries in Africa (B)

Rancangan dari "ringnet" yang dipergunakan di Laut Jawa (A) dan "purse seine" yang dipergunakan oleh perikanan artisanal pada Afrika (B)

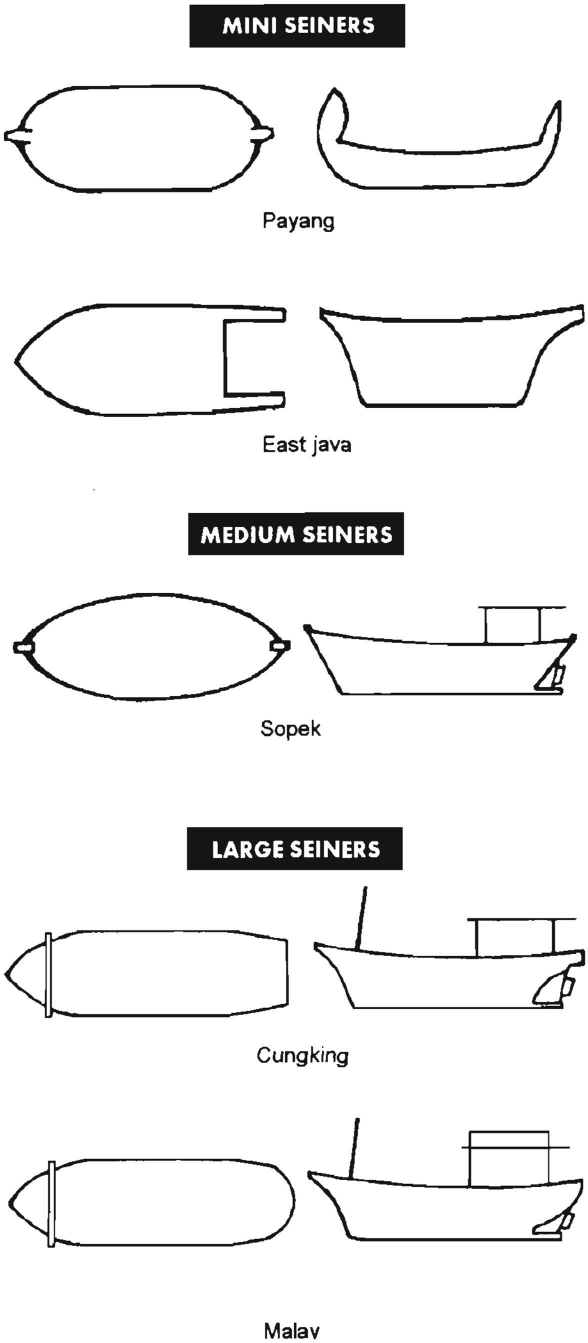


Figure 10

Various types of vessels found in the Javanese purse-seiners fisheries

Perbedaan jenis perahu pada perikanan pukat cincin di Jawa.

3.1. Mini seiners fisheries

The mini-seiners are wooden vessels between 10 and 18 meters long. They have a 25 to 60 lateral or terminal out-board engine with a long and tip-up shaft. The carrying capacity is around 1 to 2 tons.

Mini seiners fisheries use two types of vessels, semi dugout and planked vessels (fig. 10). They are locally built on temporary dockyards. The hull is made of tek and the vessel is built in two months at a cost of around 40 million Rp.

Their exploitation is based on inshore and offshore resources. Depending on their fishing grounds they can catch small pelagics as anchovies, mackerels, scads, sardinella and small tunas. They exploit the inshore waters along the North coast of Java and the South-East part of Kalimantan. Most of the fisheries are located in East Java and around the Laut Island in South Kalimantan.

In 1991, 63 000 tons of fish have been landed by the mini-seiners fisheries with a catch/rate of 36 tons/year/ fishing gear (tab. V).

The fishing area is located along the coast around 30 miles away from the shore. According to the monsoon and the target species, the fishing vessels move inside this area. They stay from 1 to 3 days at sea, and land only fresh fish mostly for local consumption. For the most part, the sale is made at sea or on the beach during the landing.

3.2. Medium seiners

This fishery appeared in the province of Central Java in 1987. At the beginning, the owners were mainly investors coming from activity sectors other than fishing or they were former fishermen with a small capital. In 1991 the fleet consisted of 142 units landing 17 300 tons (123 tons/gear/year). In 1992 ethnic Chinese entered in the fishery and gave it a boost. Medium seiners are only found in the Pekalongan harbor.

The medium seiner is a wooden vessel fitted with an inboard engine of 35 to 100 HP, and with the traditional hull shape of the North coast of Central Java (fig. 10). It has a high flared bow and a pointed stern. The length is between 15 and 20 m and the hold capacity between 20 and 25 tons. The vessels are locally built at Pekalongan and Batang in permanent dockyards. The hulls are constructed of wide Java tek plants. The planks are first laid in place, the frames are fitted latter. The price of such a vessel is around 125 million Rp.

The fishery exploits the offshore resources of the Java Sea. The exploitation is based on the catch of scads (*Decapterus russelli, Decapterus macrosoma*) and mackerels (*Rastrelliger kanagurta*). The fishing grounds are located in the Java Sea from the North of Indramayu to Bawean and Matasiri islands (fig. 2a, p. 17) over depths of 30 to 45 m. The boats fish around the islands and move to other fishing grounds according to the movements of the target fish. They stay at sea between 8 and 15 days and only land fresh fish sold under auction for local and Java Island fish market.

3.3. Large seiners

It was the first purse-seiners fishery established in Indonesia. It extended after the trawl ban when trawlers were transformed in seiners. In 1991, the catch reached 109 000 tons for a fleet of 326 vessels (334 tons/gear/year). The vessels are found in the province of Central Java, mostly in Pekalongan, Juwana and Tegal harbors.

The vessels are not built on the North coast of Java, but in Sumatra at Bagan Siapi-Api. They are of **"Cungking"** type (fig. 10). They are delivered as bare hulls to the fishing ports and are fitted out under the supervision of the owners. This includes machinery installation and fitting of the hold insulation, lining and partition. They are flat bottomed vessels with shallow draught and an inboard engine of at least 160 HP. The older vessels of this type have a vertical transom stern. Often, the new ones now have a rounded counter stern (fig. 10). This shape is more efficient for propulsion. They have a deckhouse. They are between 20 and 35 metres long. Most vessels of this size have a fish hold capacity of 50 to 80 tons, and a crew of 30 to 40 men. They are built in four months and fittings are made in two months. Such a vessel fully equipped costs around 300 million Rp (1993).

This fishery exploits the same resources as the medium seiners fishery do. Its exploitation being more offshore than the medium seiners, the catch of *Decapterus macrosoma* is higher than the one of *Decapterus russelli*.

The vessels exploit the whole Java Sea in areas more than 50 m deep, the Makassar Strait and the southern part of the South China Sea. They can stay at sea up to 40 days but the average trip is 25 days long. They land fresh and salted fish which is sold under auction and is used for local and national fish markets and turned into numerous products.

Table V

Number of units, catch and catch/rate of the seiners fisheries by province around the Java Sea in 1991.

Jumlah unit, hasil tangkapan dan laju tangkap perikanan pukat cincin sekitar Laut Jawa berdasarkan propinsi pada tahun 1991

(Source : Directorate General of Fisheries and Java Sea Project).

		Seines (Units)	Catch (Tons)	Catch rate (ton/unit)
Mini seiners	West Java	12	2 300	191
	DKI Jakarta	158	2 700	17
	Central Java	236	10 100	42.8
	East Java	1 156	41 400	35.8
	Central Kalimantan	64		
	South Kalimantan	132	6 700	50.7
Medium seiners	Central Java	140	17 300	123
Large seiners	Central Java	326	109 000	334

CONCLUSION

It seems that the widespreading of the purse seining in the Indonesian pelagic fisheries is still strong. This gear allows a better catch and fishing along the year. The Indonesian fishermen who use traditional seines nets tend to adopt it broadly.

This gear is more efficient than fishing gears such as **"lampara"** and **"payang"**, thus fishing pressure on the stocks of pelagic fish will be higher. This fact is more evident for coastal pelagic fish already heavily fished by the small scale fisheries.

As for all renewable resources, a careful management of these fisheries is needed in order to avoid overexploitation. Furthermore, stocks of small pelagic are subject to high variations related to environmental conditions. If a heavy fishing pressure is applied to these stocks, they can decrease quickly and even collapse provoking a crisis along the northern coast of Java Island.

We can notice that purse seine is used in Indonesia mainly for the exploitation of small pelagics and rarely for big fishes such as tunas as it is done in other parts of the world.

The absence of a well developed cannery industry can explain this situation. Small pelagics are only for Indonesian consumption and *Sardinella lemuru* is the sole species which is locally canned (Bali Strait).

Mini seiners fisheries are small scale ones, while medium and large seiners fisheries are artisanal. For these last ones, the passage to industrial level would lead to large technological and socio-economic changes.

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ANNEX I

INDONESIAN, ENGLISH AND SCIENTIFIC NAMES OF THE MAIN PELAGIC SPECIES CAUGHT IN INDONESIA.

NAMA INDONESIA, INGGRIS DAN NAMA ILMIAH DARI IKAN-IKAN PELAGIS UTAMA YANG TERTANGKAP DI INDONESIA.

INDONESIAN NAME	ENGLISH NAME	SCIENTIFIC NAME
Alu-alu	Barracudas	*Sphyraena spp.*
Cakalang	Skipjack	*Katsuwonus pelamis*
Cucut	Shark	
Daun Bambu	Queen fish	*Chorinemus spp.*
Golok-golok	Wolf herring	*Chirocentrus dorab*
Ikan terbang	Flying fish	*Cypselurus spp.*
Japuh	Rainbow sardine	*Dussumieria acuta*
Kembung	Indian mackerel	*Rastrelliger kanagurta* *Rastrelliger brachysoma*
Kuwe	Jack, Trevallie	*Caranx spp.*
Layang	Scads	*Decapterus russelli* *Decapterus macrosoma* *Decapterus kurroides*
Lemuru	Indian oil sardinella	*Sardinella longiceps* *Amblygaster sirm*
Selar	Trevallies	*Selar spp.* *Selaroides leptolepis*
Sunglir	Rainbow runner	*Elagatis bipinnulatus*
Tembang	Fringescale sardinella	*Sardinella fimbriata* *Sardinella gibbosa*
Tenggiri	Narrow barred king mackerel	*Scomberomorus commerson*
Tenggiri papan	Indo pacific king mackerel	*Scomberomorus guttatus*
Teri	Anchovies	*Stolephorus spp.*
Terubuk	Chinese herring	*Hilsa macrura*
Tetengkek	Hardtail scad	*Megalapsis cordyla*
Tongkol	Eastern little tunas	*Euthynnus affinis, Auxis spp.*
Tuna	*Tunas*	*Thunnus obesus* *Thunnus albacares*

BIOLOGY

REPRODUCTION OF THE MAIN SMALL PELAGIC SPECIES
S.B. ATMAJA, B. SADHOTOMO, SUWARSO 69

GROWTH PARAMETERS OF THE MAIN SMALL PELAGIC SPECIES
SUWARSO, B. SADHOTOMO, S.B. ATMAJA 85

REVIEW OF THE LEMURU FISHERY IN THE BALI STRAIT
G.S. MERTA 97

REPRODUCTION OF THE MAIN SMALL PELAGIC SPECIES

S.B. ATMAJA,
B.SADHOTOMO, SUWARSO

PEDICAB CARRYING FISH FROM THE HARBOR TO SMALL PROCESSOR PLANTS
IKAN IKAN SEDANG DIBAWA DENGAN BECAK KE PENGOLAH SKALA KECIL

ABSTRACT

Within the frame work of the Java Sea Pelagic Fishery Assessment activities, some biological examinations of major small pelagic consisting of scad (*Decapterus russelli* and *Decapterus macrosoma*), big eye scad (*Selar crumenophthalmus*), Indo-Pacific mackerel, (*Rastrelliger kanagurta*), sardine (*Sardinella gibbosa*) and spotted sardine (*Amblygaster sirm*) have been carried out. Various reproductive aspects (reproductive stages, spawning season, size at first maturity and fecundity) of these species are presented in this paper.

Purse seine fishery in the Java Sea is mostly supported by immature and recovery stages individuals of small pelagic fish for which the length at first maturity is close to the average length at first spawning.

Sebagai bagian dari kegiatan "Java Sea Pelagic Fishery Assessment Project", pengamatan biologi dari ikan-ikan pelagis kecil yang terdiri dari ikan layang (Decapterus russelli dan D. macrosoma), bentong (Selar crumenophthalmus), banyar (Rastrelliger kanagurta), tanjan (Sardinella gibbosa) dan siro (Amblygaster sirm) telah dilakukan. Beberapa aspek reproduksi (tingkat kematangan, musim pemijahan, panjang pada pertama kali matang dan feconditi) dari ikan-ikan tersebut di atas disajikan dalam tulisan ini.

Panjang pada pertama kali matang adalah sama dengan panjang pada pertama kali memijah. Perikanan pukat cincin di Laut Jawa terutama didukung oleh individu ikan pelagis kecil yang belum matang dan tingkat "recovery"

INTRODUCTION

The small pelagic fish resources in the Java Sea have been intensively exploited since the 80's. The rapid development of the purse seine fishery has created changes in the major fishing grounds as well as in the catch composition. Since 1984, the fishing grounds have been extended to the southern part of the South China Sea and to Lumu-lumu and Lari-larian Islands in the Makassar Strait (Atmaja and Sadhotomo, 1985; Boely *et al.*, 1987; Potier *et al.*, 1988)

The oceanographic condition and water characteristics of the Java Sea have been described by several authors. The influence of environmental conditions plays a significant part in the changes of catch and effort while winds and rainfalls directly influence the fishing pressure and the catch (Potier and Boely, 1990).

Preliminary studies on biology of small pelagics in the Java Sea have been carried out by Delsman (1926) (eggs and larvae) and by De Jong (1940) (spawning habits of some fishes in the Java Sea). Hardenberg's (1938) pioneer study on the scad population in the Java Sea indicated the existence of a western stock from the Indian Ocean, an eastern stock from the Flores Sea, and a northern stock from the South China Sea.

Biological information on small pelagic species is limited to *D. russelli* (Atmaja, 1983; Widodo, 1988), *D. macrosoma* (Widodo, 1988) and *R. kanagurta* (Nurhakim, 1993). However, these studies were based on short series observation data. They tended to generate input parameters instead of finding the nature of reproduction aspects.

The present study is an attempt to obtain more details and informations concerning the reproduction aspects of the main small pelagic species and is based on methods widely used in this type of study.

1. MATERIAL AND METHODS

As part of the Operation 4 of the Project, a sampling procedure was carried out at the Pekalongan and Juwana harbors. Details of this procedure have been described (Boely *et al.*, 1992). Specimens of major small pelagics were collected from the landings of commercial purse seine fishery. The samples were coming from all the main fishing grounds in the Java Sea.

1.1 Sampling procedure

Length composition of the biological samples can be adjusted using length data which is regularly obtained by measuring the sampling. In each length group, for easily distinguishable fish, 5 individuals were chosen for a biological study. The sex of each fish was determined by dissection and examination of the gonads. Maturity stage, gonad weight, and adiposity were also recorded for each examination. The ovaries were immersed and preserved in Gilson solution in order to determinate the fecundity and the distribution of eggs in each stage. A total number of females and undetermined specimens of a length over 13 cm is depicted in table I.

	1992		1993	
Species	N	Undetermined	N	Undetermined
D. Russelli	675	316	645	131
D. macrosoma	460	267	356	230
A. sirm	1 073	93	1 036	80
R. kanagurta	-	-	401	9

Table I

Number of females and undetermined specimens

Jumlah individu betina dan yang belum dapat ditentukan jenis kelaminnya

1.2 Reproductive stages

Seven reproductive stages were defined according to different authors (Raja, 1967 for *Sardinella longiceps* and Holden and Raitt, 1974) (annex I, p. 84). For this study all species are supposed to be total spawners, in which all eggs are ripen and shed within a very short time (Welcomme, 1979).

The development of gonad is expressed as follows: immature, maturing, developing, developed, gravid, spawning and spent. Then, maturity staging by macroscopic examination is confirmed by gonad index value, egg size and shape.

GI is calculated as :

$$GI = \frac{W_g \times 10^5}{L^3}$$

where **Wg** = gonad weight (gr.) **L^3** = Fish length (cm) (Le Cren *in* Weatherley, 1972).

1.3 Size at first maturity

Some data collected during the few months immediately prior to spawning were used to determine the size at first maturity. It was estimated by plotting the cumulative percentage frequency of mature fish versus size and was defined as the length at which 50 % of the fish are mature. Fishes belonging to stage IV (developed stage) and above were grouped under mature fish. Only the females were used to determine the spawning season and size at first maturity.

1.4 Fecundity

Fecundity is defined here as the total number of ripe eggs present in a female ovary immediately prior spawning. It has been determined by gravimetric method (Bagenal, 1978), while batch fecundity was estimated from:

$$F = (Wg / ws) \cdot n$$

where **F** = batch fecundity **Wg** = gonad weight (gr.) **ws** = weight of sub-sample (gr.)
n = number of eggs in sub-sample coming from the last mode of the distribution of egg diameter

2. RESULTS AND DISCUSSION

2.1 Reproductive stages

Principal gonads development in fish is usually assessed by gonadosomatic index (GSI) or gonad index (GI) (Miller, 1984). Macroscopic examination of the gonad from five species *(A. sirm, D. macrosoma, D. russelli, R. kanagurta* and *S. gibbosa*) indicates that their development is almost similar to the development of *Sardinella longiceps*. From stage V, for all species, the ovaries occupy almost the whole body cavity. Translucent eggs are ready to be spawn. This is in accord with various investigations of the same aspects (Harden Jones *in* Hempel, 1979).

Visual examination proved that the abdomen was distended, the peritoneal cavity filled and translucent eggs became visible through the ovary wall. This phenomenon very common in the development of ovaries was stated by other authors. Most fish species have transparent eggs for reducing predation by visual predator (Johannes *in* Bailey and Houde, 1978). A previous study, on female spotted sardine *A. sirm* and scad, indicated that GI values have a positive correlation with the diameter of the largest eggs groups. Maturity stages coinciding with the increase in gonad weight is proportional to GI value, as given in figure 1.

The maturation and breeding of fishes are controlled by hormones, external factors and food taken by the females (Hempel, 1979). In the Java Sea, the gonad examination of small pelagic species indicates that the majority of females reach sexual maturity between May and July. The seasonal fluctuations of monthly GI value calculated on an average year for adult fish (up to 16 cm) without taking into account the first four stages are shown in figure 2.

Every month, for all stages the average GI values found are close to the immature stage value, even if during some months mature fish is found in the samples. This most likely indicates the existence of a cohort which is reproductively inactive or in recovery stage.

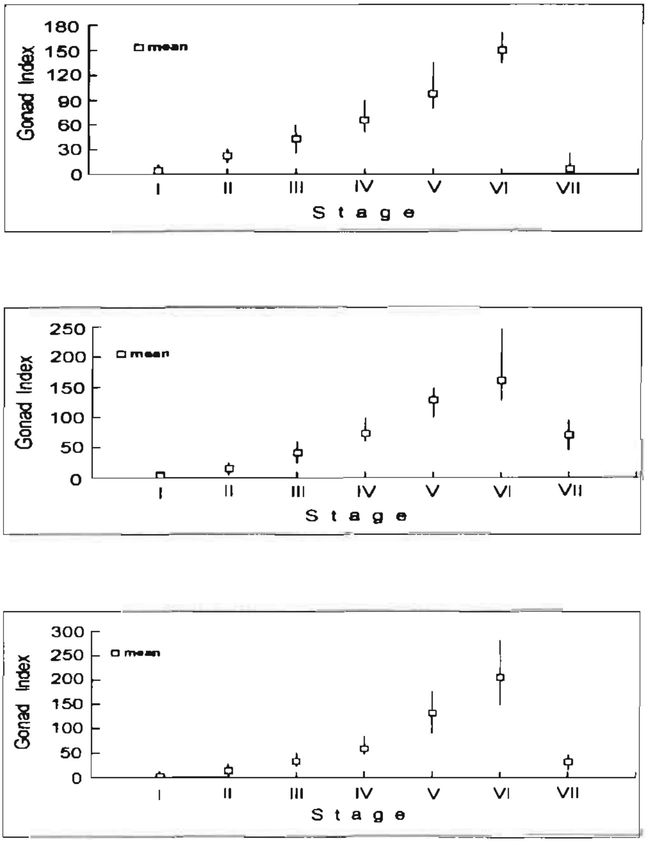


Figure 1

RELATIONSHIP BETWEEN GONAD INDEX (GI) AND MATURITY STAGES

HUBUNGAN ANTARA INDEKS GONADA (GI) DAN TINGKAT KEMATANGAN KELAMINNYA

A. *D. russelli*

B. *A. sirm*

C. *D.macrosoma*

The small number of encountered ripe and spent stages indicates that the fish, when at ripe stages, leaves the fishery or is not accessible to the purse seiners. This is likely due to the migratory behavior of the fish toward the spawning area. However, Delsman (1926) reported that eggs and larvae of small pelagic species were found near the region of the "**layang**" fishery. It is possible that fish in ripe and spent stages are not attracted by the light, such specimens tending to live in the deeper layer, because of a reduction of the volume of the swim bladder, this one being pushed by the gonad. This behavior may have much influence on the average GI value. However, in this study, the spawning seasons were determined from the peak GI value and the presence of ripe and spent stages.

2.2 Spawning season

■ SCADS

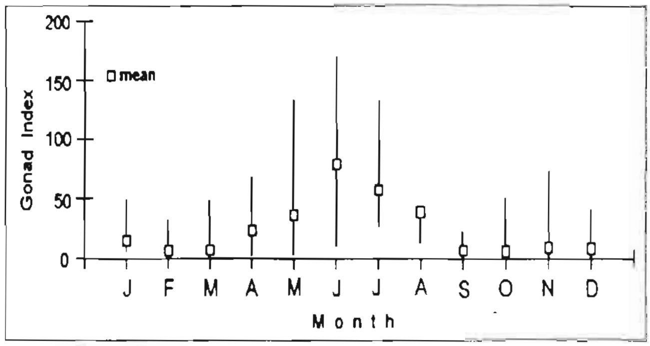
Decapterus russelli

Specimens with gonads in ripe stages were found from April to June, while those in spent stage (ovary resembles an empty sack) occurred from May to December. In February, we found one specimen only in spent resting stage (residual eggs in the posterior part strongly stuck on ovary wall, and also ovaries wrapped by fat).

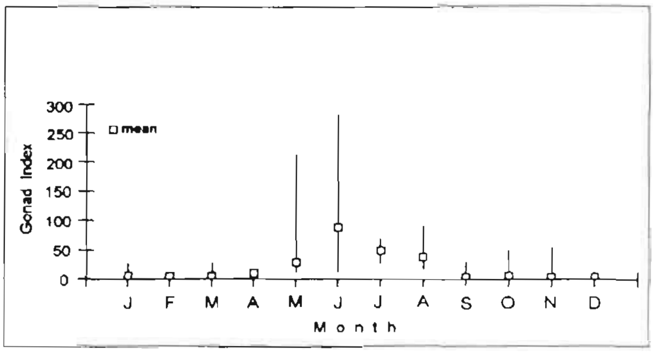
Figure 2

MONTHLY EVOLUTION OF THE GONAD INDEX (GI)

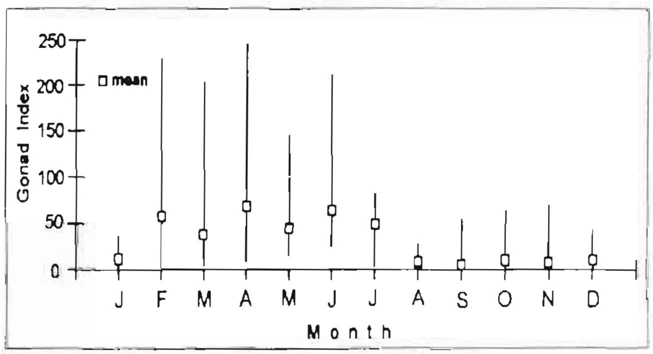
EVOLUSI BULANAN INDEKS GONADA (GI)



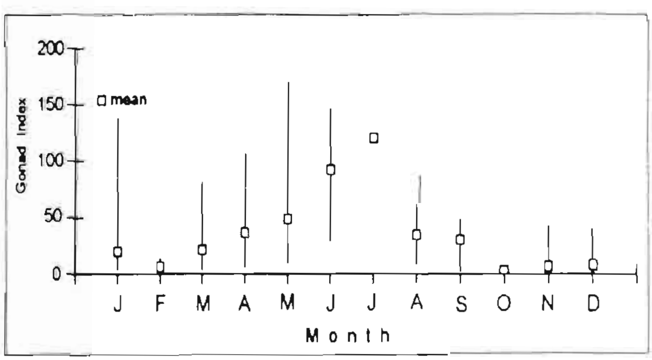
A. D. RUSSELLI



B. D. MACROSOMA



C. A. SIRM



D. R. KANAGURTA

Small juveniles have been found between March and May (average size 6 cm) (Widodo, 1988), and from May to July (mode 8 cm). These small fish presumably come from September to December spawning.

Eggs and larvae of *D. russelli* were found around Bawean waters in April - May, and around Madura waters in October-November (Delsman, *1926*). Such observations are of course closely related to the spawning time. Considering the number of fish ready to spawn (fig. 3a) and the presence of small fish (less than 12 cm) from March to June, the spawning season of this species seems to occur from May to December with a maximum activity from September to December.

Decapterus macrosoma

We found ripe stage (translucent eggs) between May and June, while the number of partially spent specimens was noticeable from July to October (fig. 3b). Small fish with a mode around 8 cm total length were found in May (Widodo, 1988) and in July, August and November. Delsman (1926) found eggs and larvae of this species around the Madura waters in October and November. It appears that the spawning season of this scad occurs in the Java Sea from May to October/November.

■ SPOTTED SARDINE
Amblygaster sirm

Fish at ripe stage (translucent eggs) could be found during February and June, while those at spent and partially spent stages were found from February to July (fig. 3c). For these species the spawning time occurs between February and June. This assertion was supported by the presence of young fish of about 9 cm mode in June in the purse seine fishery and of fish of 6.5 cm in the **"bagan"** (lift net) fishery around the Karimunjava Islands at the same period.

■ INDO-PACIFIC MACKEREL
Rastrelliger kanagurta

Fish at ripe stage (opaque eggs) are found from March to June, while from April to June and from September to December, we found fish at spent resting and recovery stages (fig. 3d). In June, small fish with a mode of 5.5 cm in fork length is caught by the **"bagan"** fishery around the Karimunjava Islands (Atmaja, 1992) while fish in mode of 8 cm is found in the purse seine fishery between May and July in the same area. Thus, we assume that Indo-Pacific mackerel spawns actively during March, May and October/November.

■ BIG EYE SCAD
Selar crumenophthalmus

Specimens are rarely found at ripe and spent stages which seems to show that there is a migration of this species for spawning. According to the presence of stage IV (opaque eggs) in the samples (fig. 3e), we suppose that these species spawn from April to November.

The presence of fish at ripe stage and of young individuals (size less than 12 cm) occurs in the Java Sea at about the same time (March - June). Nevertheless, scads and Indo-Pacific mackerel seem to spawn until November or December. Small fish entering the fishery between March and July may originally come from spawning occurring between September and November/December. However, those coming from May-June were never noticed in the purse seine catch as they are not found in the fishing grounds.

A future investigation should be conducted in the "**bagan**" fishery around Karimunjava, Bawean and Kangean Islands, and in other small scale fisheries in the eastern Java Sea.

2.3 Size at first maturity

In this case, length at first maturity was defined according to the length at which 50 % of the cumulative percentage frequency of mature fish was obtained. To avoid any mistakes in the identification of recovery stage as immature and to assume it as an exception, we only used the data collected during the periods when most specimens nearly reached ripe to spawning stages. An estimation of first maturity is also used to describe a fish which is spawning for the first time (Holden and Raitt, 1974). Data on length and percentage of mature fish, collected during a two year period covering the eastern Java Sea and the Makassar Strait are given in table II.

■ SCADS
D. russelli, D. macrosoma

Calculated lengths at first maturity (lm) were 21 cm for *D. russelli* females (fig. 4a) and 20.7 cm for *D. macrosoma* females (fig. 4b). The average fork length at first spawning of the two species is respectively 20.5 cm and 20.1 cm, (fig. 5a and fig. 5b). Tiews *et al.* (1970) suggested that in the Philippines waters, these species mature at length of 18 -20 cm at the beginning of the third year of life. They also suggested that *D. macrosoma* spawns once in its life-span only.

■ SPOTTED SARDINE
A. sirm

Females of spotted sardine begin first maturity at about 15 cm in August (Atmaja, 1993), whereas this fish will spawn when at least 17 cm in fork length. Calculated length at first maturity (lm) was 18.6 cm for females (fig. 4c). The average fork length at first spawning was 19 cm (fig. 5c). Lazarus (1990) reported that the minimum size at maturity is about 18.0 to 18.4 cm for females, while 50 % of the females reach maturity at 20.7 cm total length.

■ INDO-PACIFIC MACKEREL
R. kanagurta

This species reaches maturity at 21.4 cm in fork length (fig. 4d). The average fork length of the female at first spawning is 21 cm (fig. 5d).

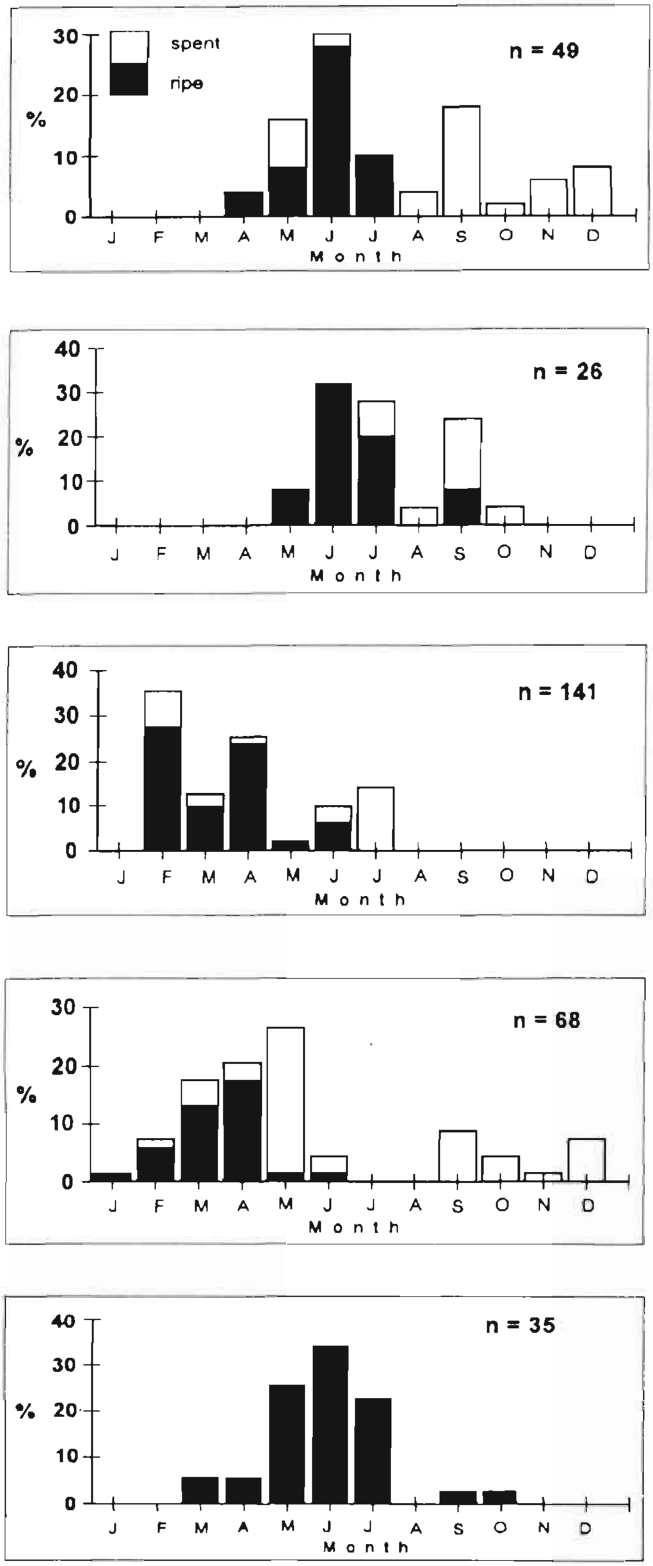
■ BIG EYE SCAD
S. crumenophthalmus

Estimation of the size at first maturity (lm) for this species is 18.7 cm (fig. 4e). The average fork length at first spawning is 18 cm (fig. 5e).

Figure 3

MONTHLY PERCENTAGE OF RIPE AND SPENT STAGES

PERSENTASE BULANGAN IKAN MATANG DAN SALIN



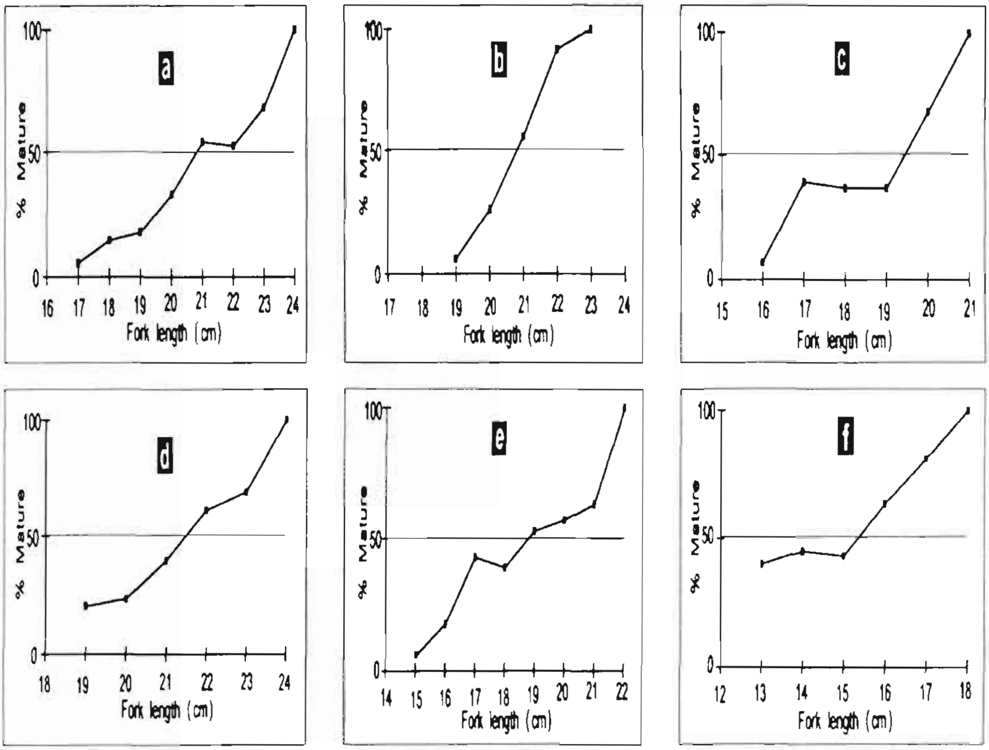
A. *D. russelli*

B. *D. macrosoma*

C. *A. sirm*

D. *R. kanagurta*

E. *S. crumenophthalmus*


a
b
c
d
e
f
% Mature
Fork length (cm)
0
50
100

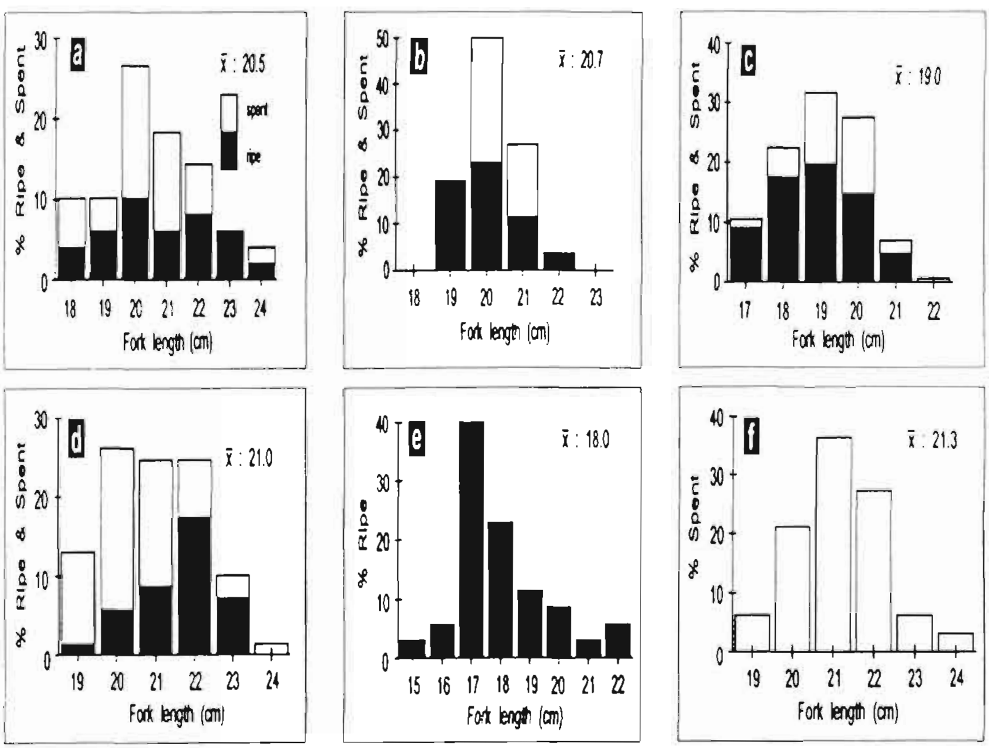

a
x̄ : 20.5
spent
ripe
% Ripe & Spent
Fork length (cm)
b
x̄ : 20.7
c
x̄ : 19.0
d
x̄ : 21.0
e
x̄ : 18.0
% Ripe
f
x̄ : 21.3
% Spent

Figure 4 *(left page, first and second row)*

PERCENTAGE MATURE VERSUS SIZE

PERSENTASE IKAN MATANG TERHADAP UKURAN

***From left to right** : D. russelli, D. macrosoma A. sirm, R. kanagurta, S. crumenophthalmus, S. gibbosa*

Figure 5 *(left page, third and fourth row)*

PERCENTAGE OF RIPE AND SPENT STAGES BY SIZE

PERSENTASE IKAN MATANG DAN SALIN BERDASARKAN UKURAN

***From left to right :** D. russelli, D. macrosoma, A. sirm, R. kanagurta, S. crumenophthalmus, S. gibbosa*

FL	D.M.		D.R.		R.K.		A.S.		S.C.		S.G.	
(CM)	N	%M	N	%M	N	%M	N	%M	N	%M	N	%M
13											5	40.0
14											69	45.9
15									33	6.1	123	43.1
16			41				14	7.1	100	18.0	134	63.4
17			88	5.6			97	39.2	217	42.9	27	81.5
18	35		182	14.8	9		230	36.1	136	39.0	3	100
19	48	6.2	162	17.9	49	20.5	177	36.7	102	52.9		
20	46	26.1	97	33.0	78	23.5	59	67.8	70	57.1		
21	34	55.9	46	54.3	68	39.7	10	100	30	63.3		
22	12	91.7	19	52.4	31	61.3			5	100		
23	1	100	19	68.4	13	69.2						
24			6	100	1	100						

Dm = D. macrosoma, Dr = D. russelli, Rk = R. kanagurta, As = A. sirm, Sc = S. crumenophthalmus, Sg = S. gibbosa

Table II

RELATIONSHIPS BETWEEN SIZE AND SEXUAL MATURITY IN MAIN SMALL PELAGIC SPECIES IN THE JAVA SEA

***N=** total number of individuals*

***M=** percentage of mature fish*

HUBUNGAN ANTARA UKURAN DAN KEMATANGAN KELAMIN PADA IKAN-IKAN PELAGIS KECIL DI LAUT JAWA

***N=** jumlah total individu*

***M=** persentase ikan yang matang*

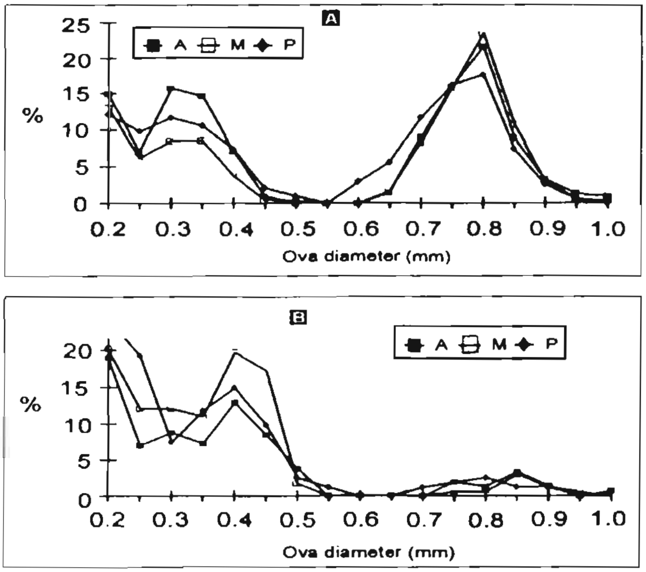


Figure 6

DISTRIBUTION PATTERN OF EGGS DIAMETER IN DIFFERENT PARTS OF OVARY OF *A. SIRM (A : ANTERIOR, M : MIDDLE, P : POSTERIOR)*
POLA DISTRIBUSI DIAMETER TELUR PADA BAGIAN BERBEDA DARI *A SIRM (A : DEPAN, M : TENGAH, P : BELAKANG)*

A : Spawning stage; B : Spent stage

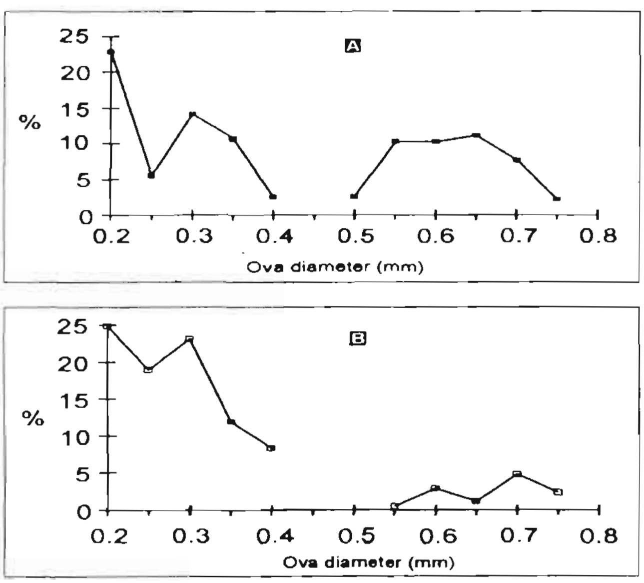


Figure 7

DISTRIBUTION PATTERN OF EGGS DIAMETER OF *D.MACROSOMA*
POLA DISTRIBUSI DIAMETER TELUR *D. MACROSOMA*

A : Spawning stage, B : Spent stage

■ SARDINE
S. gibbosa

Mature and spawning individuals have been observed in a fork length size ranging from 12.5 to 13.4 cm, while 50% of the females reach length maturity (lm) at 14.7 cm (fig. 4f).

The results show that length at first maturity is close to the average length at first spawning.

2.4 Fecundity

The fecundity is usually carried out by counting the ripening or ripe oocytes prior to ovulation. As in the most advanced batch the number of oocytes changes during the development (Le Crus, 1988). Visual examination on spawning stages of *D. macrosoma, A. sirm, S. leptolepis* showed that the eggs are scattered within the whole ovaries. Observations of the pattern of eggs diameter distribution from three different parts of the left ovary (anterior, middle, posterior) were presented in *A. sirm*. The over 0.2 mm egg diameters were measured and counted. Figure 6 is an illustration of the frequency of egg diameters distribution from different parts of ovaries immediately at prior and after spawning stages.

The patterns of the frequency of eggs diameters distribution in different parts of the ovary are relatively similar, and reveal only a single batch of mature eggs (translucent eggs), sharply separated with smaller ova stock (opaque eggs) (fig. 6A). Observation of spent females indicates that the ripe eggs from different parts are spawned at the same period (fig. 6B). The same patterns were also shown by scads *D. macrosoma* (fig. 7) and *D. russelli* (De Jong, 1940; Atmaja *et al.*, 1982).

The eggs non shed are probably reabsorbed back into the ovarian tissue or expelled as infertile eggs. Raja (1972) reported that in *Sardinella longiceps* after spawning, the remaining eggs of different stages get slowly reabsorbed. De Jong (1940) expressed that several small pelagic species as *D. russelli, S. crumenophthalmus* and *Atule mate* have only one batch of mature eggs and that after spawning, the ovary resembles an empty sack. Luther, *in* Bal and Rao (1984), examined mature ovaries of *R. kanagurta.* He found a maximum of three modal groups of eggs at this stage, and he postulated that this species liberates the ripe eggs in a succession of three batches in a single spawning season. Thus, we suggest that these species have a synchronous spawning pattern and produce only a single batch per season.

The size of mature eggs for some species is depicted in figure 8. The average diameter of mature eggs (translucent eggs) for various sizes of *A. sirm* is between 0.70 and 0.89 mm; for *D. macrosoma* it is between 0.61 and 0.70 mm, while for *S. leptolepis* it is about 0.52 mm. The structure of the eggs of small pelagic species has been described by Delsman (1926).

Figure 8

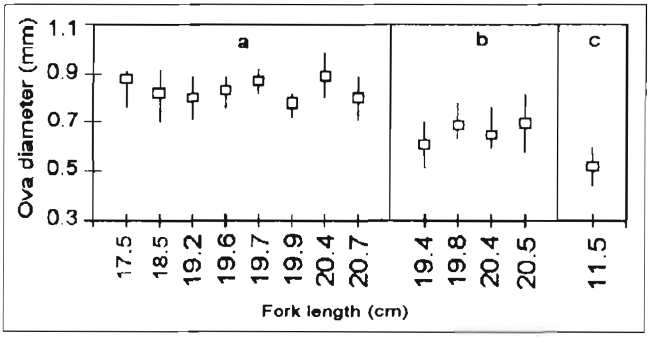
Eggs diameters according to fork length

Diamete telur berdasarkan panjang cagak

a. *A. sirm*

b. *D. macrosoma*

c. *Selar leptolepis*



The batch fecundity given in table III shows that fecundity of *A. sirm* ranges from 15 000 to 24 000 eggs (average 19 600 per 17.5 to 20.5 cm fork length fish), fecundity of *D. macrosoma* is about 43 000 to 88 000 eggs with an average of 61 000 per female. In the Philippines waters, Tiews *et al.* (1970) noticed that the fecundity of *D. macrosoma* is about 68 000 to 106 000 eggs and fecundity of *Selar crumenophthalmus* about 7 000 to 60 000.

Table III

Batch fecundity of some small pelagic species in the Java Sea

Feconditas mutlak dari beberapa species ikan pelagis kecil di Laut Jawa.

Species	Fork length (cm)	GI	Fecundity (x 1000)	Number
D. macrosoma	19.2-20.5	151-285	43-88	9
A. sirm	17.5-20.5	128-230	15-24	16
S. crume-nophthalmus	18.2-19.4	88-142	60-77	3

Batch fecundity of spotted sardine is lower than for *S. longiceps* (37 000 to 38 000 eggs) (Raja,1972) and for Japanese sardine (24 000 to 48 000 eggs) (Nikai *in* Boonprakop, 1978).

2.5 Sex ratio

These fishes are hetero-sexual, but the two sexes are not distinguishable from their external appearance. From gonad examination, sex can be differentiated for fish bigger than 13 - 14 cm in fork length. The sex ratio of small pelagic is calculated for every centimeter, then for the whole distribution (tab. IV). The results show that males and females are of equal proportion, except for *D. macrosoma* which has a preponderance of females (61%; $\chi^2 = 69.5$), and for *R. kanagurta* which has a preponderance of males.

CONCLUSION

For small pelagic species in the Java Sea the spawning season is relatively long but each individual spawns during a short period. However, the presence of juveniles (size less than 12 cm) only occurs from March to July.

Table IV

SEX RATIO OF MAIN SMALL PELAGIC SPECIES GIVEN AS THE PERCENTAGE OF FEMALES
PERBANDINGAN KELAMIN DARI BEBERAPA SPECIES IKAN PELAGIS KECIL YANG DINYATAKAN DALAM PERSENTASE BETINA

FL	D.M.		D.R.		R.K.		A.S.		S.C.		S.G.	
(CM)	N	%F	N	%F	N	%F	N	%F	N	%F	N	%F
12											2	
13	1		30	63					52	54	53	51
14	18	39	67	54	1		45	60	126	48	243	51
15	96	62	126	48	4		158	68	369	50	710	46
16	226	55	244	51	17	76	437	49	740	51	865	48
17	259	59	356	45	33	45	783	38	728	54	237	42
18	324	63	440	56	77	45	1 308	49	397	51	17	53
19	254	63	377	56	194	42	853	62	493	47		
20	185	65	359	56	262	46	642	50	347	46		
21	66	74	202	50	183	46	103	34	154	47		
22	13	46	89	48	98	37	1		34	44		
23	2	50	39	49	16	75			4	50		
24			14	43	3	33						
25	1		3									
T	1445	61	2347	52	888	45	4332	50	3444	50	2109	47

Dm = D. macrosoma, Dr = D. russelli, Rk = R. kanagurta,
As = A. sirm, Sc = S. crumenophthalmus, Sg = S. gibbosa

Especially for scads and Indo-Pacific mackerel, the size of spent resting stage ovary is very small. This can explain the low value of GI found in adult fishes. The observed low values of GI seem to indicate that the catches of the purse seiners are dominated by fish immature and at recovery stage.

The environmental characteristics of the Java Sea have a direct influence on the fishing pressure and the fluctuation of the catches from April to June, when fishes reach sexual maturity. During that period, most of the purse seiners move their fishing grounds to the southern part of the South China Sea. The fishing effort increases after this period but this also leads to an increase of immature fish in the catch.

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Annex I

MATURITY SCALE USED FOR FEMALES IN THE STUDY

STAGE I	**Immature**	**Ovaries very small with an oval shape. Eggs not visible to the naked eye.**
STAGE II	**Developing**	**Ovaries occupying 1/3 of body cavity with a length of 30 mm. Eggs visible to the naked eye.**
STAGE III	**Maturing**	**Ovaries occupying 2/3 of the body cavity. Abdomen seems normal. Eggs opaque.**
STAGE IV	**Mature**	**Ovaries occupying almost the whole body cavity. Abdomen seems normal. Eggs opaque.**
STAGE V	**Gravid**	**Peritoneal cavity filled with ovaries. Abdomen distended. Some translucent eggs visible through the ovary wall.**
STAGE VI	**Spawning**	**Ready to spawn. Ripe eggs run under slight pressure. Most of them translucent. Abdomen distended.**
STAGE VII	**Partly spent**	**Gonads flaccid. Presence of residual translucent eggs. Ovaries occupy 2/3 of the body cavity.**

GROWTH PARAMETERS OF THE MAIN SMALL PELAGIC SPECIES

SUWARSO,
B. SADHOTOMO, S.B. ATMAJA

ABSTRACT

A growth parameters estimation of main pelagic fishes in the Java Sea based on length-frequency data and an identification of the monthly average length increment applied to the Gulland and Holt plot and Von Bertalanffy plot were carried out by the Java Sea Pelagic Fishery Assessment Project from May 1991 to December 1993. A restructuring process of the data by the ELEFAN system was also done. The estimates of growth parameters were **L**∞ = 24.5 to 26.5 cm, **K**= 0.9 to 1.3 for *D. russelli*; **L**∞ = 24.6 to 27.2 cm, **K** = 0.5 to 0.9 for *S. crumenophthalmus*; and **L**∞ = 22.5 to 23.6 cm, **K**= 0.9 to 1.3 for *A. sirm*.

Dugaan parameter pertumbuhan dari ikan pelagis di Laut Jawa, berdasarkan data frequensi panjang telah dikumpulkan oleh "Java Sea Pelagic Fishery Assessment Project" dari bulan Mei 1991 sapai bulan Desember 1993. Identifikasi dari pertumbuhan panjang rata-rata bulanan yang diaplikasikan terhadap model. Gulland dan Holt plot dan von Bertalanffy plot telah dilaksanakan, demikian pula restrukturisasi data oleh metoda ELEFAN.

*Nilai dugaan parameter pertumbuhan adalah **L∞** = 24,5-26,5 cm, **K** = 0,9-1,3 untuk Decapterus russelli; **L∞** = 24,6-27,2 cm, **K** = 0,5-0,9 untuk Selar crumenophthalmus dan **L∞** = 22,5-23,6 cm, **K** = 0,9-1,9 untuk Amblygaster sirm.*

INTRODUCTION

The small pelagic fish caught by the purse seiners in the Java Sea is landed on the North coast of the Java Island (Tegal, Pekalongan and Juwana harbors). Eleven species contribute to 90 % of the total production. Scads (*Decapterus spp.*) are the main species found in the annual catch (more than 50 %), followed by Indo-Pacific mackerels (*Rastrelliger kanagurta*) for about 18 %; spotted sardinellas (*Amblygaster sirm*) for 7.4 %. Goldstripe sardinellas (*Sardinella gibbosa*) and big-eye scads (*Selar crumenophthalmus*) represent respectively 7 % of the total production.

This paper presents the first results on growth parameters of three species of small pelagic in the Java Sea, i.e. round scad (*Decapterus russelli*), spotted sardinella (*Amblygaster sirm*), and big-eye scad (*Selar crumenophthalmus*). The first two species are known as "oceanic" species, and the last one as a "coastal" species.

In the Java Sea, a growth parameters estimation based on a length frequency analysis has already been studied for some species, such as *D. macrosoma* (Atmaja 1988; Widodo 1988a and 1988b), *D. russelli* (Widodo 1988a and 1988b; Sadhotomo *et al.*, 1983), and *R. kanagurta* (Sujastani 1974; Nurhakim 1993). Ingles and Pauly (1984) assessed the growth parameters of fishes in the Philippines based on the length frequency analysis. Besides, a study on the growth of main pelagic species based on otolith reading increment and length frequency analysis has been reported by Conand (1991) for *Amblygaster sirm* in New Caledonia, Dalzell (1989) for the big-eye scad (*S. crumenophthalmus*) in the Philippines, and Dayaratne and Gjosaeter (1986) for four *Sardinella spp.* from Sri Lanka.

1. MATERIAL AND METHODS

1.1 Sampling procedure

Length frequency data was collected from May 1991 to December 1993 from a commercial purse seine fishery at Pekalongan and Juwana. A stratified sampling was conducted every day on board of vessels on one or two boxes (1 box = 25-30 kg.) of fish. The fishes were sorted by species and counted. The fork length of some individuals of each species encountered in the sample was measured. If the number of fish counted was less than 50 individuals, all of them were measured; but if it was more than 50 individuals, the length distribution measurement was only done from 50 individuals. The data was pooled by month and by fishing ground and grouped into 1 cm class intervals. The details of the sampling procedures have been described by Boely *et al.* (1990) and Potier and Sadhotomo (1991).

According to the knowledge on fish demographic distribution in the fishing grounds, the length-frequency data coming from the traditional areas (North of Indramayu, North of Tegal and Pekalongan, and around the Karimunjava Islands) is combined into one length frequency set of data, i.e. Area I, and the data obtained from the catch samples around Bawean, the Masalembo Islands, the Matasiri Islands, and Makassar Strait into another set of data, i.e. Area II.

1.2 Estimation of growth parameters

In order to assess the growth parameters, the length frequency distribution should be first split up into different modes (Battacharya, 1967), which then should be plotted according to Gulland and Holt, and Von Bertalanffy methods. The ELEFAN system (Gayanilo *et al.*, 1988) was also used to get these parameters.

■ GULLAND AND HOLT PLOT.

The relationship of the standard Gulland and Holt plot can be expressed as :

$$dL/dt = K(L\infty - Lt)$$

where : **dL** is an increment of the average length **dL/dt** is the rate of growth in length
Lt is the average length at **t**

$$(Lt = (L1+L2)/2)$$

If **Lt** is used as the independent variable and **dL/dt** as the dependent variable, the equation becomes a linear regression. The value of **K** and $L\infty$ can be obtained as

$$K = -b \text{ and } L\infty = -a/b$$

■ VON BERTALANFFY PLOT

This method estimating **K** and t-zero (**to**) parameters from age-length data first requires an estimate of $L\infty$. The Von Bertalanffy age-length relationship can be expressed as (Sparre, 1989)

$$Lt = L\infty(1 - e^{-K(t-to)})$$

where **Lt** is the average length at age **t**; **L∞** is the asymptotic length, which means the maximum length of a fish from a given stock; **K** is a growth constant, a parameter expressing the rate at which **L∞** was reached; **to** is the theoretical age **t**, which is the age of the fish at zero length. By linearizing and transposition of the variable the following equation can be obtained

$$1-(Lt/L\infty) = e^{-K(t-to)}$$

$$\ln (1-Lt/L\infty) = -K\ to + K\ t$$

Using **t** as the independent variable and the left-hand side as the dependent variable, the Von Bertalanffy growth equation becomes a linear regression. Estimation of **K** and **to** values can be obtained as

$$K = b;\ to = -a/b$$

According to the spawning seasons and to the reading of otoliths increments, the age of the smallest fish mode was estimated by guesswork.

■ THE ELEFAN SYSTEM

The ELEFAN System identifies the modes or peaks with an automatic restructuring process, where peaks would represent individual cohorts. The best fit of a Von Bertalanffy growth curve would be obtained through iterative method.

The monthly length-frequency data from the 1992-1993 periods, from fishing areas I and II, is used to trace the growth curves of the studied species.

2. RESULTS AND DISCUSSION

2.1 Modal progression analysis.

Separating monthly length-frequency distribution into modal components according to Bhattacharya's method gives one or more modes for area I or II. An average length value is assumed to represent an age/length group or a cohort. Each length-frequency data set gives 1 to 5 modes for *D. russelli,* 2 to 5 for *S. crumenophthalmus*, and only 1 to 3 for *A. sirm*. This means that there can be more cohorts of round and big eye scads present in the catch. The scatter diagram of the modes plotted against the corresponding months during the survey is shown in figure 1. The curves show which modes were used to estimate the growth parameters.

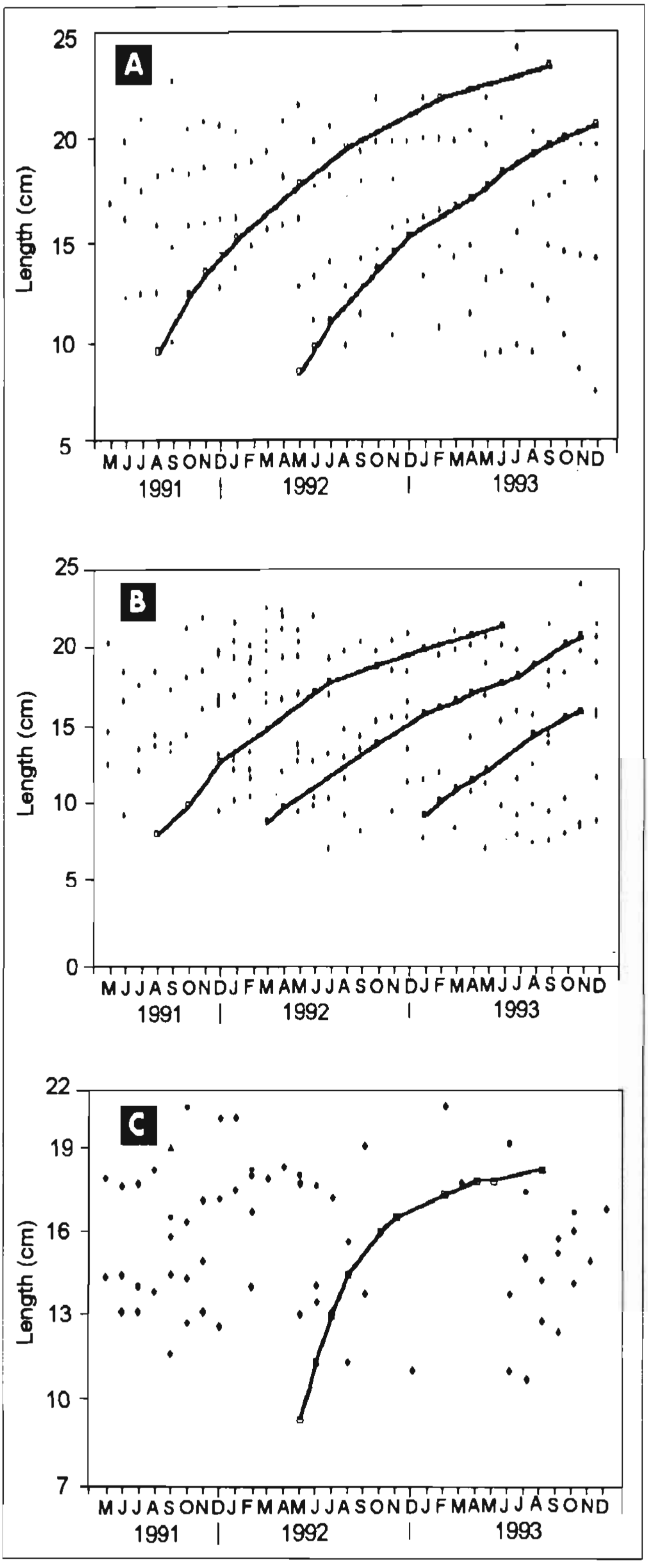


Figure 1

Scatter diagram of mean length values

Diagram sebaran nilai panjang rata-rata

A. *D. russelli*

B. *S. crumenophtalmus*

C. *A. sirm*

■ ROUND-SCAD *(D. RUSSELLI)*
Two major cohorts of this carangid could be found in the fishery during the survey. The first cohort was recorded in length-frequency measurements during August 1991 (average length 9.6 cm), and the second one was recorded in May 1992 (average length 8.5 cm) (fig. 1a). More than one cohort of this species in the same area, have also been reported by Widodo (1988). The reproduction aspects analyzed by Atmaja *et al.* (pp. 71-86) showed that fishes in ripe stage could be seen from April to June and in spent stage from May to December. Thus, we supposed that the first cohort has been spawn around May 1991 (May cohort), and the second one around February 1992 (February cohort). Based on the above assumption, both modes of 9.6 cm in August 1991 and 8.5 cm in May 1992 seemed to correspond to about 3 month old fish.

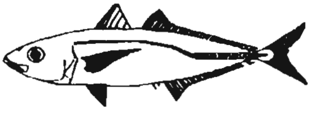
■ BIG-EYE SCAD (*S. CRUMENOPHTHALMUS*)
For this carangid we found more than one mode during the year which also shows the presence of several cohorts in the Java Sea: August 1991 (mode 8.0 cm), January 1992 (mode 8.4 cm), March 1992 (mode 8.7 cm), July 1992 (mode 7.0 cm), and January 1993 (mode 7.7 cm) (fig. 1b). Smaller sized- fishes were also found during May to December 1993. According to Atmaja *et al.* (pp. 71-86), no fish in spent stage were found during the survey and only few in ripe stage. Nevertheless, a high value of Gonad Index (up to 110) was found in March/April and October 1992 and 1993. According to Dalzell's study (1989) on growth parameters based on reading otolith, 8.0 cm long (fork-length) fish was estimated to be 4.5 month old.

■ SPOTTED SARDINELLA (*A. SIRM*)
Unlike the two species described above, it seems there was only one cohort a year during the survey. Length-frequency measurement recorded modes of 13.1 cm in July 1991, 9.3 cm in May 1992, and 10.0 cm in June 1993. The three cohorts seem to come from the same spawning period (around February). Fishes in ripe stage are found from February to June, and in spent stage from February to July (Atmaja *et al.*, pp. 71-84). By reading otolith in New Caledonia, a 2 month old fish reaches the size of 10 cm **TL** (total length) and a 4 month old one , the size of 15 cm **TL** (Conand, 1991). Dayaratne and Gjosaeter (1986) supposed that size 12 cm **TL** corresponds to a 6 month old fish. Thus the average length 9.3 cm **FL** (fork length) recorded in May 1992 would correspond to about 3 months.

2.2 Growth parameters estimation.

Based on the fitted curves of a cohort (fig. 1), the data used to estimate the growth parameters according to Gulland and Holt plot is presented in tables I and II. The results of linear regressions of modes (**L**) versus growth rate (**dL/dt**) are expressed below (**n**: number of observations; **r**: coefficient of regression):

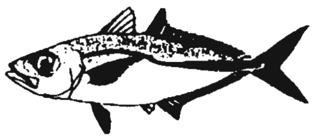
D. russelli



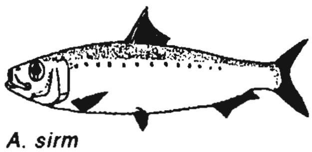
■ *D. RUSSELLI* (FIG. 3A AND 3B)
May cohort : Y= 26.5 - 1.05 X (r=0.9); n=7)
February cohort : Y=23.3 - 0.95 X (r=0.9; n=12)

■ *S. crumenophthalmus* (Fig. 2a, 2b and 2c)
March cohort : Y= 21.2 - 0.8 X (r= 0.9; n=11)
August cohort : Y = 15.9 - 0.6 X (r=0.9; n=11)
October cohort : Y = 15.5 - 0.6 X (r=0.8; n=13)

■ *A. sirm* (Fig. 4)
February Cohort : Y = 39.3 - 1.9 X (r=0.8; n=5)



S. crumenophthalmus



A. sirm

D. russelli				A. sirm	
May cohort		February cohort		February cohort	
L	dL/dt	L	dL/dt	L	dL/dt
11.1	17.4	9.1	13.2	10.3	24.0
13.3	9.0	10.4	18.0	12.2	21.6
14.6	14.4	12.4	10.4	15.5	7.2
16.5	7.8	14.0	7.2	18.5	4.8
18.7	7.2	14.8	12.0	19.8	3.9
20.8	4.8	16.4	5.3		
22.8	2.7	17.9	9.6		
		18.8	6.0		
		19.5	4.8		
		19.9	4.8		
		20.4	3.6		
		21.2	2.4		

Table I

Data used for the growth parameters estimation using Gulland and Holt plot for *D. russelli* and *A. sirm*

Input data untuk pendugaan parameter pertumbuhan melalui metoda Gulland dan Holt plot untuk *D. russelli* dan *A. sirm*

S. crumenophthalmus					
Cohort A		Cohort B		Cohort C	
L	dL/dt	L	dL/dt	L	dL/dt
9.0	11.4	9.2	12.0	9.6	13.2
11.6	13.2	11.1	8.4	10.5	9.6
14.0	9.6	13.2	7.8	11.2	7.2
16.0	9.2	14.9	6.6	11.8	7.2
17.5	8.41	6.3	6.0	13.3	9.2
18.4	4.4	16.8	6.01	4.9	5.4
19.5	4.4	17.4	4.8	15.6	6.0
20.4	3.2	18.0	4.8	16.1	6.0
21.1	3.6	19.0	4.8	16.5	4.8
21.7	1.42	0.5	3.9	18.0	5.0
22.3	3.0	21.6	4.0	19.5	6.0
				20.1	3.2
				20.7	4.8

Table II

Data used for the growth parameters estimation using Gulland and Holt plot for *S. crumenophthalmus*

Input data untuk pendugaan parameter pertumbuhan melalui metoda Gulland dan Holt plot untuk *S. crumenophthalmus*

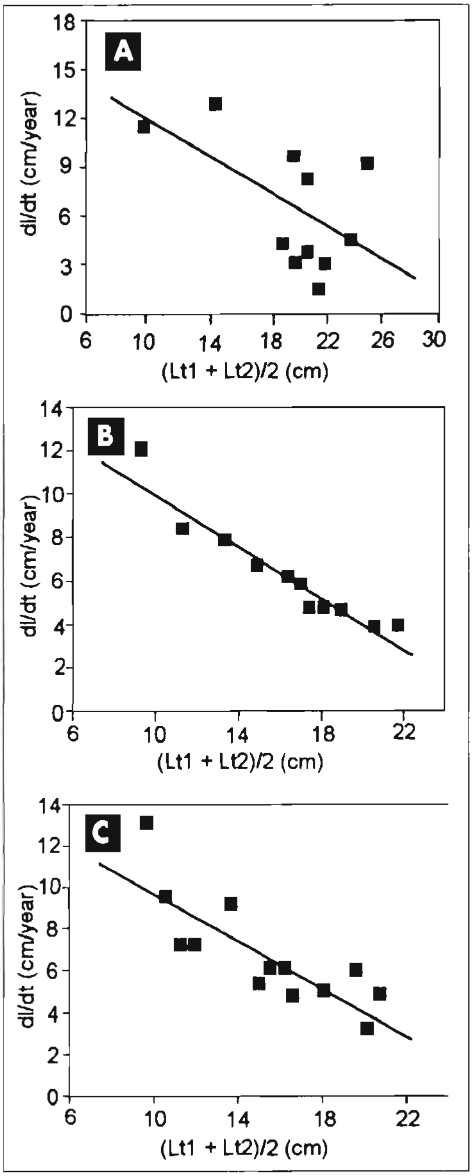


Figure 2

Linear regression of mean length (L) vs growth rate (dL/dt) from the Gulland and Holt plot for *S.crumenophtalmus*

Regresi linear dari panjang rata-rata (L) terhadap laju pertumbuhan (dL/dt) dari metoda Gulland dan Holt plot untuk *S. crumenophthalmus*

Top: *cohort A - kelompok umur A*
Center: *cohort B - kelompok umur B*
Bottom: *cohort C - kelompok umur C*

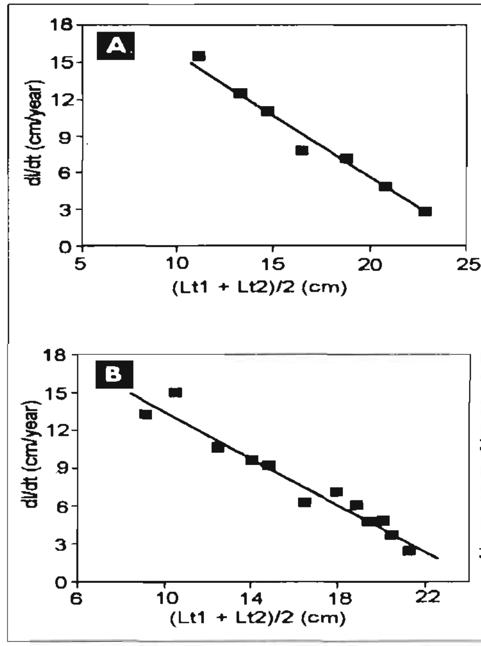


Figure 3

Linear regression of mean length (L) vs growth rate (dL/dt) from the Gulland and Holt plot for *D. russelli*

Regresi linear dari panjang rata-rata (L) terhadap laju pertumbuhan (dL/dt) dari metoda Gulland dan Holt plot dari *D. russelli*

Top *: May cohort - Kelompok umur Mei*
Center *: February cohort - Kelompok umur Februari*

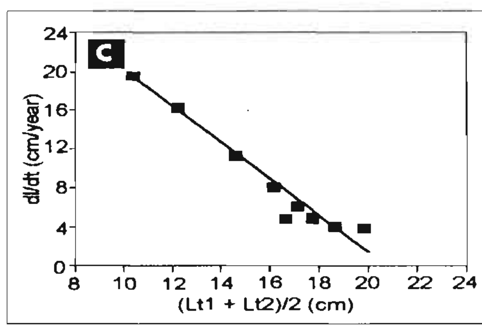


Figure 4

Linear regression of mean length (L) vs. growth rate (dL/dt) from the Gulland and Holt plot for *A. sirm*

Regresi linear dari panjang rata-rata (L) terhadap laju pertumbuhan (dL/dt) dari metoda Gulland dan Holt plot untuk *A.sirm*

According to the spawning periods assessed by Atmaja *et al.* (pp. 71-84) and to the age estimated by reading otoliths (Conand, 1991; Dalzell, 1989; Dayaratne and Gjosaeter, 1986), the length-at-age data used in Von Bertalanffy plot is presented in table III and table IV.

The growth parameters estimated by the graphical method and by the ELEFAN I System are given in table V. The L∞ values obtained from Gulland and Holt plot are usually lower than the one from ELEFAN I. The same results have been found by other authors (Widodo, 1988; Atmaja, 1988). This can be explained because the ELEFAN I System only traces one cohort, assuming that this cohort will appear every year at the same period, and the growth curve also tends to fit the highest length value found in the cohort. Consequently, the L∞ tends to be higher than it should be. The modes used to plot the growth curves (fig. 1) vary from one cohort to another, that explains the different growth parameters values found. The growth parameters estimations found by some authors in different parts of the world for the observed species are summarized in table VI.

Table III

LENGTH-AT-AGE DATA FOR GROWTH PARAMETERS ESTIMATION USING VON BERTALANFFY PLOT FOR *D. RUSSELLI* AND *A. SIRM*

L= mode in cm

t=age in year

DATA PANJANG BERDASARKAN UMUR UNTUK PENDUGAAN PARAMETER PERTUMBUHAN DENGAN METODA VON BERTALANFY PERTUMBUHAN DARI *D.RUSSELLI* DAN *A. SIRM*

L= panjang rata-rata dalam cm

t= umur dalam tahun

D. RUSSELLI				A. SIRM	
May cohort		February cohort			
L	t	L	t	L	t
9.6	0.25	8.5	0.25	9.3	0.25
12.2	0.42	9.6	0.33	11.3	0.33
14.3	0.58	11.1	0.42	13.1	0.42
15.2	0.67	13.7	0.67	17.9	1.08
17.8	1.00	14.3	0.75	19.1	1.33
19.6	1.25	15.3	0.83	20.4	1.67
22.0	1.75	17.5	1.25		
23.6	2.33	18.3	1.33		
		19.3	1.50		
		20.1	1.67		
		20.7	1.83		
		21.7	2.25		

Table IV

DATA USED FOR GROWTH PARAMETERS ESTIMATION USING VON BERTALANFFY PLOT FOR *S. CRUMENOPHTHALMUS*

INPUT DATA UNTUK PENDUGAAN PARAMETER PERTUMBUHAN MELALUI METODA VON BERTALANFY DARI *S. CRUMENOPHTHALMUS*

Cohort A		Cohort B		Cohort C	
L	t	L	t	L	t
8.0	0.33	8.7	0.33	9.0	0.33
9.9	0.50	9.7	0.42	10.1	0.42
13.2	0.75	12.5	0.75	10.9	0.50
14.8	0.92	13.8	0.92	11.5	0.58
17.1	1.17	16.0	1.25	12.1	0.67
17.8	1.25	16.5	1.33	14.4	0.92
18.9	1.50	17.0	1.42	15.3	1.08
20.0	1.75	17.8	1.58	15.8	1.17
20.8	2.00	18.2	1.67	16.3	1.25
21.4	2.17	19.8	2.00	16.7	1.33
22.0	2.58	21.1	2.33	19.2	1.83
22.5	2.75	22.1	2.58	19.7	1.92
				20.5	2.17
				20.9	2.2

CONCLUSION

A polymodal distribution is usually noticed in the monthly length-frequency data obtained during the survey. Based on the results of Bhattacharya method, it is supposed there may be several cohorts in the fishery, especially for carangid species. The estimated growth parameters derived from the different methods used in the study are gathered in table V.

The results of this study showed for a fact that the growth parameters of the different cohorts are not the same. A theoretical study on analytical models is usually based on the analysis of one single cohort, but as the growth parameters here assessed have different values according to each cohort, one model should be implemented for each different cohort.

Table V

ESTIMATES OF GROWTH PARAMETERS FOR *D. RUSSELLI*, *S. CRUMENOPHTHALMUS* AND *A. SIRM*

NILAI DUGAAN PARAMETER PERTUMBUHAN DARI *D.RUSSELLI*, *S. CRUMENOPHTHALMUS* DAN *A. SIRM*

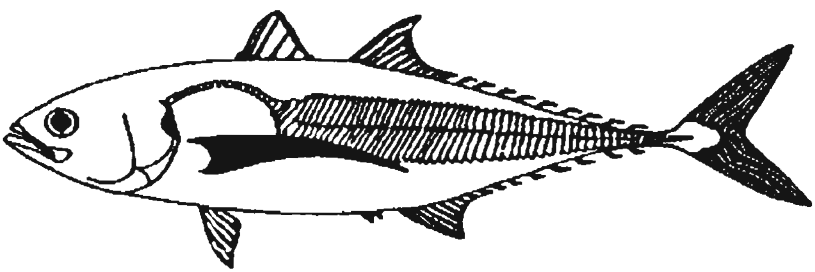
SPECIES	METHODS	GROWTH PARAMETERS		
		L_∞	K	to
D. RUSSELLI	Gulland & Holt plot			
	May cohort	25.2	1.1	
	Feb. cohort	24.5	1.0	
	VonBertalanffy plot			
	May cohort	25.2	1.08	-0.17
	Feb. cohort	24.5	0.95	-0.25
	ELEFAN	26.9	0.7	
S.CRUMENOPHTHALMUS	Gulland & Holt plot			
	Cohort A	26.5	0.8	
	Cohort B	26.7	0.6	
	Cohort C	25.8	0.6	
	VonVertalanffy plot			
	Cohort A	26.5	0.8	-0.37
	Cohort B	26.7	0.6	-0.30
	Cohort C	25.8	0.6	-0.36
	ELEFAN	26.1	1.1	
A. SIRM	Gulland & Holt plot	20.5		1.9
	VonBertalanffy plot	20.5	2.8	-0.13
	ELEFAN	23.3	1.3	

Table VI

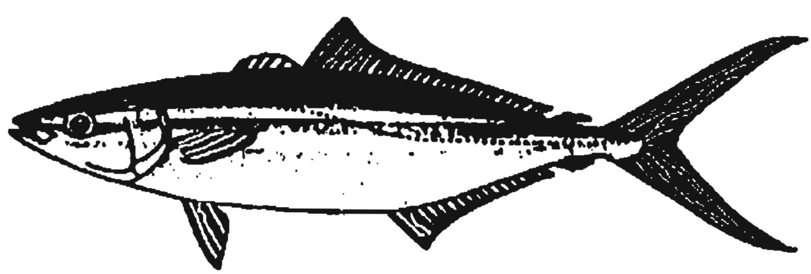
GROWTH PARAMETERS ESTIMATION FOR SOME PELAGIC FISHES FROM THE JAVA SEA AND ELSEWHERE.

NILAI DUGAAN PARAMETER PERTUMBUHAN DARI BEBERAPA JENIS IKAN PELAGIS DI LAUT JAWA DAN TEMPAT LAINNYA

SPECIES	LOCATION	L∞	K	to	AUTHORS
A. sirm	Java Sea	25.2	1.17	-	Sadhotomo & Atmaja,1985
A. sirm	Java Sea	25.8	1.15	-	Dwiponggo *et al.*, 1986
A. sirm	Sri Lanka	22 to 23	2.4 to 3.7	-0.1 to 0.7	Dayaratne & Gjosaeter,1986
D.macrosoma	Java Sea	20.6 to 24.2	0.9 to 1.3	-	Atmaja, 1988
D.macrosoma	Java Sea	23.1 to 24.4	0.73 to 0.87	-	Widodo, 1988
D.macrosoma	Java Sea	25.4	1.15	-	Dwiponggo *et al.*, 1986
D.russelli	Java Sea	24.7 to 28.3	0.4 to 0.5	1.4 10^{2} to 8 10^{3}	Widodo, 1988
D.russelli	Java Sea	25.9 to 27.0	0.95 to 1.18	-	Dwiponggo *et al.*, 1986
S.crumenophthalmus	Java Sea	25.9	1.25	-	Dwiponggo *et al.*, 1986
S.crumenophthalmus	Philippines	29.8	1.94	-0.228	Dalzell,1989



Megalaspis cordyla (**Tetengkek**)



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REVIEW OF THE LEMURU FISHERY IN THE BALI STRAIT

GEDE SEDANA MERTA

ABSTRACT

Many studies have been carried out on the **"lemuru"** fishery of the Bali Strait since 1959. The research has covered many aspects, such as fishery, biology and population dynamics or stock assessments. This paper presents a synthesis of these studies.

Disajikan hasil tinjauan perikanan lemuru di perairan Selat Bali. Sejak kira-kira tahun 1959, telah banyak dilakukan penelitian mengenai perikanan lemuru di perairan Selat Bali, baik mengenai sumberdayanya maupun lingkungannya.

INTRODUCTION

According to Burhanuddin *et al.* (1984), the word of **"lemuru"** includes four species as *Sardinella longiceps*, *Sardinella aurita*, *Sardinella leiogaster* and *Sardinella clupeoides*, which in the fishery statistics of Indonesia lumped together with *Amblygaster sirm*. The Bali Sardinella or **"lemuru"**, *Sardinella lemuru*, is a very important small pelagic species, contributing to about 39.3% of the total **"lemuru"** production of Indonesia. The total production of **"lemuru"** in Indonesia ranged from 44 175 to 145 055 tons with an average 81 000 tons per year during the period of 1981 to 1991. It increased about 12.6% per year.

This species is a highly rated fish for human consumption as well as a source of valuable by-products like sardine oil and fish meal for cattle and poultry feed. In 1990 there were 15 factories for canning and fish meal operating in this area and about 250 traditional industries for fish meal. The capacity for canning was about 200 tons/day, and for fish meal including traditional industries it amounted to about 2 000 tons/day.

Compare to other small pelagic fisheries, the **"lemuru"** fishery in the Bali Strait is very specific, in term that this fishery mainly develops in a relatively small area which was estimated to be only about 2,500 km^{-2}. Although the Bali Strait waters cover a small surface, the productivity is very high due to the occurrence of upwelling process during the East monsoon, from April to October (Salijo, 1973). During the upwelling season, the salinity of surface waters is 34 ‰, and the temperature, about 24.5 º C is low (Burhanuddin and

Praseno, 1982). Plankton concentration is generally higher on the Bali shelf than in the middle of the strait and on the Java shelf (Subani and Sudradjat, 1981). In 1973, the number of diatom cells was 58.8 x 103 cells/m^{-3} in March, and increased to 61.6 x 103 cells/m^{-3} in July (Burhanuddin and Praseno, 1982). During this year, the nutrient contents (mainly nitrate) were higher in July than in March.

1. FISHERY

1.1 Gears and Crafts

According to Soemarto (1959), before the development of the purse seine in 1974, the **"lemuru"** fishery in the Bali Strait used traditional gears, such as **"payang oras"** (seine net), **"jaring lemuru"** (**"jaring eder"** or gill net), **"serok"** (scoop or dip net) and **"jala tebar"** (cast net). These gears are still used, but they are now very few.

Purse seine gear has developed rapidly since 1974, starting with 10 purse seines, it increased to 44 in 1975 and 119 in 1977. In 1990, the number of purse seines in the Bali Strait was estimated to about 295 units, 273 units with licence and 22 units without licence. One unit of purse seine consists of 2 boats, the net boat which carries the net and the **"sleret"** which hauls it.

Since 1980 the size of the net boats has increased. Before 1980 , the size of the purse seine used in Muncar (East Java) was ranging between 165 and 204 m length and 21 and 28 m depth, and in Pengambengan (Bali) between 135-142.5 m length and 19.5-52.5 m. depth (Bandie *in* Kusuma, 1980). The size of the boats used in Muncar was about 11 x 2.7 x 1.5 m for net boat using one outboard engine, and 13 x 2.8 x 1.5 m for **"sleret"** with two outboard engines of 13 HP each.

At the end of the 80 's, the size of the net used in the Bali Strait was between 120 and 285 m in length and 50 to 95 m in depth. The size of the boats was 15 x 3.3 x 1.5 m for a **"sleret"** and 14.5 x 3.4 x 1.5 m for a net boat (net boat using 2 outboards engines and **"sleret"** using 3 engines of 19- 25 HP each).

1.2 Production

In the 80's the production of **"lemuru"** in the Bali Strait developped from 3 233 to 49 104 tons with an average 32 749 tons/year (fig. 1)

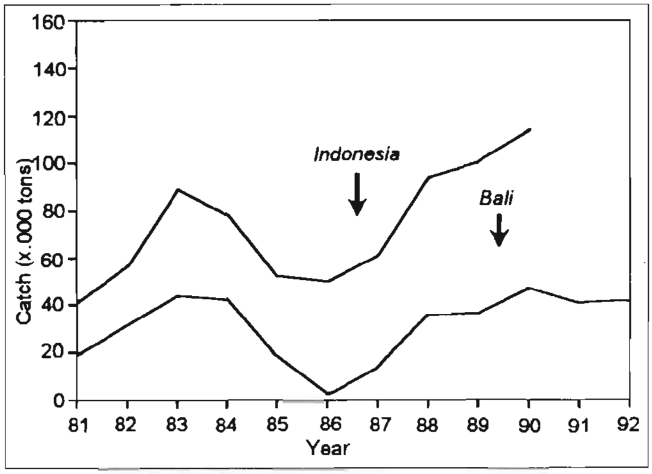
The average production of **"lemuru"** was about 78.5% of the total catch in the Bali Strait and the monthly average catch was 76% (Merta, 1992a). The highest production of **"lemuru"** in the Bali Strait reached 49 104 tons in 1983, and the lowest production 3 233 tons in 1986, According to fishermen, **"lemuru"** disappeared in 1986.

It is still not obvious why **"lemuru"** disappeared. From figure 1, it can be seen that the **"lemuru"** production was decreasing from 1984 to 1986 and increasing again up to its 1983 level in 1990. It was presumed that the very low production of **"lemuru"** in 1986 was due to the failure of recruitment. This one was assumed to be affected by El Nino event which occurred in 1982/83, and was certainly the most powerful yet studied (Longhurst and Pauly, 1987).

Figure 1

PRODUCTION OF **"LEMURU"** IN THE BALI STRAIT(1981-1992) COMPARED TO THE TOTAL NATIONAL PRODUCTION (1981- 91)

HASIL TANGKAPAN IKAN LEMURU DI SELAT BALI (1981-1992) DAN SELURUH INDONESIA (1981-91).



While **"lemuru"** was decreasing, other species caught together with **"lemuru"** among which *S. fimbriata, Decapterus spp., Auxis spp., Euthynnus affinis, Sarda orientalis, R. kanagurta, Scomber australasicus*, tended to increase as depicted in figure 2.

1.3 Fishing Grounds

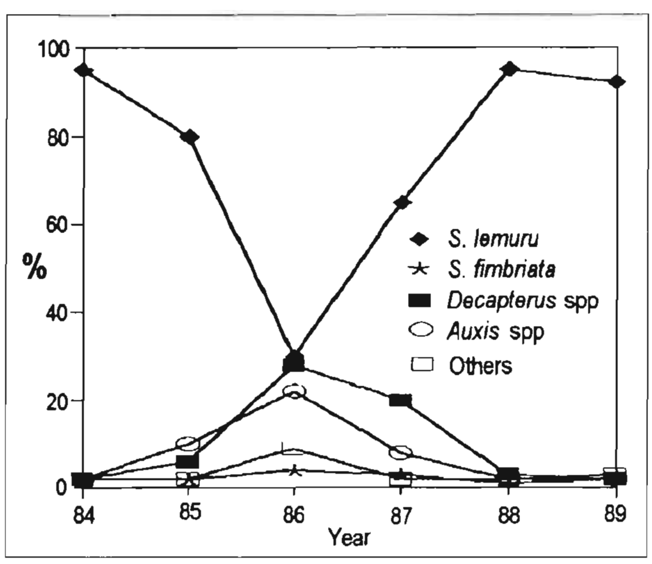
The fishing grounds of the fishery are entirely in the strait. Fishermen named the fishing grounds according to the name of bays, mountains and villages, as in figure 3. Pangpang Bay is mainly a fishing ground for **"bagan"** (lift net). At Senggrong, coastal waters are for movable/raft lift net and deeper waters for purse seine. The Jimbaran fishing ground is very close to the coast, and particularly used for cast net fishery.

Figure 2

SPECIES COMPOSITION (% WEIGHT) OF SOME IMPORTANT PELAGIC CAUGHT BY PURSE SEINERS IN THE BALI STRAIT

KOMPOSISI SPECIES (%) DARI BEBERAPA IKAN PELAGIS PENTING YANG TERTANGKAP OLEH PUKAT CINCIN DI SELAT BALI

(Merta, 1992a)



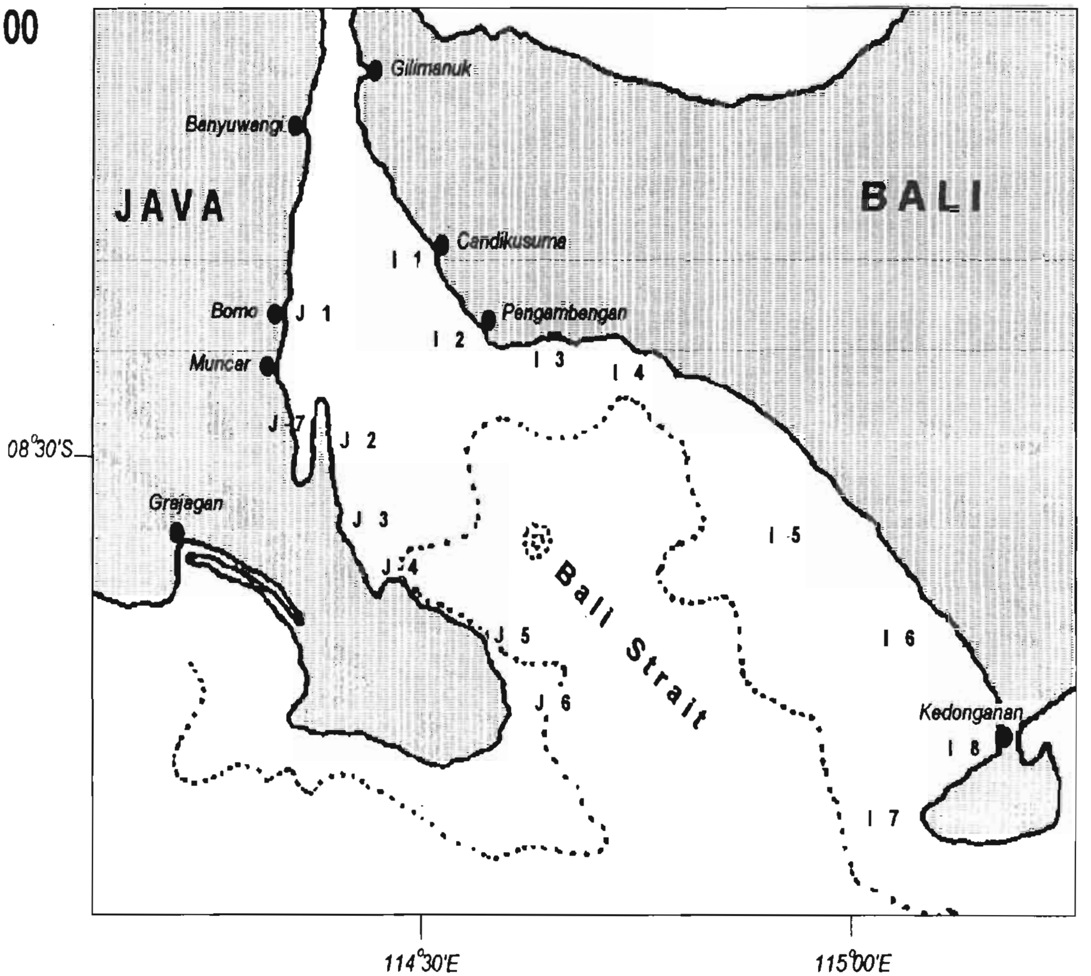


Figure 3

MAP OF THE "LEMURU" FISHING GROUNDS IN THE BALI STRAIT

PETA DAERAH PENANGKAPAN LEMURU DI SELAT BALI

Java Shelf

1. *Bomo (J 1)*
2. *East of Tanjung Sembulungan (J 2)*
3. *Klosot/Wringinan (J 3)*
4. *Senggrong (J 4)*
5. *Tanjung Angguk/Gudang Seng/Tanjung Pasir (J 5)*
6. *Karang Ente (J 6)*
7. *Teluk Pangpang (J 7)*

Bali Shelf

1. *Candi Kusuma (I 1)*
2. *Pengambengan (I 2)*
3. *Perancak (I 3)*
4. *Pulukan (I 4)*
5. *Tanjung Antab Pemancar/ Lampu Merah (I 5)*
6. *Seseh (I 6)*
7. *Tanjung Bukit/Uluwatu (I 7)*
8. *Jimbaran (I 8)*

Table I

DISTRIBUTION OF ABUNDANCE (%) BY SIZE OF FISH AND FISHING GROUNDS, BASED ON SAMPLES TAKEN FROM MUNCAR, PENGAMBENGAN AND KEDONGANAN (FIG.3)

DISTRIBUSI KELIMPAHAN (%) BERDASARKAN UKURAN IKAN DAN DAERAH PENANGKAPAN, BERDASARKAN SAMPLE DARI MUNCAR, PENGEMBANGAN DAN KEDONGANAN (GAMB. 3)

(August 1989-July1990)

Source : Merta (1992a)

REMARKS :

Sempenit < 11 cm

Protolan 11-15 cm

Lemuru 15-18 cm

L. kucing > 18 cm

	FISHING GROUNDS						
SHELF	J 1	J 2	J 3	J 4	J 5	J 6	J 7
JAVA :							
Sempenit	-	29.2	9.0	32.5	0.7	-	73.0
Protolan	100	58.8	70.2	63.5	80.5	31.5	27.0
Lemuru	-	11.6	20.5	3.9	18.8	68.1	-
L. kucing	-	0.4	0.3	0.1	-	0.4	-
Average length (cm)	13.1	12.3	13.8	12.0	13.7	15.9	9.0

	FISHING GROUNDS							
SHELF	I 1	I 2	I 3	I 4	I 5	I 6	I 7	I 8
BALI								
Sempenit	-	0.5	28.1	3.6	5.0	8.8	4.4	29.0
Protolan	98.6	92.9	46.2	53.6	45.0	43.9	18.7	70.4
Lemuru	1.4	6.6	25.1	42.6	48.7	45.9	72.7	0.6
L. kucing	-	-	0.6	0.2	1.3	1.4	4.2	-
Average length (cm)	13.4	13.5	13.1	14.5	14.9	14.6	16.1	11.4

2.1 Taxonomy

Formerly, many scientists used the word *Sardinella longiceps* as the scientific name for **"lemuru"** in the Bali Strait. This species belongs to Subfamily *Clupeinae*, Family *Clupeidae*, Suborder *Clupeoidei*, Order Clupeiformes, Infradivision *Clupeomorpha*, Subdivision *Teleostei*, Division *Halecostomi*, Infraclass *Neopterygii*, Subclass *Actinopterygii* and Class *Osteichthys* (Nelson, 1984).

After revision of Family *Clupeidae* by Wongratana (1980), the scientific name used for **"lemuru"** in the Bali Strait is now *Sardinella lemuru* (Bleeker, 1853), and its English name is Bali Sardinella (Whitehead, 1985). There are some synonyms still in use for *S. lemuru* as (Whitehead, 1985) : *Clupea nymphea* (Richardson, 1846), *Amblygaster posterus* (Whiley, 1931), *Amblygaster postera* (Munro, 1956), *Sardinella samarensis* (Roxas, 1934), *Sardinella longiceps* (Fowler, 1941), *Sardinella aurita* (Raja & Hiyama, 1969), *Sardinella aurita terrase* (Lozano and Rey) *Sardinella lemuru* (Wongratana, 1980).

2.2 Distribution

According to Whitehead (1985), the geographical distribution of the *Sardinella lemuru* is reported in the eastern Indian Ocean (Phuket, Thailand, southern coast of East Java and Bali; western Australia) and the western Pacific (Java Sea North to the Philippines, Hong Kong, Taiwan Island to southern Japan). In Indonesia besides in the Bali Strait, **"lemuru"** is usually caught in the South of Ternate, the Jakarta Bay and sometimes also in the Java Sea out of Central Java (Weber and De Beaufort *in* Soerjodinoto, 1960).

Acoustic surveys carried out by the Research Institute for Marine Fisheries indicated that the distribution of **"lemuru"** in the Bali Strait is only concentrated on the shelves of Java and Bali Islands, and could almost not be found in waters deeper than 200 m (Merta, 1976; Amin and Sujastani, 1981). The number of schools is more important in the Bali shelf and their average volume is also bigger than on the Java shelf (Merta, 1976; Amin and Sujastani, 1981).

The distribution of abundance (% number) of **"sempenit"** (< 11 cm), **"protolan"** (11-15 cm), **"lemuru"** (15-18 cm) and **"lemuru kucing"** (> 18 cm) is presented in table I. It can be seen that **"sempenit"** fish are found in all the fishing grounds, in the Java shelf as well as the Bali shelf, in coastal waters less than 70 m deep. **Sempenit** is more concentrated in bays, such as the Pangpang and Senggrong Bays on the Java shelf and the Jimbaran Bay on the Bali shelf. Beside, dense concentrations were also found in Tanjung Sembulungan (J 2) and Perancak (I 3). **Protolan** is more abundant in the northern part of the strait than in the southern one, but **"lemuru"** and **"lemuru kucing"** are more abundant in the southern part than in the northern part of the strait. The largest sized fish were mainly caught southernmost of the strait, in the fishing grounds of Tanjung Bukit (I 7) in Bali and Karang Ente (J 6) in Java (Merta, 1992a & b). According to Garcia and Josse (1988), the distribution of juveniles sardine and mackerel is generally near the coasts (inner shelf) and moves to deeper waters (outer shelf) as the fish grow. **"Sempenit"** fish appear on both shelves nearly at the same time, i.e. about May/June to September and sometimes in other months.

Authors	Length (TL) at Age (mm)			
	1	2	3	4
Dwiponggo (1972)	94	151	180	206
Ritterbush (1975)	133	184	201	211
Gumilar (1985)	128	171	190	199
Merta (1992a)	154	199	216	223
Average	127	176	197	210

Table II

LENGTH AT AGE OF LEMURU AS DERIVED FROM VON BERTALLANFY GROWTH FORMULA ACCORDING TO SOME AUTHORS

PANJANG BERDASARKAN UMUR IKAN LEMURU YANG DITURUNKAN DARI RUMUS PERTUMBUHAN VON BERTALANFY OLEH BEBERAPA PENULIS

2.3 Feeding

The **"lemuru"** is a zoo (90.5-95.5%) and phytoplankton (4.5-9.5%) feeder. The highest zooplankton component is copepod (53.8-55%) and decapod (6.5-9.4%) (Burhanuddin and Praseno, 1982).

2.4 Age

On the basis of length frequency data, the life span of the **"lemuru"** derived from Von Bertalanffy Growth Formula (VBGF) was determined by some authors to be four years, and its length at age is presented in table II. *Sardinella longiceps*, one of the species very close to **"lemuru"** (*Sardinella lemuru*) could also attained 4 years of age, with their average length at age of 115, 155, 186 and 203 mm for age 1, 2, 3 and 4 years respectively (Bal and Rao, 1984).

2.5 Spawning

■ SPAWNING SEASON

The location and time of the **"lemuru"** spawning in the Bali Strait is still not clear. Soerjodinoto (1960) notices that the **"lemuru"** tends to come toward the coast for spawning because of the low salinity. Dwiponggo (1972) presumes that **"lemuru"** spawns in June-July, which is justified by Ritterbush (1975) and Burhanuddin *et al.*, (1984). From gonad maturity studies, Merta (1992a & b) concludes that the **"lemuru"** in the Bali Strait spawns in July. This result is also justifying the conclusion of Dwiponggo (1972). Whitehead (1985) says that the **"lemuru"** spawns at the end of the rainy season every year.

Dwiponggo (1972) assumes that the spawning area of **"lemuru"** in the Bali Strait is not far from the coast . Merta (1992a) presumes that in the Bali Strait the **"lemuru"** spawns in deep waters which cannot be reached by the gear.

■ FECUNDITY

Studies of fecundity for **"lemuru"** are scarce. Ritterbush (1975) estimates the fecundity of **"lemuru"** in the Bali Strait for both gonads to be 60 000-70 000 eggs.

■ SEX RATIO

According to Soerjodinoto (1960), the sex ratio of **"lemuru"** in the Bali Strait is not constant, but males generally dominate the population. Ritterbush (1975) shows the sex ratio of **"lemuru"** to be 1:1. A recent study indicates that the sex ratio for male and female **"lemuru"** is 0.97 : 1 (Merta, 1992a).

■ Length at First Maturity

The **"lemuru"** length at first maturity is assessed as 17.79-18.3 cm with an average 18.0 cm by Merta (1992 a & b).

■ Length-weight Relationships and Condition Factors

Generally, the length-weight relationships of **"lemuru"** in the Bali Strait were allometric, the highest exponent was in October 1989 (3.6889), while the lowest value was in August 1989 (2.8438). The monthly length-weight relationships considerably varied and could not be reduced to only one length-weight relationship (Merta, 1993).

Relative Factor Conditions (**Kn**) were from 0.90 (August 1989) to 1.14 (September 1989). The low value of **Kn** in August may be due to the presence of many spent fish (Merta, 1993).

3. POPULATION DYNAMICS

3.1 Growth Parameters

The growth parameters of **"lemuru"** have been estimated by some authors mainly using the Modal Class Progression Analysis and the ELEFAN package. The estimated values of **L∞** and **K**, when using MCPA, were ranging from 21.2 - 23.8 cm and .50 - 1.00 per year, while using ELEFAN they were ranging from 20.6 - 23.2 and 0.79 - 1.28 per year. Merta (1992a & d) estimated the growth parameters using Complete ELEFAN Ver 1.1 Package (Gayanilo *et al.*, 1988) they were 22.71 cm and 0.961 per year respectively. Budihardjo *et al.*, (1990) obtained smaller **L∞** values and higher **K**, i.e. 21.4 cm and 1.37 per year respectively.

3.2 Mortalities

The total fishing and natural mortalities which have been estimated by some authors using various methods are presented in table III.

Table III

Total (Z), Natural (M) and Fishing (F) mortalities estimated by some authors.

Dugaan Kematian Total (Z), Alami (M) dan Penangkapan (F) oleh beberapa penulis.

Source : Merta (1992a & d)

Authors	Z (/year)	M (/year)	F (/ year)
Ritterbush (1975)	1.4	0.8-0.9	0.5-0.6
Sujastani and Nurhakim (1982)	2.74 (1977)	1.42	1.32
	2.76 (1978)	1.42	1.34
	1.43 (1979)	1.42	0.01
	2.89 (1980)	1.42	1.47
Gumilar (1985)	3.23	1.22	2.01

For Budihardjo *et al.* (1990), the mortality parameters for **"lemuru"** were **Z** = 5.08 and **M** = 2.17 per year, whereas Merta (1992a & d) has estimated smaller values for the total (4.82) and natural mortalities (1.0).

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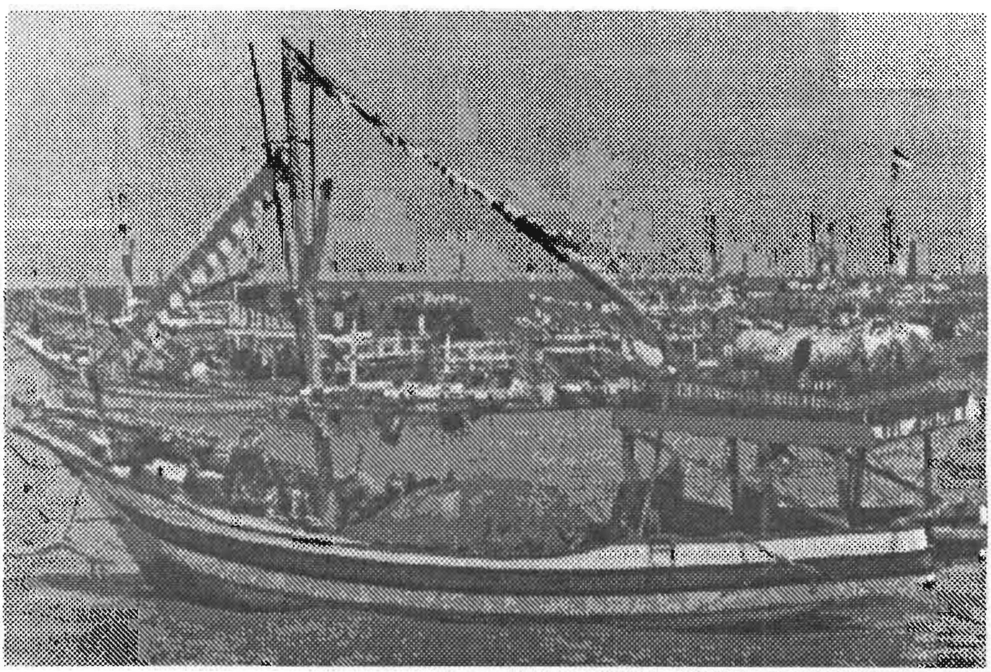
PAYANG FROM EAST JAVA

PAYANG DARI JAWA TIMUR

SMALL SEINERS FROM EAST JAVA

KAPAL PUKAT CINCIN KECIL DARI JAWA TIMUR



DYNAMICS

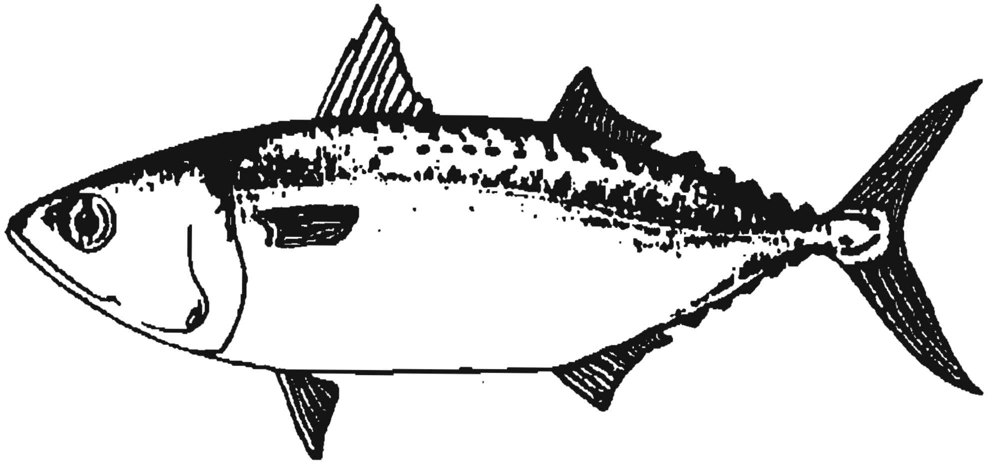
POPULATION DYNAMICS
OF IKAN BANYAR *(RASTRELLIGER KANAGURTA)*
S. NURHAKIM 109

POPULATION DYNAMICS
OF IKAN LAYANG, SCADS
(DECAPTERUS SPP.)
J. WIDODO 125

PREDICTION OF BIOMASS,
YIELD AND VALUE
OF THE LEMURU *(SARDINELLA LEMURU)*
FISHERY IN THE BALI STRAIT
G.S. MERTA, H.M. EIDMAN 137

IMPLEMENTATION
OF COMPOSITE MODEL
ON SMALL PELAGIC RESOURCES
S. NURHAKIM, B. SADHOTOMO,
M. POTIER 145

EXPLORATORY SCHEME
FOR THE RECRUITMENT
AND MIGRATION
OF THE MAIN PELAGIC SPECIES
B. SADHOTOMO, M. POTIER 155



Rastrelliger kanagurta (**Banyar**)

POPULATION DYNAMICS OF IKAN BANYAR

(Rastrelliger kanagurta)

S. NURHAKIM

ABSTRACT

This study of **"Ikan Banyar"** (*Rastrelliger kanagurta*) is based on length frequency measurements data taken from purse-seine fishing during the 1991/1992 period in the Java Sea. Several dynamics parameters concerning growth and mortality were obtained. Analytical models were employed to determine the current status and to analyze the effect of changes in the exploitation pattern of the **"Ikan Banyar"** fishery in the Java Sea. The results showed that the present fishery is probably exploiting fish just below the optimum level. It means that decreasing the mesh size or increasing the fishing effort would decrease yield per recruit.

Telaah tentang Ikan Banyar (Rastrelliger kanagurta) ini berdasarkan frequency panjang dari kapal Purse seine pada tahun 1991/1992 di Laut Jawa. Beberapa parameter yang berhubungan dengan dinamika populasi seperti pertumbuhan dan kematian telah didapatkan. Model analitik dipergunakan untuk menentukan tingkat pemanfaatan dan menganalisa akibat suatu perubahan pola pengusahaannya pada per ikanan Ikan Banyar di Laut Jawa. Hasil yang diperoleh memperlihatkan bahwa ting-

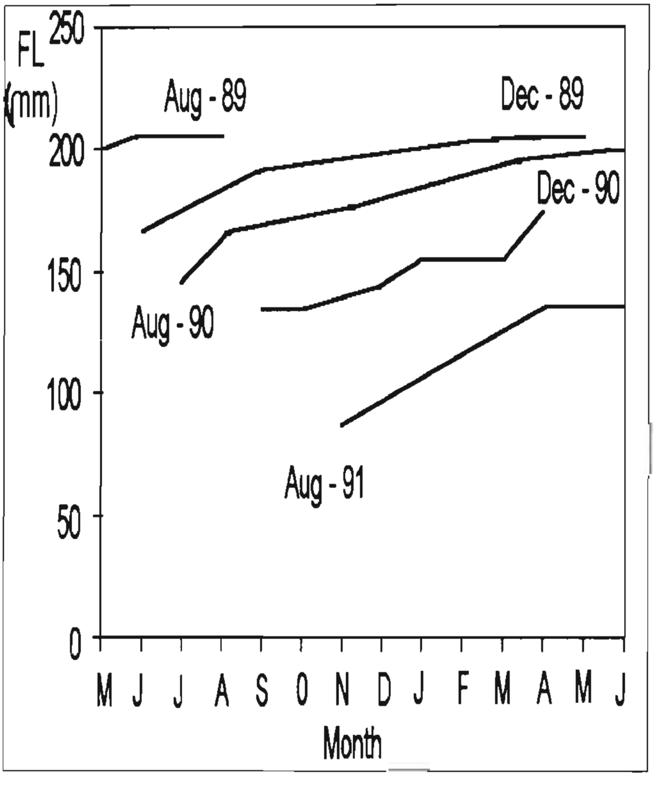


Figure 1

MODES OF *RASTRELLIGER KANAGURTA* FROM MAY 1991 TO JUNE 1992 BASED ON THE RESULTS OF THE SUCCESSIVE MAXIMA METHOD

MODUS *R. KANAGURTA* DARI MEI 1991 SAMPAI DENGAN JUNI 1992 BERDASARKAN HASIL YANG DIPEROLEH MELALUI METODA "SUCCESSIVE MAXIMA" *kat pengusahaan saat ini diduga hampir mencapai tingkat yang optimal. Ini berarti bahwa penurunan dan penambahan ukuran mata jaring dapat menurunkan hasil tangkapan per rekruit.*

INTRODUCTION

The small pelagic fishery in the Java Sea plays an important role in the 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 and 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.

The Indo-Pacific Mackerel (*Rastrelliger kanagurta*) is widely found in almost all Indonesian waters and abundantly in the Java Sea. It is the second largest catch of the purse seine fishery in the Java Sea. Since the purse seine is the main fishing gear in the exploitation of small pelagic species, this study will only cover the purse seine fishery in the Java Sea.

Basically, there are three major sources of data used for fish stock assessment: catch and effort data, research survey data, and biological studies. In the absence of accurate specific catch and effort information and considering the changes of exploited areas, the analysis of the stock could not be based on these sources. Acoustic research surveys on pelagic fish in the Java Sea are scarce and inadequately documented, which leads to a poor stock assessment. Accordingly, the main approach in this study was to carry out independent biological studies. Growth parameters and mortality rates were analyzed on the basis of the size and age composition of the samples.

The length-based method used in this study is based upon modal progression analysis. The yield per recruit is an easily accessible piece of data used in fishery management. This method can be used even without knowing the recruitment. Without any knowledge of the recruitment **R**, it is impossible to estimate the total production. The software ANALEN created by Chevaillier et Laurec (1990) and which allows catch data analysis per length classes and simulation of multi-gears fisheries with sensibility analysis, is used in this study.

This study has two purposes : to estimate the dynamics parameters such as growth parameters and mortality rates, and to analyze the yield per recruit and the effects on the yield by manipulating the length at first capture and fishing effort. We hope that all information obtained can be used as input data in the small pelagic fishery management in the Java Sea.

1. DYNAMICS PARAMETERS

Beyond the recruitment, the groups of animals are influenced by two important dynamics parameters: growth of individuals and mortality. Those parameters must be known to maintain the future balance of the stock.

■ Growth parameters

The growth of recruited groups of fish in the fisheries is well described by the Von Bertalanffy model (1938).

$$Lt = L\infty (1 - e^{-K (t-t_0)})$$

Lt = length at age t.

L∞ = theoretical asymptotic length

K = growth coefficient

t_0 = theoretical age when the growth curve cross the age axis

The estimation of the growth can be done either from the length frequencies analysis or from the analysis of the regular structure of some hard parts of the fish (otolith, scale, first dorsal fin). In our case, only the length frequencies analysis was used. The method of successive maxima (Gheno et Le Guen, 1968 ; Le Guen et Morizur, 1989) was employed in this study in order to separate the monthly length frequencies distributions. The growth parameters, **K** and **L∞** were estimated by the iterative procedure of the software "Statgraphics" and the Gulland and Holt (1959) model. The results of modes separation by the Successive Maxima method are depicted in table I. The modes of the cohorts from table I were plotted against the corresponding months of the survey (fig. 1). To illustrate the approximate growth path of each cohort, the modes assumed to be part of one cohort were joined.

The growth path depicted in figure 1 suggested that two cohorts of *Rastrelliger kanagurta* entered the purse seine fishery in the Java Sea.

The first cohort was detected in November at the mode of 85 mm, while the other was in September at the mode of 135 mm. Since there were two basic spawning periods, July/ August and December, it was most likely that fish entering the fishery in November belonged to the August cohort (3 month old fish of 85 mm length), while those entering in November belonged to the December cohort (9 month old fish of 135 mm length).

By taking August 1 and December 1 as birth dates of the

Table I

Modes of the cohorts obtained by splitting up the polymodal distribution into unimodal distributions through the method of Successive Maxima

Modus dari beberapa kelompok umur yang diperoleh dengan cara penguraian distribusi "polymodal" menjadi distribusi "unimodal" melalui metoda "Successive Maxima"

Month	Number of cohort	Mode (mm)
1991		
May	1	200
Jun	1	165
	2	205
July	1	145
	2	175
	3	205
August	1	165
	2	205
Sept.	1	135
	2	190
Oct.	1	135
	2	190
Nov.	1	85
	2	175
Dec.	1	145
	2	195
1992		
Jan.	1	155
	2	200
Feb.	1	190
March	1	155
	2	195
April	1	135
	2	175
	3	205
May	1	135
	2	205
June	1	135
	2	200

two cohorts, respectively, length-age data could be approximately calculated (tab. II). From the data in table II, an iterative procedure of fitting the Von Bertalanffy growth curve was carried out. The estimated growth parameters derived from iterative procedure are shown in table III.

The annual growth rate of the two cohorts of *Rastrelliger kanagurta* (tab. IV) was estimated by employing the growth parameters shown in table III.

Sekharan (1958), estimated that, in South Kanara - India, *Rastrelliger kanagurta* is from 12 to 15 cm in total length during the first year and reaches 21 to 23 cm at the end of the second year. Using the Bhattacharya method, based on monthly data of *Rastrelliger kanagurta* caught by purse seine in 1980 and 1981 at Manglore, Gangolli and Karwar, Udupa and Krishnabhat (1984) reached the conclusion that there were three age classes of 1, 2 and 3 years with an average total length of 19.45 cm, 23.45 cm and 25.20 cm respectively. Based on studies of scale and otolith, Sheshappa (1969) showed that *Rastrelliger kanagurta* reached the total length of 11 to 15 cm at the end of the first year, 21 to 24 cm at the end of the second year, 25 to 27 cm at the end of the third year and 28 to 29 cm at the end of the fourth year.

Growth parameters of *Rastrelliger kanagurta* were also estimated by using Gulland and Holt plot (1959) (fig. 2 and 3). The input data i.e., l1 + l2/2 and dl/dt derived from table V. The results of this analysis were :

K = 0.633 L_∞ = 263.12 mm for the August cohort (fig. 2A).
K = 0.759 L_∞ = 261.19 mm for December cohort (fig. 2B).

Table II

Length-at-age data for August and December cohorts of *Rastrelliger kanagurta* based on the assumption of August 1 and December 1 as their respective birth dates

Panjang berdasarkan umur untuk kelompok umur Agustus dan Desember dengan asumsi tanggal 1 Agustus dan 1 Desember sebagai tanggal kelahiran

August cohort		December cohort	
Age (yr)	Mode (mm)	Age (yr)	Mode (mm)
0.25	85	0.75	135
0.67	135	0.83	135
0.75	135	1.00	145
0.92	135	1.08	155
0.92	145	1.25	155
1.00	165	1.33	175
1.25	175	1.50	165
1.58	195	1.58	175
1.75	200	1.75	190
1.83	200	1.83	190
1.83	205	2.00	195
1.92	205	2.08	200
2.00	205	2.33	205
		2.42	205

Table III

PARAMETER ESTIMATES OF THE VON BERTALANFFY GROWTH EQUATION FOR *RASTRELLIGER KANAGURTA* BY MEAN OF ITERATIVE PROCEDURE. S = STANDARD DEVIATION

DUGAAN PARAMETER DARI RUMUS PERTUMBUHAN VON BERTALANFFY DARI *R. KANAGURTA* MELALUI PROSEDUR ITERATIF. S = STANDARD DEVIATION

PARAMETER	AUGUST COHORT		DECEMBER COHORT	
		S		S
L (cm)	26.33	2.5	26.14	4.3
K	0.68	0.18	0.53	0.25
t_0	-0.32	0.12	-0.57	0.37

Table IV

ANNUAL GROWTH RATE (CM) OF *RASTRELLIGER KANAGURTA* IN THE JAVA SEA BASED ON THE GROWTH PARAMETERS DERIVED FROM THE ITERATIVE PROCEDURE.

PERTUMBUHAN TAHUNAN (CM) *R. KANAGURTA* DI LAUT JAWA BERDASARKAN PARAMETER PERTUMBUHAN YANG DIPEROLEH MELALUI PROSEDUR ITERATIF.

	AUGUST COHORT			DECEMBER COHORT		
YEAR	CALCULATED AVERAGE LENGTH		ANNUAL GROWTH INCREMENT OF FL	CALCULATED AVERAGE LENGTH		ANNUAL GROWTH INCREMENT OF FL
	FL	TL		FL	TL	
1	15.61	18.19	15.61	14.75	17.30	14.75
2	20.90	23.65	5.29	19.43	22.14	4.67
3	23.58	26.42	2.68	22.19	24.99	2.75
4	24.93	27.82	1.36	23.81	26.67	1.62

The estimation of $L\infty$ derived from the above various methods was in term of fork length. t_0 provides the estimation of $L\infty$ in term of total length, the relationship between fork length and total length was employed. In summary, the estimation of the *Rastrelliger kanagurta* growth parameters derived from the length-frequency distribution using different methods is shown in table VI.

For further calculation, the values in table VI were utilized as the reference values of growth parameters. Sujastani (1974) mentioned that the growth parameters of *Rastrelliger kanagurta* in the Java Sea were $L\infty$ = 23.89 cm (TL) and **K** = 0.23 per year.

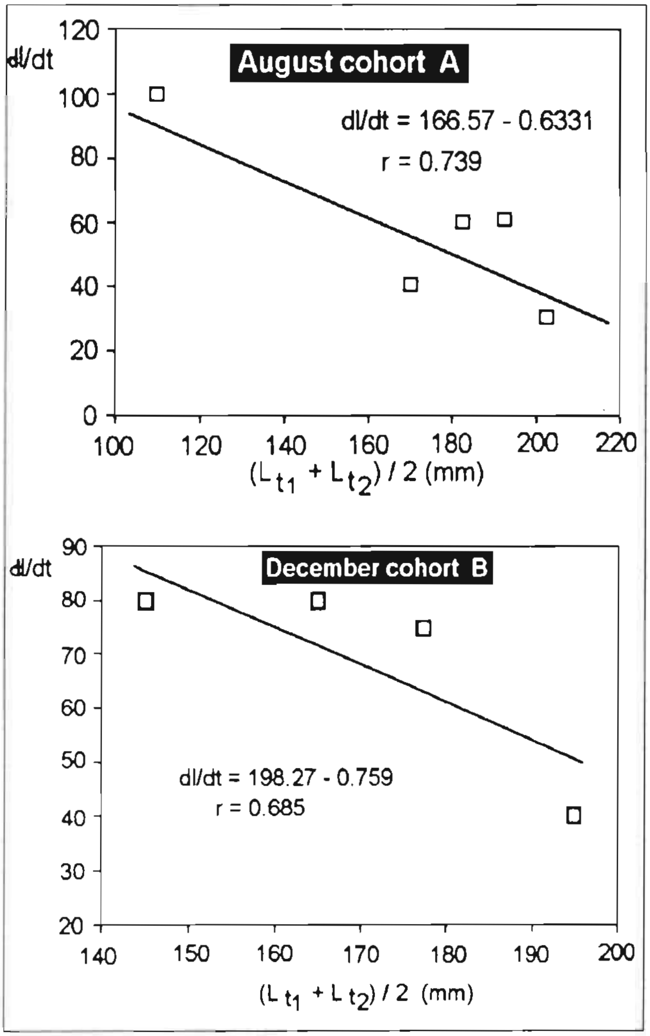


Figure 2a and 2b

Gulland and Holt plot for August (A) and December (B) cohorts of *Rastrelliger kanagurta*

Plot dari metoda Gulland dan Holt untuk kelompok umur Agustus (A) dan Desember (B) untuk

R. kanagurta
(dL/dt : mm/year)

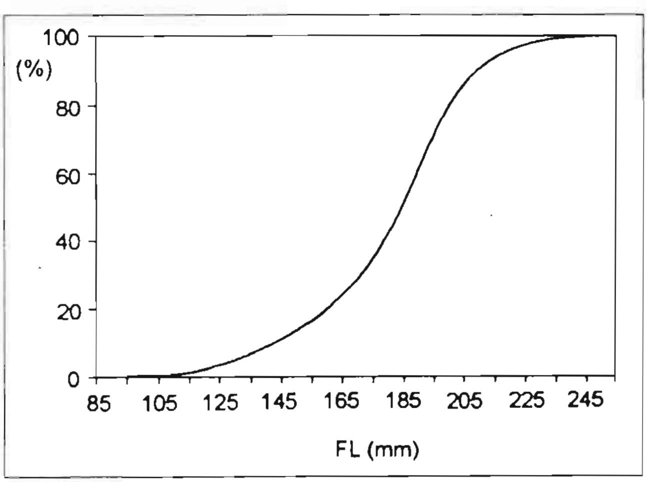


Figure 3

Relationship between length of *Rastrelliger kanagurta* and retention rate of purse seine in the Java Sea

Hubungan antara panjang *R. kanagurta* dan "retention rate" purse seine di Laut Jawa

(C : Cumulative %)

Sadhotomo and Atmaja (1985) obtained the values of:

L∞ = 25.7 cm
K = 1.625 per year.

In the Malacca Strait, Tampubolon (1988) reported that **L∞** and **K** of *Rastrelliger kanagurta* were 28.7 cm (TL) and 0.78 per year respectively. The different values of growth parameters were due to the different length intervals of the sampled individuals and the various mathematical treatment used (Laurec et Le Guen, 1981).

1.2 Length at first capture

According to the selectivity curve of purse seine utilized in purse seine fishery in the Java Sea (tab. VII, fig. 3), we can admit that the length at first capture is about 18 cm, length at which 50% of the fish are retained in the net. The obtained values of L_{25}, L_{50}, and L_{75} were about 170, 180 and 195 mm respectively.

1.3. Parameters of mortalities

■ Natural mortality coefficient

The natural mortality coefficient **M** is the most difficult parameter to evaluate in the population dynamics of the exploited stock. However, it is a vital parameter in the structural

Table V

Input data for the Gulland and Holt plot based on mixture analysis of length-frequency distribution using the successive maxima method (L1+L2/2 in mm and dL/dt in mm/yr)

Input data untuk model Gulland dan Holt plot berdasarkan analisa gabungan dari distribusi frequency panjang dengan mempergunakan metoda "Successive Maxima" (L1+L2/2 dalam mm dan dL/dt dalam mm/tahun)

August cohort		December cohort	
(l1+l2)/2	dl/dt	(l1+l2)/2	dl/dt
110.0	100	145.0	80
170.0	40	165.0	80
182.5	60	177.5	75
192.5	60	195.0	40
202.5	30		

Table VI

Estimation of the growth parameters of *Rastrelliger kanagurta* using the iterative procedure and Gulland and Holt plot

Dugaan parameter pertumbuhan dari *R. kanagurta* in the Java Sea melalui prosedur iteratif dan model Gulland dan Holt plot

Method	K	L∞ (cm) FL	L∞ (cm) TL	T_0 (year)
ITERATIVE				
August cohort	0.681	26.33	28.98	-0.32
December cohort	0.528	26.14	28.79	-0.57
GULLAND and HOLT				
August cohort	0.633	26.31	28.97	
December cohort	0.759	26.11	28.68	

Table VII

Annual catch (May 1991 to May 1992) of *Rastrelliger kanagurta* by length classes in number and in cumulative percentage

Hasil tangkapan tahunan (Mei 1991-Mei 1992) dari *R. kanagurta* berdasarkan kelas panjang dalam jumlah ekor dan persentase kumulatif

Middle class length (mm)	Catch	% cumulative
85	352 443	0.20
95	323 184	0.37
105	237 309	0.52
115	796 784	0.98
125	2 398 065	2.35
135	5 791 379	5.66
145	7 689 567	10.06
155	10 806 160	16.24
165	15 063 007	24.85
175	20 418 670	36.53
185	28 130 684	52.62
195	37 226 435	73.91
205	26 825 863	89.25
215	13 796 288	97.14
225	4 323 517	99.61
235	627 682	99.97
245	48 567	99.99
255	444	100.00

Table VIII

Estimation of natural mortality M for *Rastrelliger kanagurta* derived from several empirical formula, using input data of the growth parameters derived from iterative procedure and Gulland and Holt model

Dugaan nilai kematian alami (M) dari *R. kanagurta* yang diperoleh dari beberapa rumus dengan mempergunakan input data berupa parameter pertumbuhan yang diturunkan melalui prosedur interatif dan metoda Gulland dan Holt

METHOD

Method to obtain K and L∞	Alverson and Carney*		Pauly**	Rikhter and Efanov***	Hoenig
	tm = 3 yr	tm = 5 yr			
ITERATIVE					
August cohort	1.75	0.78	0.76	1.04	1.04
December cohort	1.92	0.92	0.64	0.82	0.83
GULLAND and HOLT					
August cohort			0.72		
December cohort			0.80		

* t_{mb} = 0.38 x tm.
** Surface temperature = 28°C
*** The age when 50% of the fish is mature corresponds to L m = 200 mm.

model. Some authors try to provide estimations of **M**, based on empirical relationship between different biological and physical parameters.

The relation established by Pauly (1980) linked the value of **M** with the growth parameters (**K** and **L∞**) and the mean water temperature:

$$\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

The other empirical formula, from Alverson and Carney (1975) established a relation between the age when some cohorts produce their maximal biomass (**tmb**), the growth parameter (**K**), and the natural mortality (**M**).

$$t_{mb} = \frac{1}{K} \cdot L_n \frac{(M+3K)}{M}$$

$$\text{then, } M = \frac{3K}{(e^{Kt_{mb}} - 1)}$$

Alverson and Carney estimated that $t_{mb} = 0.38\, t_m$, t_m is the maximum age reached by the species. It is difficult, in case of *Rastrelliger kanagurta*, to appreciate the validity of the value 0.38.

The equation of Rikhter and Efanov (1976) linked the natural mortality **M** and the age at maturity t_{m50} which is the age when 50% of the fishes are mature, called "age at massive maturity" :

$$M = \frac{1.521}{t_{m50} \cdot 0.720} - 0.155$$

In our case the estimation of t_{m50} varies according to the season.

The last one is Hoenig (1984) empirical formula:

$$Ln\ M = 1.46 - 1.01 \cdot Ln\ Tmax,$$

where **Tmax = 3/K+t_0**, **T max** = maximum age reached by the species.

In spite of doubts and critics in employing those empirical methods, we noticed some homogeneity in the results around the value of **M** = 1.00. This latter will be adopted as the first approximation value.

■ FISHING MORTALITY COEFFICIENT

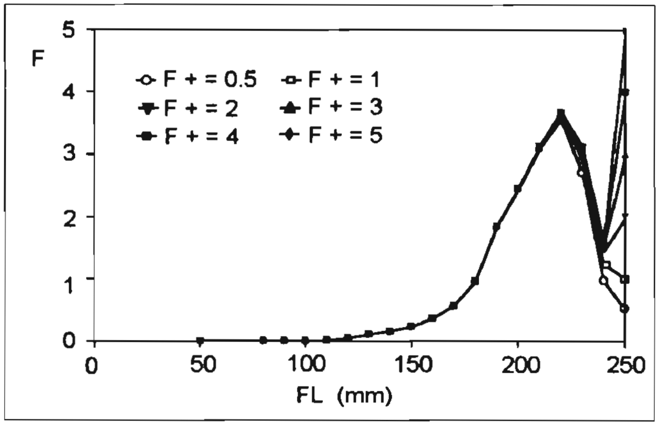
From pseudo cohort analysis with ANALEN (Chevaillier et Laurec, 1990) we can assess the fishing mortality vector, **F**, per length classes, according to **F** terminal. We chose 1.00 as the value of **M**, and we showed in figure 4, the fishing mortality vectors **F** for 1991/1992 with that value of **M** and by varying the **F** terminal of the calculation initialization. It shows a good convergence of **F** at length 240 mm for final coefficients varying from 1 to 5 (fig.

4). This shows that choosing the fishing mortality terminal value between 1 and 5 has little influence on the results. The value of **F** terminal for initialization of the next calculation was chosen as 3.00. We can see that the fishing mortality has a role only when the size is above 100 mm. They are about 0.25, 2.5 and 3.5 for 150 mm, 200 mm and 220 mm length respectively.

Figure 4

RASTRELLIGER KANAGURTA, VECTOR OF FISHING MORTALITY F ACCORDING TO F TERMINAL (M = 1.00 ; YEAR 1991/ 1992)

NILAI KEMATIAN PENANGKAPAN F DARI *R. KANAGURTA* MENURUT NILAI F AKHIR YANG DITETAPKAN (M = 1.00; TAHUN 1991/ 1992).



2. ANALYTICAL MODEL USED

In a given year the group of individuals present in the stock, forms one group which is treated as if they were yearly successive cohorts. If the stock is stable, it is possible to make a pseudo-cohort analysis based on the data collected only during one year. It is assessed that one stock is stable when the recruitment and the diagrams of mortalities have been constant during the exploitation period of the concerned cohorts (Chevaillier et Laurec, 1990). When only length structures are available, the pseudo-cohort analysis of Jones (1981), allows to estimate the coefficient of fishing mortality based on grouped length classes according to age. The pseudo cohort analysis stands on two basic equations of structural model. The first one describes the decreasing strength of the cohorts according to their age equation (1). The death which occurs in a given interval time is expressed by the catch equation (2).

$$N_{l+1} = N_l \, e^{-Zl \, . \, dtl} \qquad (1)$$

$$C_i = \frac{F_i}{Z_i} \, X \, (1 - e^{-N_i \, Z_i \, dt_i}) \qquad (2)$$

where :

- i = length class index.
- C_i = number of dead individuals due to fishing at length between l_i and l_{i+1}
- F_i = fishing mortality coefficient of length class i

Z_l = total mortality coefficient = F_l+M (M, natural mortality coefficient, assumed to be constant)

N_l = number of individuals which reach the length

dt_l = necessary time for some individuals to grow from L_l to L_{l+1}.

We replace dt_l in the equations (1) and (2) with its expression in Von Bertalanffy equation:

$$dt_l = \frac{1}{K} . \text{Log} \frac{(L\infty - L_l)}{(L\infty - L_{l+1})}$$

The dt_l can be only calculated if L_{l+1} is below L¥. All individuals which have a length above or equal to the terminal length L_{l+} are grouped together. For this last group the catch equation is :

$$C_{l+} = N_{l+} . \frac{F_{l+}}{Z_{l+}} \qquad (3)$$

The system formed by the equations (1), (2) and (3) has a bigger number of unknown variables than of equations. Then, a value for one of the unknown variables has to be chosen. It has been demonstrated that the maximal robustness of the cohort analysis was reached when the fishing mortality (F_{l+}) of the group terminal was taken into account. The solutions for each length class can not be directly calculated. They were solved with ANALEN by an iterative procedure.

The pseudo cohort analysis requires the knowledge of the following parameters :

- Number of individuals per length classes.
- **K** and **L∞** of Von Bertalanffy equation.
- Natural mortality **M**, assumed to be constant during the period of observation.
- Fishing mortality of group terminal, F_{l+}
- Lower class of length group terminal L_{l+}

Fishing mortality integrates all the causes of death due to fishing. Landed species as well as those thrown back in the sea should be taken into account. In Indonesia, this problem does not occur, since purse seine fishery never throw back any catch in the sea.

The principle of yield per recruit calculation consists of observing a theoretical cohort during its life span and determining the biomass of the fishery after it totally disappears. By this calculation the recruitment does not need to be known. However, the fishery has to be in a stable situation with a fishing mortality by length class not varying from one year to another.

The basic equation is the catch equation (2). This equation allows to calculate the death of fish for each length class. The catches in number are then converted in weights by the length-weight relationship :

$$W_i = a \, . \, L_i^b$$

where

W_i = average weight at length class i

L_i = average length at length class i

Multiplying W_i by C_i (2), gives the production of length class i (Y_i)

$$Y_i = W_i \, . \, C_i$$

the total production (**Y**) is:

$$Y = \Sigma Y_i \qquad (4)$$

If the survival equation (1) is initialized to N_i = 1, the equation (4) gives the yield per recruit.

3. ISOPLETH OF YIELD PER RECRUIT

Previous data entering into models are depicted in the table IX.

DATA	VALUES
K	0.6501 /year
L ∞	262.24 mm
a of L/W relationship	0.000006445
b of L/W relationship	3.166889
M, natural mortality	1.000
F+ terminal fishing mortality	3.00
L_{25}	170 mm
L_{50}	180 mm
L_{75}	195 mm
Mesh size of	6.35 mm
	12.70 mm
	19.05 mm
	25.40 mm
	31.75 mm

Table IX

INPUT DATA FOR YIELD PER RECRUIT ANALYSIS OF *RASTRELLIGER KANAGURTA* USING ANALEN SOFTWARE (CHEVAILLIER ET LAUREC)

INPUT DATA UNTUK ANALISA "YIELD PER RECRUIT" DARI *R. KANAGURTA* DENGAN PROGRAM ANALEN SOFTWARE (CHEVAILLIER ET LAUREC)

From the data in table IX we have calculated the yield per recruit (fig. 5, 6 and 7) according to :

- Different values of **M** : 0.8 ; 1.00 and 1.2.
- Multiplicative factors of mortality coefficient **F** (from 0.25 to 4) ;
- The different mesh-sizes (from 6.35 mm to 31.75 mm).

It appears that, using different values of **M**, with the current effort and the mesh size used, the result we obtained is close to the best yield per recruit.

CONCLUSION

Based on the results we obtained ,we conclude that:

- The length at first capture of *Rastrelliger kanagurta* varies between 17 and 19 cm. Even though the length at first reproduction is between 18.6 to 22.7 cm, the current exploitation should not be a problem in term of stock-recruitment relationship, however, we should remain vigilant.

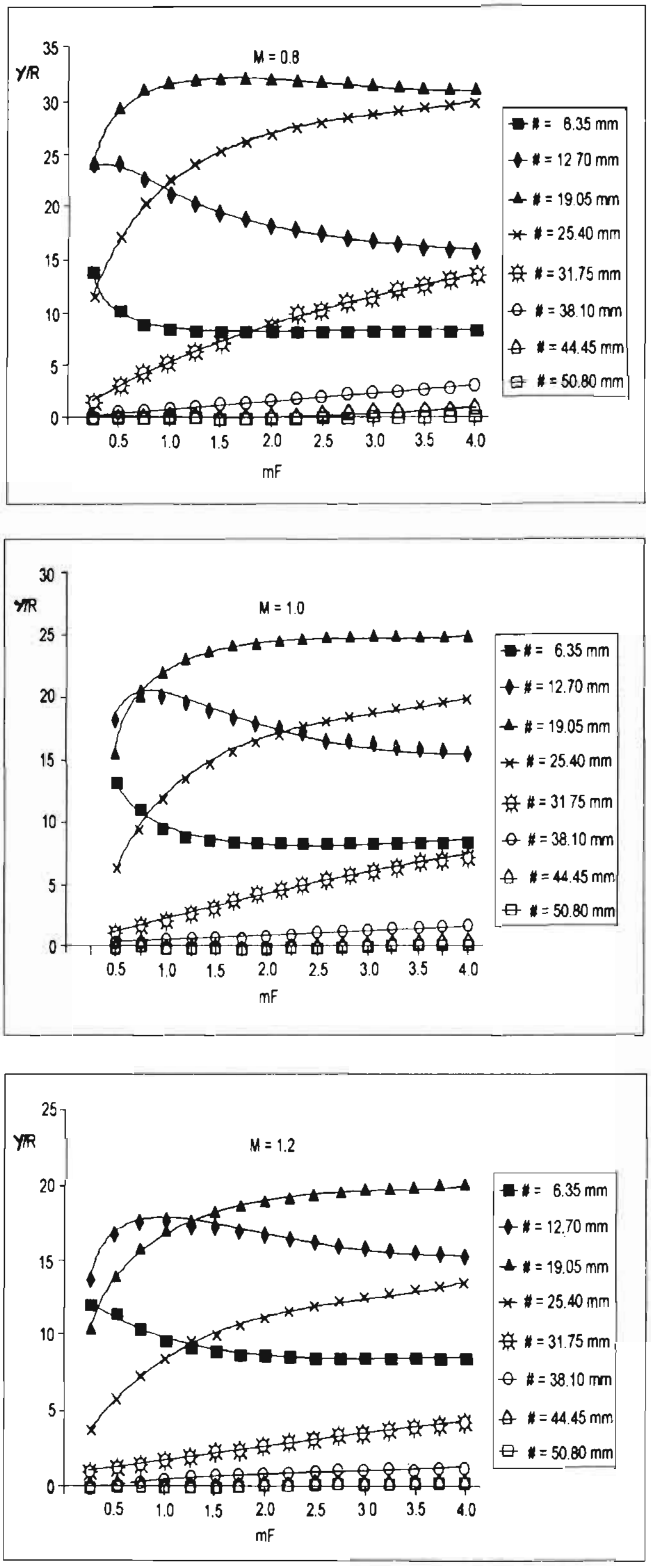


Figure 5

Yield per recruit (Y/R) of *R. kanagurta* according to multiplicators of F (mF), employing three values of M and different values of mesh size (from 6.35 to 31.75 mm)

Hasil tangkapan per recruit (Y/R) dari *R. kanagurta* menurut nilai pengali F(mF) dengan mempergunakan nilai M yang berbeda dan ukuran mata jaring (dari 6.35-31.75 mm)

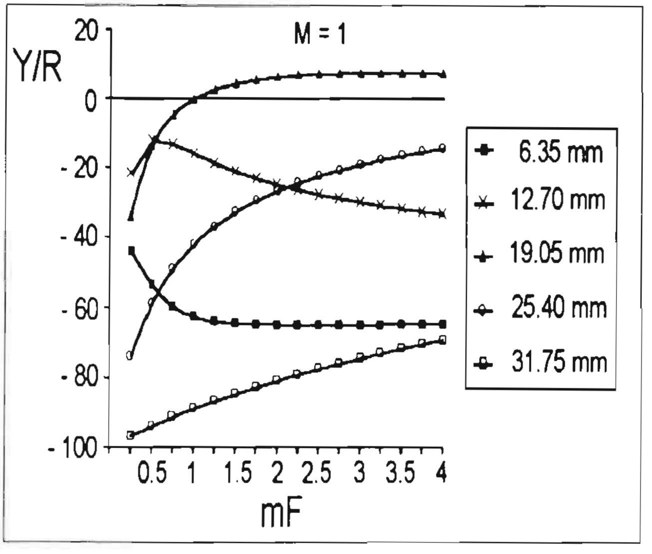


Figure 6

EVOLUTION OF YIELD PER RECRUIT AGAINST ACTUAL LEVEL OF EFFORT (%) ACCORDING TO CHANGES OF EFFORT, FOR DIFFERENT MESH SIZES.

EVOLUSI HASIL TANGKAPAN PER RECRUIT TERHADAP TINGKAT EXPLOITASI SAAT INI (%) MENURUT PERUBAHAN EFFORT UNTUK BEBERAPA UKURAN MATA JARING YANG BERBEDA.

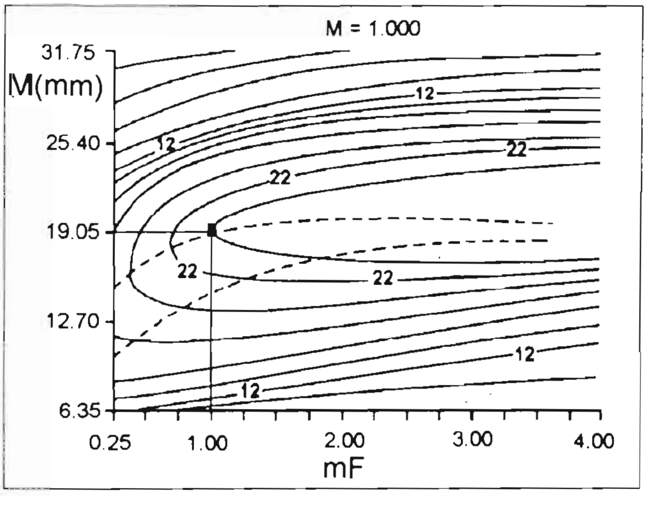


Figure 7

ISOPLETH OF YIELD PER RECRUIT OF *RASTRELLIGER KANAGURTA* VS MESH SIZE *M (MM)*. THE CURRENT STATUS OF THE FISHERY IS PLOTTED IN THE YIELD PER RECRUIT ISOPLETH FOR M = 1.00

ISOPLET HASIL TANGKAPAN PER RECRUIT DARI *R. KANAGURTA* VS UKURAN MATA *M (MM)*. STATUS PENGUSAHAAN PERIKANAN SAAT INI DIPLOT TERHADAP ISOPLET HASIL TANGKAPAN PER RECRUIT UNTUK M=1.00

- It seems that the current status of *Rastrelliger kanagurta* fishery is close to the optimum level. The increasing of the fishing effort could lead to a decreasing of yield per recruit. It would also be certainly dangerous to decrease the mesh size used.
- Without biological and dynamics informations from the other species, and based on the current status of *Rastrelliger kanagurta* fishery, it is better to keep the present mesh size.
- In order to get more accurate information on age, it is necessary to perform deeper studies about growth (sclerochronology of otoliths, scales, etc.). Furthermore the other informations collected from surveys on echo-integration, allow to estimate the total biomass, which is always interesting to know and to put in relationship with the production.
- Since the purse seine fishery in the Java Sea exploits simultaneously several species, while the analytical model was based on a single species analysis, it seems that the achieved result will be influenced by some factors of interaction between the species. Hopefully, the multi-specifics model will give more accurate information on multi-specific fisheries management.

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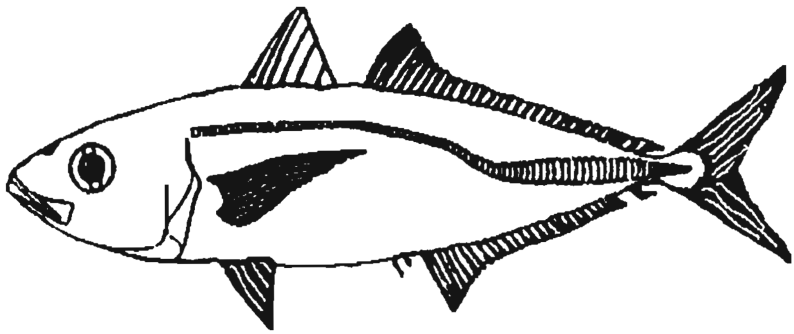
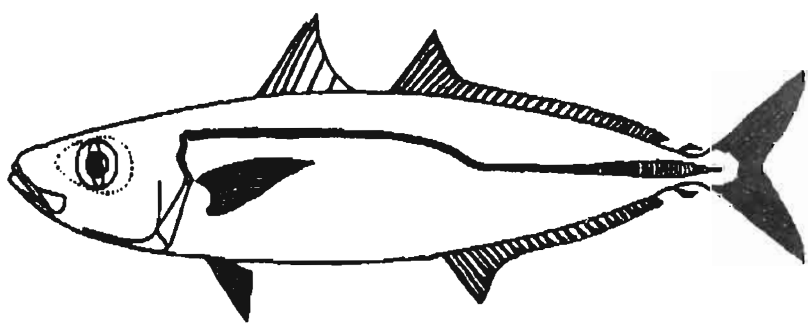
POPULATION DYNAMICS OF IKAN LAYANG, SCADS

(Decapterus spp.)

J. WIDODO



Decapterus russelli (**Layang biasa**)



Decapterus macrosoma (**Layang deles**)

ABSTRACT

"**Ikan layang**" **or** scad mackerel, *Decapterus spp.* (Pisces: *Carangidae*) which consists of two species, *viz D. russelli* and *D. macrosoma* plays a significant role in the pelagic purse seine fishery in the Java Sea.

Referring to management policy using an $\mathbf{E_{0.1}}$ criterion (analogous to $\mathbf{F_{0.1}}$) showed that the current level of exploitation rate (**E** = 0.41) for *D. russelli* was below the estimate of the $E_{0.1}$ level (**E** = 0.57), while for *D. macrosoma* (**E** = 0.70) it was beyond the $\mathbf{E_{0.1}}$ level (**E** = 0.55). Consequently, increasing the current level of exploitation rate of *D. russelli*, to a value close to its $\mathbf{E_{0.1}}$ level, would increase the yield per recruit by 21%. On the contrary, reducing the current level of exploitation rate of *D. macrosoma*, to a value close to its $\mathbf{E_{0.1}}$ level, would reduce the yield per recruit by 10%.

As a mixed pelagic fishery, increasing the mesh size from the commonly in practice (# = 15 mm) to 20 mm would reduce the overall landing of as much as 58%. Conversely reducing the mesh size from 15 mm to 10 mm would increase the overall landing as much as 36%.

Ikan layang atau scad mackerel, Decapterus spp. (Pisces : Carangidae) yang terdiri dari dua spesies yaitu D. russelli dan D. macrosoma mempunyai peranan penting didalam perikanan purse seine di Laut Jawa.

Dengan memperhatikan kebijaksanaan pengelolaan yang mempergunakan kriteria $\mathbf{E_{0.1}}$ *(analog dengan* $\mathbf{F_{0.1}}$*), terlihat bahwa tingkat laju pengusahaan sahat ini (**E** = 0.41) untuk D. russelli adalah dibawah nilai tingkat dugahan* $\mathbf{E_{0.1}}$ *(**E** = 0.57), sedangkan untuk D. macrosoma (**E** = 0.70) adalah telah melewati tingkat* $\mathbf{E_{0.1}}$ *(**E** = 0.55). Sebagai akibatnya, dengan meningkatkan laju pengusahaan D. russelli mendekati nilai* $\mathbf{E_{0.1}}$ *nya kiranya dapat meningkatkan yield per recruit sebesar 21%. Sebaliknya pengurangan laju pengusahaan saat ini untuk D. macrosoma mendekati nilai* $\mathbf{E_{0.1}}$ *kiranya dapat mengurangi yield per recruit sebesar 10%.*

Sebagai suatu perikanan pelagis yang terdiri lebih dari satu spesies, dengan memperbesar mata jaring dari yang ada sekarang (15 mm) menjadi 20 mm akan mengurangi jumlah hasil yang didaratkan secara keseluruhan sebesar 58%. Sebaliknya dengan memperkecil mata jaring dari 15 mm menjadi 10 mm akan meningkatkan hasil yang didaratkan sebesar 36%.

INTRODUCTION

The pelagic fishery in the Java Sea exploits a community of small coastal pelagic species dominated by "**ikan layang**" or scad mackerels, *Decapterus spp.* (*Carangidae*); sardines, *Sardinella spp.* (*Clupeidae*); "**ikan kembung**" or Indo-Pacific mackerels, *Rastrelliger spp.* (*Scombridae*); and "**ikan selar**" or trevallies, *Selar spp.* (*Carangidae*).

The "**ikan layang**" fishery, using purse seine nets with an effective 15 mm mesh size, is one of the most important in the Java Sea, ranking first in both total finfish value and in volume. The bulk of the fishery is dependent upon two species, first the "**layang**", or Indian scad *D. russelli* (often wrongly identified as *D. maruadsi* --restricted, according to Gushiken (1983), to the coasts of Japan and China--) which predominates in the catch, second the "**layang deles**" or shortfin scad, *D. macrosoma*.

The yield per recruit analysis has been an important basis for yield assessment, especially concerning the effects of changes in the fishing effort and in the gear selectivity on yield. Its popularity is primarily related to the ability to set up an optimum combination between fishing mortality and age of entry which maximizes the yield per recruit. This level of fishing mortality, F_{max}, i.e. the fishing mortality giving the maximum yield per recruit, has been an important part of the assessment biologists advice for decades. However, since the concept of fishing mortality rate at $F_{0.1}$, namely the level of fishing mortality that corresponds to a rate of increase at the beginning of the stock exploitation, was introduced in the North Atlantic fisheries in the early seventies, it became widely used in managing the fishery resources in the region (Anthony, 1982). An analogous concept of $F_{0.1}$, i.e., $E_{0.1}$ was introduced by Deriso (1987) by re-parameterization in term of

$$F = M \left[\frac{E}{1-E} \right]$$

1. MATERIAL AND METHODS

In its original form the annual catch per recruit (**Y/R**) as developed by Beverton and Holt (1957) involved seven independent variables: the parameters of growth (**K**, **L∞**, and t_o of the Von Bertalanffy growth model), the natural mortality rate (**M**), the fishing mortality rate (**F**), the age at first capture (t_c), and the maximum age attained (t_l).

Beverton (1963) developed a re-parameterization of the original model, so that a dimensionless index of catch per recruit can be expressed as :

$$y = \frac{Y}{R\,W_\infty} = E \sum_{n=o}^{3} \frac{U_n (1 - C)^n}{1 + \left(\frac{nK}{M}\right)(1 - E)}$$

where :

- **y** = dimensionless term of yield per recruit
- **E** = rate of exploitation = $\frac{F}{F+M}$
- **M** = natural mortality rate
- **c** = ratio of the mean selection length and maximum length $\frac{Lc}{L\infty}$
- **K, L∞, t_o** = parameters of the Von Bertalanffy growth formula
- **Y** = yield
- **R** = abundance of the year-class at l_c
- **W∞** = asymptotic weight, proportional to $L\infty^3$
- **U_n** = summation coefficient, taking value of 1,-3,3,-1 for **n** = 0,1,2,3, respectively.

In this case, **y** is the yield of a cohort recruited at length l_c during its life-time. To examine the effect of altering l_c on yield per recruit, a re-parameterization was made by Beverton and Holt (1966)

$$Y' = [\frac{Y}{R}]' = \frac{Y}{N(t_o)\ W\infty} = (1-e)^{M/K}\ y$$

where :

N(t$_o$) is the number of a cohort present at age t_o (t_o is a parameter of the Von Bertalanffy growth formula). Note that : $R = N(t_o)\ e^{-M(tr-to)}$ for age at recruitment t_r.

The model assumed an isometric growth, knife-edge recruitment, and upper limit of the life-span (t_l) was equal to ∞. Additionally, natural mortality and fishing mortality rates were assumed to be constant and independent of age beyond t_c,i.e.,age of recruitment into the fishery. The relative yield, **Y'**, was a function of three parameters - the rate of exploitation **E** and relative size **c** and **M/K**. The first two parameters (rate of exploitation **E** and relative size **c**) were governing variables subject to management control, while **M/K** was the only biological parameter required to perform the analysis.

For making first-hand approximations of the value of the yield per recruit, a series of table developed by Beverton and Holt (1969) was used. To convert this dimensionless quantity $[\frac{Y}{R}]'$ into yield (**Y**), it is necessary to multiply by R_o : the theoretical number of recruits at age t_o. As a first approximation to this quantity, it is sometimes the practice to substitute the average annual recruitment ($\bar{R}$) in number for R_o, and then multiply by an estimate of the asymptotic weight ($W\infty$):

$$Y = (\frac{Y}{R})'\ .\ W\infty\ .\bar{R}$$

Estimation of $W\infty$ was derived from the length/weight relationship $W = al^b$ and from estimates of $L\infty$ by $W\infty = aL\infty^b$, while a rough estimation of **R** was obtained from C_n /**E** where C_n is the catch in number from the cohort by the end of the exploitation phase, where $C_n = Y/\bar{w}$. The change in yield per recruit for species **A** is then given by:

$$\Delta\ Y_A = (A^{Y_2} - A^{Y_1})$$

and for the summation of species $i = 1,2,3,...n$ by:

$$\Delta Y = \sum_{i=1}^{n} (i^{Y_2} - i^{Y_1})$$

The population parameters that consist of the mean selection length, l_c, growth parameters of Von Bertalanffy growth equation (**K, L∞**), rates of natural mortality, **M**, and fishing mortality, **F**, of the dominant pelagics were derived from several references. All the population parameters resulted from a length frequency analysis of the concerned species. In addition, the total landing of each species was derived from Potier *et al.* (1993) which based on those landed by big purse seiners in the major fisheries in the North Java coast.

Finally, the randomly chosen population parameters of each species were used to calculate the yield per recruit of each species (tab. I).

2. RESULTS

2.1 Single Species Yield per Recruit Analysis

■ RESPONSE OF EQUILIBRIUM YIELD TO CHANGES IN EXPLOITATION PATTERN

Although the yield from recruit fisheries will fluctuate significantly with the recruitment, it is nevertheless useful to consider the equilibrium situation. The change in equilibrium yield per recruit as expressed in relative terms at various levels of exploitation rates **E**, and at various relative lengths at first capture were consequently examined for both D. russelli and D. macrosoma.

Table I

POPULATION PARAMETERS OF THE MAIN PELAGIC FISH IN THE JAVA SEA USED FOR THE CALCULATION OF THE RESPECTIVE YIELD PER RECRUIT

PARAMETER POPULASI DARI BERBAGAI JENIS UTAMA IKAN PELAGIS DI LAUT JAWA YANG DIPERGUNAKAN UNTUK MENGHITUNG MASING-MASING BERAT HASIL TANGKAPAN PER REKRUT

***D.r** = D. russelli, **D.m** = D. macrosoma, **A.s** = A. sirm, **R.k** = R. kanagurta, **S.c** = S. crumenophthalmus, **S.l** = S. leptolepis, **Z,M,F**: rates of total mortality, natural mortality, and fishing mortality, respectively, **E**: rate of exploitation, **lc,$\bar{l}$,lm** : respectively length at first capture, average length of catch, and length at first maturity, $\bar{W}$: average weight of catch, **a,b** : coefficient and exponential of the length-weight relationship*

	SPECIES					
PARAMETERS	D.r	D.m	A.s	R.k	S.c	S.l
L∞	26.50	23.80	25.80	25.60	25.90	18.90
K(yr^{-1})	0.48	0.80	1.15	0.23	1.25	1.20
Z(yr^{-1})	1.56	3.88	5.80	1.20	5.56	5.75
M(yr^{-1})	0.92	1.18	2.06	0.37	2.17	2.21
F(yr^{-1})	0.64	2.70	3.74	0.83	3.39	3.54
E	0.41	0.69	0.65	0.69	0.61	0.62
l_c (cm)	14.80	16.30	18.80	16.90	17.80	9.90
l_m (cm)	13.6-16.10	14.6-15.70	-	17.0-17.50	-	-
$\bar{l}$ (cm)	17.10	17.00	19.20	17.70	18.60	10.30
$\bar{w}$ (gr)	49.17	42.79	61.48	48.26	55.42	9.92
a	0.0106	0.0104	0.0062	0.0093	0.0189	0.0089
b	2.962	2.938	3.078	3.190	3.010	2.917

■ *D. russelli*

All calculations were carried out using **M/K** = 1.92 as the most likely value (1.64 to 2.36 as extremes of the likely range). The curves of relative yield per recruit against **E** for a given value of **M/K** and various values of relative size at first capture **c** (= l_c /L∞) are shown in figure 1.

A significant conclusion was that there were some gain to be achieved by delaying the relative size at first capture **c** until the value of 0.40, but a further delay could be counterproductive. Potential benefits from altering lc (fig. 2) were most significant at high levels of exploitation rate **E.** If the *D. russelli* fishery was regulated at a current level of exploitation rate (**E** = 0.41) and l_c(**c** = 0.56), little benefit could be derived by controlling the size at first capture.

The estimate of $E_{0.1}$ for *D. russelli* was 0.57 (Widodo 1988a) and the optimal yield per recruit corresponded to a value of **c** = 0.40 (fig. 2). Increasing E from the current level of 0.41 (Widodo 1988b) to a value closer to $E_{0.1}$ (E = 0.57) would increase the yield per recruit by 21%.

■ *D. macrosoma*

Figure 3 shows the relationship between relative yield per recruit and exploitation rate for **M/K** = 1.47 (0.78 to 2.16 as extremes of the likely range). Maximum yield per

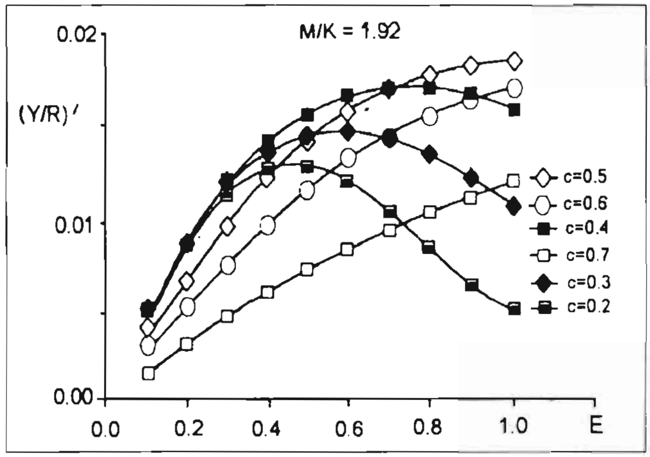


Figure 1

Relative yield per recruit **(Y/R)'** of *D. russelli* plotted against exploitation rate **(E)** employing a value of **M/K = 1.92** and various values of relative size at first capture (c)

Berat hasil tangkapan per rekrut **(Y/R)'** dari *D. russelli* diplotkan terhadap laju eksploitasi **(E)** dengan menggunakan nilai **M/K = 1.92** dan berbagai nilai ukuran relatif pertama kali tertangkap (c)

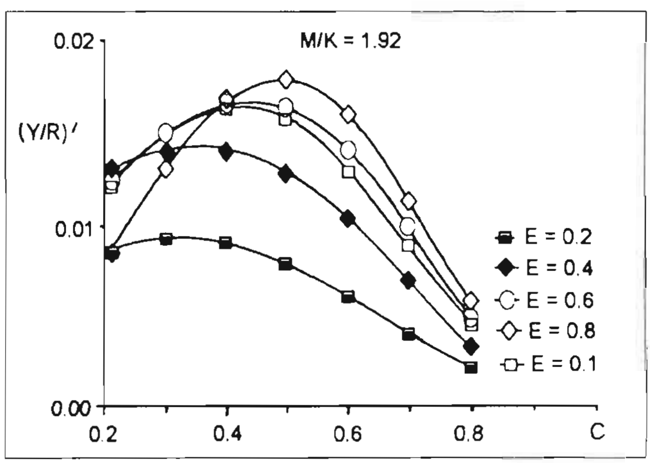


Figure 2

Relative yield per recruit **(Y/R)'** of *D. russelli* plotted against relative size at first capture **(c)** employing a value of **M/K =1.92**, various exploitation rates **(E)**, and $E_{0.1}$

Berat hasil tangkapan per rekrut **(Y/R)'** dari *D. russelli* diplotkan terhadap nilai ukuran relatif pertama kali tertangkap **(c)** dan berbagai nilai laju eksploitasi **(E)** dengan menggunakan nilai **M/K = 1.92**

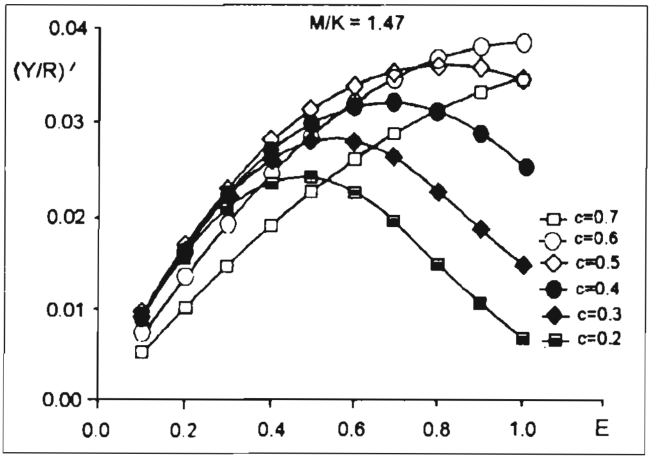


Figure 3

RELATIVE YIELD PER RECRUIT (Y/R)' OF *D. MACROSOMA* PLOTTED AGAINST EXPLOITATION RATE (E) EMPLOYING A LEVEL OF **M/K = 1.47** AND VARIOUS VALUES OF RELATIVE SIZE AT FIRST CAPTURE (c).

BERAT HASIL TANGKAPAN PER REKRUT (Y/R)' DARI *D. MACROSOMA* DIPLOTKAN TERHADAP LAJU EKSPLOITASI (E) DENGAN MENGGUNAKAN NILAI **M/K = 1.47** DAN BERBAGAI NILAI UKURAN RELATIF PERTAMA KALI TERTANGKAP (c)

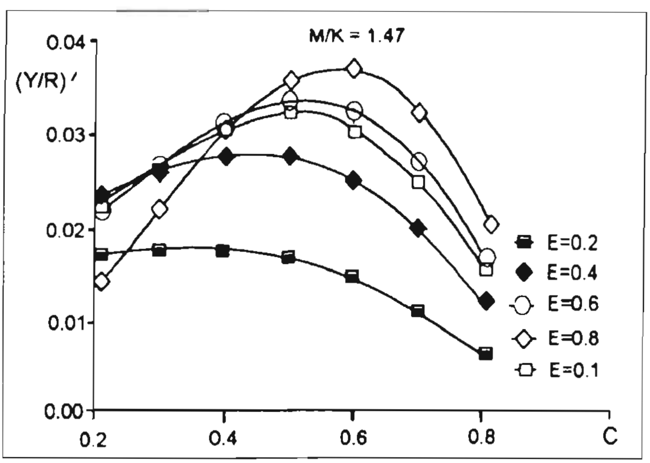


Figure 4

RELATIVE YIELD PER RECRUIT (Y/R)' OF *D. MACROSOMA* PLOTTED AGAINST RELATIVE SIZE AT FIRST CAPTURE (c) EMPLOYING A VALUE OF **M/K =1.92**, VARIOUS EXPLOITATION RATES (E), AND $E_{0.1}$

BERAT HASIL TANGKAPAN PER REKRUT (Y/R)' DARI *D. MACROSOMA* DIPLOTKAN TERHADAP NILAI UKURAN RELATIF PERTAMA KALI TERTANGKAP (c) DAN BERBAGAI NILAI LAJU EKSPLOITASI (E) DENGAN MENGGUNAKAN NILAI **M/K = 1.92**

recruit could be achieved at relative length **c** = 0.50. The estimate of $E_{0.1}$ for *D. macrosoma* was 0.55 (Widodo, 1988a) and the optimum yield corresponded to a value of **c** = 0.50 (fig. 4). Reducing **E** from the current level of 0.70 (Widodo 1988b) to a value closer to the $E_{0.1}$ level (**E** = 0.55) will reduce the yield per recruit by 10%.

2.2 Current condition of the ikan layang fishery in the Java Sea

■ *D. RUSSELLI*

Yield isopleths showing contoured levels of yield for combinations of **E** and **c**($l_c/L\infty$) were constructed. This has been done in figure 5 by putting **E** on the horizontal axis, **c** on the perpendicular axis, and connecting equal values of relative yield.

The length at first capture for a 15 mm mesh size of purse seine is l_c = 14.8 cm (**c** = 0.52 to 0.60 for L∞= 24.7 to 28.3 cm), and the current exploitation rates lie in the range of **E** = 0.24 to 0.57 (Widodo 1988b). The current status of the fishery (CS in fig. 5), when plotted on the yield isopleth diagram with **M/K** = 1.92, is such that by increasing the exploitation rates, a greater yield per recruit would result. Obviously, the current exploitation rate of the fishery was below the $E_{0.1}$ (corresponding to **E** = 0.57 and **c** = 0.40), however this region was close to the estimate of length at maturity. Consequently the exploitation in this region may impose unreasonable risks on the fishery. A reduction in **c** to about 0.40 would also increase the yield per recruit (by about 17.8%) but would increase the catch of immature fish.

■ *D. macrosoma*

The current length at first capture $\mathbf{l_c}$ = 16.3 cm (**c** = 0.67 to 0.71) corresponded to an exploitation rate of **E** = 0.55 to 0.81. The current status (CS) of the fishery of *D. macrosoma* in the isopleth diagram of yield per recruit could then be illustrated by plotting these values (fig. 6).

The present fishery is probably exploiting fish above the level of $\mathbf{E_{0.1}}$ (**E** = 0.55). Reducing the current status of the exploitation rate to the $\mathbf{E_{0.1}}$ level (**E** = 0.55, **c** = 0.55) would reduce the theoretical yield per recruit. Since the Beverton and Holt model does not consider recruitment overfishing, however, this is probably a reasonable goal.

It seems that *D. russelli* and *D. macrosoma* have a similar response to the changes in **c** and **E**. For example, if **E** was increased while leaving **c** at the same level, the yield per recruit would increase for both species. In addition, by reducing **c** and keeping **E** at the same level, an in-

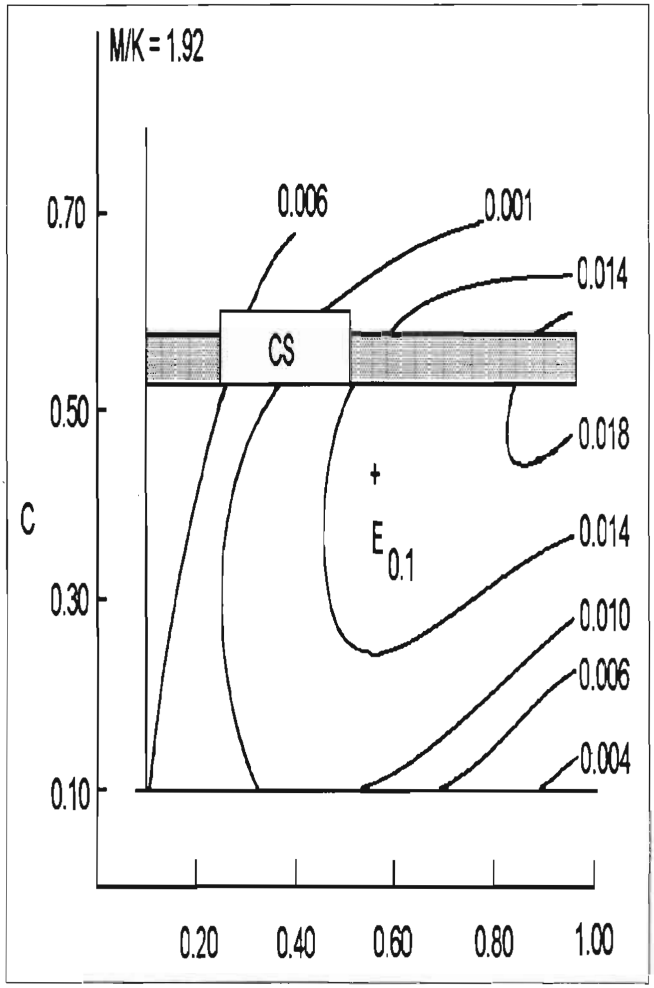


Figure 5

Isopleths of equal relative yield per recruit for *D. russelli*. The current status of the fishery (CS) is plotted on the yield isopleth for **M/K = 1.92**, within the range of relative length at first capture **c = 0.52 to 0.60** and **E = 0.24 to 0.57**. The $E_{0.1}$ level(+) corresponds to **E = 0.57** and **c = 0.40**. Relative length at maturity C_M ($L_M/L\infty$ = **0.52 to 0.57**) is indicated by crosshatching

Isoplet dari berat hasil tangkapan per rekrut dari *D. russelli*. Keadaan perikanan yang tengah berjalan (CS) diplotkan diatas isoplet dengan **M/K = 1.92**, dengan selang ukuran pertama kali tertangkap **c = 0.52 s/d 0.60** dan **E = 0.24 s/d 0.57**. Nilai $E_{0.1}$ terletak pada nilai **E = 0.57** dan **c = 0.40**. Ukuran panjang relatif pertama kali matang seksual C_M ($L_M/L\infty$ = **0.52 s/d 0.57**) dilukiskan dengan arsir

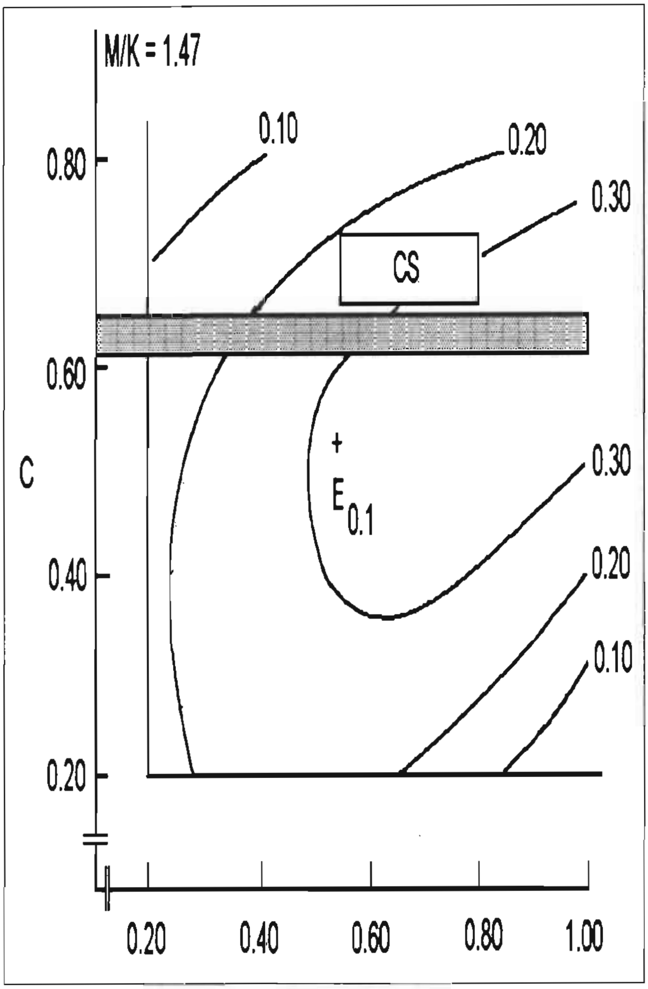


Figure 6

ISOPLETHS OF EQUAL RELATIVE YIELD PER RECRUIT FOR *D. MACROSOMA*. THE CURRENT STATUS OF THE FISHERY (CS) IS PLOTTED ON THE YIELD ISOPLETH FOR **M/K = 1.47**, WITHIN THE RANGE OF RELATIVE LENGTH AT FIRST CAPTURE **c = 0.67 TO 0.71** AND **E = 0.55 TO 0.81**. THE $E_{0.1}$ LEVEL (+) CORRESPONDS TO **E = 0.55** AND **c = 0.50**. RELATIVE LENGTH AT MATURITY **C_M ($L_M/L\infty$ = 0.62 TO 0.63)** IS INDICATED BY CROSSHATCHING.

ISOPLET DARI BERAT HASIL TANGKAPAN PER REKRUT DARI *D. MACROSOMA*. KEADAAN PERIKANAN YANG TENGAH BERJALAN (CS) DIPLOTKAN DIATAS ISOPLET DENGAN **M/K = 1.47**, DENGAN SELANG UKURAN PERTAMA KALI TERTANGKAP **c = 0.67 S/D 0.71** DAN **E = 0.55 S/D 0.81**. NILAI $E_{0.1}$(+) TERLETAK PADA NILAI **E = 0.55 DAN c = 0.50**. UKURAN PANJANG RELATIF PERTAMA KALI MATANG SEKSUAL **C_M ($L_M/L\infty$ = 0.62 S/D 0.63)** DILUKISKAN DENGAN ARSIR

creased yield per recruit would result for both species.

2.3 Relationship between size at first capture and size at maturity

Considering the effect of size limits on spawning capability, it is important to examine the relation between the length at first capture (l_c) and the length at maturity (l_m). The values of l_c and l_m for the two species were superimposed on the yield per recruit isopleths (fig. 5 and 6) to evaluate, in a preliminary way, the likely risk of recruitment overfishing.

The length at first capture for *D. russelli* l_c = 14.8 cm (corresponding to c_l = 0.56) is close to the size at maturity l_m = 13.9 to 15.2 cm (corresponding to c_m = 0.52 to 0.57) (Widodo, 1988a). In this situation, exploitation could result in recruitment overfishing if the fishing mortality is much greater than the natural mortality (Caddy, 1982). However, the estimate of the current exploitation rate was below the estimate of $E_{0.1}$ (E = 0.57) so that recruitment overfishing seems unlikely.

The length at first capture for *D. macrosoma* l_c = 16.3 cm (c_l = 0.68), was relatively higher than the size at maturity l_m = 14.86 to 14.89 cm (c_m = 0.62 to 0.63) (Widodo, 1988 a). In this situation, recruitment overfishing would be unlikely unless the progeny from the first spawners had relatively lower survival rate than from the individuals with a higher length value than at first capture **lc** (Caddy 1982). However, since the current exploitation rate has already exceeded the $E_{0.1}$ level, reducing the fishing mortality will reduce the probability of recruitment overfishing.

2.4 Multi-species yield per recruit analysis concerning the effects of changes in gear selectivity

For multi-species fishery we may use value of yield per recruit to predict the direction of change in overall yield for a mixture of species in the fishery. For preliminary results, no attempt has been made to linearly interpolate the values of yield per recruit given in tables II and III.

By increasing the mesh size from 15 to 20 mm the overall yield per recruit of six major species will decrease as much as 58% (compared with 61% in Widodo, 1989) ranging from 5 to 100%, (tab. III). On the other hand, by reducing the mesh size from 15 to 10 mm the overall yield per recruit will increase as much as 36% (compared with 46% in Widodo, 1989) ranging from 9 to more than 200% but *S. leptolepis* shows a negative change of as much as 16% (tab. III).

CONCLUSION

The yield per recruit models provide the simplest, most rapid approach for making first-hand approximations of the effects of changes in fishing mortality and size limits of single species stock. For multi-species fisheries, due to possible biological interactions between the species, the yield of each component will not depend solely on the effort put forth, but also undoubtedly on the abundance of other present components. One other shortcoming of the yield per recruit models is that they do not put into account the probability of the two types of overfishing, namely the classical growth overfishing and the recruitment overfishing. Although none of these problems can be overcome by the models, we may use the analysis to predict the possible impacts of changes in the fishery regime on the direction of change in the overall yield for a mixture of species in the fishery. The mesh size is important to a seiner skipper, mainly because he wants to avoid gilling fish. A too small mesh only presents minor problems, especially when dealing with light-fishing (such as the Java Sea pelagic fishery) which catches a mixture of pelagic species. Consequently, the enforcement of the mesh size regulations is often difficult. Furthermore, the price that fishermen have to pay for new nets of legal mesh size will not always be acceptable.

The effects of increasing the mesh size can be classified into two terms. The short-term effect will be a reduction in the catch and profits, because of the loss of small fishes which would otherwise be caught. The long-term effect will be the conservation of the spawning stock (since the large mesh will leave a larger stock of mature fish) and potential increases in the long-term yield. Eventually the stock size will increase thereby improving the catch rates. Actually, each individual in a multi-species fishery needs a different mesh size. A mesh size which captures fish with an average length at entry of 10.6 cm (corresponding to **c** = 0.40) and of 11.19 cm (corresponding to **c** = 0.50) is required for *D. russelli* and *D. macrosoma*, respectively. As the majority of the coastal small pelagic fish in the Java Sea have somewhat an homogeneous body shape and size, the balance of interest among the species might be well maintained. Setting mesh size based on **ikan layang** data probably does not entail large costs in terms of yield of the other species.

Table II

ESTIMATES OF YIELD PER RECRUIT (Y/R)' OF THE MAIN PELAGIC FISH IN THE JAVA SEA DERIVED FROM BEVERTON AND HOLT TABLE OF YIELD FUNCTION (1966)

NILAI DUGA HASIL TANGKAPAN PER REKRUT (Y/R)' YANG DIPEROLEH DARI "TABLE OF YIELD FUNCTION" DARI BEVERTON DAN HOLT (1966).

***D.r** = D.russelli, **D.m** = D.macrosoma, **A.s** = A.sirm,**R.k** = R.kanagurta, **S.c**= S.crumenophthalmus, **S.l** = S.leptolepis*

	SPECIES					
PARAMETERS	D.r	D.m	A.s	R.k	S.c	S.l
E	0.41	0.69	0.65	0.69	0.61	0.62
$c(=l_c/L\infty)$	0.56	0.68	0.73	0.66	0.69	0.52
M/K	1.92	1.48	1.79	1.61	1.74	1.84
(Y/R)'	0.023	0.051	0.031	0.054	0.033	0.038

Table III

ESTIMATION OF YIELD PER RECRUIT AS THE CHANGES OF LENGTH AT FIRST CAPTURE BY MANIPULATION OF MESH SIZE ON THE JAVA SEA PURSE SEINE FISHERY.

ESTIMASI DAMPAK BERAT HASIL TANGKAPAN PER REKRUT AKIBAT ADANYA PERUBAHAN UKURAN IKAN YANG TERTANGKAP DENGAN MENGATUR UKURAN MATA JARING DARI PERIKANAN PUKAT CINCIN DI LAUT JAWA.

***D.r** = D. russelli, **D.m** = D. macrosoma, **A.s** = A. sirm, **R.k** = R. kanagurta, **S.c** = S. crumenophthalmus, **S.l** = S. leptolepis*

	SPECIES						
PARAMETERS	D.r	D.m	A.s	R.k	S.c	S.l	Total
1. MESH SIZE(#)= 15 MM							
SF*	1.00	1.10	1.20	1.10	1.20	0.60	
l_c(cm)	14.80	16.30	18.80	16.90	17.80	9.90	
$c(=l_c/L\infty)$	0.56	0.68	0.73	0.66	0.69	0.52	
E	0.41	0.69	0.65	0.69	0.61	0.62	
M/K	1.92	1.48	1.79	1.61	1.74	1.84	
(Y/R)'	0.023	0.051	0.031	0.054	0.033	0.038	
$\bar{w}$ (gm)	49.17	42.79	61.48	52.41	121.62	9.92	
$W\infty$(gm)	197	140	106	156	328	61	
C_w(000 ton)	38	19	19	22	7	7	
$R(10^6)$	1.88	0.64	0.48	0.66	0.21	1.14	
Y_1(ton)	8,518	4,570	1,577	5,560	2,273	2,642	25,140
2. MESH SIZE(#)=20 MM							
l_c (cm)	20	22	26	22	24	14	
c	0.75	0.92	1.00	0.86	0.93	0.74	
(Y/R)'	0.014	0.013	0.000	0.013	0.006	0.036	
Y_2(ton)	5,185	1,164	0.000	1,338	413	2,503	
Y_2-Y_1(ton)	-3,333	-3,406	-1,577	-4,222	-1,860	-139	
$(Y_2-Y_1)/Y_1$ (%)	-39	-75	-100	-76	-82	-5	
3. MESH SIZE(#) = 10 MM							
l_c (cm)	10	11	13	11	12	7	
c	0.38	0.46	0.50	0.43	0.46	0.52	
(Y/R)'	0.25	0.047	0.040	0.049	0.038	0.032	
Y_3 (ton)	9,259	4,211	2,035	5,045	2,617	2,225	
Y_3 - Y_1 (ton)	741	2,543	1,385	3,117	1,774	417	
$(Y_3-Y_1)/Y_1$ (%)	9	152	213	170	210	-16	

SF (selection factor) was calculated by using the equation Lc=SF * **mesh size (Equation 3.3 of Pauly 1984).*

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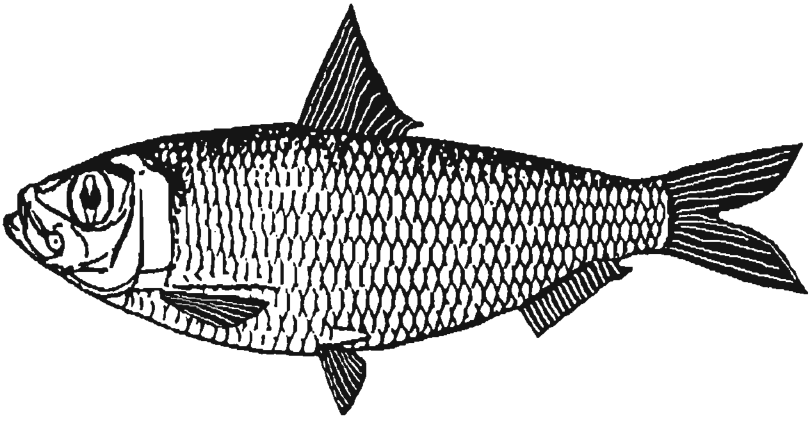
PREDICTION OF BIOMASS, YIELD AND VALUE OF THE "LEMURU" *(Sardinella lemuru)* FISHERY IN THE BALI STRAIT

G. S. MERTA,
H. M. EIDMAN



Sardinella lemuru (**Lemuru**)

ABSTRACT

Biomass, yield and value of the Bali Strait **"lemuru"** fishery have been predicted using Thompson and Bell Model. The data used in this analysis is the result of Jones' length cohort analysis carried out by Merta (1992 b). The input prices are the average price for **"sempenit"** (< 11 cm TL fish), **"protolan"** (11-15 cm) and **"lemuru"** (>15 cm) for the period of August 1989 to July 1990.

The results of the analysis showed that biomass, yield and value of the **"lemuru"** fishery in the Bali Strait were 19 628 tons, 32 835 tons and 5 357 million Rp. respectively. The yield and value have exceeded the maximum yield and value, which were estimated to be respectively 34 041 tons and 5 883 million Rp.

Disajikan prediksi biomassa, hasil dan nilai perikanan "lemuru", Sardinella "lemuru" Bleeker 1853, di perairan Selat Bali dengan mempergunakan Model Prediksi Thompson dan Bell. Input data yang dipergunakan dalam Model Prediksi Thompson dan Bell adalah data output dari hasil analisis kohor (cohort), yang telah dilakukan oleh Merta (1992b). Harga ikan adalah harga rata-rata per kilogram untuk ikan-ikan sempenit (< 11 cm TL), protolan (11-15 cm TL) dan "lemuru" (> 15 cm TL). Selama periode bulan Agustus 1989 sampai dengan bulan Juli 1990.

Hasil analisis menunjukkan bahwa hasil dan nilai dari perikanan "lemuru" di Selat Bali adalah sebesar 32 835 ton dan Rp. 5 357 juta dengan biomassa sebesar 19 628 ton. Hasil dan nilai yang diperoleh ini telah melampaui hasil dan nilai maksimum masing-masing sebesar 34 041 ton dan Rp. 5 883 juta.

INTRODUCTION

Although aquatic living resources such as fish and shrimps are renewable, they are limited. In this relation, stock assessment can be stated as determining the level of exploitation which, in the long run, will give the maximum yield (weight) of a fishery . The ""**lemuru**"" fishery in the Bali Strait is one of the most important small pelagic fisheries in Indonesia. So that, in order to provide an advice for optimum exploitation of this fishery resource, stock assessments have been carried out using various methods or models, such as acoustic method (Amin and Sujastani, 1981), surplus production model, analytical model, or yield-per-recruit model of Beverton and Holt by Gumilar (1985), of Jones (Ricker, 1975; Pauly, 1984; Wilimovsky and Wicklund, 1963) by Merta (1992 a) and cohort analysis (Merta, 1992 b). The acoustic method is used to estimate the biomass of the ""**lemuru**"" resource, production surplus and analytical models are used to predict the level of exploitation of ""**lemuru**"" fishery, while cohort analysis is used to estimate the number of ""**lemuru**"" by size.

This paper presents the results of the ""**lemuru**"" fishery stock assessment in the Bali Strait, using the prediction model of Thompson and Bell (Ricker, 1975). In this model, the number of recruits was obtained from cohort analysis, and the result was stated in total yield. This model could be used to predict the levels of biomass and yield and its value in the future, if there are any changes in effort or fishing mortality.

1. MATERIAL AND METHODS

Data used in the model of Thompson and Bell are the results of the length cohort analysis carried out by Merta (1992b). as presented in table I (columns a, b, c and d).

The results prices are the average prices of **"sempenit"** (less than 11 cm TL fish), **"protolan"** (between 11-15 cm) and **""lemuru""** including **""lemuru" kucing"** (longer than 15 cm) Rp. 100,-; Rp. 125,- and Rp. 200,- per kg.. respectively (column e).

Table I

DATA USED FOR THOMPSON AND BELL ANALYSIS.

INPUT DATA UNTUK ANALISIS THOMPSON DAN BELL.

LENGTH CLASS (CM) (L_i,L_{i+1})	$F(L_i,L_{i+1})$	$H(L_i,L_{i+1})$	$w(L_i,L_{i+1})$ (GRAM)	$v(L_i,L_{i+1})$ (RP./KG.)
a	b	c	d	e
5-6	0.001	1.031	1.15	100
6-7	0.073	1.033	1.98	100
7-8	0.070	1.035	3.15	100
8-9	0.038	1.037	4.37	100
9-10	0.143	1.040	6.78	100
10-11	0.572	1.044	9.37	100
11-12	0.608	1.048	12.58	125
12-13	1.212	1.052	16.48	125
13-14	2.311	1.058	21.14	125
14-15	2.226	1.066	26.65	125
15-16	1.959	1.075	33.07	200
16-17	2.257	1.088	40.49	200
17-18	3.808	1.105	48.98	200
18-19	4.181	1.132	58.64	200
19-20	3.444	1.178	69.54	200
20-21	3.149	1.271	81.76	200
21-Loo	3.831		95.39	200

 The calculations carried out in the model of Thompson and Bell are as follows :

Length interval : $i = (L_i, L_{i+1})$

$$Z_i = M + X \cdot F_i$$

$$N(L_{i+1}) = N(L_i) \cdot \left\{ \left(\frac{1}{H_i} - \frac{X \cdot F_i}{Z_i} \right) : \left(H_i - \frac{X \cdot F_i}{Z_i} \right) \right\}$$

$$H_i = \frac{(L\infty - L_i)(M/2K)}{(L\infty - L_{i+1})}$$ ——> **Natural Mortality Factor**

$= XL$ **(in Jones' length cohort analysis)**

$$C_i = [\, N(L_i) - N(L_{i+1}) \,] \cdot X \cdot \frac{Fi}{Z_i}$$

$$\bar{w} = a \cdot \frac{(L_i + L_{i+1})\, b}{(\quad 2 \quad)}$$ ———> **a and b from length-weight relationship**

$$Y_i = C_i \cdot \bar{w}_i$$

$$V_i = Y_i \cdot \bar{v}_i$$

$$\bar{N}_i \cdot t_i = [\, N(L_i) - N(L_{i+1}) \,] : Z_i$$

$$\bar{B}_i \cdot t_i = \bar{N}_i \cdot t_i \cdot \bar{w}_i$$

The biomass of last length class =

$$N(L_t) \cdot \bar{w}(L_l, L\infty) \,/\, Z(L_l, L\infty)$$

X = **F**-Factor = 1.0
C_I = catch (number of fish) for length class **I**
Y_I = yield (weight) in length class **I**
V_I = value of yield (Rupiah: Rp.)
$\bar{w}_I$ = average weight of fish in length class **i**
$\bar{v}_I$ = average price of fish (Rp. / Kg.) in length class **I**

2. RESULTS AND DISCUSSION

The results of the Thompson and Bell analysis with the data from table I are presented in table II. They assessed the present status of **"lemuru"** fishery in the Bali Strait. Using the same procedure, biomass, yields and values for different **F**-Factors are depicted in table III and figure 1.

Figure 1 shows that maximum yield and value have been exceeded. The estimated biomass, yield and value at the present situation are 19 628 tons, 32 835 tons and 5 357 million Rp. respectively. If **F**-Factor continuously increases, yields and values will continuously decrease. But if **F**-Factor continuously decreases, yields will reach their maximum at the **F**-Factor level of 0.8, i.e. 34 041 tons. This means that yield could increase by about 3,7% from the present status. The maximum value is obtained when **F**-Factor is 0.5, i.e. 5 883 million Rp. If **F**-Factor continuously decreases from the present status (**X** = 1.0) down to 0.5, value can increase by about 9.8%. The biomass level at maximum yield is about 24%.

The results of the analysis using the Thompson and Bell model show that the status of the **"lemuru"** fishery in the Bali Strait is overfishing. These results are similar to the results obtained when using Jones' Yield-per-recruit model (Merta, 1992a).

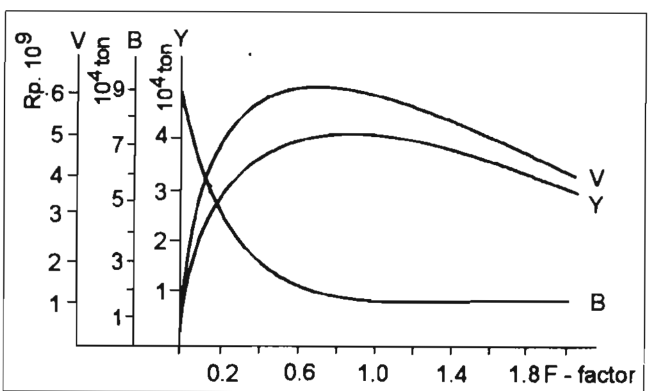


Figure 1

CURVES OF BIOMASS (B), YIELD (Y) AND VALUE (V) OF THE LEMURU FISHERY IN THE BALI STRAIT

CURVA BIOMASA (B), HASIL (Y) DAN NILAI (V) DARI PERIKANAN LEMURU DI SELAT BALI

Table II

RESULTS OF THOMPSON AND BELL ANALYSIS OF THE LEMURU (*SARDINELLA LEMURU* BLEEKER 1853) FISHERY IN THE BALI STRAIT WITH A VALUE OF **X = 1.0**

LUARAN DARI ANALISIS THOMPSON DAN BELL DARI PERIKANAN LEMURU (*SARDINELLA LEMURU* BLEEKER 1853) DI SELAT BALI DENGAN NILAI **X = 1.0**

LENGTH CLASS (CM) (L_i,L_{i+1})	F (L_i,L_{i+1}) X=1.0	$N(L_i)$ MILLION FISH	Z (L_i,L_{i+1})	C (L_i,L_{i+1}) MILLION FISH	Y (L_i,L_{i+1}) TONS	B · T (L_i,L_{i+1}) TONS	V (L_i,L_{i+1}) MILLION RUPIAHS
5-6	0.001	2 901.416 *)	1.001	0.170	0.176	197.627	0.020
6-7	0.073	2 729.395	1.073	12.422	24.596	338.842	2.460
7-8	0.070	2 545.770	1.070	11.822	37.239	531.935	3.730
8-9	0.038	2 365.081	1.038	6.350	30.036	783.248	3.004
9-10	0.143	2 193.197	1.143	23.538	159.588	1 115.740	15.958
10-11	0.572	2 005.101	1.572	92.301	864.860	1 513.160	86.486
11-12	0.608	1 751.239	1.608	92.728	1 166.518	1 918.497	111.652
12-13	1.212	1 506.013	2.212	166.352	2 741.481	2 259.913	274.148
11-14	2.311	1 202.680	3.311	263.581	5 572.102	2 409.488	557.210
14-15	2.226	825.300	3.226	194.042	5 171.219	2 321.830	517.122
15-16	1.959	544.241	2.959	126.079	4 169.433	2 129.869	416.943
16-17	2.257	353.667	3.257	104.931	4 248.656	1 881.458	424.866
17-18	3.808	202.326	4.808	102.220	5 006.736	1 315.482	500.674
18-19	4.181	73.195	5.181	46.748	2 741.303	644.757	274.130
19-20	3.444	16.229	4.444	10.289	715.497	207.619	71.550
20-21	3.149	2.961	4.149	2.125	173.740	55.180	17.374
21-Loo	3.381	0.161	4.381	0.128	12.210	3.179	1.221
TOTAL				1 255.826	19 627.774	32 835.410	5 356.582

REMARKS: - *) FROM THE RESULTS OF LENGTH COHORT ANALYSIS

Table III (top)

Biomass, yields and values for some values of F-Factor

Biomasa, hasil dan nilai dari beberapa nilai faktor F

F - Factor	Biomass	Yield	Values of Yield
	(Tons)	(Tons)	(Millions Rp.)
0.0	94 549	0	0
0.2	50 939	26 831	5 037
0.4	35 245	32 471	5 883*
0.6	27 394	33 570	5 868
0.8	22 734	34 041*	5 635
1.0	19 628	32 835	5 357
1.2	16 859	32 198	5 072
1.4	15 687	31 264	4 792
1.6	14 416	30 704	4 576
1.8	13 359	30 045	4 372
2.0	12 482	29 466	4 191

Remarks :
- MSY = 34 041 tons at X = 0.8
- MSE = Rp. 5 923 million at X = 0.5
- Biomass at MSY = 22 734 tons
- Biomass at MSE = 30 742 tons
- * = Maximum

Table IV (bottom)

Number of Boats Needed to Obtain Maximum Y/R and Total Yield

Jumlah kapal yang diperlukan untuk mendapatkan maksimum Y/R dan hasil total

	Prediction Model	
	Y/R	Thompson and Bell
Decrease from present status to obtain maximum (%)	21.47	20.00
Number of boats at maximum Y/R and Total Yield :		
- Licensed-boats	214	218
- Active boats	205	209
- Average boats operating every day	43	44

The difference between the two models to obtain maximum Y/R and Total Yield is about 1 boat for 50 boats.

The MSY estimated by previous stock assessments using acoustic method as well as surplus production models (40 000 tons) is higher than the one found in the present study (Thompson and Bell analysis). Results of both Jones Y/R and Thompson and Bell models are very close. Fishing should be decreased by about 20-21.5% from the present status (Merta, 1992).

The total number of licensed-boats in the Bali Strait was 273 units, while the number of boats which were still active and the average number of boats operating every day were 261 and 55 boats respectively . To reach the maximum yield, the number of vessels has to be decreased both in Jones and Thompson and Bell models (tab. IV).

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

- The current status of **"lemuru"** fishery in the Bali Strait is over-fishing.
- Maximum yield and value are 34 041 tons and 5 923 million Rp. respectively, at the level of **X** = 0.8 and 0.5.
- If value of **X** (F-Factor) decreases from the current 1.0 to 0.8, the yield will increase by about 3.7%.
- Biomass and value estimates at the maximum yield are respectively 22 734 and 30 742 tons .

2. Recommendations

- The number of 273 licensed-boats in the Bali Strait should be decreased to 218 boats, or
- The number of boats active in the Bali Strait should be decreased to 209, or
- The average number of boats operating every day should be decreased to 44.

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COMPOSITE MODEL ON SMALL PELAGIC RESOURCES

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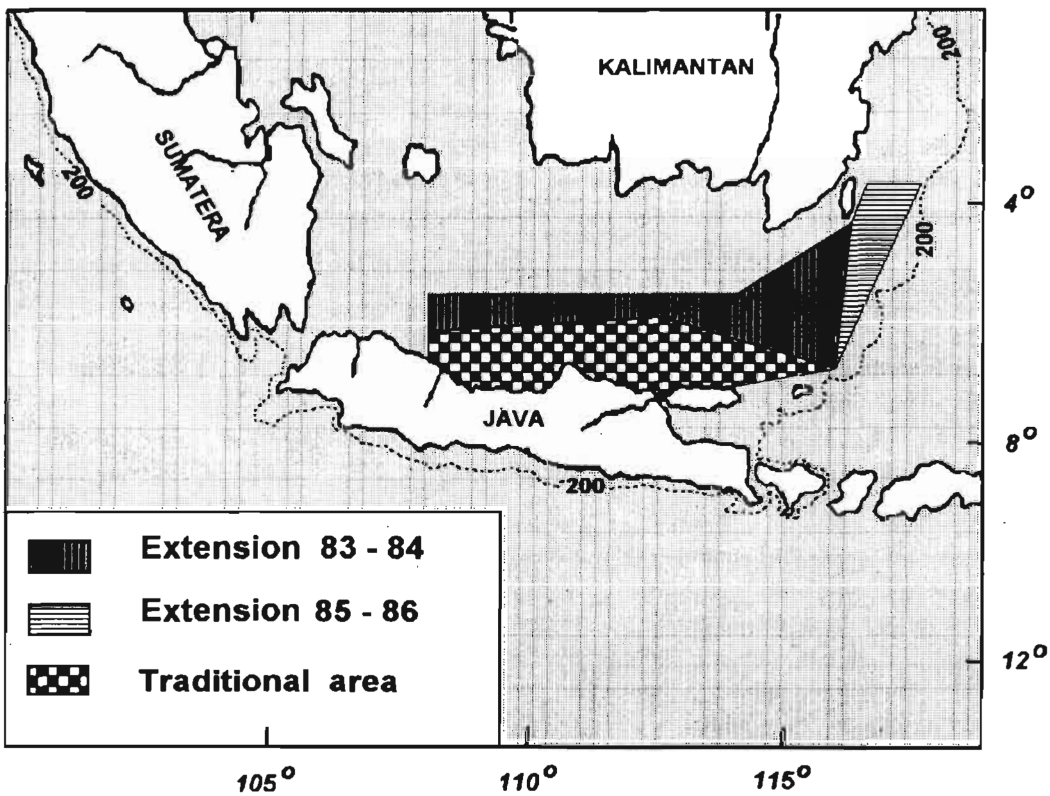


Figure 1

GEOGRAPHIC LOCATION OF THE MAIN FISHING AREAS OF THE SMALL PELAGIC RESOURCES IN THE JAVA SEA

LOKASI GEOGRAFIS DAERAH PENANGKAPAN UTAMA DARI SUMBER DAYA PELAGIS KECIL DI LAUT JAWA

Composite Model on Small Pelagic Resources

ABSTRACT

This study is based on the catch and effort data, collected from different sources between 1976 and 1986. The composite model of Caddy and Garcia (1982), one of the models derived from the Schaefer and Fox model, was used to estimate the MSY (Maximum Sustainable Yield) and the optimum effort of the small pelagic resources in the Java Sea. It seems that the current status of exploitation is near its maximal level. The fisheries exploit a lot of species with various ecological behaviors. Some, such as the coastal species, are fully and heavily exploited while others, such as the oceanic ones, are partially exploited. Thus it is difficult to give an accurate assessment. Other approaches (analytical models) would allow more precise results. This is why the statistical data collection as well as the biological and behavior study must be continued. Since 1976 the catch of small pelagic increases continuously, in 1985 it reaches 150 000 tons. During this period the CPUE fluctuates a lot.

Penelitian ini berdasarkan data hasil tangkapan dan upaya penangkapan yang dikumpulkan dari berbagai macam sumber sejak 1976 sampai dengan 1986. Model komposit dari Caddy dan Garcia (1983), adalah model yang diturunkan dari model Schaefer dan Fox dan dicoba untuk menduga MSY dan upaya optimum dari sumberdaya pelagis kecil di Laut Jawa. Tampaknya situasi tingkat pengusahaan saat ini hampir mendekati tingkat maksimum Pengusahaan perikanan ditujukan terhadap ikan-ikan yang mempunyai sifat dan kebiasaan yang berbeda, ikan-ikan yang dekat pantai tampaknya telah mengalami tekanan penangkapan yang tinggi, sedangkan ikan-ikan yang bersifat oceanik belum seluruhnya diusahakan. Oleh sebab itu suatu kajian sumber daya yang tepat tidak mudah untuk dilaksanakan. Pendekatan lain (model analitik) diharapkan dapat memberikan hasil yang lebih baik, sehingga pengumpulan data statistik, biologi dan tingkah laku harus tetap terus dilaksanakan. Sejak tahun 1976 hasil tangkapan ikan pelagis kecil meningkat terus dan pada tahun 1985 mencapai 150 000 ton, selama ini hasil tangkapan per unit upaya mengalami peningkatan dan penurunan.

INTRODUCTION

The continuous increase of the fish catch in the Java Sea reflects the development that has taken place in the last decade. As fish resources are not unlimited intense fishing may greatly affect them. To assess the fishing effect on the resources there should be reliable information on the main parameters of the fisheries such as catch, effort and biology of the main species caught.

Stock assessment is one of the important component of the fisheries management. Although there has been an increasing number of assessment models in the recent years, they generally follow three major streams : (1) analytical models, (2) surplus production models, and (3) linear models.

The surplus production model allows to estimate the MSY (Maximum Sustainable Yield) and the optimal effort. Although the concept was initiated by Graham (1935), it was Schaefer (1954) who first described it as a mathematical function based on the logistic growth model of Velhurst-Pearl. The simplicity of the model, which only requires catch and effort data, is very attractive especially in a situation where biological data is lacking.

The catch and effort data of the small pelagic species caught between 1976 and 1986 in the Java Sea was collected from several sources by the project, while the data on mini purse and Danish seines was extracted from the national statistical data of the Directorate General of Fisheries.

In this paper we present the data used for the study and we apply the composite model of Caddy and Garcia (1982) one of the model derived from Schaefer and Fox models.

1. PRESENTATION OF THE MODEL USED

Schaefer (1954, 1957) supposed that the relationship between CPUE (**c/f**), catch (**c**) and effort (**f**) could be represented by :

$$c/f = a + bf \qquad (1)$$

then,

$$c = f\,(a + bf) \qquad (2)$$

Fox (1970) has substituted to the linear relationship of Schaefer an exponential relationship where the equations are :

$$c/f = a\ .\ e^{-bf} \qquad (3)$$

then

$$c = f\,(a\ .\ e^{-bf}) \qquad (4)$$

In this model any fish population is treated as a single unit without any consideration of the structure of the population ; thus, the dynamic of the population depends on the population itself. The model relies on a steady state condition where the yield balances the growth of the population.

Considering that the small pelagic biomass exploited in the Java Sea increases in relation with the extension of the fishing ground eastward, we apply the composite model of Caddy and Garcia, derived from Schaefer and Fox models. It is built by normalizing the catch and effort data in order to use the data which originates from different sizes of the stock in the same model.

This method is based on the relationship between CPUE and fishing intensity (effort divided by the surface of the exploited fishing area). The linear and exponential relationships are represented as follows :

$$c/f = a + b(f/A) \qquad (5)$$

$$c/f = a\ .\ e^{-b(f/A)} \qquad (6)$$

where **A** = surface of the fishing area.

By multiplying the equations (5) and (6) by f/A, we obtain the following normalized production model :

$$c/A = (f/A)(a + bxf/A) \qquad (7)$$

$$c/A = (f/A)(a \, . \, e^{-b(f/A)}) \qquad (8)$$

From the equations (7) and (8), we can rebuild the theoretical production model for each considered zone by multiplying the two axes of the model by the surface of the fishing area (A):

$$c = f\,(a + bf/A) \qquad (9)$$

$$c = f\,(a \, . \, e^{-b(f/A)}) \qquad (10)$$

Since 1976 the large seiners fishery has extended twice its fishing areas (fig. 1). Three fishing areas can now be recognized :

- The North coast of Java, Karimunjava, Bawean (91 000 km^{-2}), since 1976.
- The Masalembo and Matasiri Islands (88 000 km^{-2}), since 1983.
- The Makassar Strait (23 000 km^{-2}), since 1985.

2. ESTIMATION OF CATCH AND EFFORT

2.1 Catch

The small pelagic species in the Java Sea are mostly caught by large purse seines. Only a small part is caught by mini purse seines and Danish seines, **"Payang"**. The annual catch for every fishing gear is given in table I from 1976 to 1986.

Between 1976 and 1978 the catch slightly increased. It kept stable from 1979 until 1982, before increasing sharply in 1983. The stagnation of the large purse seines catch between 1976 and 1982 seems due to the heavy fishing pressure exerted on the traditional fishing ground. The extension of the fishing area to the East in 1983 led to an increase of the catch related to the beginning of the exploitation of new small pelagic resources or a larger part of the stocks already exploited. The mini purse seines catch increased regularly. In 1986 it was 4 times higher than in 1976 while during this period the Danish seines landing kept stable .

2.2 Fishing effort

Among many indexes, the fishing effort can be expressed in number of fishing vessels registered or in number of days at sea. If we had used the number of fishing vessels as a unit of fishing effort, the result would have been biased. It would have been over estimated since many vessels while not fishing anymore are still registered.

At this stage of the study, considering the available documents (based on the large purse seine data from the fishing port and harbor master of Pekalongan), the best estimation for fishing effort on small pelagic species in the Java Sea is the number of days at sea. Since every year the average horse power of seiners increases, a correction of the fishing effort was used in table II. Other parameters affecting the fishing power of the fishery such as the increase of the fishing vessels capacity, the net size or the changes in the fishing tactics are not taken into account in this study.

Concerning the days at sea, the corrected fishing effort of the large purse seines increases from 1976 to 1986 with a peak in 1985 (almost 20 times that of 1976). This sharp increase is due to the fast extension of the fishery since the trawl ban in the Java Sea in 1980 and 1981. Many trawlers were transformed into purse seines and widely modified the figure of the fishery.

Table I

Small pelagic species caught in the Java Sea from 1976 to 1986 (in Tons)

Ikan pelagis kecil yang tertangkap di Laut Jawa dari tahun 1976 sampai dengan 1986 (dalam ton)

Year	Large Seiners	Mini Seiners	Danish Seines	TOTAL
1976	22 000	7 184	17 796	46 980
1977	27 104	8 769	16 341	52 214
1978	33 842	9 473	18 149	61 464
1979	44 073	13 013	19 680	77 396
1980	46 126	20 039	19 040	85 205
1981	38 444	23 283	19 103	80 830
1982	49 898	22 701	17 301	89 900
1983	74 931	22 506	13 505	110 942
1984	80 314	28 245	14 300	122 859
1985	117 265	23 946	14 021	155 232
1986	108 097	31 864	17 788	157 749

Table II (bottom)

Effective fishing effort (days at sea) of large purse seiners from 1979 to 1986 in the Java Sea.

Upaya penangkapan efektif (hari laut) dari Purse Seiners besar di Laut Jawa dari tahun 1979 sampai dengan 1986

Year	Nb. of Vessels	Average HP	Total HP	Correction Factor	Nominal Effort	Effective Effort
1976	138	85	11 730	0.16	35 599	5 696
1977	155	90	13 950	0.19	42 350	8 047
1978	233	99	23 067	0.32	52 796	16 895
1979	329	104	34 216	0.47	75 316	35 399
1980	344	110	37 840	0.52	74 055	38 509
1981	398	115	45 770	0.63	78 282	49 318
1982	422	119	50 218	0.69	85 741	59 161
1983	422	113	47 686	0.66	91 414	60 333
1984	422	121	51 062	0.70	86 916	60 841
1985	520	130	67 600	0.93	85 257	79 289
1986	531	137	72 747	1.00	90 742	90 742

3. ESTIMATION OF TOTAL EFFORT AND FISHING INTENSITY ACCORDING TO FISHING AREA

Small pelagic species are caught either by large purse seines, mini purse seines or Danish seines (**"Payang"** and **"Lampara"**). The large purse seine is the most important fishing gear exploiting the small pelagic resources in the Java Sea. In 1983 and 1984 large purse seiners expanded their fishing area up to the Masalembo and Matasiri Islands (fig. 1). Around 63% of the effort of the large seiners was exerted in this area, and only 37% in the traditional area. In 1985 the eastern extension of the fishery continued, reaching the Makassar Strait. The fishing effort in the traditional fishing areas decreased and was about 25% of the total effort, while the rate of exploitation in Masalembo - Matasiri area increased to about 66% in 1985. Since 1985 the fishing effort of the large seiners is distributed among these three fishing areas.

Using the composite model of Caddy and Garcia, three fishing areas were taken into consideration. This model allows to use all the available series of data from 1976 to 1986 in a same model, although since 1982 the surface of fishing areas changed (tab. III). To obtain the fishing intensity, the corrected fishing effort was divided only by the surface of the traditional fishing area from 1976 to 1982, while since 1983 it was calculated for three fishing areas.

Table III

TOTAL CATCH, TOTAL EFFORT (IN DAYS AT SEA LARGE SEINERS STANDARD), CPUE AND TOTAL FISHING INTENSITY OF SMALL PELAGIC RESOURCES IN THE JAVA SEA THREE FISHING AREAS FROM 1976 TO 1986

TOTAL HASIL TANGKAPAN, TOTAL UPAYA PENANGKAPAN (DENGAN STANDAR HARI LAUT PURSE SEINE BESAR), HASIL TANGKAPAN PER UNIT UPAYA DAN TOTAL INTENSITAS PENANGKAPAN DARI SUMBERDAYA PELAGIS KECIL DI LAUT JAWA BERDASARKAN TIGA DAERAH PENANGKAPAN YANG BERBEDA DARI TAHUN 1976 SAMPAI DENGAN TAHUN 1986

FISHING AREA	YEARS	TOTAL CATCH (TONS)	CPUE LARGE SEINERS	TOTAL EFFORT AT SEA LARGE SEINERS	TOTAL FISHING (DAYS AT SEA/km²)
Traditional	1976	46 980	3 862	12 163	0.13
	1977	52 214	3 368	15 501	0.17
	1978	61 464	2 003	30 684	0.34
	1979	77 396	1 263	61 287	0.67
	1980	85 205	1 198	71 134	0.78
	1981	80 830	780	103 692	1.14
	1982	89 900	843	106 589	1.17
	1983	62 237	1 170	53 194	0.58
	1984	70 655	1 250	56 524	0.62
	1985	75 492	1 480	51 008	0.56
	1986	69 110	970	71 247	0.78
1st extension	1983	48 705	1 280	38 042	0.43
	1984	52 204	1 360	38 385	0.44
	1985	73 877	1 500	49 251	0.56
	1986	78 911	1 240	63 638	0.72
2nd extension	1985	5 863	1 230	4 767	0.21
	1986	9 728	1 340	7 259	0.32

4. MAXIMUM SUSTAINABLE YIELD AND OPTIMAL EFFORT

The relationship between the fishing intensity, CPUE and productivity (fig. 2) provides a normalized model (independent of the surface of the fishing area), which can be subdivided in three models ; fishing area 1976-1982 (91 000 km^{-2}), fishing area 1983-1984 (179 000 km^{-2} and fishing area 1985-1986 (202 000 km^{-2}), by multiplying the fishing intensity and the productivity by the respective surfaces (fig. 3).

The fishing intensity in the traditional fishing area increased between 1976 and 1982 and decreased in 1983 due to the eastward extension of fishing area which reduced the fishing pressure elsewhere. The fishing intensity was then transferred to the other fishing areas where it increased quickly (tab. III).

The decrease of the CPUE in the traditional area urged the large seiners to search for virgin fishing areas .

The results obtained by Caddy and Garcia models are given in table IV. The results achieved by the different models are very similar. The MSY is found between 175 000 and 180 000 tons with an optimal effort comprised between 138 000 and 187 000 days at sea.

Table IV

RESULTS OF MSY AND OPTIMAL EFFORT ACCORDING TO THE SCHAEFER AND FOX MODELS

NILAI HASIL TANGKAPAN LESTARI DAN UPAYA PENANGKAPAN OPTIMAL MENURUT MODEL SCHAEFER DAN FOX

	SCHAEFER	FOX
MSY (tons)		
Area 1976 - 1982	81 000	79 000
Area 1983 - 1984	159 000	155 000
Area 1985 - 1986	180 000	175 000
Optimal effort (days at sea)		
Area 1976 - 1982	62 000	84 000
Area 1983 - 1984	123 000	165 000
Area 1985 - 1986	138 000	187 000
Regression output		
a	2.620	2.60
b	-1.908	-1.09
r^2	0.470	0.62

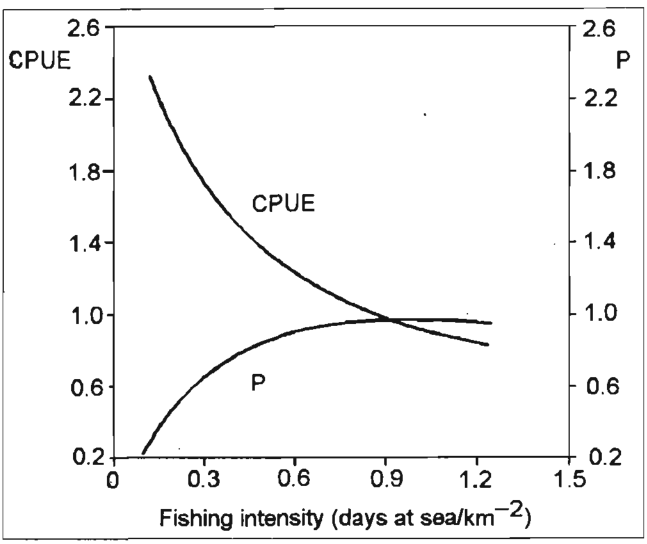


Figure 2

RELATIONSHIP BETWEEN FISHING INTENSITY, CPUE(TONS/DAYS AT SEA) AND THE PRODUCTIVITY (TONS/KM^{-2}) OF SMALL PELAGIC RESOURCES IN THE JAVA SEA

HUBUNGAN ANTARA INTENSITAS PENANGKAPAN, HASIL TANGKAPAN PER UNIT UPAYA (TONS/HARI DI LAUT) DAN PRODUKTIVITAS (TONS/KM^{-2}) SUMBER DAYA PELAGIS KECIL DI LAUT JAWA

The catch and effort registered in 1980 exceeded the MSY and the optimal effort for the traditional area. Although the effort increased in 1981 in this area, the CPUE decreased and the traditional fishing area seemed fully exploited. In 1983 the large seiners began to fish around the Masalembo - Matasiri Islands. In this area, the increase of the effort is related to the increase of CPUE. The same trend is observed in the Makassar strait since 1985. In 1986, the catch of small pelagic and the effort exerted on the resources in the Java Sea are close to the MSY and optimal effort values. It could mean that in 1986 the small pelagic stock in the Java Sea was nearly fully exploited.

Applying the composite model, we suppose that the considered stocks only differ in their size (then in their biomass) and that the other sources of variations can be neglected (Garcia, 1984). The pelagic species with high migratory behavior do not fully comply with this hypothesis. The migration of the pelagic species is not taken into account by this model, and it is known that in the Java Sea the fish availability according to the years is highly related to this behavior.

CONCLUSION

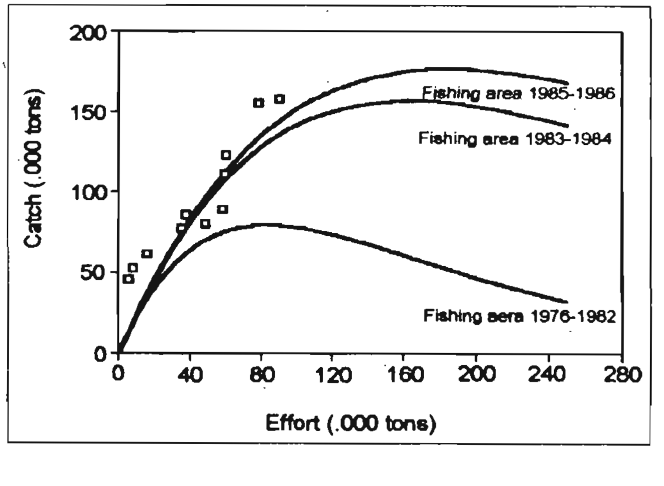
All fisheries exploiting pelagic resources of the Java Sea tend to extend their fishing areas and improve the fishing efficiency. Size and vessels number increase. Thus the fishing pressure on the stock is higher. As the small pelagic are highly variable resources, it is necessary to remain cautious about this trend. The number of days at sea would be one of the effort estimation, but corrections have to be done to improve the quality of the effort estimation.

The results given by this type of model depend on the accuracy of collected data statistics, and the knowledge we have of the fisheries. Regarding the catch and effort data between 1987 and 1991 concern, it seems that the data do not fit well with the model used, as some important changes in the fishing strategy and tactics occurred and are not taken into account by the model. However all pieces of information cannot be taken into account. Those are only tools allowing to give a first approximation of the exploited stage. Among the management measures, allocation of the effort on the different fishing areas or freezing of the effort at the current level can be considered. Although fishery resources are limited the improvement of the resource management entirely depends upon a good communication among scientists, administrators, fishermen and others involved parties.

Figure 3

Production model of the small pelagic resources for various fishing areas in the Java Sea

Model produksi dari sumber daya pelagis kecil dari beberapa daerah penangkapan di Laut Jawa



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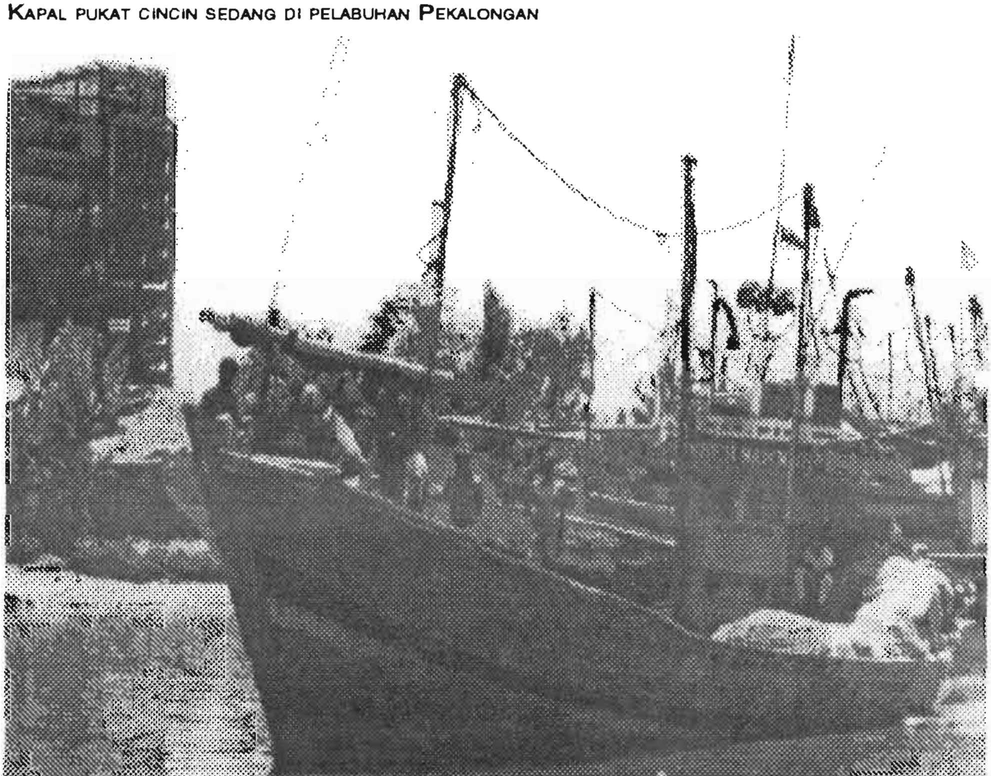
EXPLORATORY SCHEME FOR THE RECRUITMENT AND MIGRATION OF THE MAIN PELAGIC SPECIES

B. SADHOTOMO, M. POTIER

MEDIUM SEINER IN THE PEKALONGAN HARBOR

KAPAL PUKAT CINCIN SEDANG DI PELABUHAN PEKALONGAN



ABSTRACT

In order to obtain the catch frequency length of the species caught by the purse seiners fleet a sampling scheme was set at two main landing places. The present article covers the data collected from December 1991 to December 1993.

In the Java Sea there is a spatial stratification of the fish population, the juveniles staying more inshore than the adults, while the evolution of the average length of the fish caught by the seiners increases from West to East, following a West-East axis. Due to different fishing tactics, the large seiners tend to catch bigger sized-fish than the medium one do.

Dalam rangka mendapatkan komposisi hasil tangkapan berdasarkan species dan panjangnya, dari hasil tangkapan purse seine, cara-cara pengambilan contoh diterapkan pada dua pendaratan utama. Tulisan ini mencakup data yang dikumpulkan dari Desember 1991 sampai dengan Desember 1993.

Terdapat suatu stratifikasi berdasarkan tempat, dimana ikan-ikan muda tinggal lebih dekat ke pantai dari yang dewasa, sedangkan evolusi panjang rata-rata dari ikan-ikan yang tertangkap menunjukkan penambahan dari Barat ke Timur. Karena adanya perbedaan dalam taktik penangkapan, purse seine besar cenderung untuk menangkap ikan yang mempunyai ukuran lebih besar dari pada purse seine sedang.

Dua rekruitment tahunan tampak terjadi dalam perikanan, rekruitment utama terjadi dari Juni sampai Agustus dan rekruitment yang tidak begitu besar timbul pada periode musim Barat daya.

INTRODUCTION

The pelagic fishery in the Java Sea has developed sharply specially after the spreading of the purse seines in the 1970s. Improvement of the fishing boats design as well as changes in the fishing tactics have marked this development (Nurhakim *et al.*, 1987; Boely *et al.*,1992). The need of assessment (*e.g.*. equilibrium yield) for fishery regulation is obvious and it becomes very important to determine the regulatory scheme. Values of the maximum equilibrium yield have been estimated by investigators using landing statistics and other official data until 1976. After that the National Statistical data base collection system had been introduced .

The results tend to the conclusion that the maximum equilibrium yield is close to the highest catch used in the analysis (SCS, 1979; Sujastani, 1978). An attempt to use the same method with longer series of data without any modification will face some constraints due to the change of fishing pattern and the inter-annual variation of abundance in the Java Sea (Sadhotomo and Widodo, 1992).

The second approach, so called analytical model of Beverton and Holt (1957) includes biological population aspects and can give optimal values of the fishing mortality as well as other figures or parameters such as an average length at first capture. This model or others based on age structure based models can also be used with length structure, as it has been done by Widodo (1988) and Nurhakim (1993) for respectively *Decapterus spp.* and *Rastrelliger kanagurta*. Nevertheless, when one applies the model it is impossible to include some phenomena (*e.g.* inter-annual change of environmental characteristics) or other disturbances that cannot be explicitly measured. We believe these latent characteristics could eventually make the assumptions underlying the model invalid.

The purpose of our analysis is to briefly illustrate the nature of the length composition data of the main pelagic species in the Java Sea, to see the insight of the data and the possibility to apply the data to suitable models.

1. MATERIAL AND METHODS

A length frequency sampling was carried out in Pekalongan and Juwana harbors as part of the operation of the project. The procedures have been described in details by Boely *et al.* (1990) and Potier and Sadhotomo (1991). The sampling scheme aims to get the most accurate data of length frequency, the species composition in the samples, as well as the statistical data. The compilation and study of these sets of data give the structure of the catch at length which will serve as input data to some model analysis for pelagic fish stock assessment in the Java Sea.

The length frequency data of the six main pelagic species sampled from December 1991 to December 1993 are used in the analysis. Informal exploratory data analysis such as simple summary of the data and graphical presentation are applied in order to interpret these data.

2. RESULTS AND DISCUSSION

2.1 Summary of length composition and migration

We use descriptive techniques, such as average length, as summary and histogram to indicate the central tendency and the shape of the length frequency distribution. We present the monthly evolution of average length to show the general tendency of geographic distribution by size (fig. 1 and 2).

As seen in that figure, the average size tends to increase following a "West-East axis". It can be shown that the average size for the six species from the Karimunjava samples is generally lower than those from Lumu-lumu (Makassar Strait). Young fishes enter the fishery, first in the West part of the Java Sea (*i.e.* Karimunjava Islands and coastal waters North of the central part of Java) from May to August (fig. 2a, p.17).

In this case the average size represents all cohorts. We present a rough average size estimation of the first (youngest) and the second cohorts (modes of distribution) of *D. russelli, D. macrosoma, R. kanagurta* and *A. sirm.* Based on the appearance of the young fishes, we determine three recruitment patterns (fig. 3 and 4). To clarify further explanation, we name "major young cohort" the young fish entering the fishery in June-August and "minor young cohort" the fish entering at other periods. The first one is the type of *D. macrosoma* and *A. sirm*, for which young fishes only appear during June-August. For the second one, young fishes appear during the June-August period and during the North-West monsoon, as shown by *D. russelli* and *R. kanagurta*. In the third type, the appearance of minor ones occurs more than once a year while the major one appears during the June-August period. *S. crumenophthalmus* is an example for the last type. All pelagic fishes of this type are coastal inhabitants of which the seiner fishery never covers the entire distribution in the Java Sea waters. For this reason, we do not discuss it any further.

Assuming that the average age of the recruits is around six months, it can be indicated that the major recruitment originally comes from September-December spawning periods. On the other hand, the minor recruitment of *D. russelli* and *R. kanagurta* which occurs during the North-West monsoon period may result from spawning from March to July.

These recruits entered the fishery in the West part of the Java Sea (*i.e.* the North coast of Central Java and Karimunjava Islands in 1991 and 1992) while in 1993, they enter it in the Central part of the Java Sea (*i.e.* Bawean and Masalembo waters). However, these recruits never fully enter the fishery at that age, but sometimes at older ages. This is one of the reasons why some length classes are missing in the length distribution for some cohorts.

For all species, particularly for oceanic ones, the catch is made on part of the stocks, and more than 50% of it consists of immature fish. This may be attributed to the highly migratory behavior of the pelagic species. No data has been collected outside the fishing grounds of the seiners fleet, such as Flores Sea or the deepest part of the Java Sea (*i.e.* near the continental slope). Thus the hypothesis cannot be confirmed yet.

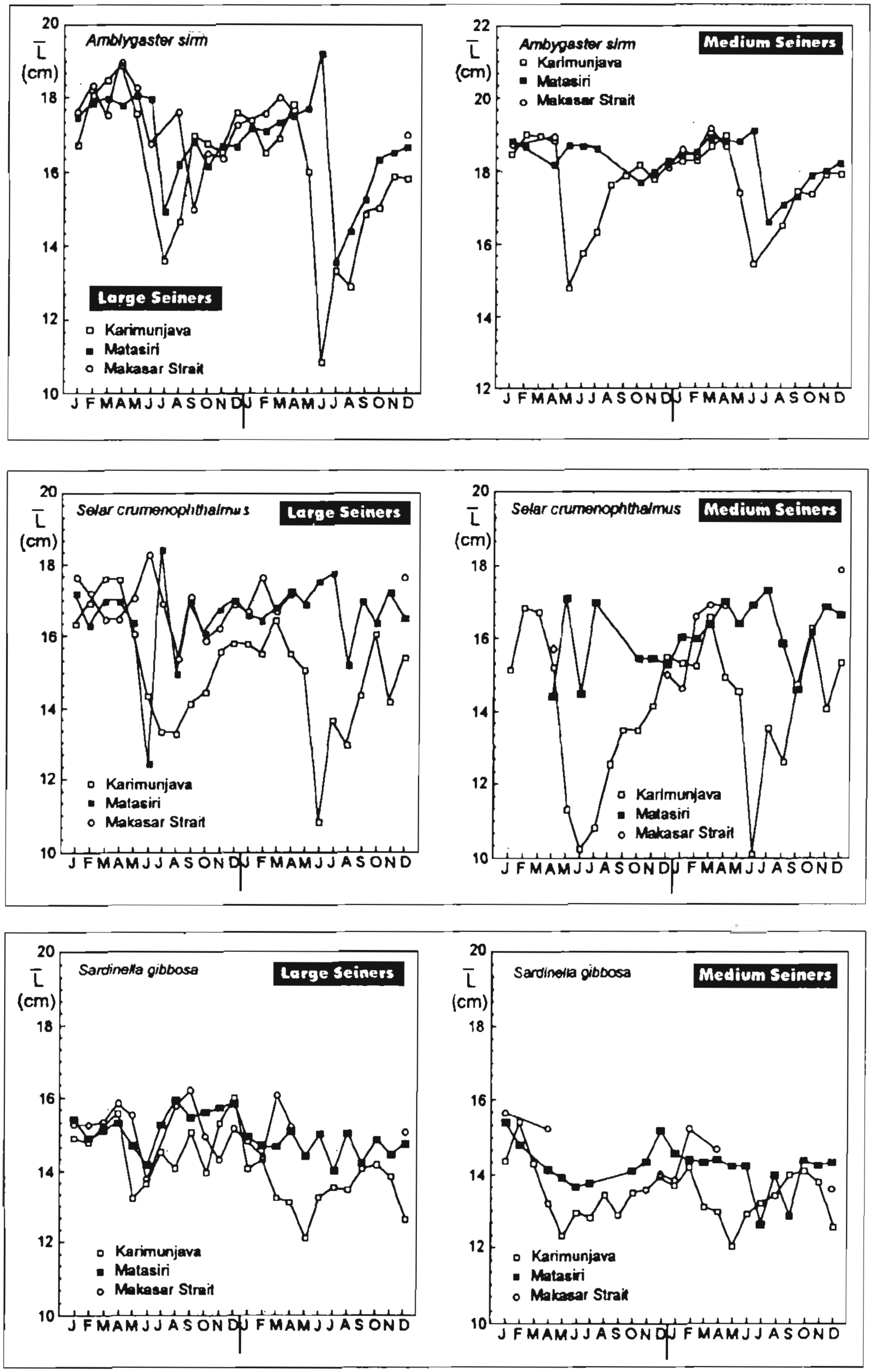
Meanwhile, cruises carried out by RIMF (Research Institute for Marine Fisheries) last year found the same species (*i.e. D. russelli, D. macrosoma* and *R. kanagurta*) caught by small ring nets (local name : "**gae**") in South-East Sulawesi in August and October. The fishing season occurs at the same period as in the Makassar strait waters for large seiners. The difference in length of adult fishes born during different spawning seasons is small and not obvious. An attempt to trace such cohorts will be difficult except if age data are available.

Change in occurrence for juveniles of oceanic species may be caused by the change in surface salinity profile in the Java Sea. High rainfall which occurred during 1993 can explain the pattern of recruitment for that year. During the peak season (September-November), when prevailing winds and currents come from the South-East, the range of the fish size is narrower than the previous quarter, when more oceanic species such as *D. macrosoma* dominate in the catch composition of the seiners. For instance, we can notice, the narrow range of length class of *A. sirm* that is found in almost all the samples.

Figure 1

MONTHLY EVOLUTION OF THE JAVA SEA MAIN PELAGIC SPECIES AVERAGE LENGTH ($\bar{L}$, CM) FOR 1992-1993

EVOLUSI BULANAN DARI PANJANG RATA-RATA IKAN PELAGIS KECIL DI LAUT JAWA ($\bar{L}$, CM) UNTUK 1992-1993


Amblygaster sirm
Large Seiners
Karimunjava
Matasiri
Makasar Strait
Amblygaster sirm
Medium Seiners
Karimunjava
Matasiri
Makasar Strait
Selar crumenophthalmus
Large Seiners
Karimunjava
Matasiri
Makasar Strait
Selar crumenophthalmus
Medium Seiners
Karimunjava
Matasiri
Makasar Strait
Sardinella gibbosa
Large Seiners
Karimunjava
Matasiri
Makasar Strait
Sardinella gibbosa
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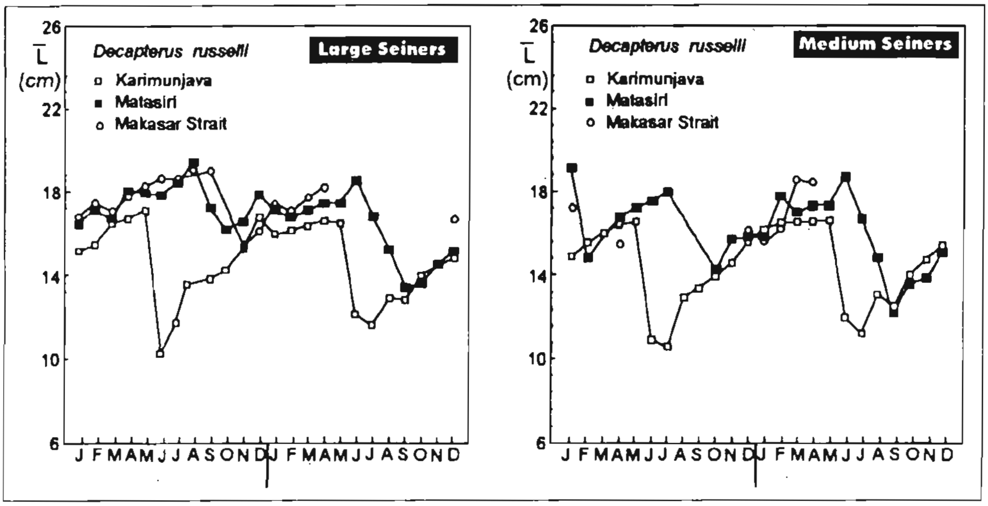
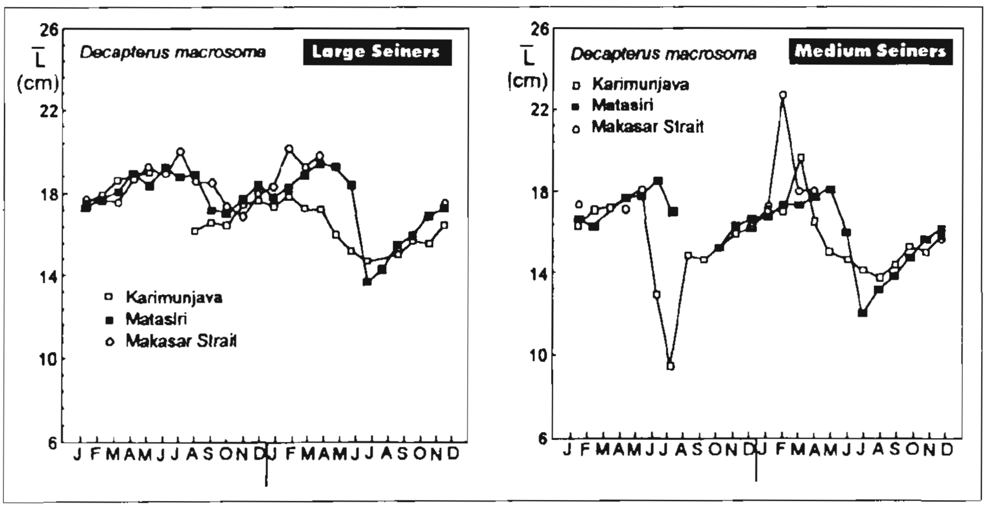
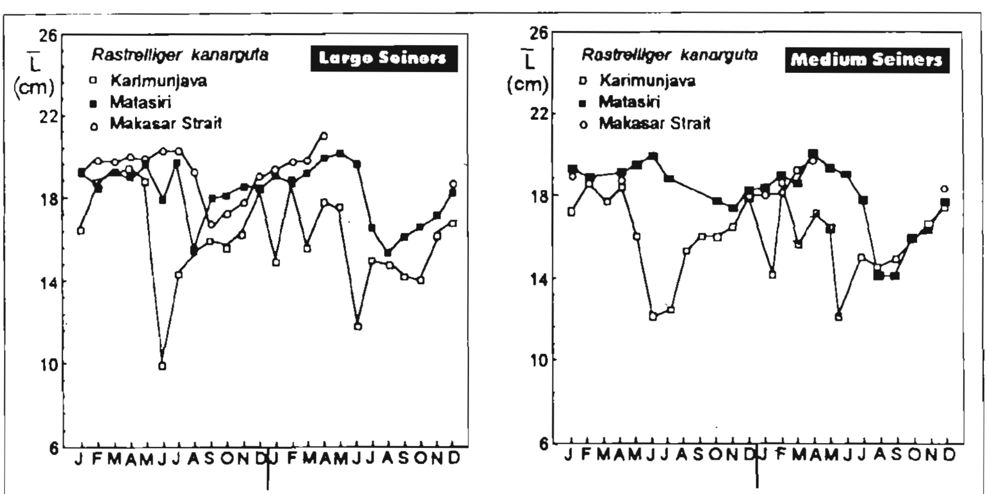
L (cm)
J F M A M J J A S O N D J F M A M J J A S O N D



Decapterus russelli
Large Seiners
L (cm)
Karimunjava
Matasiri
Makasar Strait
J F M A M J J A S O N D J F M A M J J A S O N D
Decapterus russelli
Medium Seiners
L (cm)
Karimunjava
Matasiri
Makasar Strait
J F M A M J J A S O N D J F M A M J J A S O N D



Decapterus macrosoma
Large Seiners
L (cm)
Karimunjava
Matasiri
Makasar Strait
J F M A M J J A S O N D J F M A M J J A S O N D
Decapterus macrosoma
Medium Seiners
L (cm)
Karimunjava
Matasiri
Makasar Strait
J F M A M J J A S O N D J F M A M J J A S O N D



Rastrelliger kanarguta
Large Seiners
L (cm)
Karimunjava
Matasiri
Makasar Strait
J F M A M J J A S O N D J F M A M J J A S O N D
Rastrelliger kanarguta
Medium Seiners
L (cm)
Karimunjava
Matasiri
Makasar Strait
J F M A M J J A S O N D J F M A M J J A S O N D

Figure 2 (left page)

MONTHLY EVOLUTION OF THE JAVA SEA MAIN PELAGIC SPECIES AVERAGE LENGTH ($\bar{L}$, CM) FOR 1992-1993

EVOLUSI BULANAN DARI PANJANG RATA-RATA IKAN PELAGIS KECIL DI LAUT JAWA ($\bar{L}$, CM) UNTUK 1992-1993

For all species the appearance of the same length class every month during the year can be interpreted as a result of the spatial distribution pattern and differences among ecological needs between juveniles and adults due to the prolonged major spawning season or to the existence of a minor spawning season.

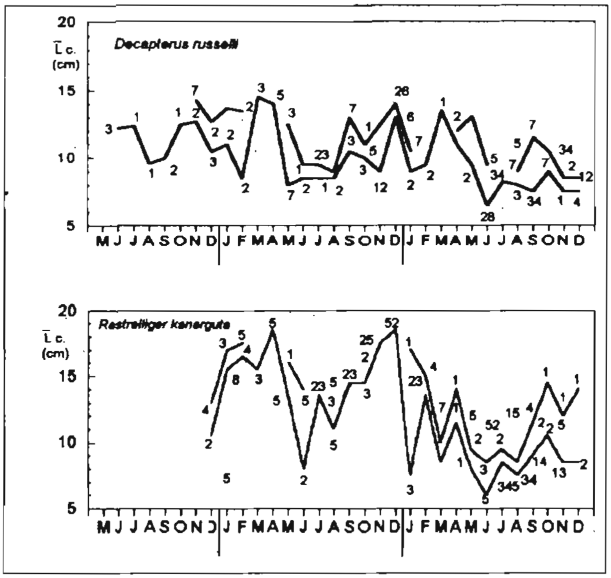


Figure 3

MODAL EVOLUTION OF THE YOUNGEST COHORT FOR *D. RUSSELLI* AND *R. KANAGURTA*

EVOLUSI DARI MODUS KELOMPOK UMUR YANG TERMUDA DARI *D. RUSSELLI* DAN *R. KANAGURTA*.

1 = North coast of Central Java
2 = Karimunjava
3 = Bawean
4 = Masalembo
5 = Matasiri
6 = Makassar Strait
7 = Kangean

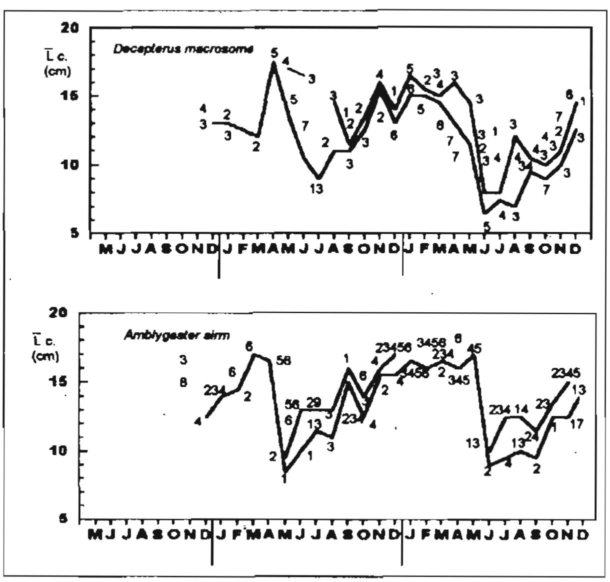


Figure 4

MODAL EVOLUTION OF THE YOUNGEST COHORT FOR *D. MACROSOMA* AND *A. SIRM*

EVOLUSI DARI MODUS KELOMPOK UMUR YANG TERMUDA DARI *D. MACROSOMA* DAN *A. SIRM*.

1 = North coast of Central Java
2 = Karimunjava,
3 = Bawean
4 = Masalembo
5 = Matasiri,
6 = Makassar Strait
7 = Kangean

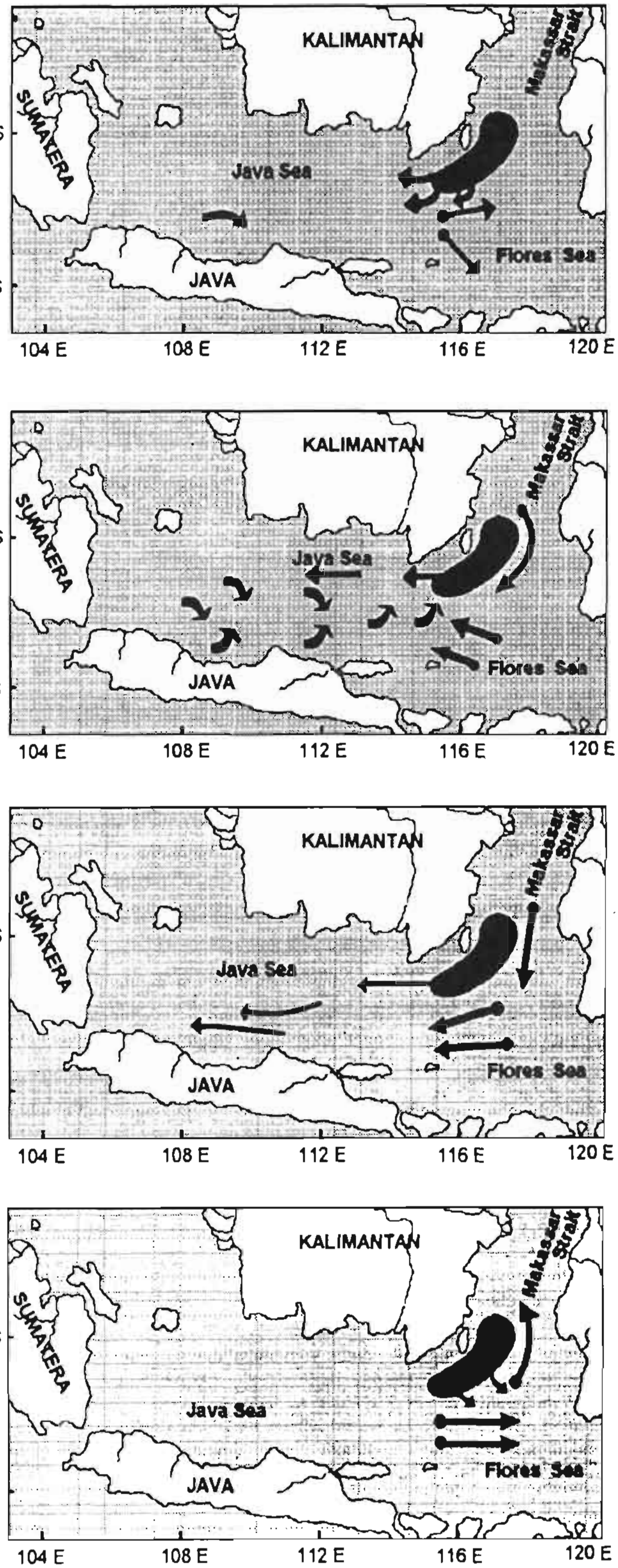


Figure 5

MOVEMENT OF FISH "TYPE ONE" (*D. MACROSOMA* AND *A. SIRM*) IN THE JAVA SEA

PERGERAKAN DARI IKAN-IKAN "TIPE SATU" (*D. MACROSOMA* DAN *A. SIRM*) DI LAUT JAWA

Based on these informations, the hypothetical movement of the fish in the Java Sea would be as follows (fig. 5 and 6):

Quarter 1: March-May

- Type 1: *D. macrosoma* and *A. sirm*
  - a. Minor spawning probably still occurs around Masalembo and Matasari
  - b. Emigration of adult fish to the Flores Sea and Makassar Strait, or disperse migration in the Java Sea
  - c. Minor recruitment in the West part of the Java Sea
- Type 2: *D. russelli* and *R. kanagurta*
  - a. Minor spawning probably occurs around Masalembo, Matasiri and Karimunjava
  - b. Same pattern as Type 2, point b.

Quarter 2: June-August

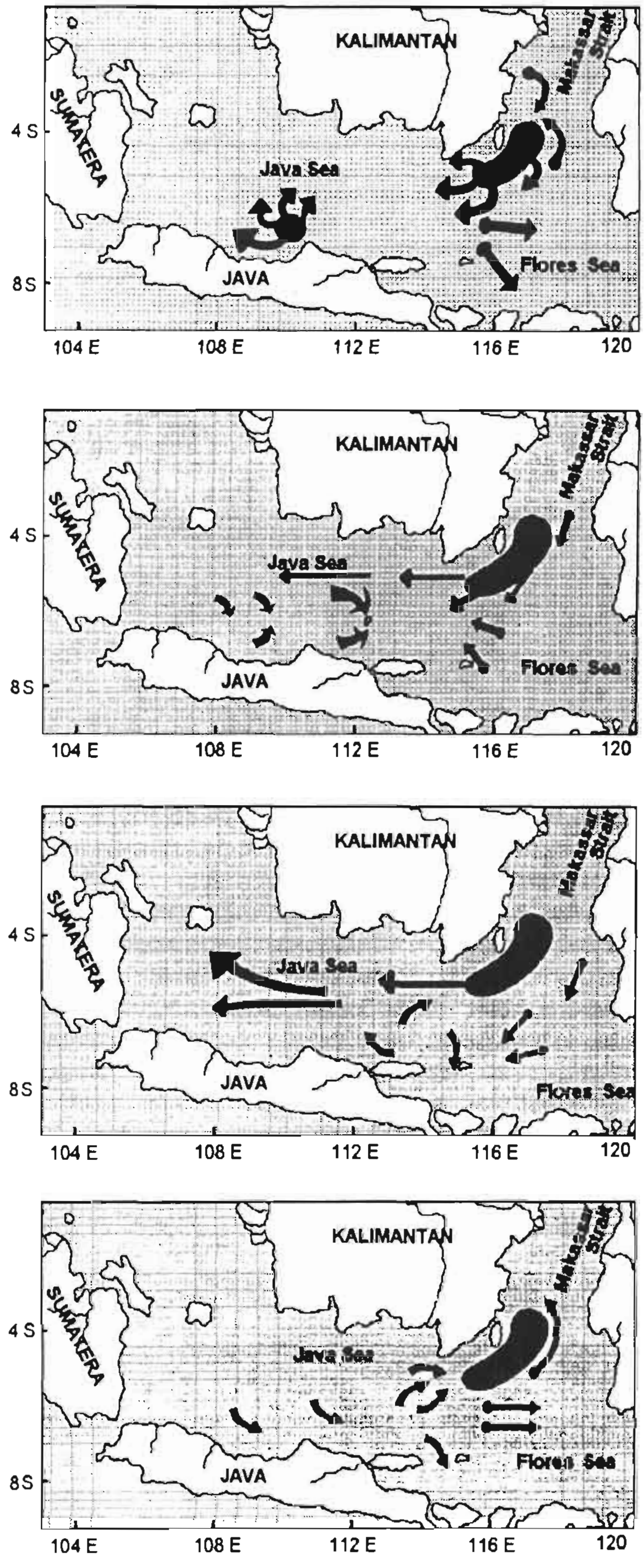
- Type 1.
  - a. Major recruitment
  - b. Immigration from the Flores Sea
  - c. Minor spawning
- Type 2. Same as Type 1.

Quarter 3: September-November

- Type 1
  - a. Immigration from the Flores Sea
  - b. Major spawning
- Type 2
  - a. Same as above
  - b. Minor spawning
  - c: Beginning of minor recruitment in the East part of the Java Sea (November)

Quarter 4: December-February

- Type 1
  - a. Emigration to the Flores Sea
  - b. Major spawning in the East part of the Java Sea
- Type 2
  - a. Emigration to the Flores Sea
  - b. Major Spawning in the East part of the Java Sea
  - c. Minor recruitment in the West and East parts of the Java Sea



Quarter 1 *: March-May*

Quarter 2 *: June -August*

Quarter 3 *: September-November*

Quarter 4 *: December-February*

Figure 6

MOVEMENT OF FISH "TYPE TWO"(*D. RUSSELLI* AND *R. KANAGURTA*) IN THE JAVA SEA

PERGERAKAN DARI IKAN-IKAN "TIPE DUA" (*D. RUSSELLI* DAN *R. KANAGURTA*) DI LAUT JAWA

2.2 Average size of the catch

To clarify the background we decided to smooth the presentation of the data from a monthly to a quarterly basis by setting June-August period as a quarter. Also, this way enabled us to reduce errors caused by the differences in fishing dates of the sampled boats and gave a more real biological description.

We apply this procedure on the six species caught by the two types of seiners. Length at which the cumulative catch reaches 50 % is determined from the graph. Proximity values are presented in annex I.

Fifty per cent of the seiners catch consist of juveniles approximately less than one year old and still immature. The low values of the probability of capture are mainly caused by two factors.

- First, the entering of a huge recruitment occurs in the fishery from June to August which significantly influences the shape of the distribution.
- Second, the presence of young fish from June to December 1993, probably caused by changes in the salinity profile in the Java Sea.

This method gives rough estimates because some graphs are plotted from a mixture or asymmetric distribution data. Nevertheless, the non gaussian type of the distribution is believed to be the real one and is found in nature. Statistically, the polymodal distribution would raise some problems in estimation, but, in the context of the application to Virtual Population Analysis model those can be ignored.

Due mainly to fishing tactics the large seiners catch bigger fish than the medium seiners do.

CONCLUSION

The spatial distribution of the size of the main pelagic species in the Java Sea is related to hydrographic conditions and to life cycle of the species. The gradient observed in the average size is related to physiological characteristics common to almost all pelagic species. If fishermen knew this pattern and would not select the size of fish in fishing grounds, the length composition would represent the length composition of the population in the sea.

The boundaries of the stocks units, at least for the oceanic pelagic species caught in the Java Sea, extend eastward beyond the Java Sea until South-East Sulawesi.

However, to apply the analytical model with the catch at length, the total number of the same unloaded species, from fisheries exploiting the same stocks outside and inside the Java Sea, should be considered.

Annex I (next pages)

LENGTH (FL : FIRST LENGTH) PROXIMATE AT 50 % OF THE PROBABILITY OF CAPTURE
DUGAAN PANJANG PADA PELUANG 50% TERTANGKAP

Left page :

Top *: Decapterus russelli,* ***Middle*** *: Decapterus macrosoma,* ***Bottom*** *: Rastrelliger kanagurta*

Right page :

Top *: Amblygaster sirm,* ***Middle*** *: Selar crumenophthalmus,* ***Bottom*** *: Sardinella gibbosa*

SEINERS TYPE	LARGE			MEDIUM		
ZONES	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA .
QUARTERS						
Dec.91-Feb.92	14.50	15.75	-	14.25	15.75	-
Mar.92-May92	16.00	17.50	15.00	15.20	14.75	-
Jun.92-Aug.92	13.50	18.25	16.30	12.30	-	-
Sep.92-Nov.92	14.50	17.75	-	13.50	-	-
Dec.92-Feb.93	15.75	15.75	15.75			
Mar.93-May 93	16.25	16.75	16.00	15.75	17.25	12.75
Jun.93-Aug.93	12.50	-	15.25	11.75	-	16.50
Sep.93-Nov.93	12.75	-	13.75	12.75	-	12.25

SEINERS TYPE	LARGE			MEDIUM		
ZONES	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA .
QUARTER						
Dec.91-Feb.92	15.75	16.20	-	15.75	16.75	-
Mar.92-May92	17.00	17.75	15.00	16.75	16.75	-
Jun.92-Aug.92	13.75	18.75	15.00	12.75	-	14.30
Sep.92-Nov.92	15.75	15.50	-	14.75	-	-
Dec.92-Feb.93	16.75	16.75	15.75	16.75	17.00	-
Mar.93-May 93	17.60	17.75	13.75	16.25	17.60	14.25
Jun.93-Aug.93	12.75	-	15.50	12.00	-	13.50
Sep.93-Nov.93	15.25	-	14.25	14.75	-	13.75

SEINERS TYPE	LARGE			MEDIUM		
ZONES	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA .
QUARTERS						
Dec.91-Feb.92	18.00	19.25	-	17.75	18.75	-
Mar.92-May 92	18.75	19.75	16.75	17.75	17.75	-
Jun.92-Aug.92	15.40	20.00	18.70	12.50	-	14.75
Sep.92-Nov.92	17.75	17.75	-	16.50	-	-
Dec.92-Feb.93	18.50	18.75	18.60	17.75	17.75	20.25
Mar.93-May 93	18.85	19.70	18.00	18.20	19.00	18.00
Jun.93-Aug.93	14.25	-	16.30	14.00	-	16.00
Sep.93-Nov.93	16.00	-	14.50	15.50	-	14.50

SEINERS TYPE	LARGE			MEDIUM		
ZONES	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA .
QUARTERS						
Dec.91-Feb.92	17.00	17.60	-	17.20	16.75	-
Mar.92-May 92	17.60	17.80	17.00	16.50	17.50	-
Jun.92-Aug.92	15.20	17.20	15.60	11.75	-	14.50
Sep.92-Nov.92	16.00	16.20	-	15.50	-	-
Dec.92-Feb.93	16.75	17.00	16.50	16.25	16.10	16.25
Mar.93-May 93	17.00	17.20	16.50	16.85	16.70	16.60
Jun.93-Aug.93	12.75	-	16.00	12.50	-	15.50
Sep.93-Nov.93	15.50	-	15.00	15.00	-	14.90

SEINERS TYPE	LARGE			MEDIUM		
ZONES	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA .
QUARTERS						
Dec.91-Feb.92	15.90	17.00	-	16.00	14.25	-
Mar.92-May92	16.50	16.00	11.80	14.30	14.90	-
Jun.92-Aug.92	13.75	17.75	13.00	9.75	-	8.75
Sep.92-Nov.92	15.00	15.50	-	13.50	-	-
Dec.92-Feb.93	15.50	16.40	15.60	14.50	15.60	16.50
Mar.93-May93	16.10	16.10	15.90	15.80	16.10	16.10
Jun.93-Aug.93	11.35	-	12.40	11.20	-	11.30
Sep.93-Nov.93	14.30	-	12.25	14.25	-	13.20

SEINERS TYPE	LARGE			MEDIUM		
ZONES	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA	JAVA SEA	MAKASSAR STRAIT	SOUTH CHINA .
QUARTERS						
Dec.91-Feb.92	14.25	14.75	-	14.20	14.25	-
Mar.92-May 92	14.20	14.75	14.65	12.25	14.50	-
Jun.92-Aug.92	14.20	13.30	14.75	12.50	13.75	-
Sep.92-Nov.92	14.70	14.15	-	13.10	-	-
Dec.92-Feb.93	14.20	14.20	15.00	13.75	13.70	12.50
Mar.93-May93	12.60	14.75	11.80	12.15	14.00	11.60
Jun.93-Aug.93	13.20	-	14.20	13.00	-	-
Sep.93-Nov.93	13.70	-	13.75	13.70	-	13.75

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EXPLOITATION

FISHING STRATEGIES AND TACTICS IN THE JAVANESE SEINERS FISHERIES
M. POTIER, D. PETIT 171

NORTH JAVA COAST FISHERIES : PRELIMINARY OBSERVATIONS ON SMALL SEINE NETS EXPLOITATION
T. HARIATI, M.M. WAHYONO, SUWARSO, D. KRISSUNARI 185

EXPLOITATION OF THE LARGE AND MEDIUM SEINERS FISHERIES
M. POTIER, B. SADHOTOMO 195

THE GENERALIZED LOGISTIC MODEL AS A TOOL FOR THE ASSESSMENT OF SMALL PELAGIC SPECIES
S.B.SAILA 215

THE INFLUENCE OF ENVIRONMENT ON STOCK ASSESSMENT : AN APPROACH WITH SURPLUS PRODUCTION MODELS
P. FREON 231

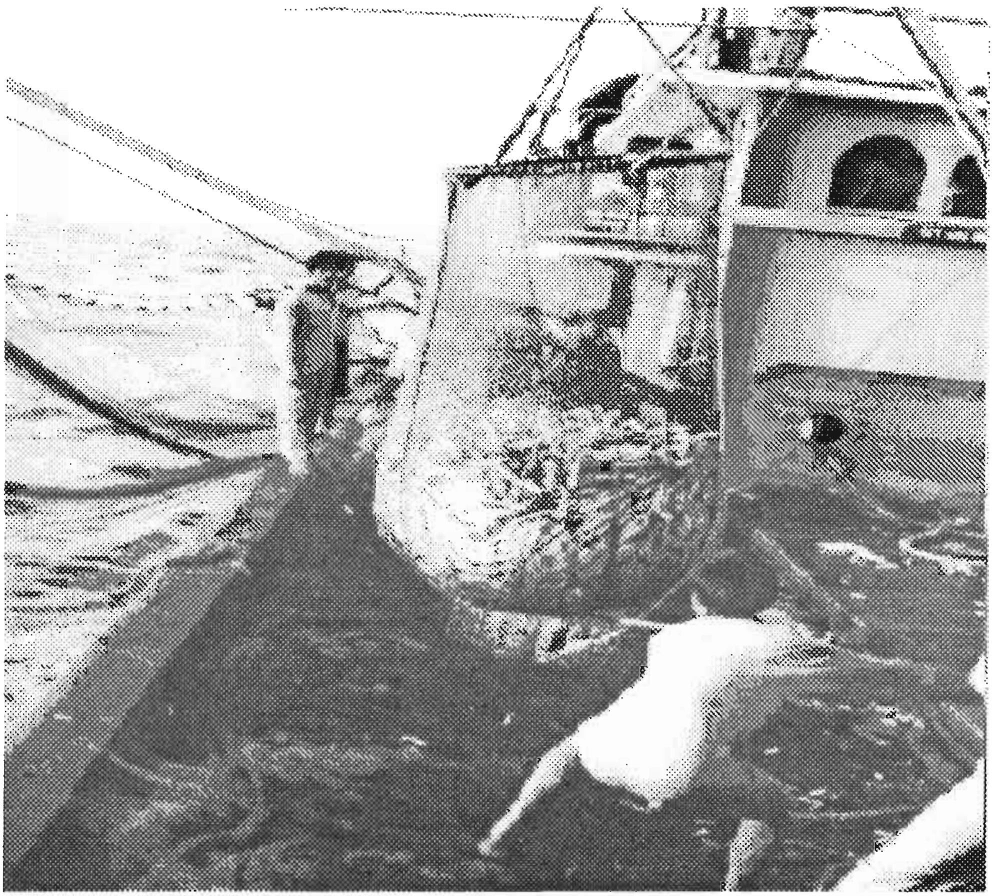
FISAT AND STOCK ASSESSMENT
F.C. GAYANILO, JR. 257

FISHING STRATEGIES AND TACTICS IN THE JAVANESE SEINERS FISHERIES

M. POTIER, D. PETIT

BRAILING THE FISH ON BOARD

MENANGKAI IKAN KE ATAS KAPAL



ABSTRACT

Fishing strategies and tactics are related to the knowledge fishermen have about environment, to the behavior of the fish and to the socio-economical factors which affect the fishery.

The fishermen knowledge is applied to the strategy (time scale from the trips - less than one month up to one year), and to the tactics which is the way fish are caught (time scale, fishing operations). The strategy of the Javanese fishermen is highly correlated with the monsoons regime. The alternation of these seasons induces changes in the abundance of fish in the Java Sea. Fishermen choose their fishing areas according to the fluctuation of the abundance.

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 equipped with radio and the strategy is to prospect two or three fishing zones during one trip. The strategy which was an individual one is becoming a fleet 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 behavior and of the vessels they use, the fishing tactic of the Javanese fishermen consists of concentrating the fish by means 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 grounds.

Strategi dan taktik penangkapan adalah berhubungan dengan pengetahuan alami dari nelayan, tingkah laku ikan yang akan ditangkap dan faktor sosial ekonomi yang mempengaruhi perikanan.

Pengetahuan tersebut diterapkan dalam pengaturan strategi dan taktik penangkapan untuk penangkapan ikan. Strategi penangkapan nelayan Jawa sangat berhubungan dengan musim muson. Pergantian musim mempengaruhi perubahan kelimpahan ikan di Laut Jawa. Nelayan akan memilih daerah penangkapan menurut naik turunnya ikan yang tersedia pada daerah tersebut. Sebelum 1992, dalam satu trip dipilih hanya satu daerah penangkapan. Selanjutnya setelah kapal-kapal dilengkapi dengan radio, maka dalam satu trip dapat beroperasi pada beberapa daerah penangkapan. Pada bulan baru penangkapan meningkat dengan harapan hasil tangkapan lebih baik.

Sesuai dengan tingkah laku ikan dan kondisi kapal, maka dipakai rumpon dan lampu untuk mengumpulkan ikan. Pada awalnya rumpon mempunyai peranan yang penting dan setelah tahun 1988 peranan tersebut digantikan oleh lampu. Jumlah tawur per malam berbeda, tergantung apakah saat itu bulan penuh atau bulan baru. Penyebaran kapal pada suatu daerah penangkapan adalah tidak acak.

INTRODUCTION

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 seine in the Java Sea was a technological improvement

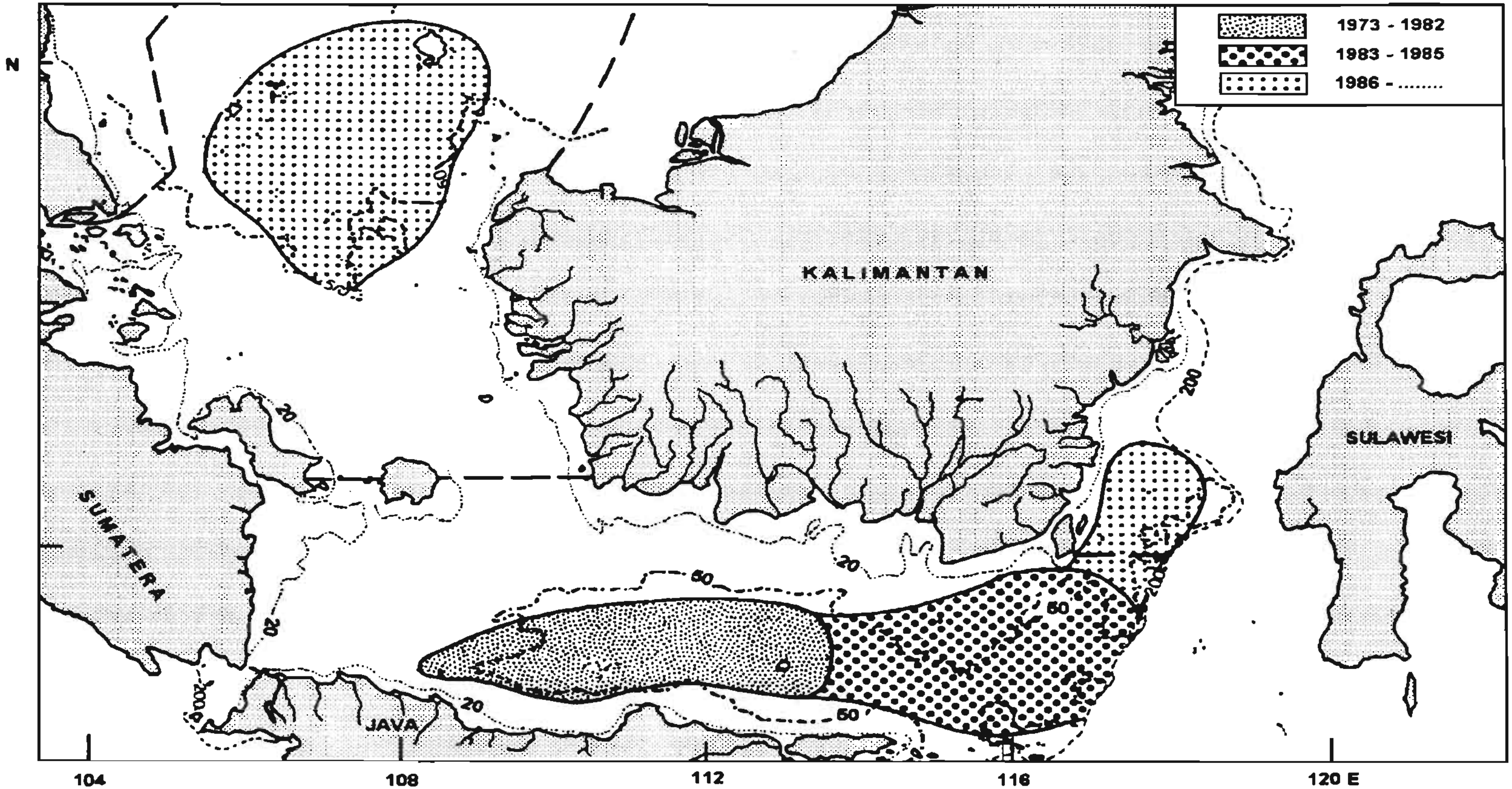


Figure 1

FISHING GROUNDS EXTENSION FOR THE LARGE SEINERS FISHERY.

PERLUASAN DAERAH PENANGKAPAN PURSE SEINE BESAR 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 of the environment and of the fish behavior then they apply it to the fishing strategies and tactics. The fishing strategies are related to mid and long time scales (Ferraris, 1993) such as the trips or the yearly occupation of the fishing space by the fisheries. They are a set of coordinate actions to track and find the fish. The fishing tactics are related to short time scale, mainly the fishing operation to catch fish.

In this paper, we analyze the strategies and fishing tactics of the Javanese seiners fisheries. We used the data collected by the Project since 1985, as we know the number of trips by fishing ground only since that year. We also performed monthly enquiries among the fishing masters of large, medium and mini seiners.

1. FISHING STRATEGIES

Three times scales can be used to understand the fishing strategies followed by the seiners fisheries of the Java Sea; a long-term one (historical evolution), a mid-term one (yearly occupation of the space) and a short-term one (trip).

1.1 Long-term strategy : Occupation of the available space.

Since its implementation in 1971, the seiners fisheries continuously extend the prospected space. The large seiners fishery had two extension phases;

- In the first one, from 1973 to 1985, the fishery occupied the whole Java Sea above 50m deep. Concentrated on the traditional fishing grounds until 1982, it extended its fishing zones eastward to Masalembo, Matasiri and Kangean (fig. 1).
- In the second one, from 1986 to 1988, the seiners left the fishing grounds of the Java Sea to extend eastward to the Makassar Strait, and northward to the South China Sea. First, located in the fishing grounds of the Central Java Sea, the medium seiners which appeared in 1987 at Pekalongan extended eastward to Masalembo and Matasiri since 1990.

1.2 Mid-term strategy : Use of the space.

It is based on the yearly occupation of the space and differs from one fishery to another.

- LARGE SEINERS.

The strategy of large seiners is to change fishing grounds according to the environmental conditions and to the fish accessibility. A multivariable analysis in principal components of the number of trips according to the fishing grounds since 1985 shows that the scheme is almost the same year after year (fig. 2). From January to April the vessels are concentrated on the Makassar Strait grounds. In April-May they move to the grounds of the South China Sea. In August they come back on the Central Java Sea fishing grounds close to the landing places and move eastward as the North-West monsoon approaches. In December they reach the eastern limit of the Java Sea (fig. 3). At the time being, half of the fishing year is spent outside the Java Sea.

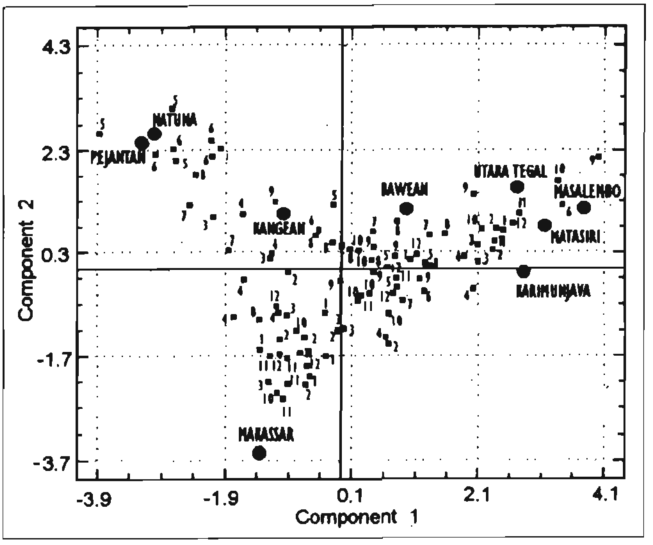


Figure 2

MULTIVARIATE ANALYSIS OF THE LARGE SEINERS TRIPS DISTRIBUTION ACCORDING TO THE FISHING GROUNDS BETWEEN 1985 AND 1992

ANALISIS MULTIVARIAT PENYEBARAN TRIP PURSE SEINE BESAR BERDASARKAN DAERAH PENANGKAPAN DARI TAHUN 1985 SAMPAI DENGAN 1992.

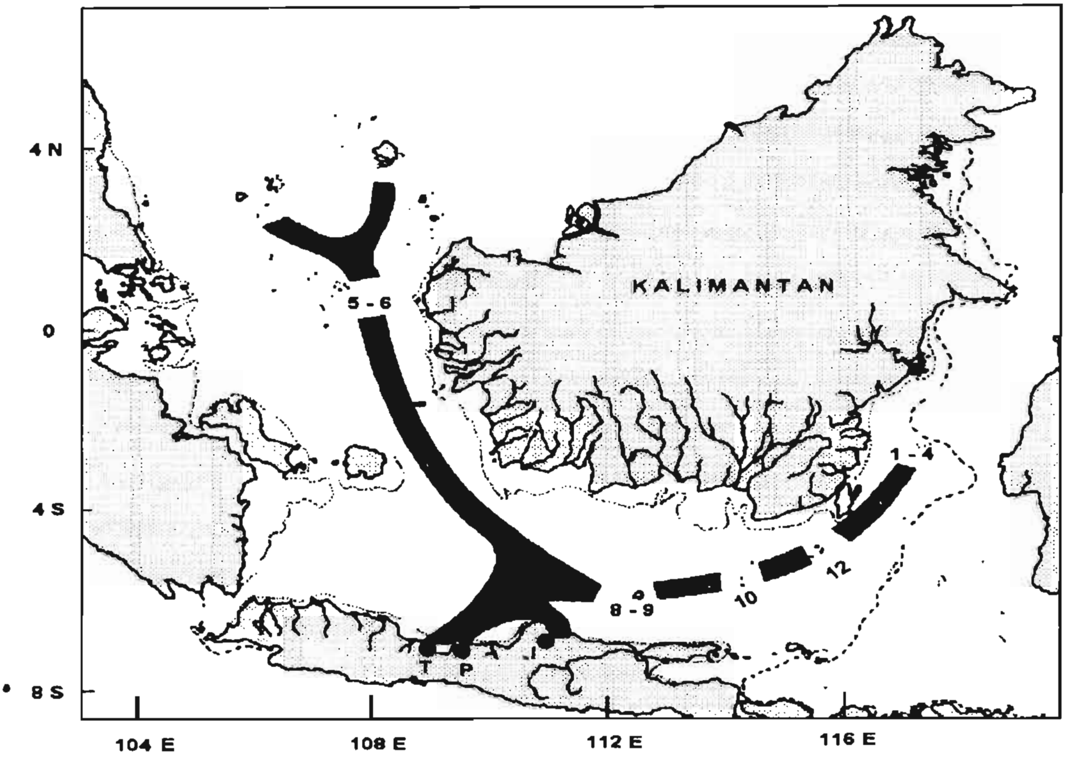


Figure 3

YEARLY FISHING CYCLE OF THE LARGE SEINERS FISHERY

CYCLUS TAHUNAN PENANGKAPAN PERIKANAN PURSE SEINE BESAR

1-12 : Months

T : Tegal, P : Pekalongan, J : Juwana

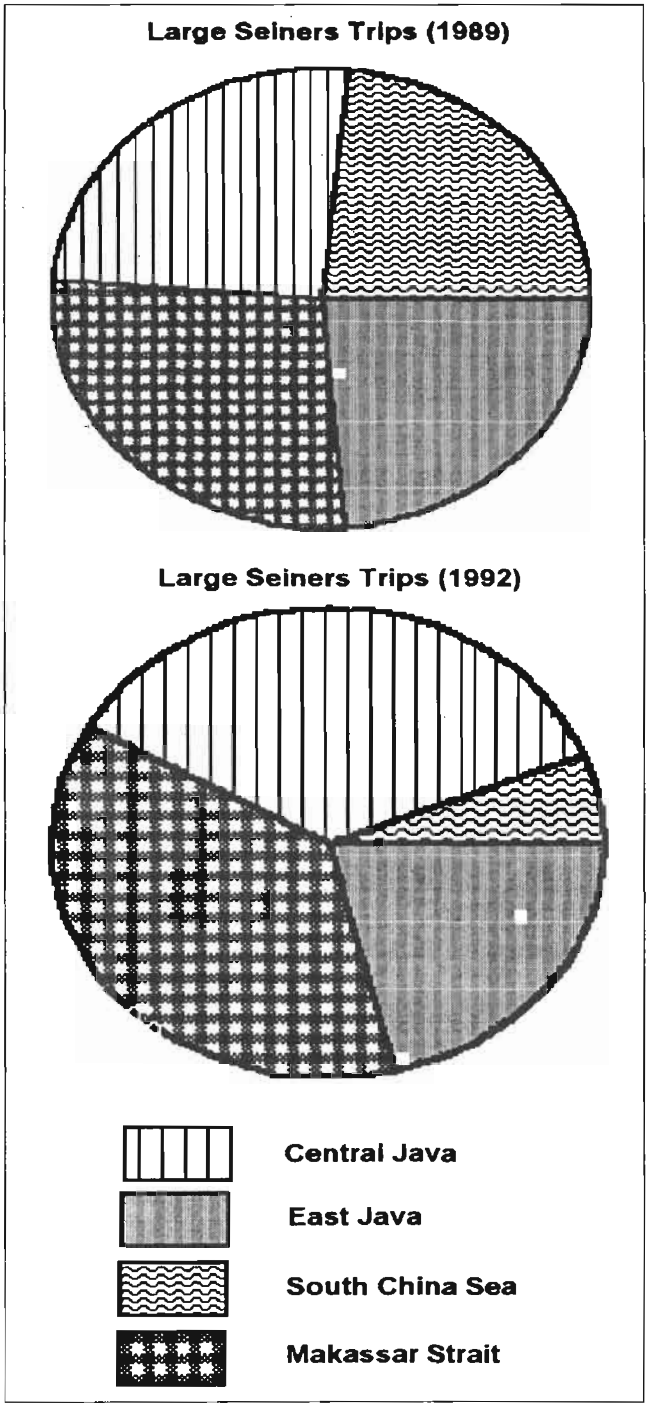


Figure 4

FISHING STRATEGY FOR TWO TYPICAL YEARS

STRATEGI PENANGKAPAN UNTUK DUA TAHUN YANG BERBEDA.

However, this strategy can be easily adapted. Sometimes, when the environmental conditions prevailing in the Java Sea are not good (1989) the fishing vessels spend more time outside the Java Sea (fig. 4a). Similarly, due to low rainfalls during the first months of the year or to a delay in the beginning of the North-West monsoon, the oceanic waters enter far in the Java Sea and the fish is found in the fishing grounds close to the landing places (1992). In this case the fishing vessels stay longer on these fishing grounds (fig. 4b).

■ MEDIUM SIZE SEINERS

These seiners stay along the year in the Java Sea and follow a strategy used by the large seiners before 1985. In May-June, when the fish accessibility is low, they lay up or dock. They start fishing in July-August on grounds close to the landing places. Until December they move eastward as the large seiners do. From January to April they stay close to the coast because of the bad weather (strong winds) (fig. 5).

■ MINI SEINERS

The mini seiners based along the northern coast of the Java Island move along the coast toward the Sunda Strait and the Bali Strait (fig. 6). During the July-December period they remain in the vicinity of their registration places. From

January to April, the mini seiners of the province of East Java move to the Madura Strait and the western part of the Java Island in order to avoid the rough conditions of the Java Sea. In May-June they leave the Java Sea and reach the Bali or Sunda Strait as during the **"Musim Sepi"** (quiet monsoon) the Java Sea seems to be empty of fish.

To avoid the prevailing winds of the monsoons, the mini seiners of South Kalimantan migrate from around the Laut Island during the North-West monsoon and to the **"Matasiri"** archipelago during the South-East monsoon.

Some of them can change fishing gear according to the target species. The Laut Island fishermen use seines for the mackerel season which occurs from November to April (*Rastrelliger kanagurta* and *Rastrelliger brachysoma*) and gill nets to fish small tunas. In Bulu, the fishermen change the bunt of the seine according to the target species.

1.3 Short-term strategy: The trip

■ LARGE SEINERS.

Since radio (S.S.B.) has been set on the vessels board, the fishery has changed from an individual to a fleet strategy. Before 90-91, the vessels did not prospect more than one fishing ground per trip.

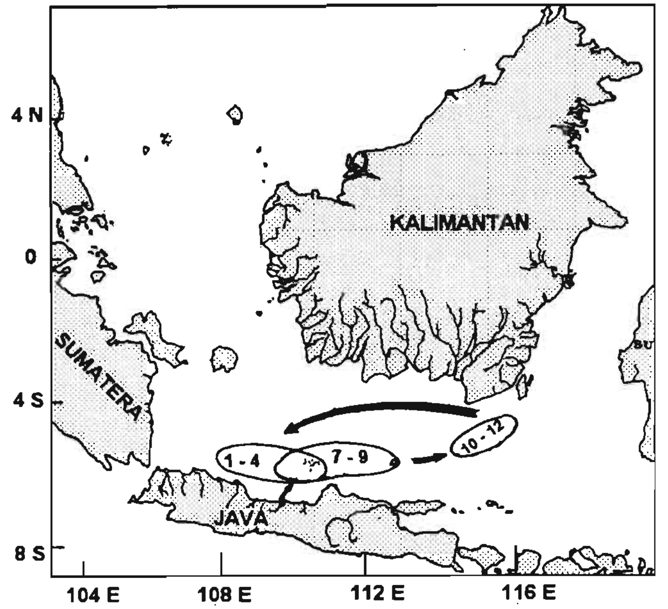


Figure 5

MEDIUM SEINERS FISHING GROUNDS ALONG THE YEAR.

DAERAH PENANGKAPAN PURSE SEINE SEDANG MENURUT PERIODE TAHUN.

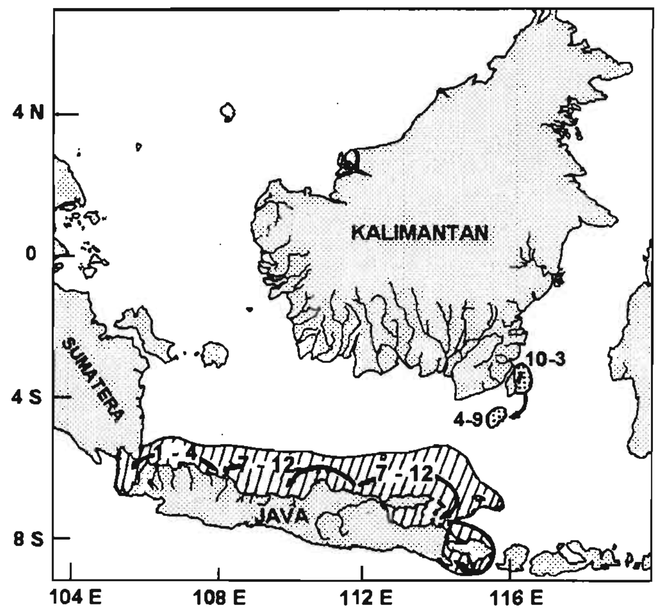


Figure 6

MINI SEINERS FISHING GROUNDS ALONG THE YEAR

PERIKANAN MINI PURSE SEINE, DAERAH PENANGKAPAN MENURUT PERIODE TAHUN.

With the radio, they use a pack strategy. Seiners from a same fishing company prospect different fishing grounds. When one of them find the fish it calls the others which then concentrate on this area. When the catch decreases they spread again on several fishing grounds in order to find the fish. With this expansion-contraction strategy they can survey two or three fishing grounds during the trip. For a few years the strategy was to stay at sea until the vessels were full. Nowadays, most of the owners can call their vessels and ask them to come back to the landing places when the price of the fish is high. But, the strategy is still to be at sea around the new moon when the catch is believed to be higher.

■ MEDIUM SEINERS.
These vessels still spend most of the trips on the same fishing ground and land in the registration place. They stay 8 to 10 days at sea, their strategy being to land fresh fish.

■ MINI SEINERS.
The strategy is adapted to the target species. If they catch small tunas or mackerels, they only stay one day at sea, looking for fish during daytime.

For the ones which catch small pelagic as scads, sardines and mackerels, the strategy is to maximize the benefit of the trip. They can stay at sea up to eight days even if they only have 4 days food and water stocks. Staying along their FAD they sell their catch at sea to some buyers coming on small boats who provide them some food and fuel.

2. 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 seiners fisheries in Indonesia use these tools widespread in Asia. In the seiners fisheries of the Java Sea lamps and rafts are combined. More often, the fishing operation takes place at night (Potier *et al.*, 1992) after aggregation of the fish.

2.1 Traditional Fishing tactics

The tactic is similar for all the fisheries and only differs in small details. It can be divided in two parts; the mooring of the rafts and the fishing operation itself.

■ MOORING OF THE RAFTS.
The choice of the rafts on a fishing ground depends on 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 good indicators.

Until 1988 the large seiners 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.

Mini seiners often moor only one raft which can stay five to six months in activity. This raft is moored 20 to 30 nautical miles of the coast. It is not used before 3 to 4 days, average time to get colonized. However, sometimes the sets occur the first night after the raft is moored.

■ Fishing operation.

Choice of the "rumpon": it starts in the afternoon when the vessel inspects 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. Mini seiners leave their landing place at 14h00-15h00 to be near their raft at dusk. After mooring they light on some paraffin pressure lamps placed on the raft.

Hauling the "rumpon": the setting starts by hauling the raft (fig. 7A) 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**

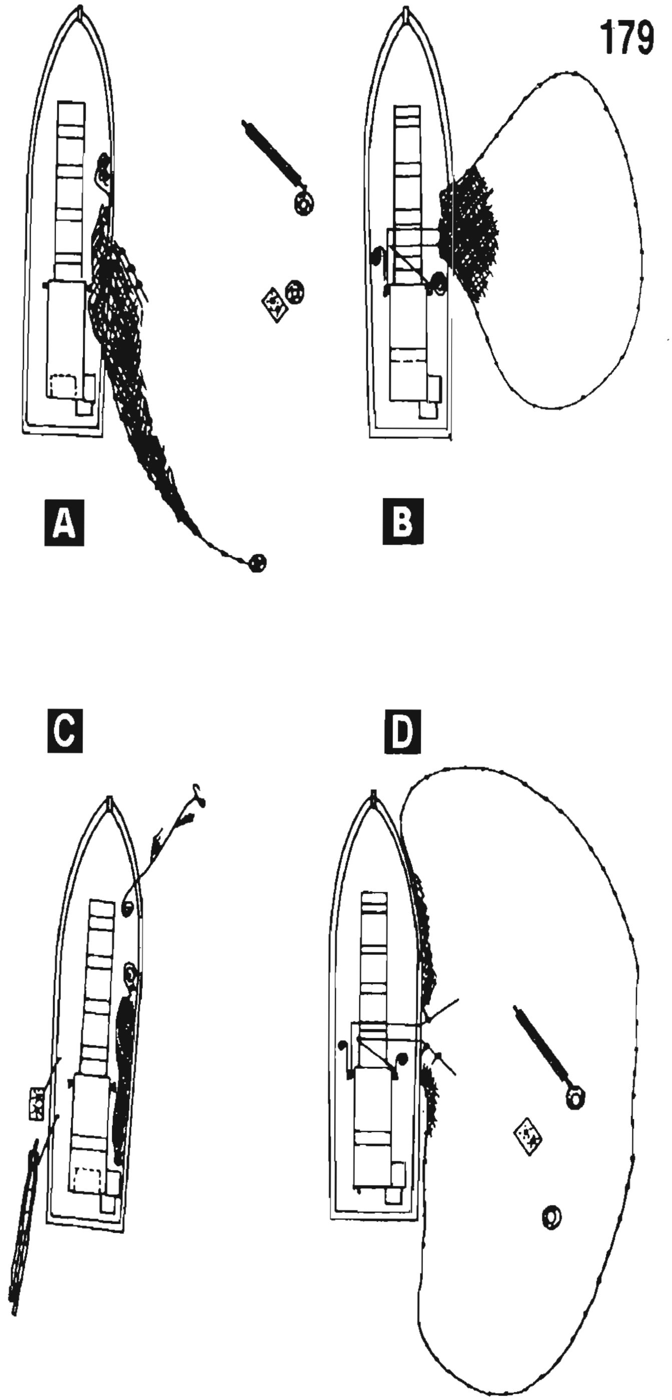


Figure 7

Different phases of a purse seine set

Urutan operasional penangkapan dengan purse seine arus" (current master) about the current direction and the fish position .

Starting leeward, the net is shot over the stern (fig. 7B) 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. 7C) and 35 minutes to form the bag (fig. 7D). According to the moon one or two sets will take place during the night (Boely *et al.*, 1988). Setting times are usually between 11 p.m. and 1 a.m. and between 3 a.m. and 5 a.m. (fig. 8).

The mini seiners catch the small pelagic species as scads and sardines in the same way. To catch small tunas and mackerels they fish during the day "at sight" when the shoals are near the surface. At night they can catch some mackerels (*Rastrelliger brachysoma*). The fishermen look for the luminescence coming from the shoals of this species.

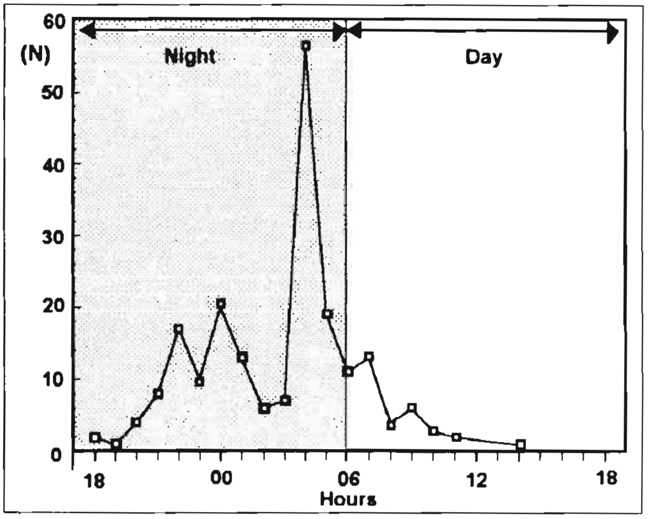


Figure 8

DISTRIBUTION OF THE SEINE SETS(N) ACCORDING TO THE NIGHT HOURS
PENYEBARAN JUMLAH SETING (N) BERDASARKAN WAKTU.

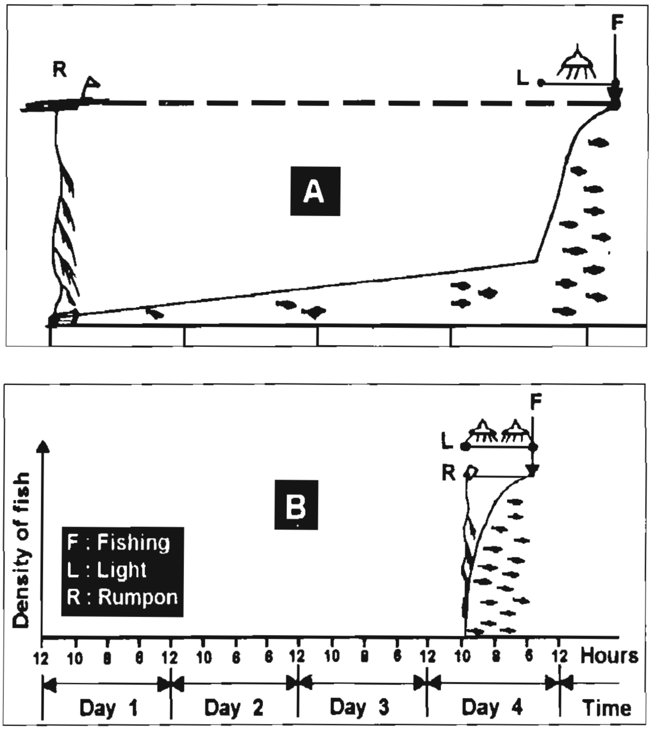


Figure 9

PHASES OF FISH ATTRACTION. OLD (A) AND NEW (B) FISHING TACTICS
TINGKAT KETERTARIKAN IKAN. TAKTIK PENANGKAPAN LAMA (A) DAN BARU (B)

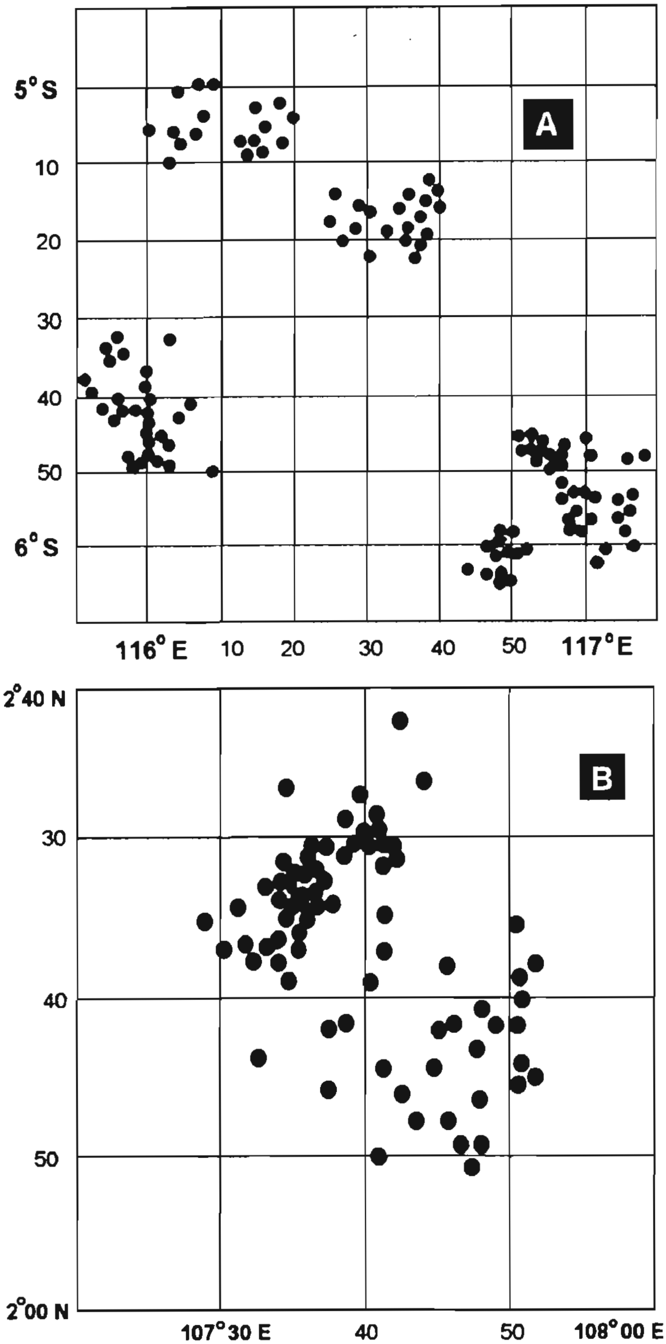


Figure 10

DISTRIBUTION OF THE PURSE SEINERS DURING THE FISHING OPERATIONS IN MATASARI (A), 4 NIGHTS IN OCTOBER 1992 AND SOUTH CHINA SEA (B), APRIL 20 AND 21, 1993.

PENYEBARAN PURSE SEINE SELAMA OPERASI PENANGKAPAN PADA DUA DAERAH PENANGKAPAN.

2.2 Evolution of the traditional tactic

It only occurs in the medium and large seiners fisheries.

■ LIGHT FISHING

Since 1987, the use of auxiliary generators has widely replaced the paraffin pressure lamps formerly used in the large seiners 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. 9). Fish search is still done late afternoon. When the fishing master estimates an area good, he stops the boat. The lights 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.

■ 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. 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 areas 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 informations collected during enquiries on the field. The survey of these distributions consisted of the following method. The trips made on **Bawal Putih I** followed a transect line Semarang-Matasiri. This line goes through the fishing area of medium and large seiners in the Java Sea. 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 **Bawal Putih I** and these clusters is less than 15 nautical miles, the position of each fishing vessels is noted with the help of the radar.

In October and November 1992, large clusters of purse-seiners were observed South of the Matasiri Island and in April 1993 South the Midai Island (South China Sea). In October 1992 and April 1993 their movements were observed during several days. Such clusters consisted of 36 vessels in October and 79 vessels in April. They make up patches of 20 to 30 nautical miles in surface (fig. 10A and 10B). 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 seiners is 1.4 nautical miles and the maximal 4 nautical miles. Sometimes seiners are less than half a nautical mile apart (fig. 11A and 11B).

From such observations, we can assess that the fishing vessels are not randomly distributed in a fishing area. Using this strategy, even if their fishing zone is not located over areas where the fish abundance is the highest they can exploit a fishing ground to its maximum level.

The average surface of attraction of the fishing vessels is not yet known and we don't know if such a strategy leads to a competition among the fishing vessels for the aggregation of the fish.

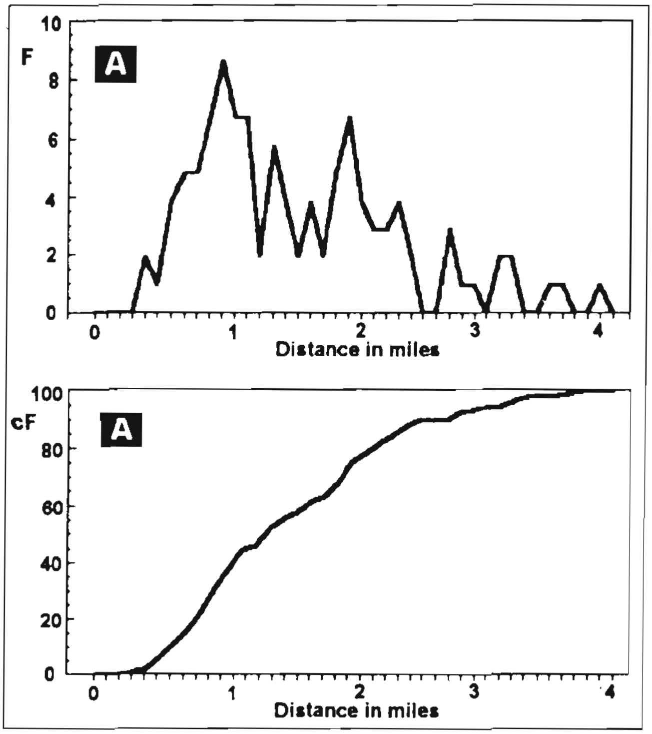
CONCLUSION

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

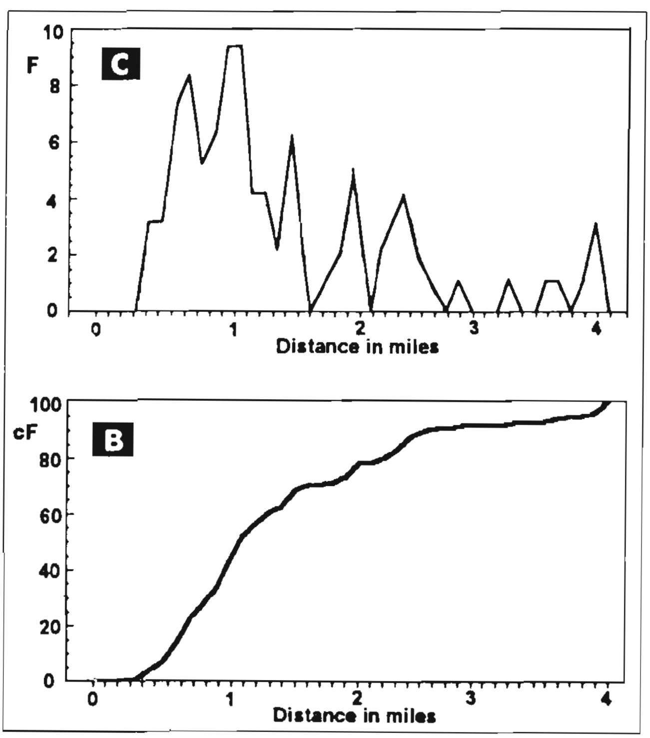
- First, the seiners are not able to fish at "sight" shoals seen at the surface because of their low speed.
- Second, shoals are small and not numerous. Fish is often scattered.

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 lights could be linked to a change in the fish accessibility since 1990-1991. Changes in strategy and tactic happen when the fisheries have to face difficulties as stagnation or decrease of the catch (fig. 12).

The mini seiners still use the traditional methods of the Javanese fishermen and don't show any innovative tendencies.



Matasiri (night) :
October 1992, 107 vessels



South China Sea (night) :
April 1993, 96 vessels

Figure 11

FREQUENCY (F) AND CUMULATED FREQUENCIES(cF) OF THE DISTANCE BETWEEN THE FISHING VESSELS DURING THE FISHING OPERATIONS

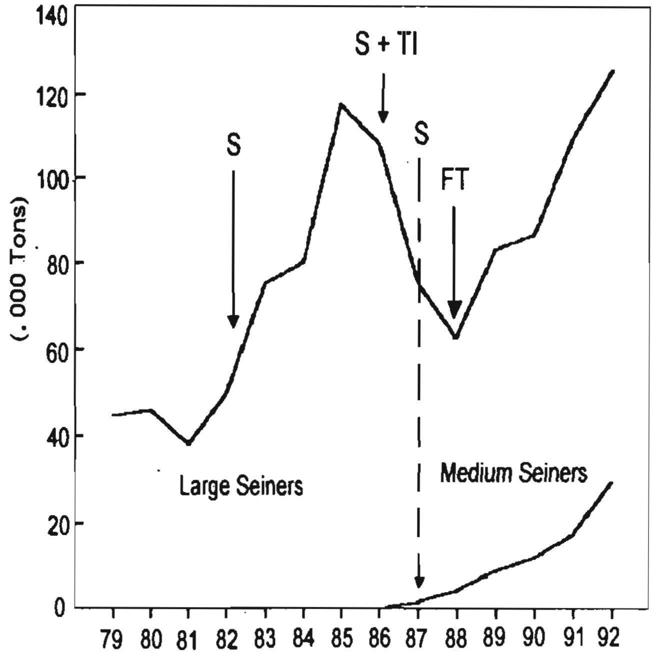
FREKUENSI (F) DAN FREKUENSI KOMULATIF (cF) DARI JARAK ANTAR KAPAL WAKTU OPERASI PENANGKAPAN

Figure 12

STRATEGIC AND TECHNOLOGICAL INNOVATIONS DURING THE SEINERS HISTORY

INOVASI STRATEGI DAN TEKNOLOGI PURSE SEINE DARI TAHUN 1979 SAMPAI DENGAN 1992

S: Strategy changes
TI: Technological Innovation
FT: Fishing technics improvement



These different behaviors seem related to geographical and economical reasons. In Central Java there are rivers where seiners can easily enter and land their catch. Before the trawl ban, these landing centers were used by trawlers owned by ethnic Chinese of the Sumatra Island. When the trawl ban became effective they heavily invested in the seiners fishery. Coming from ethnic groups fishing for many centuries, they are open to technological innovations and can adopt them very quickly. In East Java, the owners are small operators which are unable to highly invest. It is difficult for them to adopt the new technics.

In the actual state of the technology the seiners fisheries in the Java Sea exploit all the space available. As the knowledge of Javanese fishermen about environment and fish behavior is quite good, the fishing strategies and tactics are efficient. The fishing pressure is high on the prospected fishing grounds. A new evolution will be only possible with changes at high cost not only leading changes in fishing strategy but also in economic and commercial ones.

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NORTH JAVA COAST FISHERIES : PRELIMINARY OBSERVATIONS ON SMALL SEINE NETS EXPLOITATION.

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MARIA M. WAHYONO,
SUWARSO,
D. KRISSUNARI.

ABSTRACT

The small seines such as **payang**, **lampara** and the small purse seine fisheries have an important role in exploiting the small pelagic fishes in the North coast of Java. In order to have a basic knowledge of this fisheries several aspects such as the catch, the effort and the CPUE as well as the catch composition and the size composition have been studied.

The results show that the catch composition of the small seiners from Eretan Wetan and Rembang is different from the catch of the large purse seiners from the same origin, while in Brondong it is almost similar. It is supposed to be due to the fishing grounds prospected. The catch, the effort and CPUE of the small seiners tend to increase from 1990 to 1992. Most of their catch consists of immature fish.

Perikanan payang, lampara dan purse mini mempunyai peranan penting dalam pengusahaan ikan pelagis kecil di Laut Jawa. Untuk mendapatkan pengetahuan dasar dari perikanan *tersebut beberapa aspek seperti hasil tangkapan, hasil tangkapan per unit upaya seperti juga komposisi hasil tangkapan dan komposisi ukuran hasil tangkapan telah dipelajari.*

Hasil pengamatan menunjukan bahwa komposisi hasil tangkapan yang didaratkan di Eretan Wetan dan Rembang adalah berbeda dengan komposisi hasil tangkapan purse seine besar, sedangkan komposisi yang didaratkan di Brondong tidak menunjukan perbedaan. Hasil tangkapan dan hasil tangkapan per unit upaya cenderung meningkat dari tahun 1990 sampai tahun 1992. Sebagian besar dari hasil tangkapan purse mini merupakan ikan-ikan yang belum matang telur.

INTRODUCTION

Coastal small pelagic fishes of the Java Sea are mainly exploited by seine nets such as small purse seine, Danish seine (**payang**), and encircling net (**lampara**). These fisheries are important and contribute to more than 50% of the total production of small pelagic, in the whole Java Sea. During this period the average catch was 79 800 tons.

The small purse seines were introduced by fishermen from the province of East Java and then extended to the provinces of Central and West Java. The fishing grounds are located in shallow waters (20 - 50 m) along the northern coast of the Java Island (fig. 1) up to Biawak, Karimunjava, Bawean, Masalembo, and Kangean (fig. 2a, p. 17). The Danish seine is the traditional net of the Javanese fishermen and is used along the northern coast of Java since 1950. The "lampara" or encircling net is a modification of the Danish seine and it operates in the same areas as this last one.

The small purse seiners operating along the north coast of Java are typically 12 - 17 m total length with a gross tonnage of 14 GT and powered with one or two outboard engines. The length of the seine net is usually 300 m. Vessels which carry Danish seine and encircling net are smaller, 4 to 11 m long with 10 GT and are powered by outboard or inboard engine.

In 1991, 1555 small purse seines were counted on the North coast of the Java Island, while both Danish seines and encircling nets consisted of 5748 units. Most fishermen are from Madura Island, East Java (Lamongan, Tuban) and Central Java (Rembang, Batang, and Pemalang). They land in the province of East Java at Pasongsongan (regency of Sumenep, Madura), Brondong, Kranji, Labuhan, Weru (Lamongan) and Bulu (Tuban) but also in Central Java at Tasik Agung and Sarang (Rembang), Tayu (Pati), Bulu (Jepara), Klidang Lor (Batang) and Pemalang, as well as in the province of West Java at Dadap and Eretan Wetan (Indramayu), Blanakan (Subang), Muara Angke (Jakarta) up to Labuan on the coast of the Sunda Strait (Widodo and Mahisworo, 1991). This paper tries to give a basic knowledge of small seine nets fisheries in the coastal waters of the Java Sea.

1. MATERIAL AND METHODS

Data used in this study consists of total catches per fish commercial category, number of trips, number of days at sea, and fishing grounds exploited by these nets. They were collected at three landing places : Eretan Wetan (Indramayu, West Java), Tasik Agung (Rembang, Central Java), and Brondong (Lamongan, East Java) as shown in figure 1.

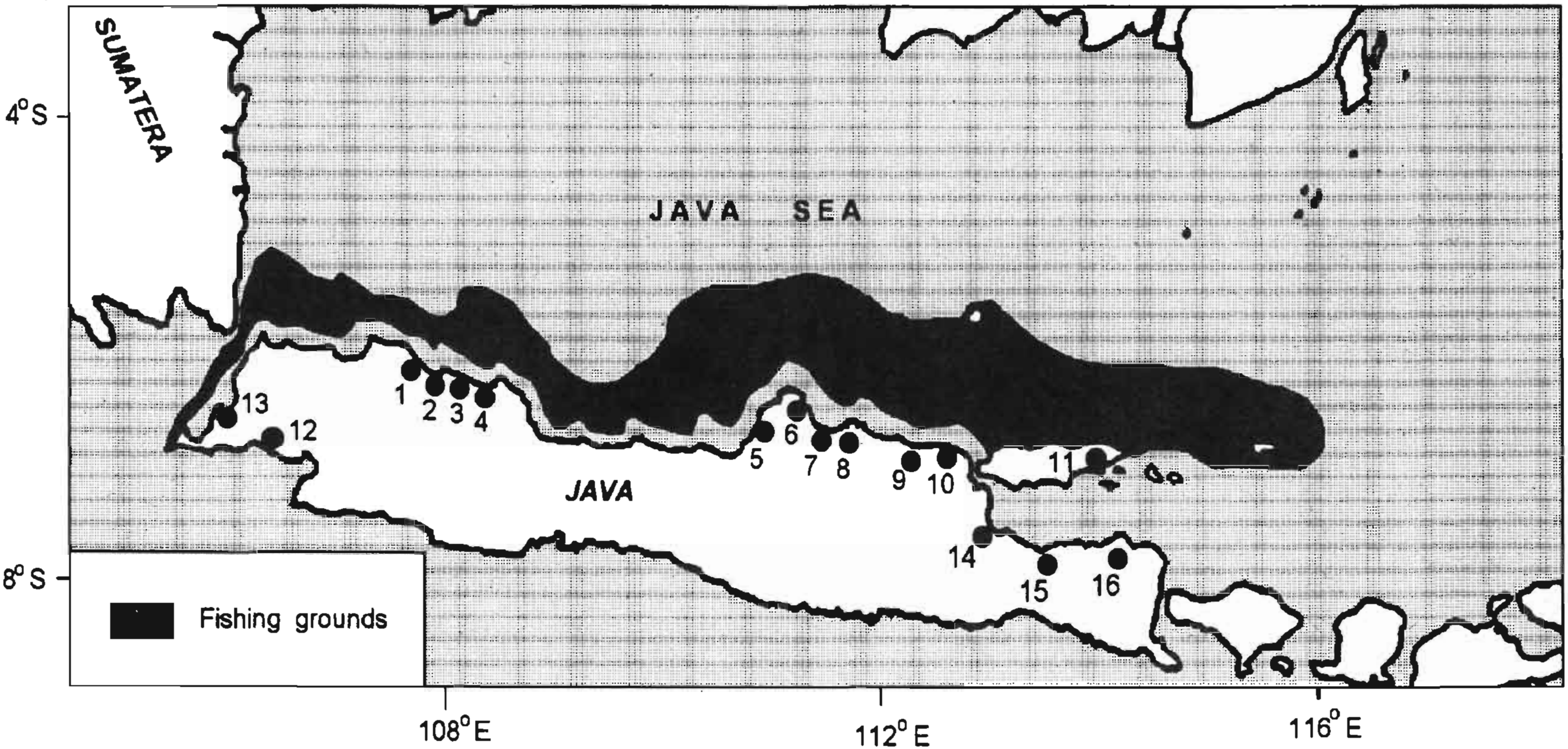


Figure 1

FISHING GROUNDS AND LANDING PLACES OF SMALL PELAGIC FISHERIES ON THE NORTH COAST OF JAVA

DAERAH PENANGKAPAN DAN TEMPAT PENDARATAN PERIKANAN PELAGIS KECIL DI PANTAI UTARA JAWA

1 : Cilamaya, 2 : Blanakan, 3 : Eretan Wetan, 4 : Dadap, 5 : Jepara, 6 : Tayu, 7 : Juana, 8 : Rembang, 9 : Brondong, 10 : Kranji, 11 : Sumenep, 12 : Binuangeun, 13: Labuan

Catch data was collected from daily landing books (**buku bakul**). Usually the Danish seines and the encircling nets catches are mixed in the statistics. The fishing grounds of the vessels were obtained from enquiries to the fishermen. Only the number of trips is available at the landing places. Nevertheless the effort of the three fishing gear devices is expressed as an estimate of the number of days at sea which is derived from the number of trips, multiplied by the average of days at sea per trip known from a sample of boats. The CPUE is expressed in kgs/days at sea. Some length frequencies measurements (**FL**: Fork Length) were made during some months in these landing places. They give a first figure of the catch demographic structure of these nets.

2. CATCH AND EFFORT

2.1 Total catch

The annual catch landed in the three landing places is presented in table I. The catch of the mini-seines tends to increase while the catch of Danish seines and encircling nets stays stable or decreases slightly. This can be explained by the tendency of the small scale fishermen along the North coast of Java to replace the Danish seines which are their traditional fishing device by small seines as this device is believed to have a better efficiency. In Brondong the catch recorded in table I is not a real figure as a large part of the mini-seines and Danish seines catch is not recorded in these categories. It is due to the fact that most of the catch is bought at sea by traders called "gendong" which sale it later at different landing places. Usually the trader uses his own vessel and collects the catch of several fishing boats. During his trip it supplies the fishing vessels with food and fuel to allow them to stay longer on the fishing ground.

Table I

CATCH (IN TONS) LANDED BY SMALL SEINES NETS IN THREE LANDING PLACES ON THE NORTH COAST OF JAVA.

HASIL TANGKAPAN (TON) YANG DIDARATKAN OLEH PURSE SEINE KECIL, PAYANG DAN LAMPARA PADA TIGA DAERAH PENDARATAN DI PANTAI UTARA JAW

	Gear	1987	1988	1989	1990	1991	1992
Eretan	Mini Purse Seine				118	494	1 168
Wetan	Danish Seine and encircling nets				756	400	101
Rembang	Mini Purse Seine	2 075	5 045	2 933	4 132	4 116	
Brondong	Mini Purse Seine					7 545	4 013
	Danish Seine					9 332	9 037

The seiners and Danish seines which usually stay at sea two to three days, can extend their trips up to one week. In 1992, a survey made at Brondong estimates that more than 50% of the vessels which landed fish there were "**gendong**" vessels.

1.2 Catch composition

The sardines (*Sardinella spp.*) are the main species caught by the small seines in Eretan and Rembang (fig. 2 and 4). The catch composition of the Danish seines is more varied and the category "diverse or others" dominates the catch (fig. 3). In Brondong (fig. 5), the scads (*Decapterus spp.*) dominate the catch of the two fishing gears. That difference in composition is due to the various locations of the fishing grounds and the different fishing tactics. In Eretan and Rembang, the fishing grounds are close to the coast (10 to 30 nautical miles) and located in the western and central part of the Java Sea. In Brondong, the fishing grounds are more offshore (30 to 50 nautical miles from the coast) and located in the central and eastern part of the Java Sea. As in the Java Sea pelagic distribution is based mostly on its tolerance to the salinity, the catch composition varies according to the location of the fishing grounds.

Figure 2

CATCH COMPOSITION OF SMALL PELAGIC SPECIES LANDED BY MINI PURSE SEINES IN ERETAN IN 1992
KOMPOSISI HASIL TANGKAPAN IKAN PELAGIS KECIL YANG DI DARATKAN OLEH PURSE SEINE MINI DI ERETAN, TAHUN 1992

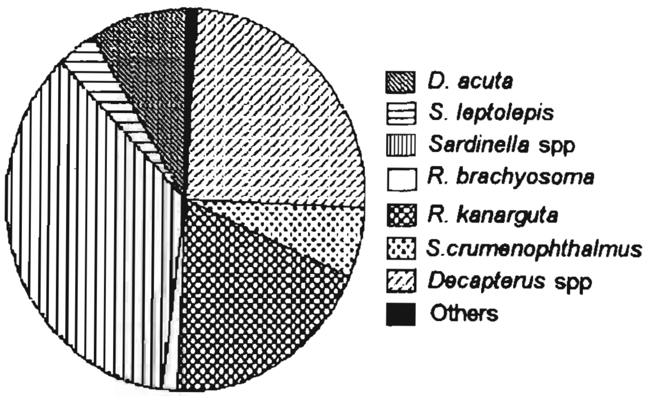
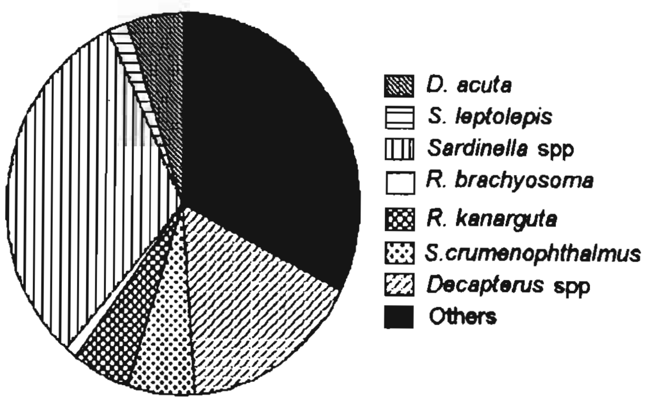


Figure 3

CATCH COMPOSITION OF SMALL PELAGIC SPECIES LANDED BY DANISH SEINES IN ERETAN IN 1992
KOMPOSISI HASIL TANGKAPAN IKAN PELAGIS KECIL YANG DIDARATKAN OLEH PAYANG, LAMPARA DI ERETAN, TAHUN 1992



When the fleet uses **"rumpon"** (Fish Aggregating Device) as in Brondong where the small and Danish seines use this fishing tactic along the year, the catch is dominated by the scads and the catch composition is comparable to the large and medium seiners. This is not the case in Eretan and Rembang where this tactic is used only during the **"musim ikan"** (fish season) from August to January. The rest of the year, mainly between April and July, lamps are used alone and sardines (*Sardinella gibbosa*), mackerel (*R. brachysoma*) as well as rainbow sardines (*Dussumieria acuta*) form the bulk of the catch. Among the scads *D. russelli* are captured in great quantity in Eretan and Rembang, while *D. macrosoma* is rarely found there.

1.3 Effort

The total effort of the fleet shows great annual variations due to the fact that small purse seines and Danish seines migrate along the northern coast of Java. The number of vessels which land in every harbor can vary a lot from year to year.

In Eretan the peak of activity occurs from September to February (fig. 6). From 1991 to 1992, 3 was the average number of days at sea per trip for Danish and encircling net seines.

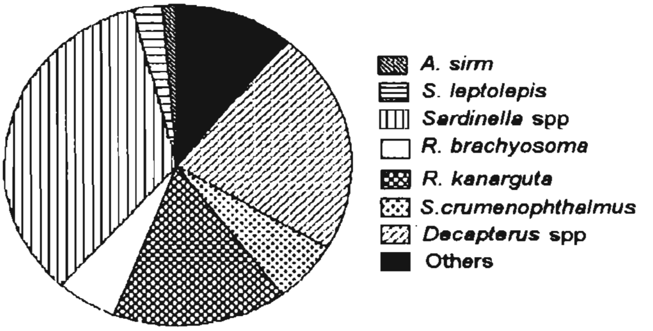


Figure 4

Catch composition of small pelagic species landed by mini purse seines in Rembang in 1989

Komposisi hasil tangkapan ikan pelagis kecil yang didaratkan oleh purse seine mini di Rembang, tahun 1989

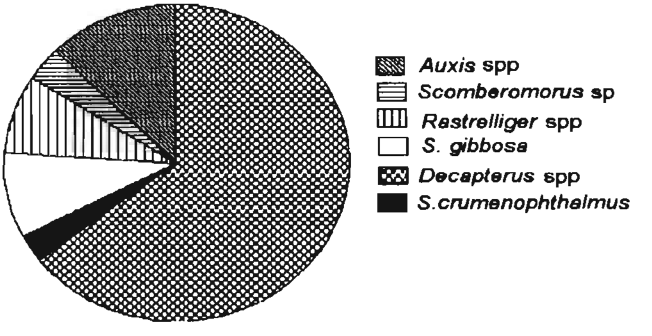


Figure 5

Catch composition of small pelagic species landed in Brondong in 1992

Komposisi hasil tangkapan ikan pelagis kecil yang didaratkan di Brondong, tahun 1992

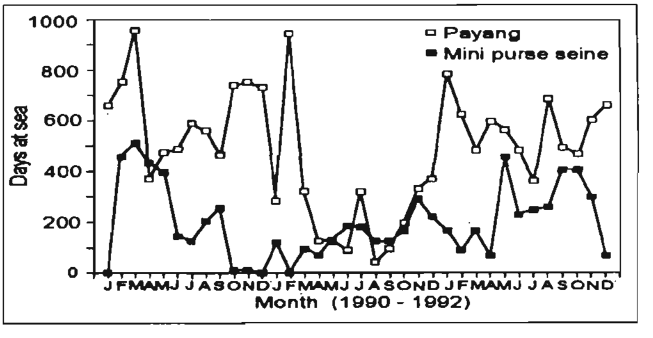


Figure 6

Days at sea of Payang and Mini Purse Seines landing at Eretan, Indramayu

Lama hari dilaut dari payang dan purse seine mini yang mendarat di Eretan, Indramayu

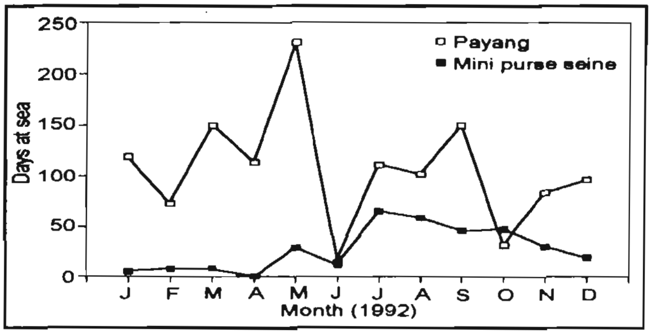


Figure 7

DAYS AT SEA OF PAYANG AND MINI PURSE SEINES LANDING AT BRONDONG, EAST JAVA

LAMA HARI DILAUT DARI PAYANG DAN PURSE SEINE MINI YANG MENDARAT DI BRONDONG, JAWA TIMUR

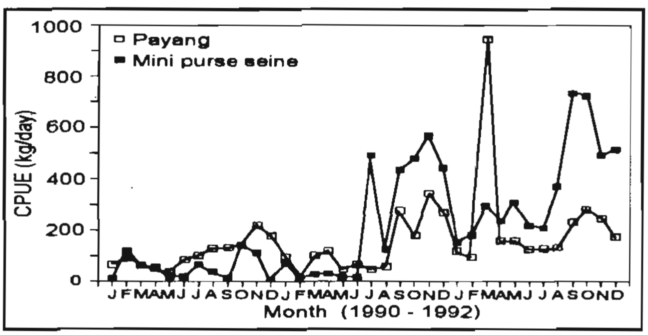


Figure 8

CPUE OF PAYANG AND MINI PURSE SEINE, LANDING AT ERETAN WETAN, INDRAMAYU

HASIL TANGKAPAN PERUNIT UPAYA DARI PAYANG DAN PURSE SEINE MINI YANG DIDARATKAN DI ERETAN WETAN, INDRAMAYU

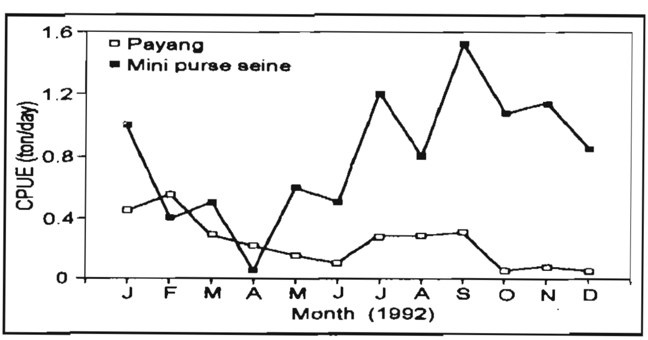


Figure 9

CPUE (TONS/DAY) OF PAYANG AND MINI PURSE SEINE LANDING AT BRONDONG, EAST JAVA

HASIL TANGKAPAN PER UNIT UPAYA DARI PAYANG DAN PURSE SEINE MINI YANG DIDARATKAN DI BRONDONG, JAWA TIMUR

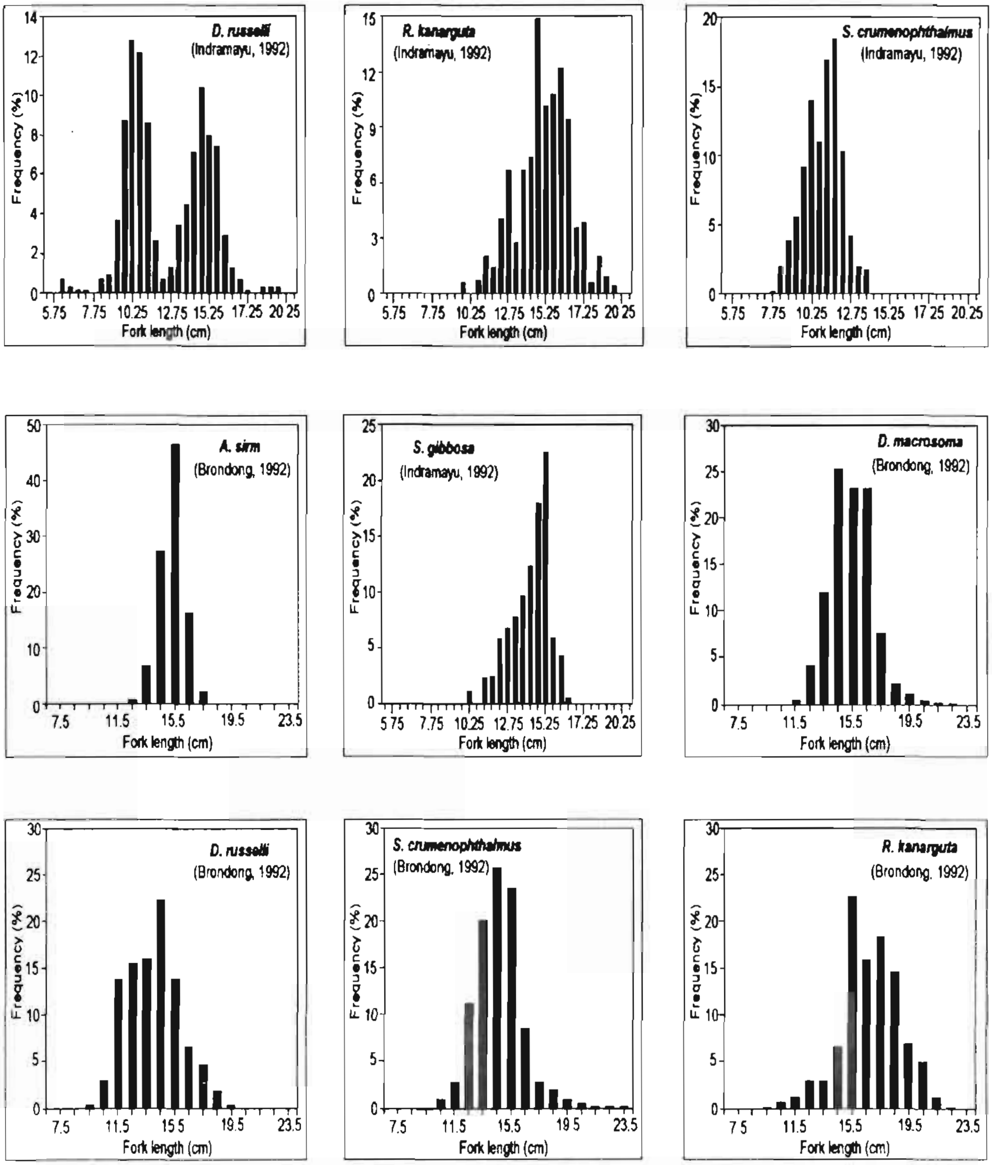
The mini-seines trips lasted longer, from 5 days in 90 - 91 to 10 days in 92. But this value has to be corrected since medium seiners from Pekalongan started to land in Eretan, this port being closer to the Biawak Island fishing ground. These vessels stay from 10 to 15 days at sea and are registered in the mini-seiners category. It explains the sharp increase in days at sea noticed in 1991 and 1992.

In Rembang the peak of activity is the same as in Eretan and the trips of mini-seiners last one day or more exactly one night fishing. The vessels leave the landing place between 3 and 4 pm. and come back between 4 and 5 am. to sale their catch.

In Brondong the peak of activity is registered in May - July for mini-seines and in May and September for Danish seines (fig. 7). But, it is difficult to obtain an accurate view of the effort exerted by these fleets as most of the fishing vessels do not return always to their landing place.

1.4 Catch per unit effort

The CPUE of these fleets tended to increase from 90 to 92 showing a great seasonality (fig. 8 and 9). During the first part of the year from January to June the CPUE is usually low, as in the second part it reaches high value.



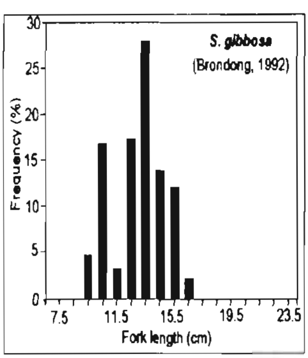
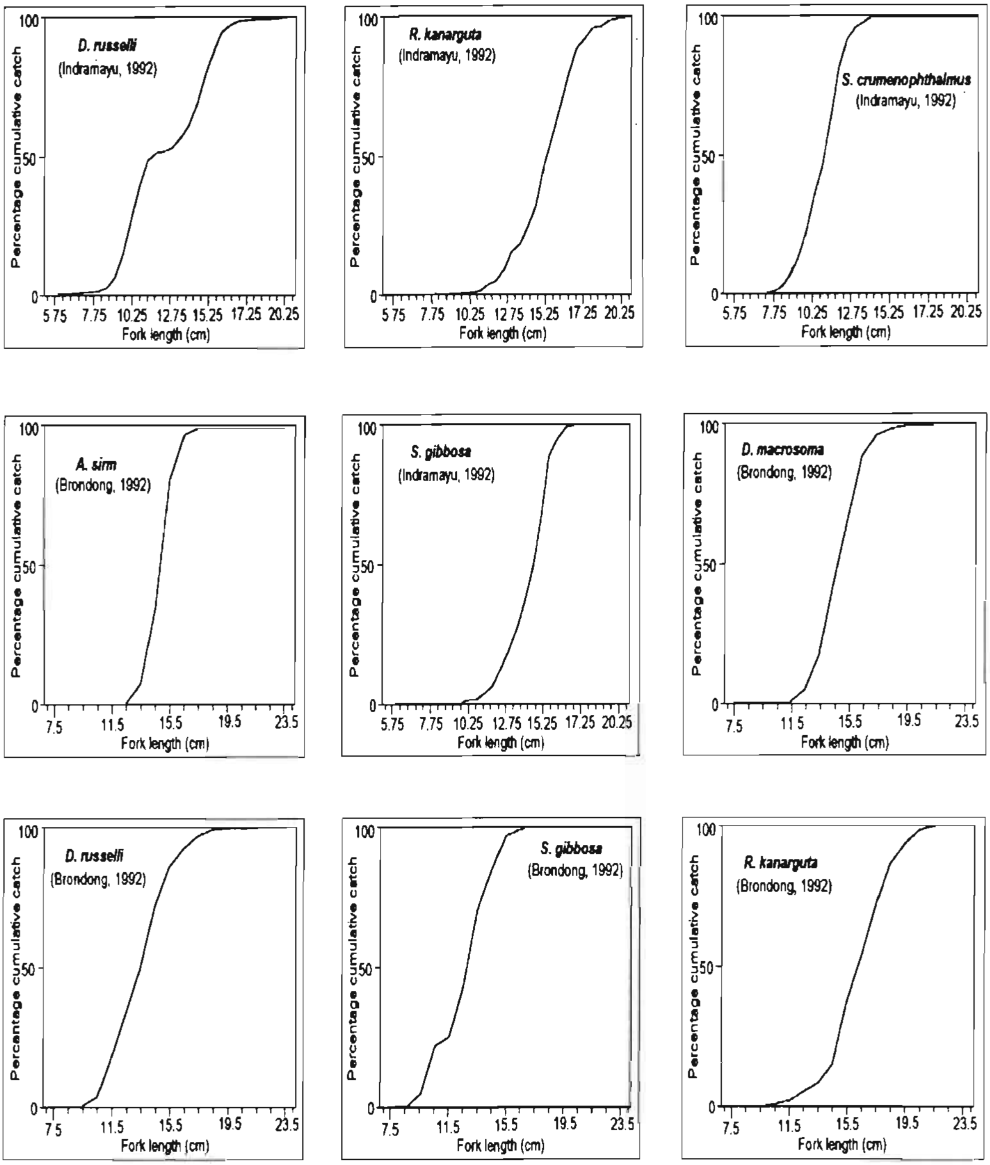


Figure 10

LENGTH FREQUENCIES DISTRIBUTION OF SEVERAL SPECIES LANDED IN DIFFERENT PLACES

DISTRIBUSI FREKUENSI PANJANG DARI BEBERAPA SPECIES YANG DI DARATKAN PADA PELABUHAN YANG BERBEDA



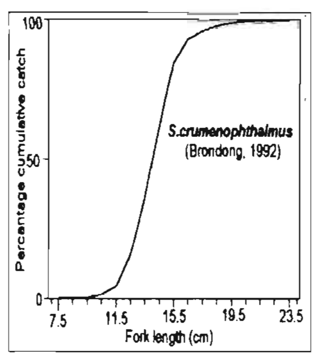


Figure 11

LENGTH CUMULATIVE FREQUENCIES OF SOME SPECIES CAUGHT BY THE MINI PURSE SEINES IN THE JAVA SEA

FREKUENSI PANJANG KUMULATIF BEBERAPA SPECIES YANG TERTANGTAP OLEH, PURSE SEINE MINI DI LAUT JAWA

In Eretan Wetan CPUE values reached 700 kgs/day for small seines in September 92 and 250 kgs/day for Danish seine during the same period. In Brondong the In Eretan Wetan CPUE values reached 700 kgs/day for small seines in September 92 and 250 kgs/day for Danish seine during the same period in Brondong the CPUE of small seines is higher, reaching 1.5 tons/day in September 92.

In the same way the annual effort shows a great seasonality which is a characteristic of all fisheries in the Java Sea.

CONCLUSION

Due to the few length frequencies measuring, they were grouped by year. As shown in figure 10, there are no significant differences between the landing places, the average length varying between 10 to 14 cm, except for *R. kanagurta* whose average length ranges between 14 and 18 cm. Comparing with values found for the large purse seine fleet, the average length of the fish caught by the small purse seine and Danish seine fleets is smaller.

As the fishing grounds of these fleets are close to the coast in waters with high salinity fluctuations they tend to fish on young individuals which are often more euryhaline than the older individuals. In term of exploitation and management it is important to note such a fact as the catch of these fleets consists of immature fish only (fig. 11).

2. SIZE COMPOSITION

The three landing places selected for this study can be considered as representative of the small seine nets fisheries on the North coast of Java. The catch composition of the landings at Eretan Wetan and Rembang is different from the large purse seine catch, while in Brondong it is almost similar. The catch, the effort and the CPUE tend to increase. Most of their catch consist of immature fish. As they play an important role for the coastal communities and are a receptacle of manpower, this fisheries ought to be studied more in depth.

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EXPLOITATION OF THE LARGE AND MEDIUM SEINERS FISHERIES

M. POTIER, B. SADHOTOMO

REPAIRING THE NET

MENJURAI DAN MEMPERBAIKI JARING

ABSTRACT

Since the trawl ban in 1980 pelagic species are the main resources exploited in the Java Sea by numerous fisheries. Among those the purse-seine fisheries are the main ones. The large and medium seiners located in the province of Central Java are heavily involved in this exploitation. The fleets consisting of wooden vessels prospect the Java Sea, the Makassar Strait and the southern part of the South China Sea.

Pekalongan and Juwana are the main centers where 70% of the vessels gather and 90% of the catch is landed. If the activity in Pekalongan is

high since 1976 it is new in Juwana and related to the displacement of the main fishing grounds to the eastern part of the Java Sea.

Since 1979, the landing of the seiners has increased four times reaching 155 000 tons in 1992. Among the thirty species caught by the seiners seven species form 90% of the landings. Two species of scads are the main targets of the exploitation and represent up to 60% of the catch. Mackerels, sardines and big eyes scads are the other species caught in great number by the seiners. Their importance in the landings varies according to the years. These species are part of different populations with different ecological needs. According to the environment and the geographic location of the catch, they are more or less exploited by the seiners. The fishing pressure is high on the coastal and neritic populations and lower on the oceanic populations. Modelization of these resources is difficult as some parameters are still lacking.

Sejak larangan trawl pada tahun 1980, ikan-ikan pelagis adalah sumber daya utama yang diusahakan di Laut Jawa, dimana sumber daya tersebut diusahakan oleh bermacam-macam alat tangkap. Diantara alat tangkap yang ada, purse seine merupakan alat tangkap utama. Purse seine besar dan sedang yang berada di Propinsi Jawa Tengah mempunyai peranan yang paling penting di dalam pengusahaan sumber daya tersebut. Armada purse seine terdiri dari kapal kayu yang beroperasi di seluruh Laut Jawa, Selat Makassar dan bagian Selatan Laut Cina Selatan. Pekalongan dan Juwana merupakan pusat dari penangkapan purse seine, 90% dari hasil tangkapan didaratkan disana dan 70% dari kapal-kapal purse seine berasal dari Pekalongan dan Juwana. Kegiatan di Pekalongan sangat tinggi sejak tahun 1976, sedangkan di Juwana berkembang belum lama setelah daerah penangkapan bergeser lebih ke Timur Laut Jawa.

Sejak tahun 1979 ikan yang didaratkan oleh purse seine mencapai 155.000 ton pada tahun 1992. Diantara tiga puluh species yang tertangkap, 7 species diantaranya merupakan 90% dari hasil tangkapan yang didaratkan. Dua species ikan layang merupakan tujuan penangkapan dan mencapai 60% dari hasil tangkapan. Banyar, Siro dan Bentong merupakan species lain yang tertangkap cukup banyak oleh purse seine. Berdasarkan tahun, jumlah masing-masing species yang tertangkap sangat bervariasi.

Species-species tersebut merupakan bagian dari populasi yang berbeda yang mempunyai kebutuhan ekologi yang berbeda. Berdasarkan keadaan lingkungan dan lokasi geografi dari pada hasil tangkapan, mereka lebih banyak tertangkap oleh purse seine. Tekanan penangkapan lebih besar di daerah pantai dan populasi neuritik dari pada populasi yang bersifat oseanik. Modelisasi dari sumber daya tersebut adalah tidak mudah, sepanjang beberapa parameter belum diketahui.

INTRODUCTION

Since the trawl ban in 1980, pelagic species are the main resources exploited in the Java Sea. Their exploitation by artisan fisheries is very old and has an important socio-economic impact on the islands bordering that sea. First limited to onshore 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 fluctuations of the catch occurring there. The exploitation of the resource by the large purse seiners is now twenty years old and during this period many changes occurred.

The fishery is not a static but a dynamic system which quickly reacts to internal and external changes. In 1987 smaller seiners coming from the Pekalongan harbor entered the fishery The geographic distribution of pelagic 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 into account.

1. MATERIAL AND METHODS

Accurate data has been available since 1979. Before that year a lack of accuracy in the national system or the implementation lag of the sampling scheme proposed by FAO in 1976 did not allow to have reliable data. Since 1985 with the beginning of the cooperation between ORSTOM (French Institute for Research and Development in Cooperation) and BPPL (Indonesian Research Institute for Marine Fisheries) a sampling scheme for the collect of data coming from the 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 Java Sea Pelagic Fishery Assessment Project started in May 1991 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. Such data has been available since mid-1984.

Table I

DEFINITIONS OF THE DIFFERENT CATEGORIES REFERRING TO DIVERSE SOURCES

PENJELASAN DARI BEBERAPA KATAGORI YANG BERBEDA BERDASARKAN BEBERAPA SUMBER

STATISTICAL	LANDING PLACES	SIZE CATEGORIES	SPECIES
Layang	**Layang**	**Unyir** = very small **Bloco** = small **Layang** = standard **Korok** = big	*Decapterus russelli macrosoma*
Lemuru	**Siro**		*Amblygaster sirm*
Kembung	**Kembung**	**Kemari** = small **Kembung** = standard	*Rastrelliger brachysoma*
	Banyar	**Kemari** = small **Banyar** = standard	*Rastrelliger kanagurta*
Tembang	**Tanjan -Juwi**		*Sardinella gibbosa lemuru fimbriata*
Selar	**Bentong**	**Mandring** = small **Bentong** = standard	*Selar crumenophthalmus*
	Selar	**Selar** = standard **Como** = big	*Selaroides leptolepis* *Atule mata* *Alepes djeddaba*
Lain-lain	**Campuran**		Mixed species

2. EXPLOITED SPECIES

The Javanese seiners catch around thirty pelagic and semi-pelagic species. Eleven of these species form 90% of the landings. 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 (tab. I).

3. 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 357 units in activity in 1992 (fig. 1), is still far from the 1985 figure. This fleet represents 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. In 1992, with new investors, the fleet quickly expanded and reached 232 units (fig. 1).

These two well distinct fleets with different vessels and fishing strategies tend to overlap each other. Since 1979, size, horse power (fig. 2) and fish hold capacity have increased. This evolution linked with a better fishing efficiency (fig. 3) allowed the exploitation located in the traditional Javanese fishing grounds to extend to the eastern part of the Java Sea, to the Makassar Strait and to the South China Sea. In 1992, we can assess three segments (fig. 3) exploiting different fishing grounds in the fishery :

Table II

SEINERS LANDINGS IN THE DIFFERENT LANDING PLACES OF THE FISHERY FROM 1979 TO 1992

PENDARATAN PURSE SEINE PADA TEMPAT PENDARATAN IKAN YANG BERBEDA DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992

YEAR	TEGAL	PEKALONGAN	BATANG	JUWANA	REMBANG
1979	8 100	21 200	12 100		3 200
1980	9 100	24 300	8 400		4 400
1981	8 600	21 700	4 900		3 200
1982	12 500	28 300	4 400		4 700
1983	16 100	45 100	4 700		9 100
1984	11 500	49 800	5 500	6 400	7 100
1985	13 500	67 600	11 900	15 700	8 600
1986	11 700	63 300	8 800	20 600	3 800
1987	10 100	45 100	2 400	18 500	1 200
1988	9 200	41 400	1 400	13 300	
1989	12 600	56 800	600	22 200	
1990	13 000	57 500	1 000	27 000	
1991	13 700	74 300	600	33 400	1 700
1992	16 000	86 000	400	47 300	5 100

Figure 1 (top)

Evolution of the number of large and medium seiners units between 1979 and 1992

Evolusi nomor purse seine besar dan sedang dari tahun 1979 sampai dengan tahun 1992

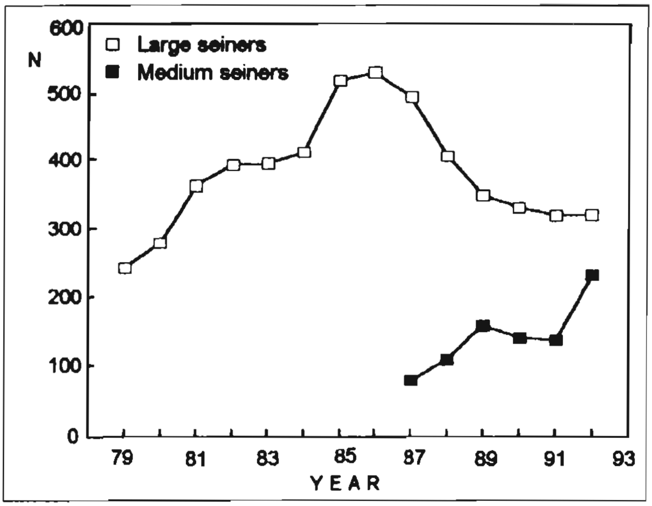


Figure 2 (middle)

Evolution of the large and medium average engine power (EP, Horse Power) between 1979 and 1992

'Evolusi purse seine besar dan sedang, rata-rata "HP" dari tahun 1974 sampai dengan tahun 1992

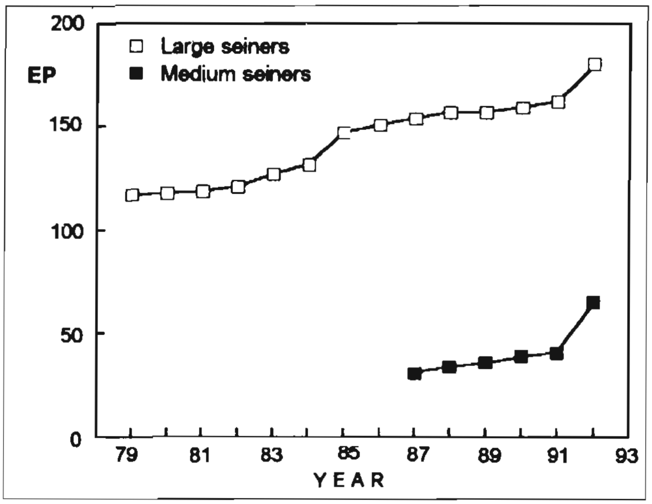
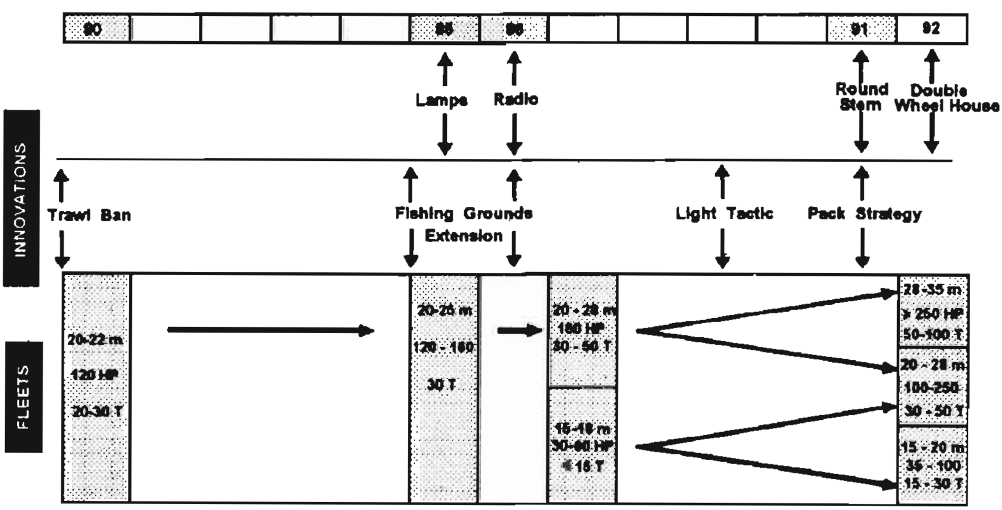


Figure 3 (bottom)

Technical innovations and fleet evolution which occurred in the seiners fisheries between 1980 and 1992

Evolusi inovasi teknik dan armada purse seine dari tahun 1980 sampai dengan tahun 1992



■ The first one which exploits the traditional fishing grounds of the Javanese fishermen consists of the old medium seiners (15-18 meters).

■ The second one whose fishing grounds extend from the Karimunjava Islands (fig. 4) to Matasiri is made of old large seiners built before 85 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 consists of the newest large seiners built since 1985.

4. LANDING PLACES

At the beginning of the seiners exploitation the fishing vessels landed in five harbors of the province of Central Java : Tegal, Pemalang, Pekalongan, Batang and Rembang. Quickly Pemalang was abandoned and the landings concentrated in the three areas of Tegal, Pekalongan-Batang and Rembang-Juwana. Since 1979 Pekalongan is the main landing place (tab. II, fig. 5). Most part of the fleet is registered there.

As the fishing grounds moved eastward their distance from Tegal increased which led landings to decrease there. Batang and Rembang are secondary landing places dependent on the Pekalongan and Juwana activity. The activity of Batang is hampered by a fast silting up which prevents the large seiners to enter the river. At Rembang the auction is made along the beach and the seiners cannot land directly.

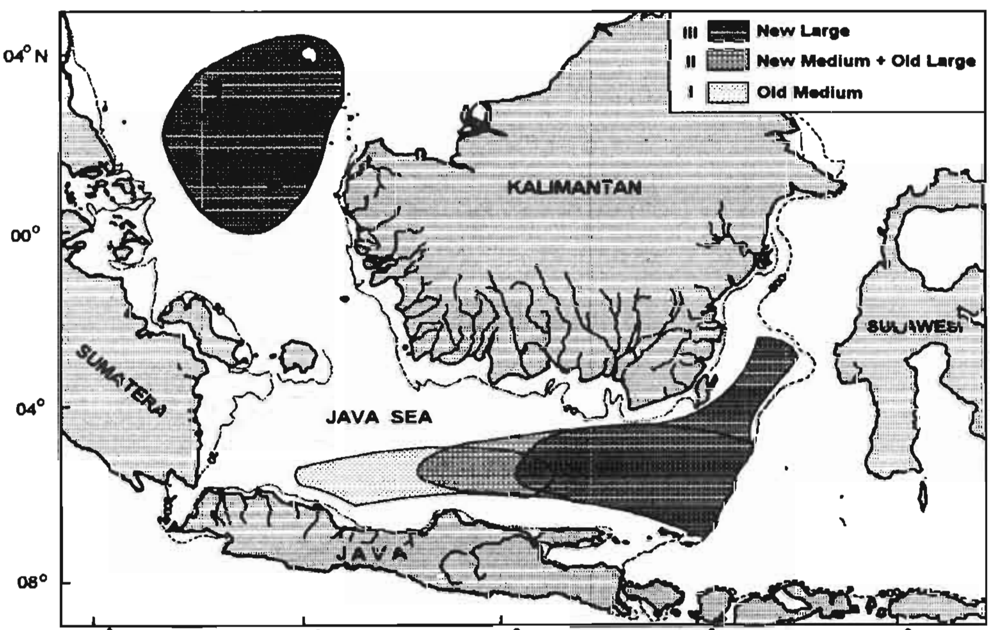


Figure 4

Fishing areas of the different seiners fleets in 1992

Daerah penangkapan dari armada purse seine yang berbeda pada tahun 1992.

In 1992, 90% of the seiners catch was landed at Pekalongan and Juwana but the situation of the two harbors is rather different. The fishing vessels landing at Pekalongan are registered there, while the activity of Juwana mainly depends on vessels registered in other places (fig. 6). Opened in 1984 to the large seiners the landings made at Juwana, quickly grew. The harbor is well located, near the main fishing grounds.

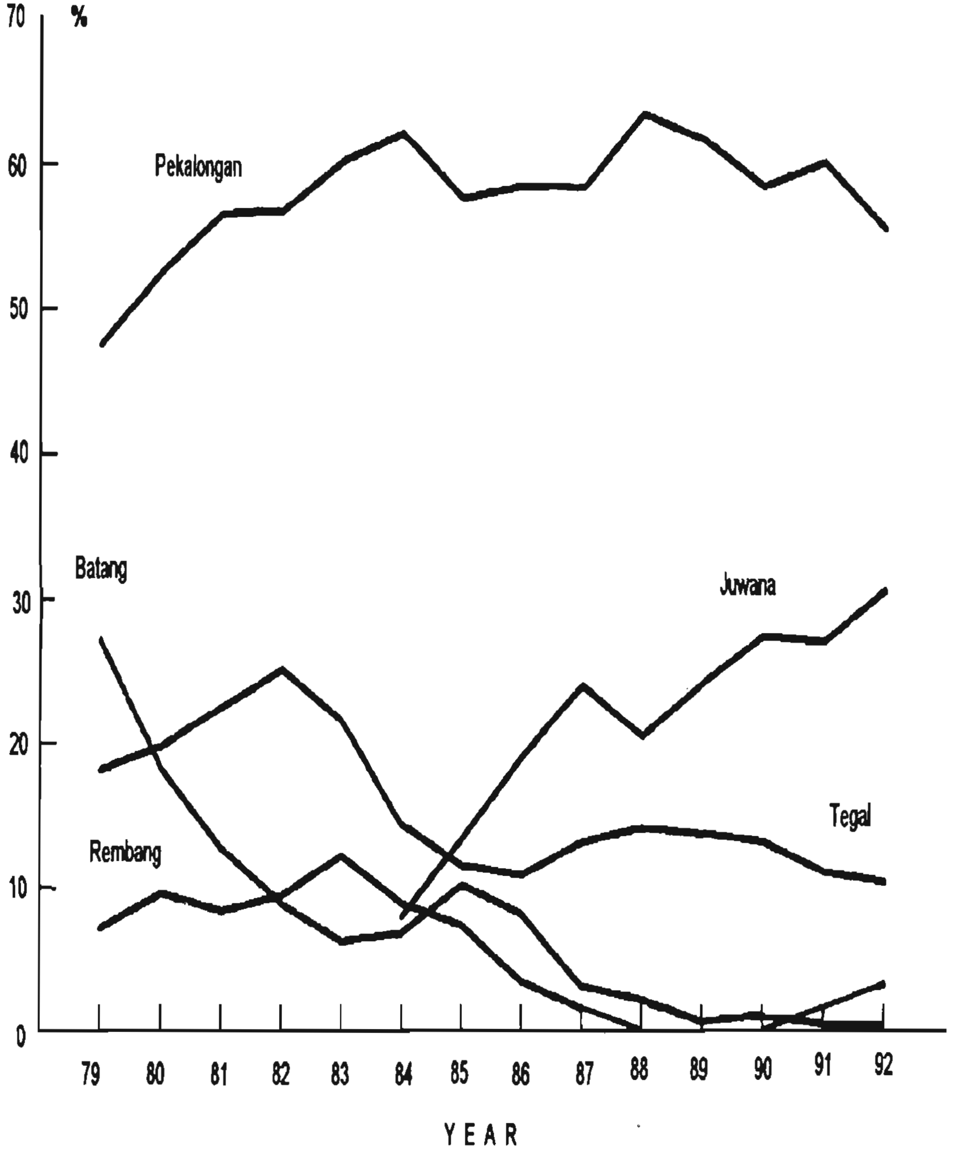


Figure 5

EVOLUTION IN PERCENTAGE OF THE LANDINGS IN THE LANDING PLACES OF THE SEINERS FLEET BETWEEN 1979 AND 1992

EVOLUSI PERSENTASE PENDARATAN PADA DAERAH PENDARATAN PURSE SEINE DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992

Table III

LANDINGS EVOLUTION OF THE MAIN COMMERCIAL CATEGORIES CAUGHT BY PURSE SEINERS FROM 1979 TO 1992
EVOLUSI HASIL TANGKAPAN YANG DIDARATKAN OLEH PURSE SEINE DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992

Layang : *Decapterus russelli*, *Decapterus macrosoma*
Tanjan : *Sardinella gibbosa*, *Sardinella lemuru*, *Sardinella fimbriata*
Banyar : *Rastrelliger kanagurta*
Lemuru : *Amblygaster sirm*
Bentong : *Selar crumenophthalmus*

YEAR	TOTAL	LAYANG	BANYAR	LEMURU	TANJAN	BENTONG	SELAR
1979	44 700	14 800	5 900	2 400	5 900	11 100	700
1980	46 100	10 300	4 900	7 700	8 000	10 000	700
1981	38 400	8 200	6 700	7 900	5 800	6 100	700
1982	50 000	15 400	7 300	8 300	6 900	8 100	1 800
1983	75 300	34 500	8 300	14 200	7 200	6 400	1 400
1984	80 400	49 800	10 800	7 000	3 900	5 400	600
1985	117 300	67 900	17 100	9 000	8 900	8 900	2 000
1986	108 100	50 100	23 000	7 800	7 300	11 500	700
1987	77 200	35 000	13 200	6 500	7 400	7 800	300
1988	66 800	25 200	10 900	9 400	7 000	7 800	900
1989	92 200	53 300	12 100	6 000	5 900	8 200	1 000
1990	98 600	58 200	11 300	7 900	6 600	7 900	1 000
1991	126 900	67 200	18 600	17 500	7 600	8 700	900
1992	155 000	70 300	26 800	22 800	9 300	17 200	900

5. CATCHES

Landings of large and medium seiners show great variations. But since 1979 the catch increases four times reaching 155 000 tons in 1992 (tab. III).

5.1 Composition of the commercial categories

Ninety to ninety-five per cent of the catches consist of six commercial categories including seven species (tab. I). Two species of scads (*Decapterus russelli* and *Decapterus macrosoma*) are caught by the seiners. The catch shows high fluctuations with two peak productions in 1985 and 1992 (fig. 7a). 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 (fig. 8). The total landings of the seiners fishery is highly related to the fluctuations of the scads landings (fig. 9). As the fishing grounds move eastward, the catch of the two species shows different trends. The landings of *Decapterus russelli* decrease while those of *Decapterus macrosoma* increase. In 1992 *Decapterus macrosoma* is dominant in the landings (fig. 10). Due to different fishing areas, the exploitation of the two fleets do not focus on the same species. Medium seiners mainly catch *Decapterus russelli*.

Figure 6

DISTRIBUTION OF THE LANDINGS AMONG VESSELS (%) REGISTERED IN THE HARBOR AND OTHERS BETWEEN 1985 AND 1992

PENYEBARAN PENDARATAN ANTARA KAPAL PURSE SEINE (%) YANG TERDAFTAR SETEMPAT DAN KAPAL PENDATANG PADA PELABUHAN PERIKANAN YANG BERBEDA DARI TAHUN 1985 SAMPAI DENGAN TAHUN 1992

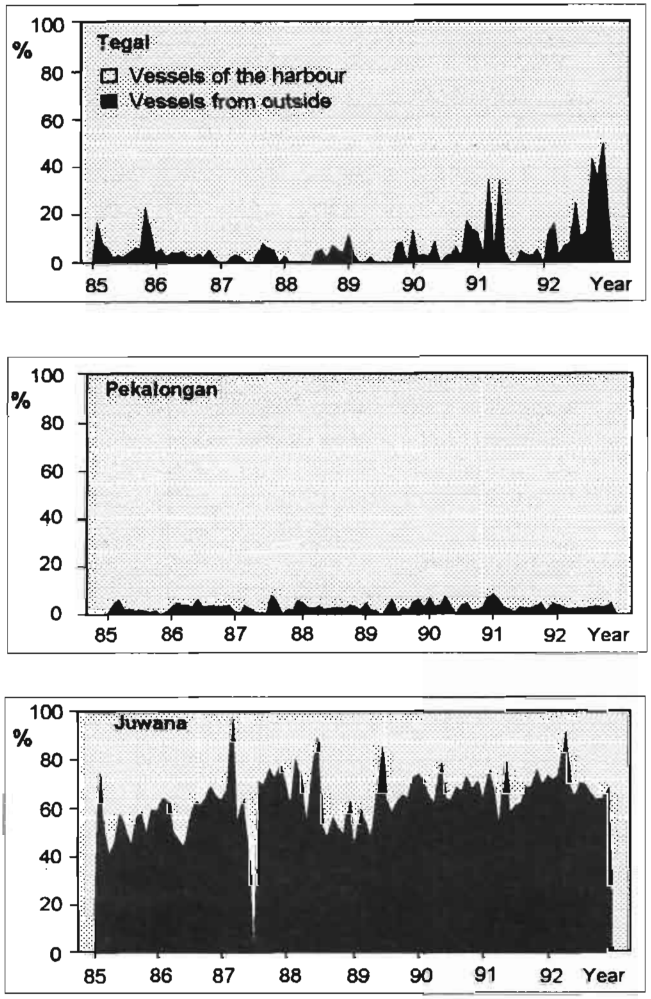


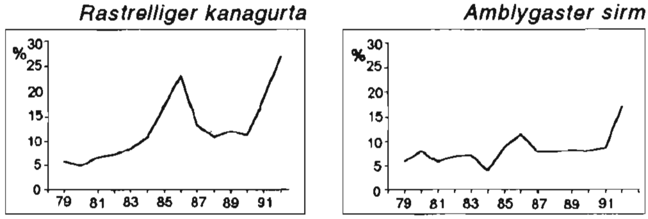
Figure 7

YEARLY EVOLUTION OF THE CATCH FOR THE MAIN COMMERCIAL SPECIES BETWEEN 1979 AND 1992

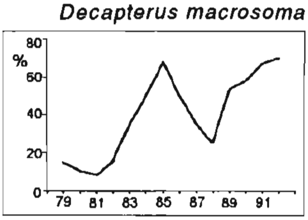
EVOLUSI TAHUNAN UNTUK SETIAP KATAGORI HASIL TANGKAPAN DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992

C : ' 000 tons

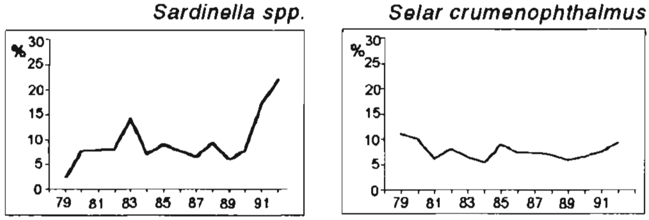
Rastrelliger kanagurta — *Amblygaster sirm*



Decapterus russelli
Decapterus macrosoma



Sardinella spp. — *Selar crumenophthalmus*



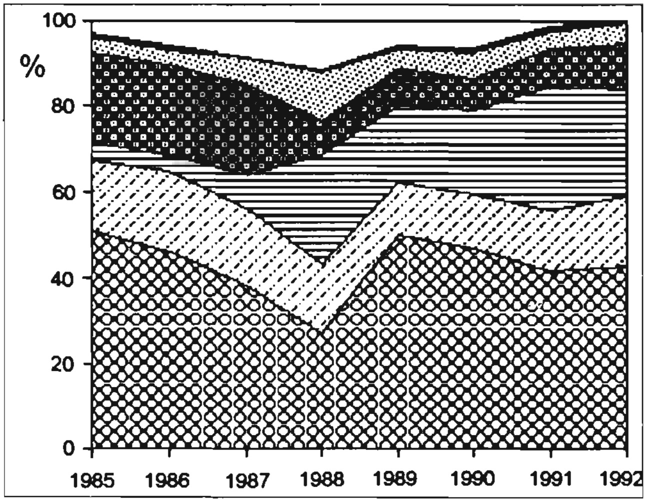


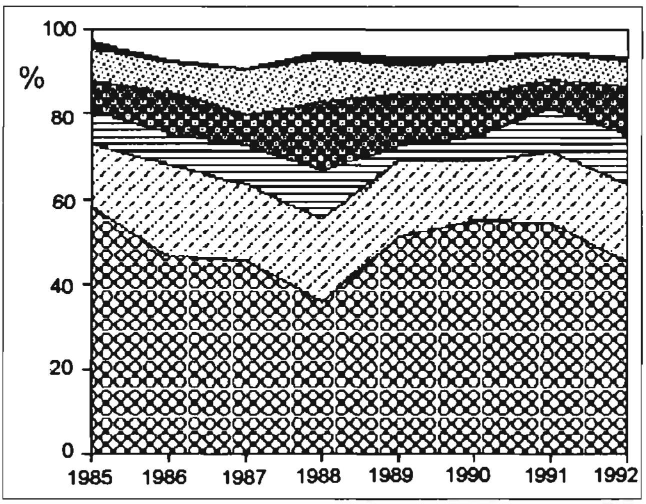
Figure 8

YEARLY CATCH EVOLUTION FOR THE MAIN COMMERCIAL CATEGORIES BETWEEN 1985 AND 1992

EVOLUSI HASIL TANGKAPAN TAHUNAN DARI KATAGORI KOMERSIAL UTAMA DARI TAHUN 1985 SAMPAI 1992

Legend:

- Scads
- Trevallies
- *Sardinella* spp
- Big eye scad
- *Amblygaster sirm*
- Mackerel
- Others



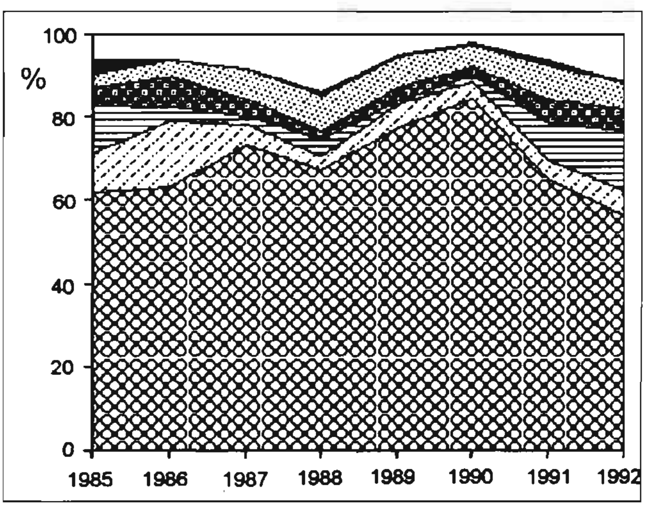


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Figure 9 *(top)*

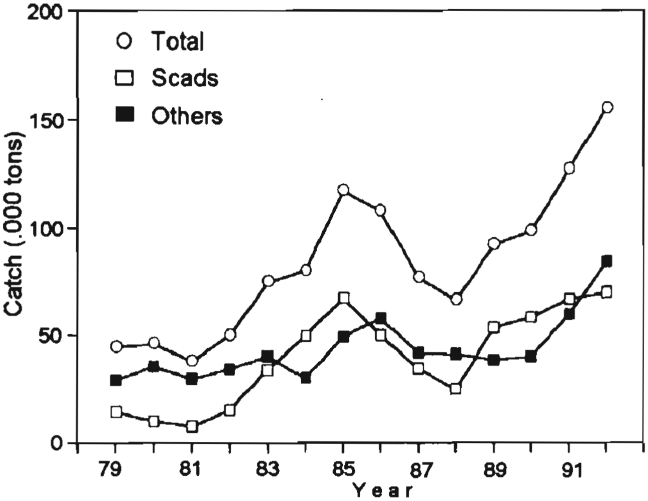
YEARLY EVOLUTION OF THE TOTAL CATCH (SCADS AND OTHER SPECIES) LANDED BY THE SEINERS BETWEEN 1979 AND 1992

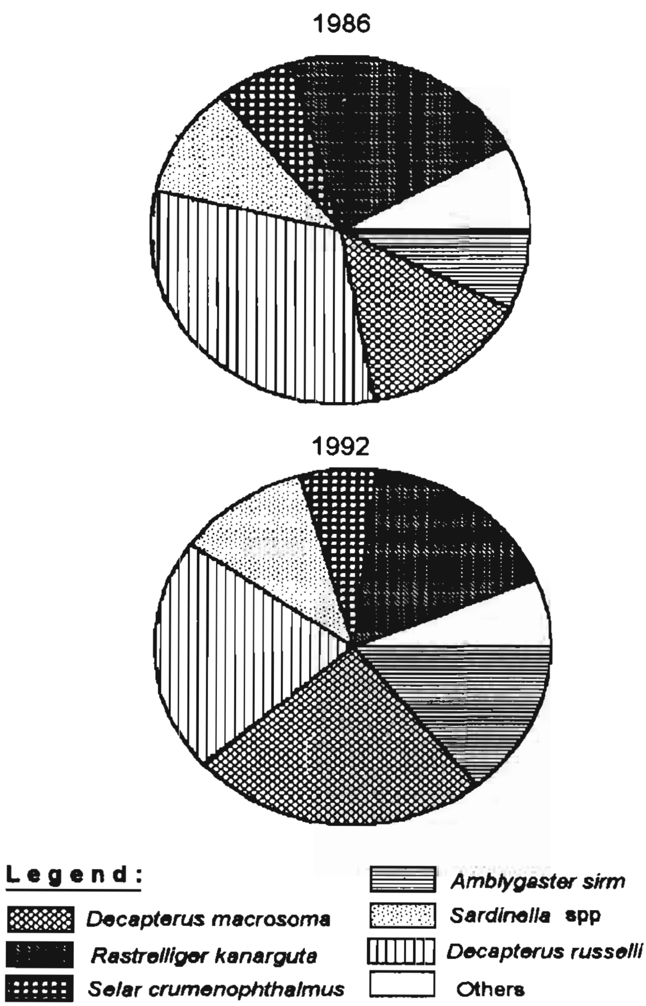
EVOLUSI TAHUNAN DARI TOTAL HASIL TANGKAPAN, LAYANG DAN GABUNGAN SPECIES LAIN YANG TERTANGKAP OLEH PURSE SEINE DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992

Figure 10 *(bottom)*

DISTRIBUTION OF THE SEINERS CATCH BY SPECIES IN 1986 (TOP) AND 1992 (BOTTOM)

PENYEBARAN HASIL TANGKAPAN BERDASARKAN SPECIES PADA TAHUN 1986 (ATAS) DAN TAHUN 1992 (BAWAH)





Most mackerels represented in the large and medium seiners catch are *Rastrelliger kanagurta*, *Rastrelliger brachysoma* being accidentally present in the landings. The evolution of the *Rastrelliger kanagurta* catch shows the same trend as for the scads with high fluctuations and a peak production in 1986 (fig. 7b) 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 *Amblygaster sirm* was important between 1979 and 1983. It could represent up to 20% of the seiners catch. From 1983 and until 1988 the landing decreased a lot before increasing again sharply in 1991 and 1992 (fig. 7c). 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, Sardinella lemuru*) shows regular fluctuations. These fishes are not the target species of the seiners fleets. They are caught by the large as well as the medium seiners. In 1992 the landing sharply increased (fig. 7d). The major part of the catch is made in the Java Sea in May-June.

The big-eye scad (*Selar

crumenophthalmus) is caught in small quantity by the large and medium seiners. Since 1979, the landing tends to decrease slightly (fig. 7e). 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**" (*Dussumieria acuta*), "**Bawal hitam**" (*Formio niger*) and small tunas as *Auxis spp.*

5.2 Seasonal and geographic composition

Landings show a high seasonal trend which is more or less related to the monsoons (Potier et Boely, 1990). A monthly seasonal index based on average ratio to the moving average shows two peaks, a minor one in March-April, a maximum one in September-November (fig. 11).

The decrease of the landings 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. The environmental conditions of this part of the year are extremely important for the seiners exploitation. As the rainfalls are positively correlated to the winds strength during this period, they condition the extension of the area covered by low salinity waters, the length of the stagnation of these waters and the entry of oceanic waters in the Java Sea. Thus, they influence the length of the low fishing season, the movements of the fish and the displacements of the fishing vessels among the fishing grounds.

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.

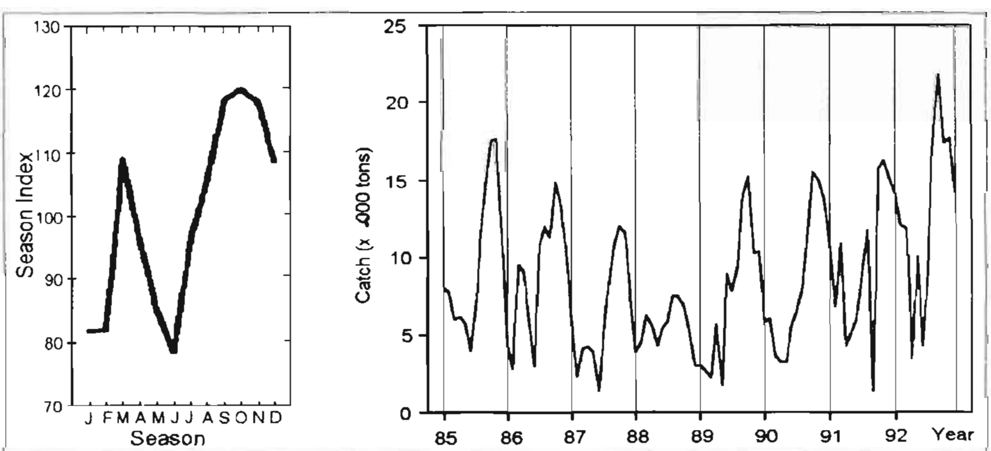


Figure 11

ESTIMATED SEASONAL COMPONENT AND MONTHLY EVOLUTION OF THE SEINERS TOTAL CATCH BETWEEN 1985 AND 1992

DUGAAN KOMPONEN MUSIMAN DAN EVOLUSI BULANAN DARI HASIL TANGKAPAN TOTAL PURSE SEINE DARI TAHUN 1985 SAMPAI DENGAN TAHUN 1992

According to these moves the catch of the different species change. Because of their different ecological needs, the species are not equally distributed in the fishing grounds.

A sun ray plot analysis performed on the distribution of the catch in various fishing grounds for each species (fig. 12) shows that the geographical distribution of the species varies. *Decapterus macrosoma* and *Amblygaster sirm* are found in the eastern part of the Java Sea and the Makassar Strait, the mackerel *Rastrelliger kanagurta* in the eastern part of the Java Sea, *Decapterus russelli* and *Selar crumenophthalmus* in the Central Java Sea and the South China Sea while the **"tanjan"** (mainly *Sardinella gibbosa*) is found in the Java Sea waters.

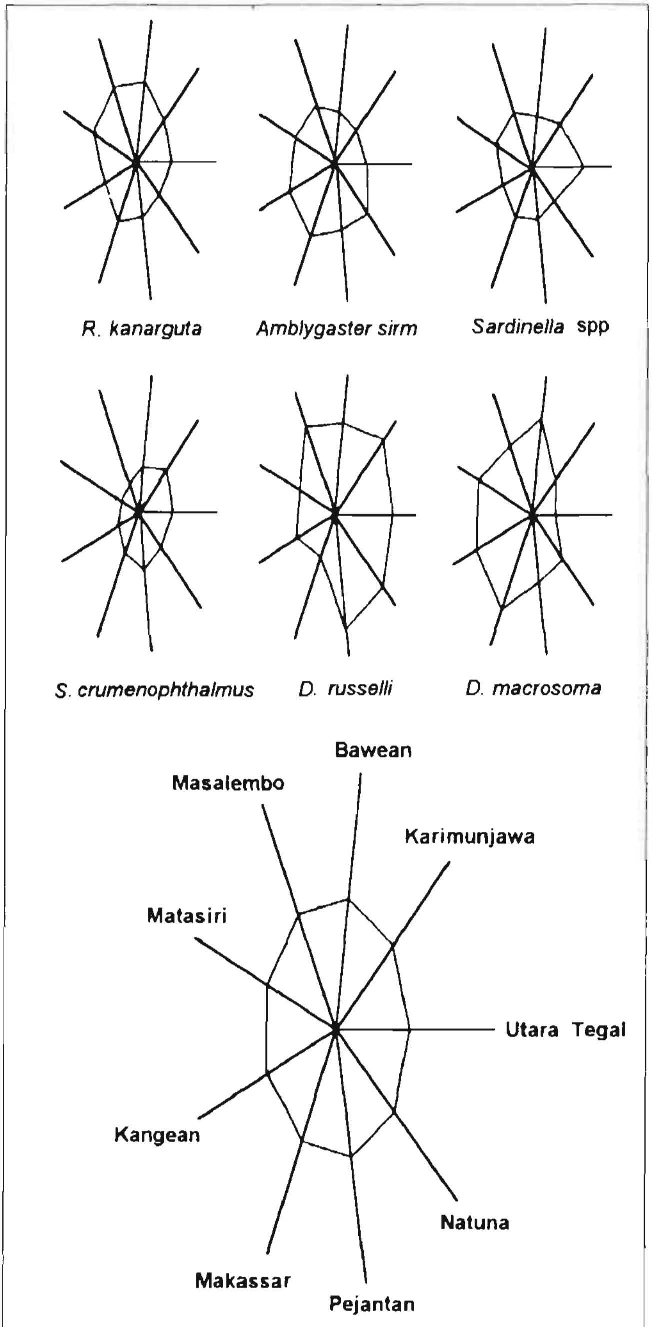
A cluster analysis carried out with the average distance method allows us to group the different species into clusters of "similar" points (fig. 13). Taking into account the sun ray plot results, the yearly catch and the CPUE trends, three groups are found. They correspond to three different types of populations among the seiners catch.

■ OCEANIC POPULATIONS
Decapterus macrosoma, Amblygaster sirm, Rastreliger kanagurta. They live

Figure 12

RESULTS OF A SUN RAY PLOT ANALYSIS PERFORMED ON THE SPECIES CAUGHT BY THE SEINERS

HASIL ANALISIS "SUN RAY PLOT" PADA IKAN-IKAN YANG TERTANGKAP OLEH PURSE SEINE



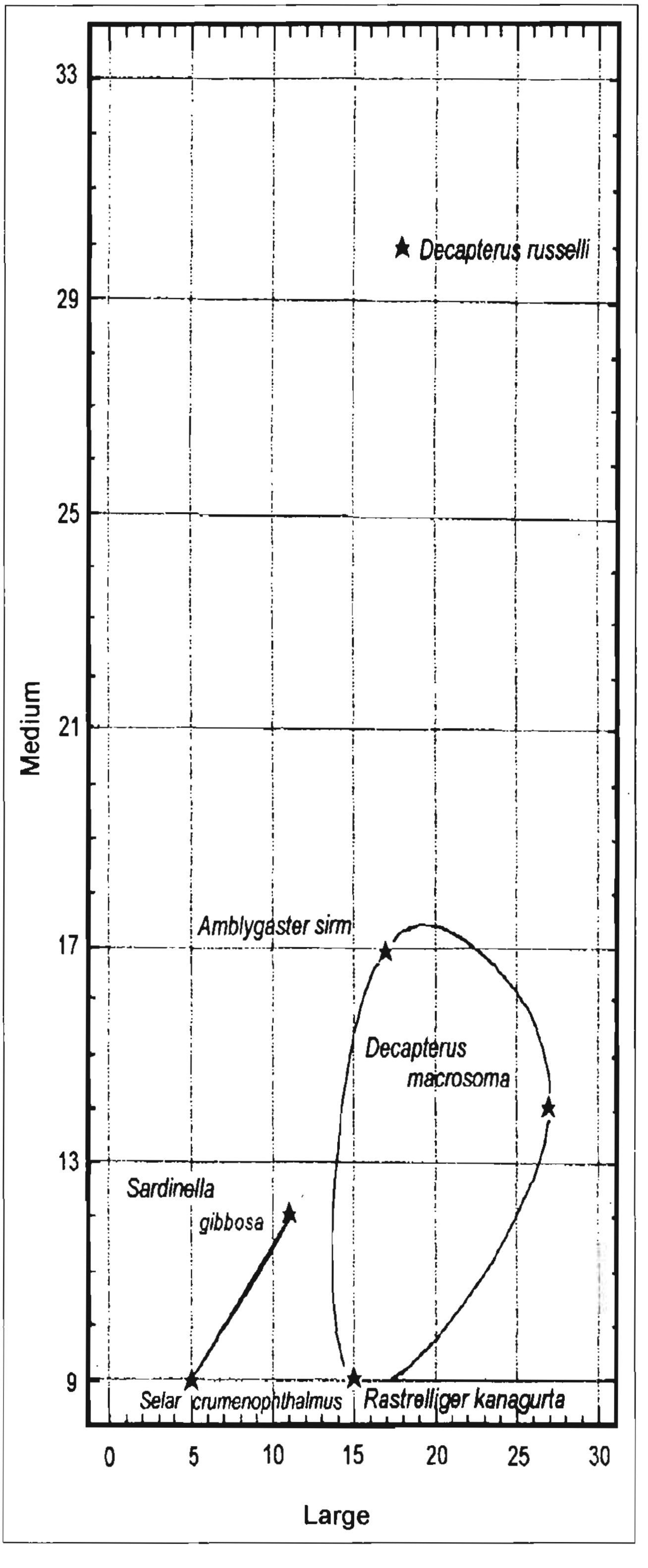


Figure 13

RESULTS OF A CLUSTER ANALYSIS PERFORMED ON THE SPECIES CAUGHT ON THE SEINERS.

HASIL ANALISIS CLUSTER PADA IKAN-IKAN YANG TERTANGKAP OLEH PURSE SEINE

Right page

Figure 14 (top)

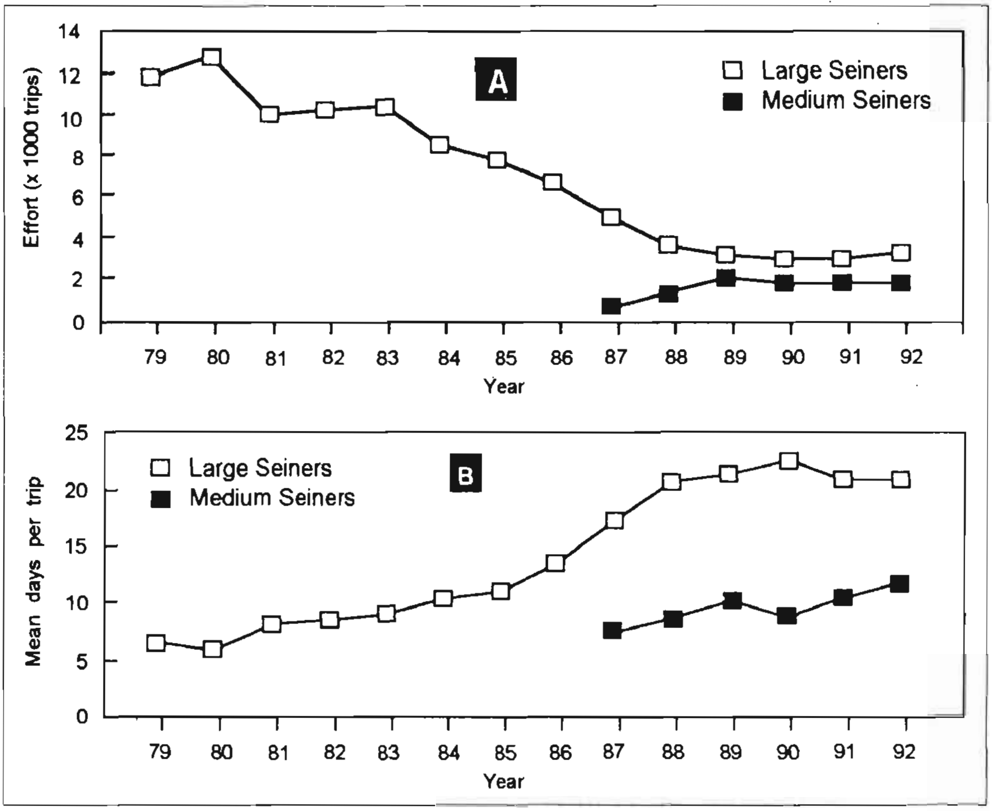
EVOLUTION OF THE NUMBER OF TRIPS (A) AND MEAN DAYS PER TRIP(B) IN THE LARGE AND MEDIUM SEINERS FISHERIES BETWEEN 1979 AND 1992

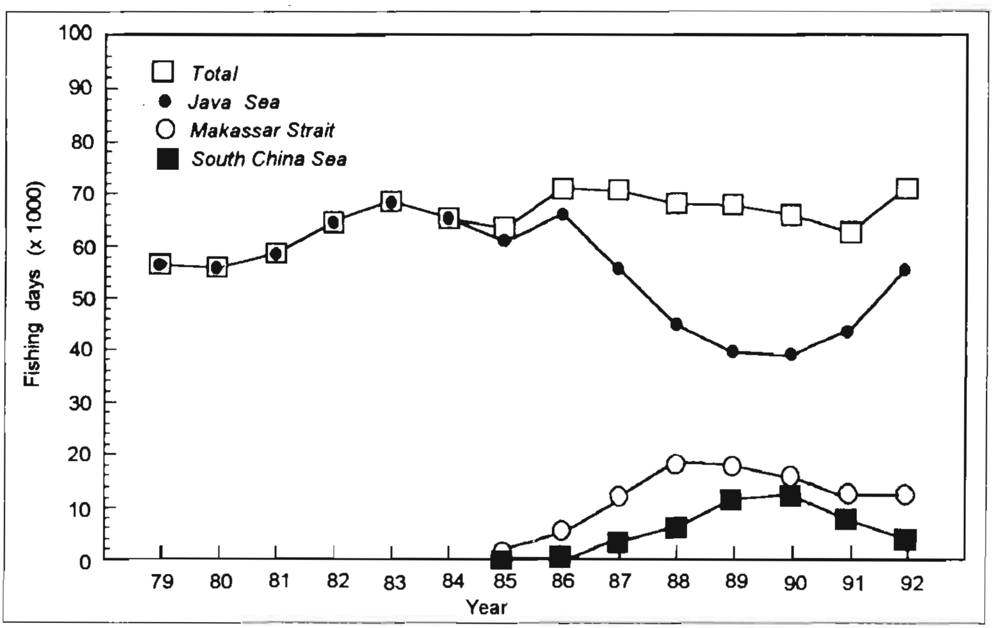
EVOLUSI JUMLAH TRIP DAN JUMLAH HARI RATA-RATA SETIAP TRIP PADA PURSE SEINE BESAR () DAN SEDANG (.) DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992

Figure 15 (bottom)

YEARLY EVOLUTION OF THE EFFORT IN FISHING DAYS IN DIFFERENT FISHING AREAS OF THE SEINERS BETWEEN 1979 AND 1992

EVOLUSI TAHUNAN DARI UPAYA PENANGKAPAN PURSE SEINE DALAM HARI LAUT PADA DAERAH PENANGKAPAN YANG BERBEDA DARI TAHUN 1979 SAMPAI DENGAN TAHUN 1992


A
Large Seiners
Medium Seiners
Effort (x 1000 trips)
Year
B
Large Seiners
Medium Seiners
Mean days per trip
Year


Total
Java Sea
Makassar Strait
South China Sea
Fishing days (x 1000)
Year

near the continental shelf edge. They are found in waters where salinity is more than 34‰. They are caught at the end of the year when the oceanic waters enter the Java Sea.

■ NERITIC POPULATIONS

Decapterus 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

Selar crumenophthalmus, Sardinella gibbosa. They are found near the coasts and live in waters with high fluctuations of salinity. They are found along the year in small quantity in the seiners catch.

6. EFFORT

It is difficult to classify the seiners fishing power and define a standard fishing vessel. Length, width and gross tonnage are underestimated in the registration forms. The engine power is the only parameter which could allow to perform this task, as it is well reported and acts on the fishery at one level; the surface of the prospected area grows when the engine power grows.

The time spent to search actively the fish has been defined as the best index of effort for purse seine fisheries by Marchal (1967) and Fréon (1980). According to them the days not related to search actively for fish, *i.e.* route from harbor to fishing grounds, setting time and rest time, have to be deducted from the days spent at sea. Since the Javanese fishermen fish around rafts, the seiners cannot be considered as searching actively for the fish. Thus, that index might not be the best one for the study of this fishery.

The number of sets, the number of rafts or the light power could give a good estimation of the effort. Because the Pelfish Project has not yet enough data to use these estimations, the number of trips and fishing days have been taken to estimate the effort. The number of days at sea and the fishing grounds prospected are known from enquiries and from the exit-entries books. From the time spent to go from the harbor to the fishing ground, we estimate the number of fishing days.

Expressed in number of trips (fig. 14A) the effort has decreased continuously since 1979. As the trips decreased the average number of days at sea per trip increased from 8 in 1979 to 24 in 1992 (fig. 14B). It can be related to the extension of the fishery, the growing distance between harbors and fishing grounds and the use of larger vessels which stay longer at sea.

The number of fishing days (tab. IV) increased from 1985 to 1987. Since 1987, it slightly decreased until 1991 before increasing sharply again in 1992. 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 Strait and in the South China Sea (fig. 15). The effort is highly seasonal and related to environmental and human factors (fig. 16). When winds are stronger than 20 knots the vessels are not able to stay at sea. This situation occurs mainly during the first months of the year when the North western monsoon is well established. During these months, floods on the North coast of Java Island can entirely stop the activity of the seiners because the landing places are flooded. The fishing vessels are also at port around the end of the fasting month and during two weeks the effort drastically decreases. The effort is high in the 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.

Table IV

EVOLUTION OF THE EFFORT (FISHING DAYS) AND THE CPUE (KG/FISHING DAYS) OF THE LARGE AND MEDIUM SEINERS FLEET SINCE 1985

EVOLUSI UPAYA PENANGKAPAN (HARI LAUT) DAN HASIL TANGKAPAN PER UNIT UPAYA DARI PURSE SEINE BESAR DAN SEDANG SEJAK TAHUN 1985

EFFORT	1985	1986	1987	1988	1989	1990	1991	1992
Large	56 282	62 052	70 345	56 087	50 086	51 256	46 364	52 889
Medium			2 873	8 157	16 915	12 569	14 136	17 539
Total	**56 282**	**62 052**	**73 218**	**64 244**	**67 001**	**63 825**	**60 500**	**70 428**
CPUE								
Large	2 120	1 742	1 077	1 097	1 683	1 697	2 350	2 387
Medium			512	477	511	939	1 226	1 688

7. CPUE

Values of the CPUE (tons/fishing day) decreased twice from 1985 to 1987 (fig. 17A) when the catch rate of the large seiners was 1 ton per fishing day. Since 1988, it increases 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 increases since 1989.

The fluctuations 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 (fig. 17B). In the medium seiners fishery there is only one annual peak during September-November (fig. 17D). The evolution of CPUE differs among the fishing areas. The Makassar strait and the Java Sea have a similar evolution (fig. 17C) with higher values in the Makassar strait. In the South China Sea CPUE fluctuates a lot.

CONCLUSION

The exploitation of the small pelagic in the Java Sea is highly related to the monsoons and the change they induce in the water masses in that sea. The rainfalls of the North-West monsoon play a major role. The abundance of pelagic fish in the Java Sea is linked to the discharge of islands rivers which have an important role in the productivity of the sea and the availability of the fish. The large seiners extending their fishing ground outside the Java Sea try to avoid fluctuations of fish abundance, but the seasonal trend of the landings is still strong.

Until 1985 the effort exerted by these fisheries was exclusively concentrated on the stocks or part of the stocks living in the Java Sea. Now it also focuses on the stocks of the Makassar Strait and the South China Sea. According to this exploitation scheme, several stocks complexes are exploited by the seiners. Their structure is not yet well defined, but we can recognize three types of stocks; oceanic; neritic; and coastal. Nevertheless, fish move and mix among them and at least for the Java Sea and the Makassar Strait the resource has to be considered as common. Statistics and stock evaluations have to be examined together. On the other hand, South China Sea stocks could probably be managed alone.

Fishermen know very well the fish behavior and the environmental conditions affecting the fishing grounds. The pressure on the fishing area is high but according to the different stocks defined above, the level of exploitation is different.

The geographic boundaries of the neritic and coastal stocks overlap the fishing boundaries of the seiners and the coastal fisheries. Since many years these stocks have been heavily exploited.

Regarding oceanic stocks, the fishing pressure is lower as their geographic distribution exceeds the fishing boundaries of the seiners fishery and of any other fishery which catch them. With the present tactic and technological level reached by the fishery, the seiners cannot extend their prospecting beyond the 200 m isobath and part of these stocks are not vulnerable to fishing.

On same fishing grounds (Java Sea), the catch rate of the large seiners is always higher than those of small seiners (fig. 17D). The size of the net or the light power used to attract fish and to aggregate can explain such differences.

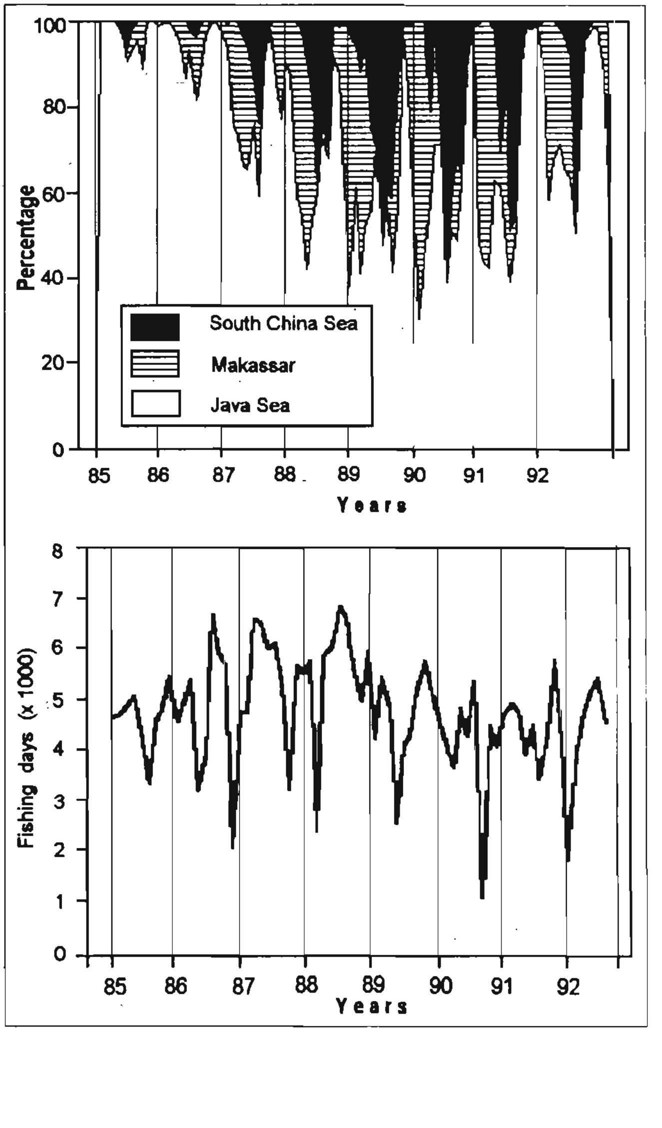


Figure 16

MONTHLY EVOLUTION OF THE EFFORT EXPRESSED IN FISHING DAYS AMONG VARIOUS FISHING AREAS AND TOTAL FOR THE SEINERS BETWEEN 1985 AND 1992

EVOLUSI BULANAN DARI UPAYA PENANGKAPAN PURSE SEINE DALAM HARI LAUT DI ANTARA DAERAH PENANGKAPAN YANG BERBEDA, DAN DAERAH PENANGKAPAN SECARA KESELURUHAN DARI TAHUN 1985 SAMPAI DENGAN TAHUN 1992

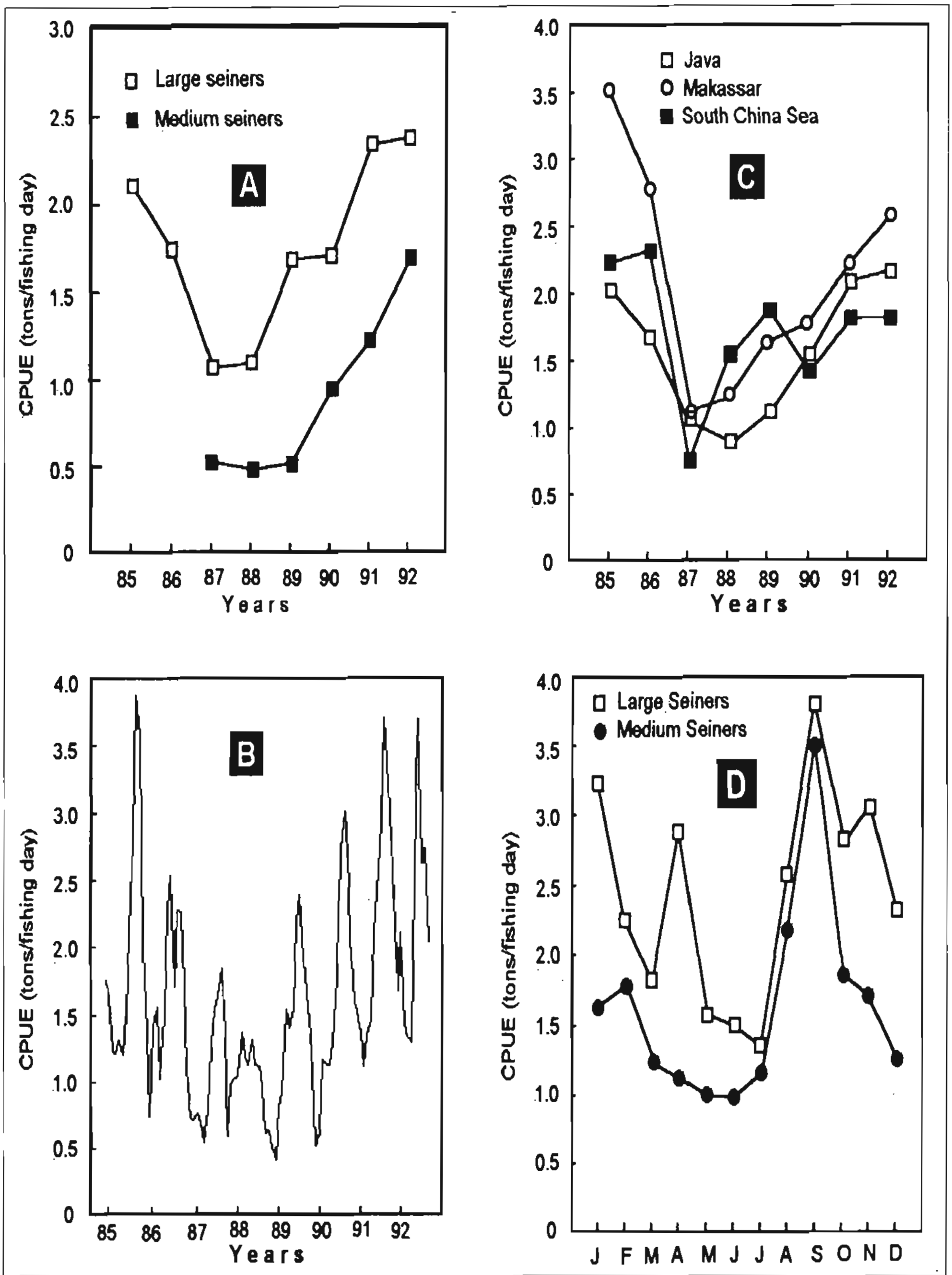


Figure 17

CPUE evolution (tons/fishing days) of the seiners between 1985 and 1992

Evolusi hasil tangkapan per unit upaya (ton/hari laut) dari tahun 1985 sampai dengan tahun 1992

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MARCHAL E., 1967. La pêche des sardiniers ivoiriens en 1966. *Doc. Scient. Prov. Centre Rech.Oceanogr. Abidjan*, **19**, 26p.

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POTIER M. et BOELY T., 1990. *Influence de facteurs climatiques sur la pêcherie à la senne tournante et coulissante en mer de Java. Aquatic Liv. Res.*, **3**, 193-205.

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POTIER M., SADHOTOMO B. and SUWARSO, 1992. Big purse seiners fishery. Statistical collection. Year 1991. ALA/INS/87/17. *Scien. and Tech. doc.*, **9**, 29p.

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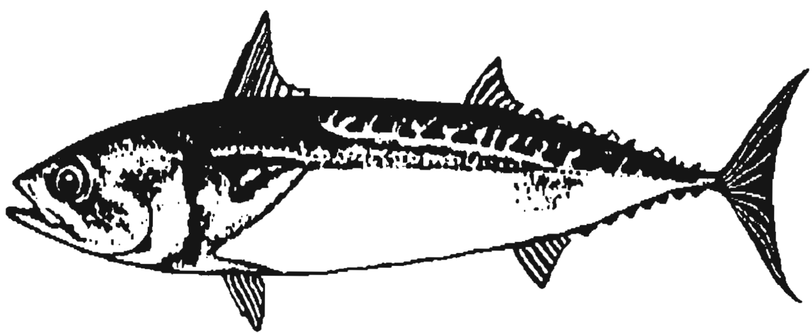
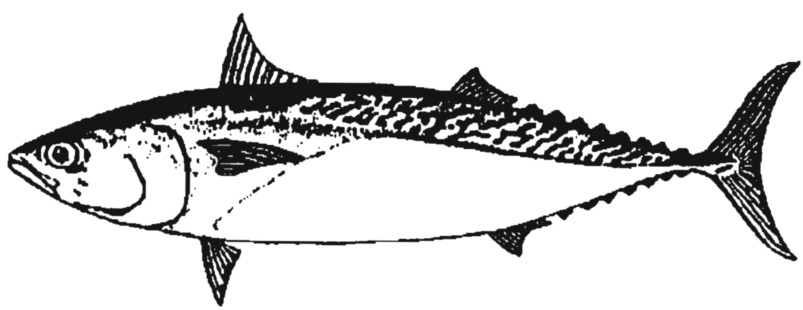
THE GENERALIZED LOGISTIC MODEL AS A TOOL FOR THE ASSESSMENT OF SMALL PELAGIC SPECIES

S. B. SAILA



Auxis rochei (**Tongkol lisong**)



Auxis thazard (**Tongkol**)

BACKGROUND

The purpose of this report is to utilize available theoretical and empirical information about the general logistic equation which is then utilized as a population model for small pelagic species of fishes including small tunas. It is recognized that the nominal catches of the so-called "small tunas", such as longtail (*Thunnus tonggol*), kawakawa (*Euthynnus affinis*), frigate tuna (*Auxis thazard*), and bullet tuna (*Auxis rochei*) are assuming an increasingly dominant position in the Southeast Asian region (FAO statistical Area 71) which includes Indonesia (FAO, 1993). Regrettably, Indonesian catch statistics listed as "tuna NEI" do not accurately reflect the importance of the above-mentioned species in Indonesian catches. However, it is becoming increasingly evident that effective management regimes for these species must soon be put in place in order to assure sustainability of yields. This report addresses one possible scheme for improved management procedures.

The general logistic equation has the following form :

$$N(t) = N\ (t-1) * \exp\ A \left([1- \frac{N\ (t-1)}{L}\right) \left([1- \left(\frac{N(t-T)}{K}\right)\ Q] + v\ (0,S) \qquad (1)$$

where :

- **t** = discrete time; takes values 1,2...;
- **N(t)** = population density (or an index of population density) at the time **t**;
- **T** = time delay in the response of the feedback mechanism(s);
- **A** = intrinsic rate of increase when **N** approaches zero;
- **L** = negative root used to produce an underpopulation or "Allee" effect;
- **K** = positive root or environmental carrying capacity;
- **Q** = coefficient of curvature which bends the R function to produce contest (**Q**>1) or scramble (**Q**<1) type interactions;
- **V(0,S)** = standard normal deviate with zero mean and standard deviation S which represents environmental variation.

Eqn. (1) is a delay difference equation and is used as a basic model in the POPSYS™ software developed by Ecological System Analysis, Pullman, Washington. This software is used in the model application to small pelagic species.

Population models (discrete and continuous) that include time delays are widely used in the literature and accepted by the biomathematical community. Continuous models are described by delay differential and discrete model by delay difference equations. For recent results about the dynamics of continuous delay models, see Györi and Ladas (1991) and Gopalsamy (1992). For the discrete case, see Kocic and Ladas (1993) and the references cited therein.

Levin and May (1976) said the following about the importance of time delays in population models : **"In systems where population growth is a continuous process, but where density-dependent regulatory mechanisms operate with some finite time delay, the basic models are differential-delay equations."... "For organisms with non-overlapping generations growth is modeled by difference equations. Even if there is no explicit time delay in the**

operation of density-dependent mechanisms, such difference equations have a one-generation time lag built into them."...

There remain, however, situations where in difference equations the density-dependent mechanisms themselves operate with an explicit time delay of **T** generations; that is where

$$N_{t+1} = N_t F(N_{t-T})$$

Murray (1989) gives the following reasons why time delay is important in delay discrete models."**All of the discrete models we have so far discussed are based on the assumption that each member of the species at time t contributes to the population at time t+1: this is implied by the general form**

$$N_{t+1} = N_t F(N_t), \text{ or } U_{t+1} = f(U_t\,;\, r)$$

in a scaled version. This is, of course, the case with many insects but not so with many other animals, where, for example, there is a substantial maturation time to sexual maturity. Thus, the population's dynamic model in such cases must include a delay effect: it is in a sense like incorporating an age structure. If this delay, to maturity say, is T time steps, then we are led to study delay difference models of the form:

$$U_{t+1} = f(U_t, U_{t-T})"$$

1. MODEL DERIVATION

Start with the continuous growth equation

$$\frac{dN}{dt} = RN(t)$$

where **dN/dt** is an instantaneous growth rate, **N(t)** is a population density or an index of population density, **R** is an instantaneous or intrisic rate of increase and **t** is time.

In general case, **R** is not a constant, but it is a function that varies in time. Assuming that **R** remains constant in any time interval of length 1 which corresponds to one generation or one breeding cycle

$$R = R_n \text{ for } n-1 \leq t < n,\ n = 1,2...$$

It follows for n=1,2 ...

$$N(t) = N(n-1)\ e^{Rn(t-n)} \text{ for } n-1 \leq t < n$$

When t=n (multiple of the time increment), we obtain

$$N(n) = N(n-1)^{*}\exp(R_n),\ n = 1,2,...$$

Finally, by assuming that the variable t takes only the values 0,1,2,..., we obtain the general form of discrete population models

$$N(t) = N(t-1)^{*}\exp(R),\ t = 1,2,... \quad (2)$$

Intrinsic rate of change R can be represented in the form:

$$R = f[N(t-1),\ N(t-T)] + V(0,S) \qquad (3)$$

where **f** is a feedback function that depends on population densities at the time **t-1** and time **t-T** (population density in the previous generation or cycle and population density **T** generations or cycles ago, respectively). Density-independent factors (environment) are taken into account by adding the standard normal random variable **V** with zero mean and variance **S**. The larger values of **S** indicate increased amount of random "noise" in the environment.

There are many possible forms of the density-dependent feedback **f**, but the following was utilized herein :

$$f = A\left(1-\frac{N(t-1)}{L}\right)\left(1-\frac{N(t-T)}{K}\right)Q \quad (4)$$

where **T** is the time delay in the response of the feedback mechanism(s), **A** is a intrinsic rate of increase when **N** approaches zero, **L** is a negative root used to produce an underpopulation or "Allee" effect, **K** is a positive root or environmental carrying capacity, and **Q** is a coefficient of curvature which bends the **R** function to produce contest (**Q>1**) or scramble (**Q<1**) type interactions.

The non-linear negative feedback function incorporates the effects of non-linearity in the growth rate.

$$A \left(1- \left(\frac{N \ (t-T)}{K}\right) Q\right) \qquad (5)$$

There are many reasons why non-linear negative feedback is taken to be in the form (5). One of the reasons is competition between individuals. Competition that becomes strong near the carrying capacity **K** is called contest competition. Then the feedback function becomes steeper when **N** approaches **K**, and the feedback function will be concave down. This corresponds to the case when **Q>1.** Competition that is more intense at low population densities is known as scramble competition. Then the negative feedback function is concave up which corresponds to the case when (**Q<1**). Another reason for non-linear feedback function is, for example, predators that are more efficient at high prey densities.

Non-linearities of this form in population models are known in the literature. For example, Gilpin and Ayala (1973) proposed the following non-linear population model:

$$\frac{dN(t)}{dt} = rN(t) \left(1-\left(\frac{N \ (t)}{K}\right) \theta\right)$$

where **r** and θ are positive. The same model with a time delay in the non-linear feedback function can be found in Gopalsamy (1992).

The recruitment term in the discrete baleen whale population model proposed by the International Whaling Commission (see, for example, Botsford (1992), Clark (1976), Fisher (1984), May (1980). Kocic and Ladas (1993), and the references cited therein).

$$N\ (t) \ = (1-\mu)N(t-1) + \mu N(t-T) \left(1 + q \left(1-\left(\frac{N(t-T)}{K}\right)z\right)\right)$$

is also of the form (5).

The under-population effects or “Allee” effects were modeled by introducing the following term:

$$\left(1-\frac{N\ (t-T)}{L}\right)$$

If **L** is a negative number, then the population will never go extinct. On the other hand, the positive value for **L** is the extinction threshold, and the population can become extinct when the population density falls under that level.

Eqn.(1) contains, as a special case, many important population models. In the case when

$$L \to -\infty, \ Q=1 \ T=1$$

we obtain the well known discrete logistic equation

$$N(t) = N(t-1)^{*}\exp\left(A\left(1-\frac{N(t-1)}{K}\right)\right) \qquad (6)$$

that was thoroughly studied in literature [see, for example. May (1975), Caravalho and Cooke (1988), Seifert (1985), Györi and Ladas (1991), and the references cited therein.

Eqn.(6) is a discrete analog of the continuous logistic model

$$\frac{dN(t)}{dt} = rN(t)\left(1-\frac{N(t)}{K}\right)$$

It is important to point out that the following well-known equation

$$N(t) = N(t-1)\left(1+ r\left(1-\frac{N(t-1)}{K}\right)\right) \qquad (7)$$

is also known as a discrete analog of the continuous logistic equation. May (1975) gave biological reasons why Eqn. (6) is a more realistic model than Eqn.(7).

Furthermore, Eqn (1) in the case when

$$L \to \infty, \ Q=1 \ T=2$$

was studied in Murray (1989). For the cases where the time delay **T** is greater than 1, see Györi and Ladas (1991), Kocic and Ladas (1993), and the references cited therein.

1.1 The POPSYS Programs

The computer programs in the POPSYS system assist in the construction of dynamic models of single species populations from a time series of density or density indices over annually censused periods of about ten years or more. They are built around a generalized discrete logistic equation described previously. It is assumed that CPUE is a direct proportional index of abundance. It is also recognized that this is probably not true in very technologically-developed tuna fisheries. However, it seems reasonable for small pelagic fisheries in the developing world.

The system contains a data manager for handling inputs and for data management. An inductive analysis program allows fitting a model to census data (in this case, a series of annual observations of adjusted or unadjusted CPUE). The user must first decide if the system has one or two equilibrium points from an examination of the **R-N** phase portrait of the data. The phase portrait shows how the observed values of **R=ln[N(t)/N(t-1)]** are related to population density **N(t-1)**. The phase portrait may visually indicate the existence of two equilibria, and the mean return time (**MRT**) and variance of return time (**VRT**) values are also used in making decisions about multiple equilibria. Next, time delays in the system are considered. In general, if the **R-N** phase portrait shows a clockwise circular orbit and if **MRT>2** with **VRT** not much greater than **MRT**, then the time lag(**T**) should be increased. When the time delay has been examined or corrected, the **R**-function is fitted. A linear or non-linear function can be fitted, which includes an estimate of **(S)** the standard deviation of the data about the regression, and **RSQ**, the percent variation explained by the **R**- function model. If a non-linear fit is used, two other parameters are altered. They are **L**, an underpopulation parameter initially set at a large negative number, and **Q**, an overpopulation parameter, or coefficient of density-dependent curvature. This parameter is initially set at one and is always greater than zero. **Q>1** adds convexity, and **Q<1** adds concavity to the **R**-function.

Simulations are next done by calculating **N(t)**, the density of the population at time **t**, from **N(t-1)** the prior density, **(R)** the per-individual rate of increase, and **(S)** the random variability. Simulations are run for periods of time usually equal to the length of the data set. However, they can be run for any lengths of time up to 100 intervals. Simulations were made in a mixed deterministic/stochastic environment containing empirically determined parameters and environmental variability. Simulations are plotted as a time series to compare with the observational data as one means of models verification. However, comparison of the shapes of the **R-N** phase trajectories between the data, and the model is the more effective method for model validation. The reason for this statement is that the phase trajectory is time independent, whereas the stochastic model incorporates variability anywhere in the time series, and this may make a simulated time series look different from the observed data in spite of the fact that the magnitude of variability is about the same. Even in the case of the **R-N** phase-space comparisons, it must be recognized that the simulations may not exactly mimic the data, but they should fall in the same general region of phase-space, if the phase portraits are superimposed. A rigorous comparison of phase portraits remains to be developed.

Sensitivity analysis is done to evaluate the sensitivity of various models to variations in individual parameter values. The sensitivity graphs illustrate the influence of single parameter variations on the behavior of the model. If a stable solution exists for a particular set of values of a parameter, a relatively straight line is evident for this range in the graph.

Bifurcation into two lines suggests two-point limit cycles, and highly scattered lines which oscillate indicate the presence of complex cycles or chaotic behavior.

Predictions are also possible with the POPSYS system model. A minimum of **T** data points are necessary for a prediction where **T** is the length of the time lag. Predictions from this model are made as follows. Firstly, the last **T** data points are used to calculate the expected per-individual rate of increase, **R**, using the fitted **R**-function. Then a random normal deviate, **V**, is drawn from a normal distribution with mean zero and calculated standard deviation. Secondly, the predicted population density is calculated from the exponential equation and compared to stated collapse or danger thresholds. Finally, the above calculations are repeated 100 times, and the mean, standard deviation and 95 percent confidence intervals are calculated and displayed-as well as probabilities of increase or decrease from prior levels.

The final methodological procedure involves testing management options. This includes various rates of additional removal (harvest) of the organisms of interest under specified danger levels and population densities at which exploitation is initiated. The simulation is usually run for 50 years or more. Variation of the harvest rate permits an estimation of an acceptable additional harvest rate which minimizes the danger of population collapse for a previously established collapse threshold. This could be interpreted as an indication of the robustness of the population.

In the following analysisit is assumed that the CPUE, expressed as catch-per-standard boat day, is a valid index of population density. This value has been derived from catch expressed in weight rather than numbers. Both approaches are acceptable under defined conditions.

1.2 Results

A brief description and interpretation of the model parameters are provided herein. This is in addition to the technical descriptions of the model provided previously. The parameter **K** was described as the intercept of the density-dependent **R**-function with the x-axis at **R=0**. Because **dn/dt** or **dB/dt =0** at this point, it represents a population equilibrium or sustained carrying capacity. **K** is conservatively represented as the estimated carrying capacity of the environment. **K** values were found to change at various developmental stages of the fishery. Changing the value of **K** moves the equilibrium level, but it does not influence the stability properties of the logistic equation used in this study.

A is an intercept of the density-dependent **R**-function with the **y**-axis at **N(t-T)=0**. This parameter represents the per-individual rate of increase of the population biomass when its density is very low in the absence of density-dependent feedback. A may also be construed to represent the average favorability of the environment. Changing the parameter **A** represents altering the quality of the environment for the population. **S**, the standard deviation, represents the variation in the density-independent environment.

L is the other intercept of the density-dependent **R**-function with **x**-axis at **R=0**. When the value of **L** is positive, this intercept is called an extinction threshold. In this analysis, **L** is never allowed to be positive under the assumption that the population never enters the extinction domain.

Q is a coefficient of curvature of the **R**-function that can produce non-linear density-dependent relationships. When **Q=1**, the **R**-function is linear, when **Q<1**, it is concave, and when **Q>1**, it is convex.

The time delay T in the elemental logistic equation assumes that negative feedback occurs within one time period. That is, **N(t)** is determined by density one time period previously at **N(t-1)**. This is a case of a time lag of **T=1** in the action of the negative feedback loop. It is possible for time lags of **T=2** or **T=3** to occur. Time delays are interpreted as a measure of the inertia of the feedback process, and time lags may be introduced into negative feedback loops when populations affect properties of the environment-such as food resources or the presence of predators. A time delay of one suggests that density-dependent negative feedback is acting quickly that is, within the first year of life.

RSQ indicates the percent of the variation in the data which is explained by the fitted **R**-function. That is, it shows how much of the variation in the data set is determined by density-dependent feedback processes. From this, it is inferred that density-independent factors are responsible for **1-RSQ** of the variation. This provides an estimate of the relative significance of density-dependent and density-independent processes in affecting populations fluctuations.

2. AUXIS DATA ANALYSIS

The *Auxis* data set consists of a ten-year time series of CPUE obtained from seine netters at Pelabuhan Ratu, the same location as a skipjack gill net fishery. In contrast to skipjack tuna, Auxis *spp.* are relatively small coastal species. Members of the genus *Auxis* are frequently called frigate mackerel. This record of catch and effort is the first available for small coastal tunas in Indonesia, and it, therefore, is of some relevance in management planning. The *Auxis* CPUE

Table 1

AUXIS CPUE DATA AND PRELIMINARY STATISTICS. THIS IS A TEN-YEAR RECORD OF CPUE FOR A SEINE FISHERY OPERATING OUT OF PELABUHAN RATU FROM 1981 TO 1990

DATA HASIL TANGKAPAN PER UNIT UPAYA DAN STATISTIK DARI AUXIS. HASIL PENGUMPULAN DATA HASIL TANGKAPAN PER UNIT UPAYA SELAMA 10 TAHUN DARI PERIKANAN PUKAT YANG BEROPERASI DILUAR PELABUHAN RATU DARI TAHUN 1981 SAMPAI TAHUN 1990

AUXIS CPUE DATA

DENSITY PER 1.00 SEINE CPUE

Time	Density	Rate of Increase
1	1.9100E+02	5.4682E-01
2	3.3000E+02	-7.7521E-01
3	1.5200E+02	-4.3891E-01
4	9.8000E+01	6.9824E-01
5	1.9700E+02	-6.1037E-01
6	1.0700E+02	1.3698E+00
7	4.2100E+02	-3.4554E-01
8	2.9800E+02	-2.2314E+00
9	3.2000E+01	-2.8768E-01
10	2.4000E+01	0.0000E+00

Mean response time :
***MRT** = 1.1667E+00*
Response time variance:
***VRT** = 6.0313E-01*
Mean period of oscillation
***PER** = 4.0000E+00*
Mean amplitude of oscillation
***AMP** = 2.1183E+02*
Mean density of population
***MEAN** = 1.8500E+02*

Auxis cpue Simulation
Data from Simulation #5

Time	Density	Rate of Increase	Random Variation
0	1.9100E+02	-6.1452E-01	-4.3385E-01
1	1.0331E+02	-3.7153E-01	-5.5707E-01
2	7.1252E+01	-2.6437E-01	-5.8380E-01
3	5.4699E+01	-1.7966E-01	-5.6822E-01
4	4.5704E+01	6.0025E-02	-3.6610E-01
5	4.8532E+01	-6.1264E-01	-1.0270E+00
6	2.6300E+01	2.3395E+00	1.8323E+00
7	2.7289E+02	-1.7060E+00	-1.1833E+00
8	4.9556E+01	-3.7358E-01	-7.8362E-01
9	3.4108E+01	-2.0248E-01	-6.7703E-01
10	2.7856E+01	1.1386E+00	6.3797E-01

Standard Deviation of Random Variable = 8.9094E-01

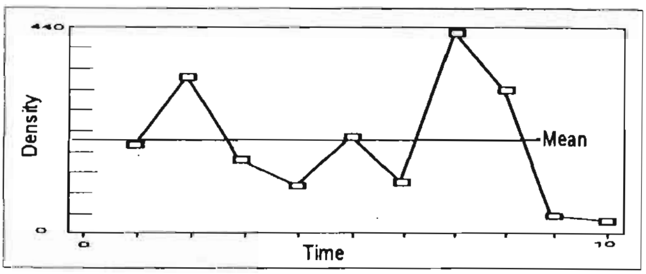


Figure 1

Auxis cpue time series plot for ten years (1981 to 1990) in the Pelabuhan seine net fishery

Data serial hasil tangkapan per unit upaya dari Auxis selama 10 tahun (1981 sampai 1990) pada perikanan pukat di pelabuhan

Table II (top left)

Model definition and results of a simulation run for the Auxis data set. Auxis cpue Model

Definisi model dan hasil dari simulasi data Auxis. Model hasil tangkapan per unit upaya Auxis

The model we have chosen to : describe the data is given by:
R= A(l) * (1-[N(t)/L(l)]) (1-[N(t-T(l)) /K (l)] ^Q(l)) +V(s)
*where **l** = 1 when N(t)>E*
l = 2 when N(t)<E
***R** is the per-capita rate of increase*
***N(t)** is the density of the population at time t,*
***V** is a random normal variate,*
***E** is the escape threshold.*
Parameters of your model are
***A**=the value of R at N=0*
= 6.1700E-01
***K** =the equilibrium point*
=1.4774E+02
L=the underpopulation effect
=-1.0000E+06
***Q**=the coefficient of curvature*
=1.000E+00
T=the feedback time-lag=1
*and the goodness of fit statistics are **S**=standard deviation*
=8.9094E-1
***RSQ**=% of variation explained*
=25.6%

data is illustrated in table I, and the time series plot and related statistics are shown in figure 1. It is evident from the figure that the population is subject to rather severe oscillations. However, the mean return time (**MRT**) is about one, and the variance of the return time (**VRT**) is less than one. The estimated periodicity is four, and the amplitude of the oscillations is greater than the mean. From this, one would expect a phase trajectory which is not tightly grouped, and this is certainly the case in figure 2. The R-function curve fit was estimated by a linear model, and the fit is not very good as shown in figure 3. Only about 26 percent of the variation is estimated to be density-dependent, with the remaining 74 percent being density-independent. An attempt was made to develop a simulation model from the derived parameters. Figure 4 illustrates the results of one simulation run which contains a spike somewhat similar to that found in figure 1. This large amount of variability found in the simulation runs is directly related to the fact that the estimated density-independent variability was about three times higher than the density-dependent variation.

The phase portrait shown in figure 5 bears some resemblance to that derived from the raw data. This is a verification diagram, and it should be compared with figure 2 obtained from the original

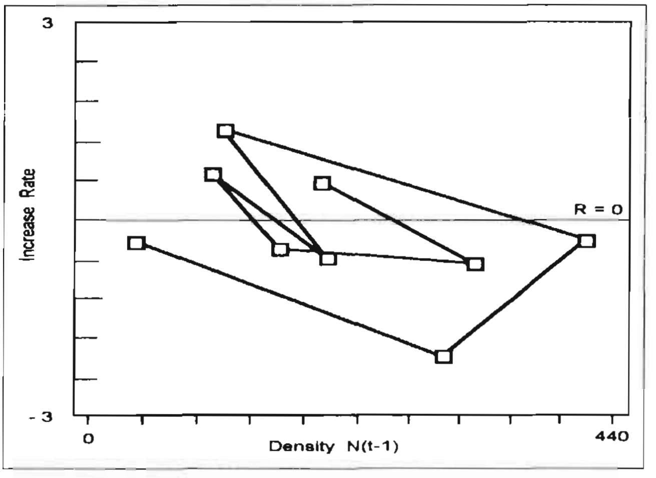


Figure 2

AUXIS R-N PHASE TRAJECTORY DERIVED FROM THE DATA OF TABLE I
ARAH TAHAPAN R-N DARI AUXIS, YANG DITURUNKAN DARI DATA PADA TABEL I

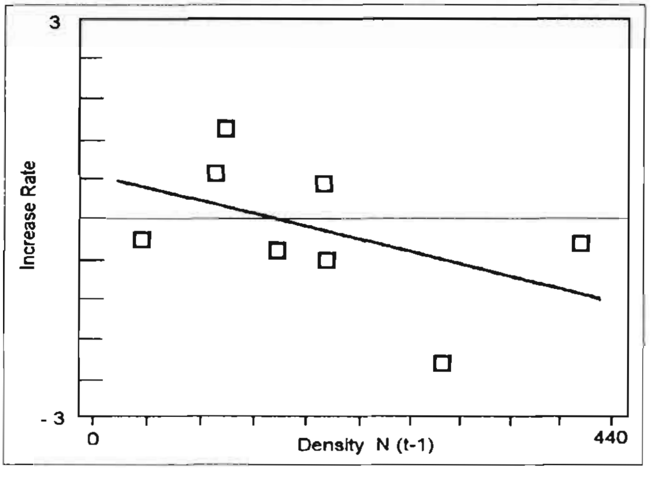


Figure 3

AUXIS IS R-FUNCTION AUX.FIT. THE PARAMETERS OF THE LINEAR REGRESSION MODEL ARE SHOWN BELOW
AUXIS ADALAH FUNGSI R "AUX. FIT". PARAMETER DAN MODEL REGRESI LINIER ADALAH SEBAGAI BERIKUT

Regression intercept at N=0	*A<1>*	=	*6.1700E - 01*
Equilibrium point at R=0	*K<1>*	=	*1.4334E + 12*
Lower root of function	*L<1>*	=	*1.0000E + 06*
Coefficient of curvature	*Q<1>*	=	*1.0000E + 00*
Feedback time log	*T <1>*	=	*1.0000E + 00*
Standard derivation about line	*S*	=	*8.9094E - 01*
Percentage variation explained	*RSQ*	=	*25.6%*

data. A description of the stochastic model, the estimated model parameters, and the results of a simulation run are illustrated in table II.

In view of the high variability on the time series data, some sensitivity analyses were performed on the model. figure 6 shows a very interesting condition, namely that increasing values of the model parameter (**S**), which is random variability, quickly produces what appears to be chaotic results. This is related to the observation made previously that *Auxis* population has a high level of density-independent variability. With respect to the rate of increase of parameter (**A**), it was found that the model was insensitive to changes until A reached rather high values of about 2.7. When bifurcation was observed (fig. 7), chaotic behavior soon followed. However, these conditions were well outside the estimated value of the parameter derived from the data which is illustrated by the vertical line.

The derived model was also utilized for prediction purposes in view of its interesting behavior. Table III illustrates predictions for two years ahead as well as probabilities associated with these predictions. It is of particular interest to note the probabilities of encountering a dangerous condition (i.e., density at or below a critical level, estimated to be between 20-25 percent of the maximum carrying capacity). These danger probabilities were relatively high, suggesting that the forecasting and control of a fishery with such high density-independent variability would not be easy by conventional management methods.

Concern about the stability of this fishery under a constant proportional harvest rate management regime were justified by the results of the management gaming exercises based on the simulation model (table IV and V). From table IV, it is evident that even moderate incremented rates of removal beyond a critical density provided extremely high risks of danger. This is further confirmed by table V which illustrates that even lower rates of removal of 15 and 10 percent of the stock beyond current exploitation levels may be dangerous in the long term. The third panel of table V illustrates the results of a manual management strategy. In this strategy a proportion of the estimated stock is removed to bring it back to the threshold level. This strategy is largely

Table III

AUXIS POPULATION PREDICTIONS BASED ON THE STOCHATIC SIMULATION MODEL. PROJECTED DAMAGE AND DANGER LEVELS ARE ALSO INDICATED FOR THE FORECASTS

RAMALAN POPULASI AUXIS BERDASAKAN MODEL SIMULASI STOKASTIK. PROYEKSI KERUSAKAN DAN TINGKAT KRITIS DIPERLIHATAN UNTUK PERAMALAN

AUXIS CPUE PREDICTIONS

POPULATION DENSITY PER SEINE CPUE

Time	Mean	Maximum	Minimum	St.Deviation	95 % Interval
			INPUT	DATA	
1	1.9100E+02				
2	3.3000E+02				
3	1.5200E+02				
4	9.8000E+01				
5	1.9700E+02				
6	1.0700E+02				
7	4.2100E+02				
8	2.9800E+02				
9	3.2000E+01				
10	2.4000E+01				
			PREDICTED DATA		
11	6.3500E+01	3.9772E+02	4.7434E+00	6.8159E+01	+- 1.3632E+02
12	9.5721E+01	4.1092E+02	2.2769E+00	9.8995E+01	+- 1.9799E+02

AUXIS CPUE PREDICTIONS

		PROBABILITIES		
Time	P(increase)	P(decrease)	P(damage)	P(danger)
11	0.74	0.26	0.00	0.49
12	0.64	0.36	0.00	0.38

based on the fact that the population oscillates above and below the critical value due to the large amount of density-independent variability. From these management simulations it is concluded that no management strategy short of forecasting the next year's abundance and adjusting fishing effort each year to account for the large stochastic variation seems reasonable.

Table IV

EXAMPLES OF SPECIFIC MANAGEMENT STRATEGIES BASED ON USE OF THE AUXIS STOCHASTIC SIMULATION MODEL
CONTOH STRATEGI PENGELOLAAN YANG SPESIFIK BERDASARKAN MODEL SIMULASI STOKASTIK DARI AUXIS

MANAGEMENT STRATEGY 1 FOR AUXIS CPUE		
REMOVAL STRATEGY :		
40.00% of organisms removed when population	>	7.5000E+01
Number removed over 50 time periods	=	1.3165E+03
Average removed per time period	=	2.6330E+01
Number of removal episodes	=	16
Proportion of time removals are made	=	0.320
POPULATION DYNAMICS :		
Total length of simulation run	=	50
Mean population density	=	6.5672E+01
Number of dangerous episodes	=	43
Probability of danger (risk)	=	0.86
MANAGEMENT STRATEGY 2 FOR AUXIS CPUE		
REMOVAL STRATEGY :		
30.00% of organisms removed when population	>	7.5000E+01
Number removed over 50 time periods	=	2.1423E+03
Average removed per time period	=	4.2848E+01
Number of removal episodes	=	20
Proportion of time removals are made	=	0.400
POPULATION DYNAMICS :		
Total length of simulation run	=	50
Mean population density	=	1.2284E+02
Number of dangerous episodes	=	35
Probability of danger (risk)	=	0.70
MANAGEMENT STRATEGY 3 FOR AUXIS CPUE		
REMOVAL STRATEGY :		
20.00% of organisms removed when population	>	7.5000E+01
Number of removed over 50 time periods	=	1.1525E+03
Average removed per time period	=	2.3049E+01
Number of removal episodes	=	30
Proportion of time removals are made	=	0.600
POPULATIONS DYNAMICS :		
Total length of simulation run	=	50
Mean population density	=	1.1091E+02
Number of dangerous episodes	=	25
Probability of danger (risk)	=	0.50

Table V

ADDITIONAL MANAGEMENT STRATEGIES FOR AUXIS. THE BOTTOM PANEL ILLUSTRATES A COMPLETELY MANUAL STRATEGY BASED ON ESTIMATED ABUNDANCES AND EXPLOITATION ONLY ABOVE CRITICAL LEVELS

STRATEGI PENGELOLAAN TAMBAHAN DARI AUXIS. PANEL YANG PALING BAWAH MENGGAMBARKAN STRATEGI PENGELOLAAN SECARA MANUAL BERDASARKAN PERKIRAM KELIMPOLIAN DAN EKSPLOITASI DIATAS TINGKAT KRITIS

MANAGEMENT STRATEGY 4 FOR AUXIS CPUE

REMOVAL STRATEGY :		
15.00% of organisms removed when population	>	7.5000E+01
Number of removed over 50 time periods	=	1.2343E+03
Average removed per time period	=	2.4686E+01
Number of removal episodes	=	30
Proportion of time removals are made	=	0.600
POPULATIONS DYNAMICS :		
Total length of simulation run	=	50
Mean population density	=	1.5555E+02
Number of dangerous episodes	=	22
Probability of danger (risk)	=	0.44

MANAGEMENT STRATEGY 5 FOR AUXIS CPUE

REMOVAL STRATEGY :		
10.00% of organisms removed when population	>	7.5000E+01
Number of removed over 50 time periods	=	7.7963E+02
Average removed per time period	=	1.5593E+01
Number of removal episodes	=	37
Proportion of time removals are made	=	0.740
POPULATIONS DYNAMICS :		
Total length of simulation run	=	50
Mean population density	=	1.5173E+02
Number of dangerous episodes	=	18
Probability of danger (risk)	=	0.36

MANUAL MANAGEMENT OF AUXIS CPUE

REMOVAL STRATEGY :		
Number of removed over 30 time periods	=	2.9552E+03
Average removed per time period	=	9.8507E+01
Number of removal episodes	=	15
Proportion of time removals are made	=	0.500
POPULATIONS DYNAMICS :		
Total length of simulation run	=	30
Mean population density	=	8.3080E+01
Number of dangerous episodes	=	18
Probability of danger (risk)	=	0.60

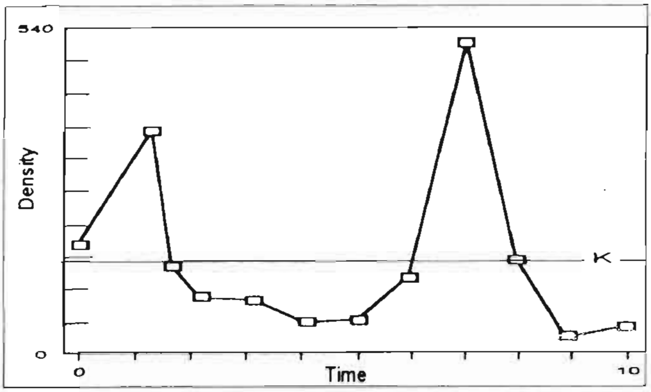


Figure 4

Results of a simulation run for the stochastic-simulation model of the Auxis data

Hasil dari simulasi untuk model simulasi stokastik dari data Auxis

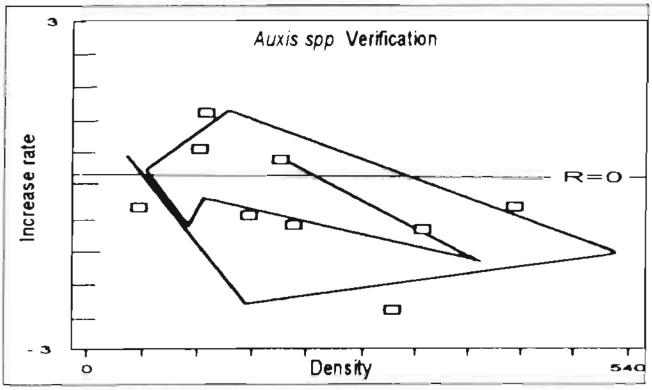


Figure 5

Auxis CPUE simulation model verification results

Hasil verifikasi model simulasi hasil tangkapan per unit upaya dari Auxis

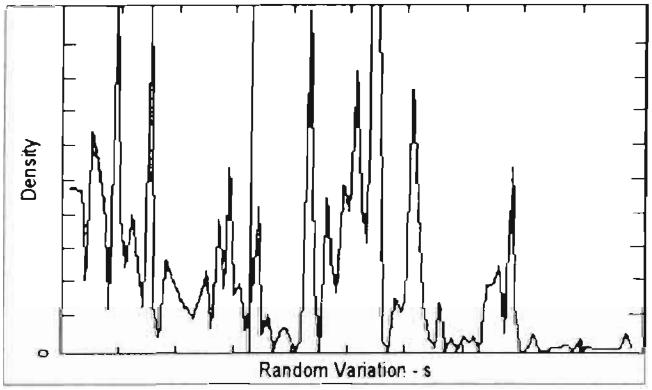


Figure 6

Results of sensitivity analysis of random variation (S) for the stochastic simulation model

Hasil analisis sensitiviti dari variasi acak (s) untuk model simulasi stokastik

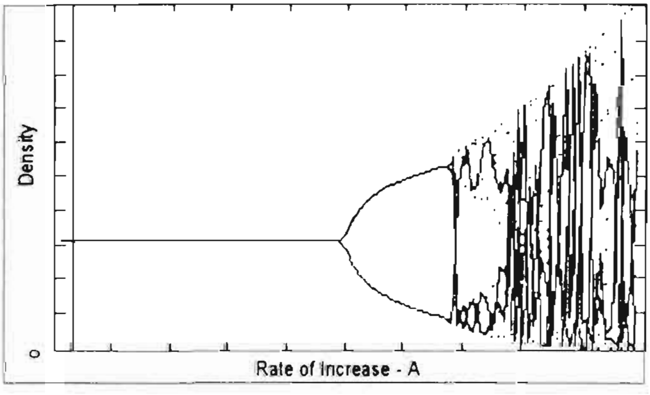


Figure 7

Results of sensitivity analysis for increments in the rate of increase parameter (A)

Hasil analisis peningkatan sensitiviti pada derajat penambahan parameter (A)

DISCUSSION

Although the available single time series of *Auxis* data is a very limited sample, it does provide some interesting tentative information on the status and problems of small coastal tuna species. The results from the analysis of this fishery clearly suggest that it is subject to relatively violent oscillations in abundance. Adaptive threshold management as outlined by Quinn *et al.* (1990) seems to be a rational way to manage fisheries of this nature. More specifically, it is suggested that accelerated efforts to develop valid indices of relative abundance for some early life history stages or stages be initiated for the major exploited small pelagic species in Indonesian waters. Clearly, small coastal pelagics are a management responsibility for the nation state within which they occur. Based on this limited analysis, the effective management of small coastal tunas should be based on a limiting or threshold biomass and as assessment of the predicted exploitable biomass prior to the commencement of the fishery to determine the likely biomass which can be harvested each year. This is expected to be highly variable with complete closures in some seasons. If the results of this analysis are indicative of results for other coastal species which have not yet been analyzed a similar management approach is suggested for them. Finally, it is suggested that the generalized logistic model described herein has considerable utility in the assessment of stocks of small coastal species.

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THE INFLUENCE OF ENVIRONMENT ON STOCK ASSESSMENT

An approach with surplus production models[1]

P. FREON

ABSTRACT

Conventional global production models are not suitable for some stocks because fishing effort variations only explain only a small part of the total variability of annual catches. Often the residual variability originates from the influence of environmental phenomena, which affects either the abundance or the catchability of a stock from one year to the next. Therefore an additional environmental variable has been inserted into conventional models in order to improve their accuracy. These variables appear in simple formulae regarding either the stock abundance (surplus production), or the catchability coefficient, or both. The models are developed from the Schaefer's linear production model, the Fox's exponential model or the Pella and Tomlinson generalized model.

CLIMPROD is an experimental expert-system, using artificial intelligence, which provides a statistical and graphical description of the data set and helps the user to select the model corresponding to his case according to objective criteria. The software fits the model to the data set using a non-linear regression routine, assesses the fit with parametric and non-parametric tests, and provides a graphical representation of the results.

1: This communication is mainly based on two papers : Fréon (1983) and Fréon et al. (1989). See bibliography for more details.

Limitations of this kind of model are considered. The models can provide a fairly good interpretation of the fishery history, particularly when a stock collapses unexpectedly without any appreciable increase in the nominal fishing effort. These models can also provide a useful tool for efficient management of a fishery in those instances where climatic phenomena can be forecast, or when their influence is restricted to the year(s) preceding exploitation.

Model surplus produksi yang konvensional adalah tidak cocok untuk mengkaji sedian ikan tertentu, dimana hal ini disebabkan karena variasi upaya penangkapan hanya diterangkan oleh sebagian kecil dari variability total dari hasil tangkapan tahunan. Seringkali "residual variability" berasal dari pengaruh fenomena lingkungan, yang mempengaruhi kelimpahan maupun "catchability" suatu sediaan dari satu tahun ke tahun berikutnya. Oleh sebab itu tambahan variable lingkungan dimasukan kedalam model konvensional untuk meningkatkan ketepatan model tersebut. Variable-variable tersebut ditampilkan dalam suatu rumus yang sederhana sehubungan dengan kelimpahan sediaan ataupun koefisien "catchability" atau kedua-duanya. Model model tersebut dikembangkan dari model produksi linier Schaefer, model eksponensial Fox ataupun model umum dari Pella dan Tomlinson.

CLIMPROD adalah percobaan "expert - system", dengan mempergunakan "artificial intelegence" yang menyediakan diskripsi statistik dan grafik dari satu set data dan membantu pengguna untuk memilih model menurut kasus yang ada sesuai dengan kriteria-kriteria yang diinginkan. Piranti lunak yang dibuat menyesuaikan model terhadap suatu set data dengan mempergunakan rutin regresi non linier, pengkajian kesesuaian dilakukakan dengan uji parametrik dan non parametrik, dan menyediakan representasi grafik dari pada hasil-hasil yang diperoleh.

Keterbatasan dari model-model tersebut seyogianya dipertimbangkan. Model-model tersebut dapat memberikan interprestasi yang cukup baik dari evolusi suatu perikanan, tertutama bila sediaan merosot drastis tanpa adanya peningkatan upaya penangkapan nominal. Model-model ini juga menyediakan cara-cara yang berguna untuk pengelolaan perikanan yang eficien bila fenomena iklim dapat diduga sebelumnya, atau bila pengaruh-pengaruh tersebut terbatas pada tahun sebelum eksploitasi.

INTRODUCTION

Conventional surplus production models for stock assessment use only one input variable i.e. fishing effort. From the initial linear "Schaefer" model (Graham, 1935; Schaefer, 1954), two other global models have been developed and widely used : the exponential model (Garrod, 1969; Fox, 1970) and the generalized production model (Pella and Tomlinson, 1969). They have been further developed and adapted in order to improve the fit of models to observed data, particularly for non-equilibrium conditions of fishery or for time lags in stock response (Schaefer, 1957; Gulland, 1969; Uhler, 1980). In these models, variability not linked to the fishery is considered as random noise, and some stochastic models use a random variable (Doubleday, 1976).

Although the relationships between environment variations and stock abundance or availability have been described (e.g. Saville, 1980; Le Guen et Chevallier, 1983; Sharp and

Csirke, 1983; Csirke and Sharp, 1983), I am not aware of any deterministic model using both fishing **E** and an environmental variable **V**. Such an approach was suggested by Dickie (1973) but, as far as I know, only Griffin *et al.* (1976) used an empirical relationship between shrimp yield **Y** on the one hand, fishing effort **E** and river out-flow **V** on the other :

$$\mathbf{Y = aV^b (1\text{-}c^E)}$$

where **a,b** and **c** are constant parameters.

This relationship is an increasing asymptotic function and is relevant only in a few special cases. However, theoretical bases for such models are available in various publications on terrestrial or aquatic ecology. Some authors have introduced hydro-climatic variables into structural production models (Nelson *et al., 1977*; Loucks and Sutcliffe, 1978 ; Parrish and Mac Call, 1978), but they all require detailed data on the life history as some complex simulation models do (Laevastu and Larkins, 1981).

This paper gives a theoretical basis for production models using an environmental variable as an independent variable in addition to fishing effort. The influence of environmental factors has been considered at two levels : on stock abundance and on stock catchability. For each case, the linear and exponential models (and sometimes the generalized model) are considered. Then the case of an influence on both abundance and catchability is considered.

Limitations and applications of this kind of model in transitional states (non-equilibrium conditions) are then considered. Implications for fisheries management are indicated, especially for unstable stocks, and the method and criteria of fitting, as the choice of the appropriate model, are described. The CLIMPROD software allowing to perform all these tasks and to overcome part of them is then presented.

1. HOW AN ENVIRONMENTAL VARIABLE ACTS UPON SURPLUS MODELS

1.1 Definitions

Let **V** be an environmental variable representing any factor likely to modify the fisheries catches. Common examples are temperature, salinity, wind speed, turbidity, strength or direction of currents, river out-flow, etc.

The conventional notation, mainly from Ricker (1975), used in this paper is as follow :

- B : instantaneous stock biomass
- Bi : mean annual biomass
- B∞: environmentally limited maximum biomass or "carrying capacity" (K of terrestrial ecological models)

- k : constant of the rate of population increase (r of terrestrial ecological models)
- t : time, conventionally in years
- F : fishing mortality
- q : catchability coefficient
- Ei : annual fishing effort during year i, standardized to be proportional to F : Fi=qiEi
- Yi : annual yield
- Ui : annual mean catch per unit of effort (or CPUE)
- Be, Ee, Ye and Ue : correspond respectively to B,E,Y, and U under equilibrium conditions
- Ymax : maximal sustainable yield
- Umax : optimal CPUE corresponding to Ymax
- fmax : optimal effort corresponding to Ymax
- e : base of natural logarithms

1.2 Background

The background and the way of introducing an environmental variable into models are presented for the linear model only. More details on other models are presented in an other publication (Fréon, 1988). Surplus-yield models are based on the logistic equation expressed in terms of relative rate of stock increase :

$$\frac{dB1}{dtB} = \frac{k(B\infty - B)}{B\infty} = k\left(1 \quad \frac{B}{B\infty}\right) \qquad (1)$$

Various authors (synthesis in Mac Call (1984)), working on terrestrial ecology, studied the effects of habitat modification (in time or space) on this relationship. Habitat modification can theoretically be introduced into equation (1) in three different ways : effect on **B∞** only, effect on **k** only, or effect on both **B∞** and **k**. After analyzing all these cases, Mac Call (1984) concludes that the latter one is the most convenient, specially using the solution of a constant slope for equation (1):

$$\frac{dB1}{dtB} = k - hB \qquad (2)$$

where **k** keeps the same meaning and **h** is the slope of the relative rate of population increase. This means that : **h** = **k/B∞** = constant, and so far **h** corresponds to $\mathbf{k_1}$ from Schaefer (1954), who also considered it as a constant.

Expressing absolute rate of the exploited stock increase as a function of environmental capacity and fishing mortality rate **qE** leads to the conventional equation of the Schaefer's model :

$$\frac{dB}{dt} = kB - hB^2 - qEB = hB\,(B\infty - B) - qEB \qquad (3)$$

1.3 Introducing an environmental variable

Using this formulation environmental factors may interact at only two levels : with **q** if catchability changes or with the pair of variables **k-B∞** (the ratio of these two variables being constant) if natural variations of abundance are considered. In the latter case, to make the presentation easier, I chose only formulae in which **B∞** and **h** appear and allowed **B∞** to change according to the environment. However, it should be noted that any variation of **B** corresponds to a symmetrical variation in **k**. Moreover, **B∞**, in production model mathematical formulations, cannot simply be interpreted as the carrying capacity for the recruited stock. Growing evidences (i.e. Sharp, 1980) indicate that the temporal and spatial processes affecting the eggs and larvae dispersal may well dominate the density-dependent energetic/ trophic processes in the limitation of the cohort biomass before recruitment. In such cases adult stocks will not necessary fill the carrying capacity of their environment.

Let **g(V)** and **y(V)** be the functions representing fluctuations of respectively **B∞** due to environmental factors, and **q**. Schaefer's model assumes that, under equilibrium conditions, the rate of population increase is zero, which can be obtained from (3) if :

$$Be = B\infty - qE/h = g(V) - y(V)\,E/h \qquad (4)$$

such that :

$$Ue = qBe = qB\infty - q^2 E/h = y(V)\,g(V) - y^2(V)\,E/h \qquad (5)$$

$$Ye = EUe = qB\infty E - q^2 E^2/h = y(V)\,g(V)E - y^2(V)\,E^2/h \qquad (6)$$

E_{max} will be the value of **E** obtained by cancelling out the derivative of equation (6) such that:

$$E_{max} = B\infty\, h/2q = g(V)h \,/\, 2y(V) \qquad (7)$$

1.4 Functions g(V) and y(V)

The real mathematical functions **g(V)** or **y(V),** linking a climatic variable with respectively **B∞** or **q**, are generally unknown. So far a very flexible function has been used such as :

$$g(V) \text{ or } y(V) = a+bV^{c} \qquad (8)$$

which will be used only as a general tool leading to the four particular cases where :

$\alpha = 0;\ \beta = 0$ and $\lambda = 1$	or: βV	(8.I)
$\alpha = 0;\ \beta = 1;\ \lambda = 0$ and $\lambda = 1$	or: V^{λ}	(8.II)
$\alpha = 0;\ \beta = 0$ and $\lambda = 1$	or: $\alpha + \beta V$	(8.III)
$\alpha = 0;\beta = 0$ and $\lambda = 1$	or: βV^{λ}	(8.IV)

Functions (8.I) and (8.II) are justified in particular cases where a constant is fortunately not required. The last function (8.IV) is still very flexible : if we are just interested in situations where **g(V)** or **(V)** are positive and monotonic functions it covers a large number of situations. Mac Call (*in* : Fox, 1974) used it to describe the relationship between **q** and **B∞**.

In the case where **g(V)** is non-monotone but is a shaped function, other equations must be used as for example the parabolic one used in this work :

$$g(V) \text{ or } y(V) = aV - bV^{2} \qquad (9)$$

The value of parameters α, β and λ (or the value of global parameters **a**, **b**, **c**, or **d** obtained after restructuring the equations) will be estimated by fitting the model to the data using a regression technique. Models with more than four parameters will not be retained because they could reduce the degrees of freedom too much, owing to the usually short length of the data series.

1.5 Final models

Following the line presented above for linear or exponential model leads to several equations corresponding to the case of an environment influence on the stock abundance (fig. 1), catchability (fig. 2) or both (fig. 3 and 4, Appendix 1).

Numerous hypothesized examples about an environmental influence or abundance, through recruitment and/or population growth, can be found in the literature, such as : influence of upwelling strength, relationship between stock production and rivers discharges, influence of temperature during a critical stage, etc. (tab. I). Schematically four periods or critical stages have been identified :

- Before spawning by influencing the fecundity of the parent stock;
- During early life stages by influencing the fecundation and/or the natural mortality of eggs and larvae;

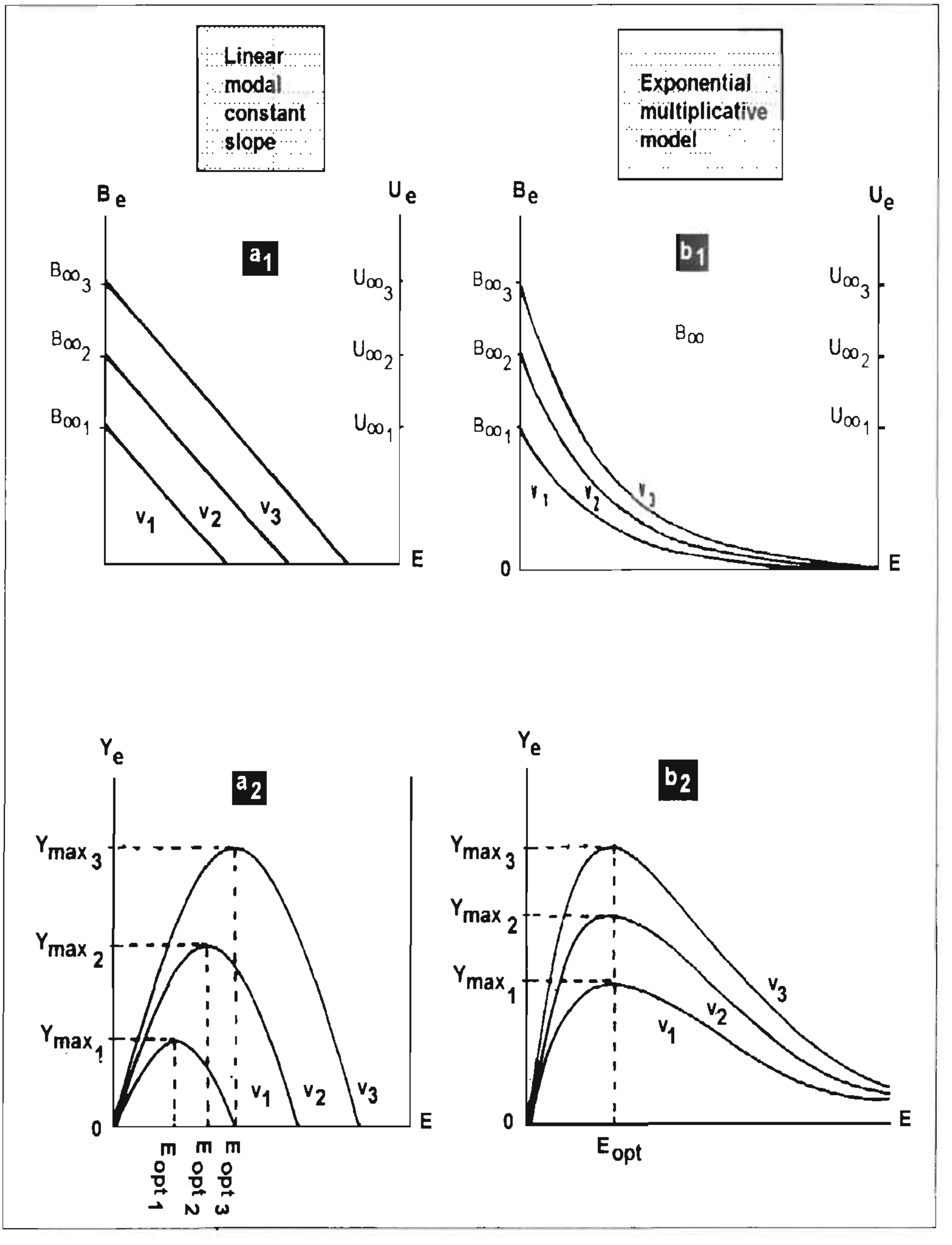
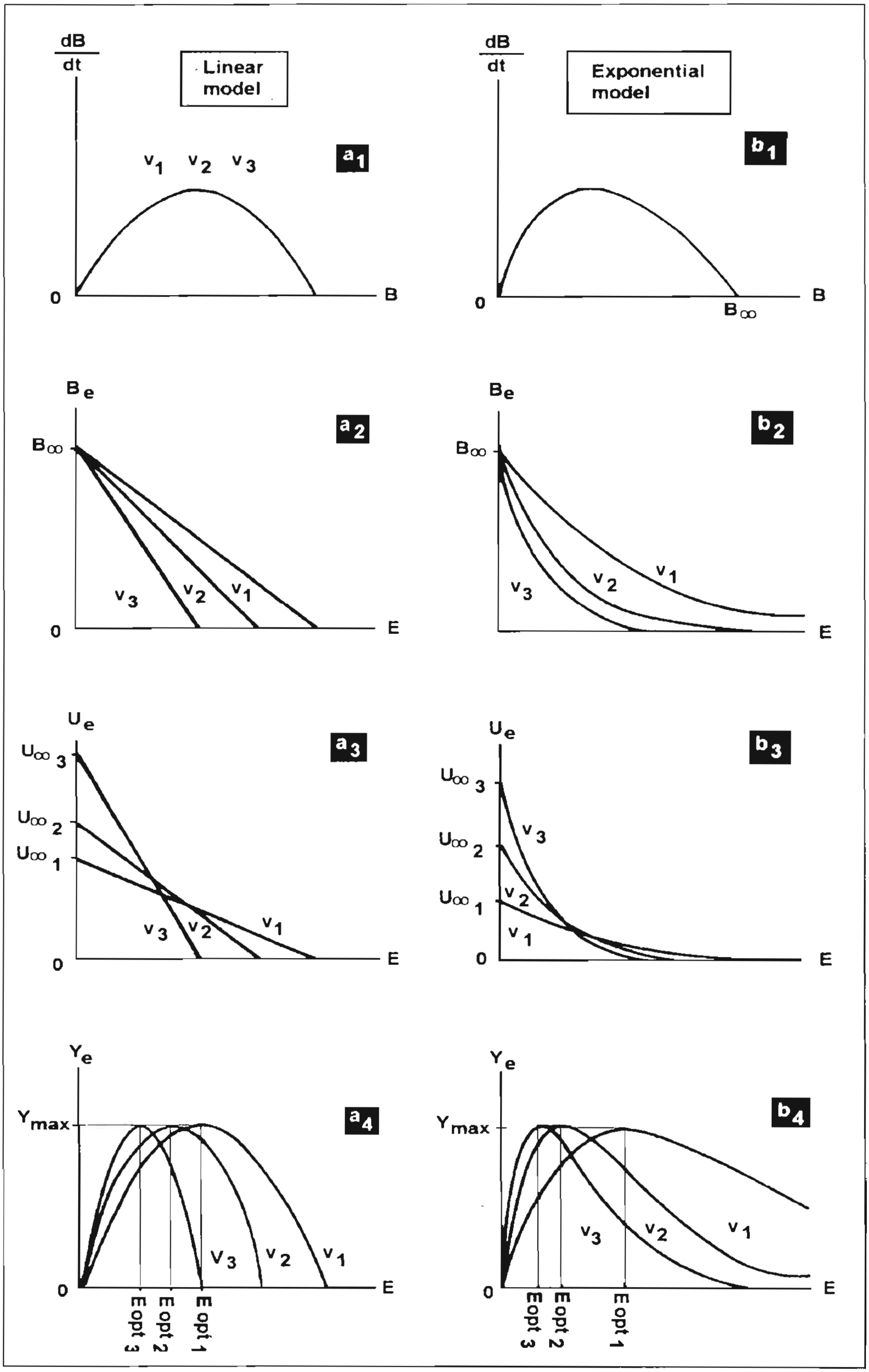


Figure 1

LINEAR PRODUCTION MODEL (FIG. A1, A2) AND EXPONENTIAL MULTIPLICATIVE MODEL (FIG. B1, B2) WHERE AN ENVIRONMENTAL VARIABLE V INFLUENCES THE ABUNDANCE ($B_\infty = g(V)$) ACCORDING TO THREE DIFFERENT VALUES (V_1, V_2, V_3)

MODEL PRODUKSI LINIER (GAMBAR A1 DAN A2) DAN MODEL EKSPONENSIAL MULTIPLIKATIF (GAMBAR B1 DAN B2) DIMANA PEUBAH LINGKUNGAN V MEMPENGARUHI KELIMPAHAN ($B_\infty = g(V)$ BERDASARKAN TIGA NILAI YANG BERBEDA (V_1, V_2, V_3)



Linear model
Exponential model
a1
b1
a2
b2
a3
b3
a4
b4
dB/dt
B
B∞
Be
E
Ue
U∞ 3
U∞ 2
U∞ 1
Ye
Ymax
v1
v2
v3
0
E opt 3
E opt 2
E opt 1

Figure 2 *(left page)*

LINEAR PRODUCTION MODEL (FIG. A1,...A4) AND EXPONENTIAL PRODUCTION MODEL (FIG. B1, ...B4) WHERE AN ENVIRONMENTAL VARIABLE V INFLUENCES THE CATCHABILITY ACCORDING TO THREE DIFFERENT VALUES (V_1, V_2, V_3)

MODEL PRODUKSI LINEER (GAMBAR A1 ..... A4) DAN MODEL EKSPONENSIAL (GAMBAR B1 .... B4) DIMANA PEUBAH LINGKUNGAN V MEMPENGARUHI CATCHABILITY BERDASARKAN TIGA NILAI YANG BERBEDA (V_1, V_2, V_3)

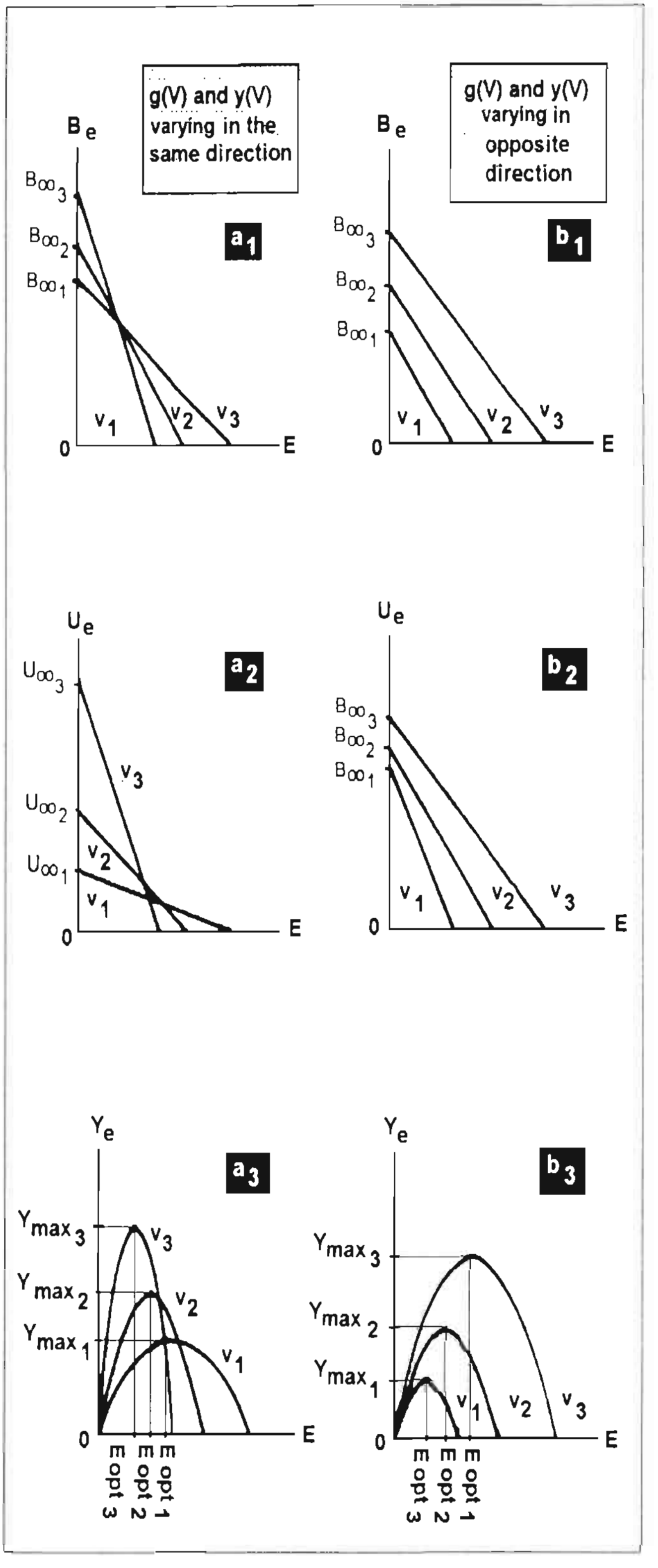


Figure 3

LINEAR PRODUCTION MODEL FOR THREE VALUES (V_1, V_2, V_3) OF AN ENVIRONMENTAL VARIABLE V INFLUENCING BOTH THE STOCK ABUNDANCE ($B\infty = g(V)$) AND THE CATCHABILITY ($q = y(V)$), WHEN G(V) AND Y(V) VARY IN THE SAME DIRECTION (FIG. A1, A2, A3) OR IN OPPOSITE DIRECTIONS (FIG. B1, B2, B3)

MODEL PRODUKSI LINEER UNTUK TIGA NILAI (V_1, V_2, V_3) DARI PEUBAH LINGKUNGAN V YANG MEMPENGARUHI KELIMPAHAN SEDIAAN ($B\infty = g(V)$ DAN CATCHABILITY ($q = y(V)$), BILA G(V) DAN Y(V) BERFARUASI DALAM ARAH YANG SAMA (GAMBAR A1, A2 DAN A3) ATAU DALAM ARAH YANG BERLAWANAN (GAMBAR B1, B2 DAN B3)

Table 1

ENVIRONMENTAL EFFECTS ON PRODUCTION MODELS; KEY VARIABLES, BIOLOGICAL MECHANISM INVOLVED, TIME WINDOW OF THE EFFECT, LAG ON PRODUCTION, TYPE OF EFFECT AND ITS SIGN

PENGARUH LINGKUNGAN PADA MODEL PRODUKSI; VARIABLE KUNCI; MEKANISME BIOLOGI SKALA, WAKTU PERBEDAAN PRODUKSI, JENIS PENGARAN DAN TANDANYA

ENVIRONMENTAL MECHANISM	VARIABLE	BIOLOGICAL MECHANISM	TIME WINDOW	LAG PROD.	EFFECT	EFF. SIGN
Increase of primary production by upwelling	Wind speed or Ekman transport or SST	Fecundity	Season	Years	Abundance	+
"	"	Natural mortality (any stage)	Season or year	Years	Abundance	+
"	"	Growth	Season or year	Years	Abundance	+
"	"	Migration pattern	Season	Month	Catchability	+
"	"	Aggregation level	Season	No lag or days	Catchability	+ or -
Current increase (upwelling or other)	Ekman transport or current data	Larval advection	Month	Years	Abundance	-
Water column turbulency	Wind speed[3]	Difficulty of larval alimentation	Month	Years	Abundance	-
Sea temperature anomalies (not linked to upwelling)	SST or water column T or thermocline depth	Physical effect on eggs and larvae survival	Month	Years	Abundance	+ or -
"	"	Change in biotope	Year	Years	Abundance	+ or -
"	"	Change in vertical distribution or aggregation	Season or year	No lag or days	Catchability	+ or -
Increase of primary production by rivers discharge	River flow or level near mouth or plume extension (satellite obs.) or rainfall	Fecundity (any stage)	Season or year	Years	Abundance	+
"	"	Natural mortality (any stage)	Season or year	Years	Abundance	+
"	"	Growth	Season or year	Years	Abundance	+
Physical water mass changes in relation to rivers discharge	" or salinity or turbidity	Spatial distribution or aggregation level	Season or year	No lag or days	Catchability	+ or -

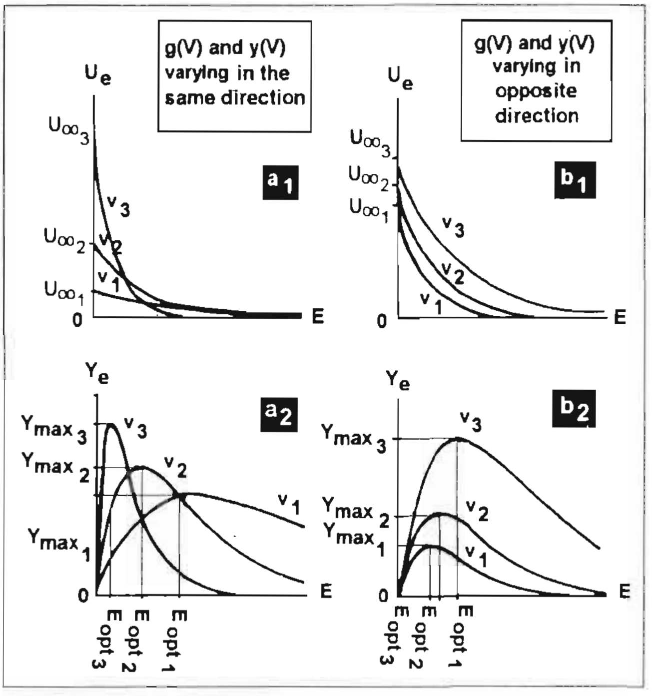


Figure 4

Linear production model for three values (V_1, V_2, V_3) of an environmental variable V influencing both the stock abundance (B_∞ = g(V)) and the catchability (q = y(V)), when g(V) and y(V) vary in the same direction (fig. a1, a2) or in opposite directions (fig. b1, b2)

Model produksi linier untuk tiga nilai (V_1, V_2, V_3) dari peubah lingkungan V yang mempengaruhi kelimpahan sediaan (B_∞ = g(V) dan catchability (q = y(V)), bila g(V) dan y(V) berfariasi dalam arah yang sama (gambar a1, a2) atau dalam arah yang berlawanan (gambar b1, b2)

- During the period of high growth rate (usually corresponding to the pre-recruitment stage) when the environment influences the individual growth and/or the natural mortality;
- During the post-recruitment, if the natural mortality and/or condition factor (and secondarily the growth rate) are concerned at this stage.

These four cases are not mutually exclusive, of course, and in some cases it is difficult to identify at which stage the environmental influence is the greatest. Nevertheless, stages 1 to 3 (especially stage 2) are usually known as the most important ones in terms of natural abundance variability, meanwhile stage 4 is generally concerned with fishing mortality variation in relation with environmental changes.

The catchability coefficient **q** may be linked to the environmental conditions through any of its two components : accessibility or vulnerability. For instance, water mass movements can modify the migrations pattern and are therefore linked to the accessibility especially in the case of short-range fleets. Water turbidity can increase either the vulnerability of the fish to some type of gear (gill-nets, trawls) or decrease it (light fishing). The case where **q** changes according to stock abundance has been already investigated by Fox (1974).

In some cases, it is reasonable to postulate that the environment influences both stock abundance and catchability. In such cases **q** and **B∞** will be replaced by functions of **V** (Appendix 1; fig. 3 and 4). I have examined only the simple case where both **g(V)** and **y(V)** are described by the function (8.IV), in order to limit the number of parameters. This is acceptable because this function is very flexible but theoretically nothing allows us to suppose that **g(V)** and **y(V)** would be identical. Moreover, the past-effort-averaging approach used for estimating model parameters in the case of transitional state allows to use these models only in particular cases (see below).

2. USING THE MODELS WITH TRANSITIONAL STATE DATA

2.1 General presentation

The preceding equations are based upon a stock in equilibrium state at various stable levels of fishing effort and environmental conditions. The "transition prediction approach" was adopted for a model to fit the observed data. It consists in adjusting the data of fishing effort and environment so as to estimate an equilibrium state. Fox (1974) modified it by using a weighted average of the effort series instead of the simple average initially proposed by Gulland (1969). The same approach can be used for the environmental variable (see Fréon, 1988 for further details).

This approach is easy to use but the problem of the artifact caused by the non-independence of the data series concerning fishing effort and CPUE is to be faced (Roff and Fairbairn, 1980). This approach is neither precise when **g(V)** and/or **y(V)** are linear functions nor acceptable in the case of non-monotonic functions when the inter-annual variation of **V** is large and when, for certain years, the mean value of **V** results from values located on each side of the optimum value. Nevertheless, I propose to adapt it to the environmental production models for pragmatic reasons. It is recognized that the transition prediction approach can lead to some bias or errors about the parameter estimations, as emphasized by Walter (1975), Schnute (1977), Uhler (1980) and Hilborn and Walters (1992). However, Uhler (1980) shows that the best statistical estimations of the parameters do not necessarily provide the best estimations of **Ymax** and **fmax** which are the main objectives of the global production models.

2.2 Transitional states and environmental influence

Concerning the environmental variable, the use of the transition prediction approach assumes that the life stage during which the environment acts upon the stock is already known. The shorter the life span is (or at least the fishable life span) the better the transition prediction approach will be. In such cases it is easier to determine and to quantify the environmental effect on catchability or on abundance. In the latter case, the most favorable situations are provided by a rapid action of the environment on a life stage or by slow fluctuations of environment (auto-correlated data series). In order to make the presentation easier the inter-annual environment fluctuations may be considered as cyclic with a "period" **T**. However, in most cases, the reality is no more than an alternation between positive and negative climatic anomalies, not necessarily of same duration. In the special cases where the environmental fluctuations would be truly periodical, the resonant frequencies of the ecosystem could be observed as noted by Silvert (1983).

If the fishery data series have a negligible duration compared to **T** (century scale for example) it will be difficult to quantify an eventual environmental influence such as suggested by the results of Soutar and Isaacs (1974). Stochastic production models using a periodical function can also be used in such a case (Steele and Henderson, 1984). When the extent of the fishery data series is shorter than **T** but greater than **T/4** a model can be attempted if, by chance, the whole data series is located on a single side (increasing or decreasing) of the "periodical function T". But in this limited case, any extrapolation of the result would be hazardous.

If the duration of the critical stage **p** is greater than or equal to **T**, it will be very difficult to identify the environmental effects because they will be smoothed for each cohort. The most favorable conditions for using these models occur when **p** is shorter than **T**, and especially when shorter than **T/2**, and when the fishable life span **n** is also shorter than **T/2**. In such cases, the mixture of various cohorts in annual catches will produce a minimal smoothing of global yields.

3. IMPLICATIONS FOR FISHERIES MANAGEMENT

3.1 Influence of the environment on abundance

We have seen that, in some cases, the environmental effect on stock abundance is more than "white noise" and therefore it is possible to modulate the fishing effort according to abundance predictions.

In situations where the forecasting of abundance is reliable (delay of climatic influence or remote connections) the difficulty of management will result from its dual objective: on one hand, optimization of the yield by increasing effort when the abundance increases, on the other hand, protection of the stock against a collapse by quickly

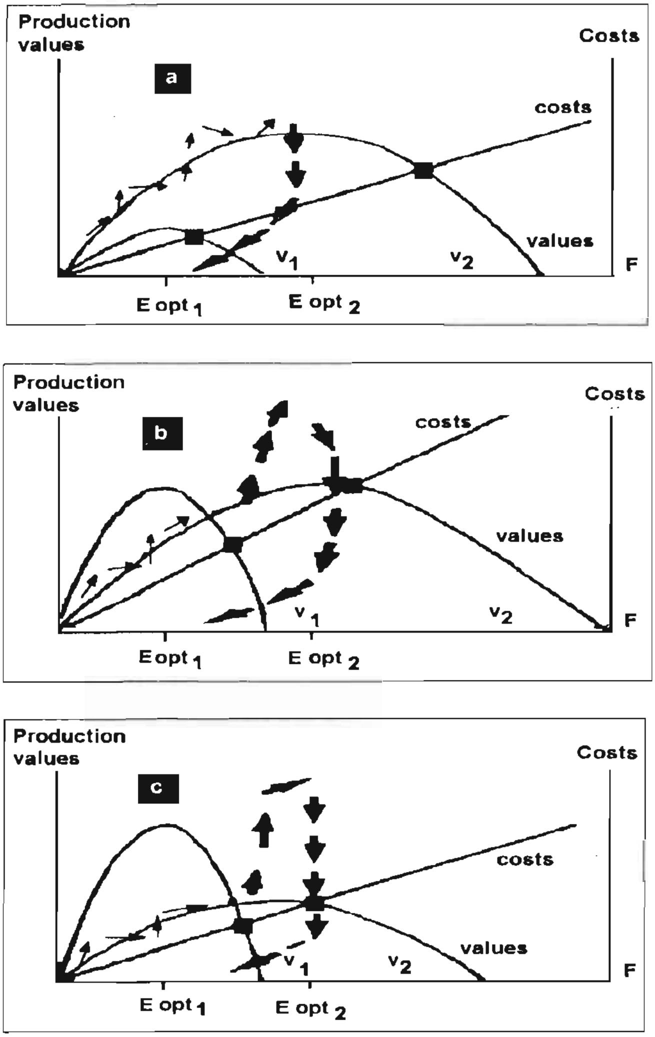


Figure 5

BIO-ECONOMICAL PRODUCTION MODELS AND THEORETICAL EXAMPLES OF STOCK COLLAPSES WHEN THE ENVIRONMENT INFLUENCES THE STOCK ABUNDANCE (FIG. A), THE CATCHABILITY (FIG. B) OR BOTH THOSE TWO FACTORS IN THE SAME DIRECTION (FIG. C) ACCORDINGTO TWO VALUES (V_1 AND V_2) OF THE ENVIRONMENTAL VARIABLE V

MODEL PRODUKSI BIO-EKONOMI DAN CONTOH TEORITIS DARI SEDIAAN YANG MENURUN DRASTIS BILA LINGKUNGAN MEMPENGARUHI KELIMPAHAN SEDIAAN (GAMBAR A), CATCHABILITY (GAMBAR B) ATAU KEDUA FAKTOR TERSEBUT DALAM ARAH YANG SAMA (GAMBAR C), MENURUT DUA NILAI (V_1 DAN V_2) DARI PEUBAH LINGKUNGAN V

———— *theoretical curves (V_1 and V_2)*
— — — → *observed values under V_2*
▬ ▬ ▬ → *observed values under V_1*
■ *threshold of probability*

reducing the fishing effort when the environmental factors are unfavorable. Such a collapse can, in fact, happen rapidly without any increase of effort if an "optimal" effort is maintained, which no longer corresponds to the actual climatic situation (fig. 5a). The collapse will occur more rapidly when there are few exploited cohorts acting as a buffer and when the critical life stage lasts less than a year (Fréon, 1983 and 1984). This permanent adjustment of the fishing effort is not easy to apply because of a delay between profits and investments. An analysis of this problem is available (Csirke and Sharp, 1983). Fishery management can be based on variable yearly quotas or on variable maximum allowable efforts.

3.2 Influence of the environment on catchability

Here the main risk of collapse occurs when from unfavorable climatic conditions to favorable ones. Following the usual bio-economic model (Troadec, 1982) the first situation will lead after a few years to an increase of the fishing effort providing catches closed to **Ymax** (fig. 5b). When catchability then suddenly increases the yields may increase too and the non-equilibrium state of the fishery will result in its collapse. In such a case the proper management decision is to fix a single quota, generally easier to determine and to control than variable effort limitations.

3.3 Influence of environment on both abundance and catchability

Depending on whether the environment influences **B∞** and **q** in the same direction or in opposite directions the resulting figures will be completely different (fig. 3a and 3b). Only two extreme cases will be analyzed here, but there are numerous intermediate situations.

In the first case, where **g(V)** and **y(V)** have the same sign of variation, a sudden occurrence of an unfavorable environment relative to abundance is not dangerous because the catchability would then be low. On the other hand, when the environmental conditions are both favorable to abundance and to catchability, and if there is no regulation mechanism provided by a market saturation or by a price adjustment, the fishing effort will tend to exceed **Emax** (fig. 5c). A strong limitation is then necessary.

In the second case, when a high abundance is associated with a low catchability, the main risk of collapse occurs when bad climatic conditions follow good ones. This situation is comparable to the one described above in the case of an influence of the environment on the abundance only (fig. 5a).

4. METHOD AND CRITERIA OF FITTING

Most of these models require non-linear regressions for fitting as, for example, those based on Marquardt's (1963) algorithm, on Gauss-Newton's modified method (Dixon and Brown, 1979) or on Simplex method (Nelder and Mead, 1965). These methods are iterative and used the least-square criterion. Fitting can be done by using formulae of CPUE (**Ui**) or catches (**Yi**). This last solution makes the fit more difficult but theoretically avoids the bias on regression coefficients due to non-independence of **Ei** and **Ui** (provided that **fi** and **Yi** have been estimated independently).

Some modifications of the procedure can be made by weighting the residuals. Fox (1971) analyzed this problem and retained the solution considering the error proportional to the estimated catches **Yi**, leading to a minimization of function **S** :

$$S = \sum_{i=1}^{n} [(Yi-Yi) / Yi]^2 \qquad (9)$$

All the algorithms need estimated starting values of the parameters for initializing the iterative process. In order to avoid convergencies toward local minima or toward irrational solutions from a biological point of view, those starting values must be carefully estimated . This can be done by using the initial model formulation where $B\infty$ or $U\infty$ appear. Their values can be estimated by doubling the maximum catch (or CPUE) observed in the data series. Exponents of **g(V)** and **y(V)** function can be initialized as 1 or zero.

A non-parametric estimation of the fit can be obtained using jackknife or cross-validation methods (Ducan, 1978; Efron and Gong, 1983). These methods show the stability of the model when one year observation is removed from the data series. It is interesting to notice that, in some cases, all the parameter values change while the fitting remains more or less the same inside the range of observed data but the curves are divergent outside this range. This indicates the risk in using such models outside the range of observed data on fishing effort and environmental factors. On some occasions it seems preferable to fix a "reasonable" value to one of the parameters, as already mentioned by Pella and Tomlinson (1969) in their generalized model.

5. CHOICE OF THE APPROPRIATE MODEL

Owing to the generally low number of yearly observations and to the relatively high number of parameters to estimate, the models present few degrees of freedom. Consequently the choice of the appropriate model among the numerous presented here must not be reasonably based on the criterion of the best fit. Additional information independent from the catch and effort statistical series must be taken into account in order to avoid spurious correlations.

Two categories of objective criteria can be identified and are briefly presented here. First, it must be decided if environment influences stock abundance or catchability. The choice of models where both phenomena are considered must be supported by some observations instead of being an opportunist choice. Time-series analysis, using a short time interval, may allow to distinguish between a contemporaneous effect of environment on catchability, and a delayed one on abundance (in this last case the lag can be estimated). In order to remove the seasonal effects and to determine the critical stage, transfer functions between CPUE and environment can be performed. Fishermen interview may also be useful in those instances where large inter-annual variations of environment allow to detect a long term effect despite a seasonal one.

The second step is then to decide whether a linear or an exponential model must be used. If the stock has never been over-exploited when considering any "maximal fishing efforts", the three kinds of models provide similar fits. However, the curves are divergent over those maximal efforts and it is preferable to give a representative trend, though any model should not be used for predicting situations outside the range of observed data.

An additional information on the stock structure may help to choose between a pessimistic linear model and an exponential one which allows a slow decline toward the stock collapse. Qualitative data on the stock history can directly provide a decisive information when collapses have already been reported. Linear models are suitable for short-lived species when all year-classes are exploited. Subdivision into sub-stocks, natural reserves where fishing is impossible or high gear selectivity on adults would incite to use exponential models. The expert-system CLIMPROD optimizes the choice according to such information.

6. CLIMPROD SOFTWARE

6.1 General presentation

CLIMPROD is based on an experience in artificial intelligence for choosing the best adapted model to each situation and for assessing the fit according to the data series and to the background on the stock. It is designed as an expert-system. Its conception was aided by FAO grants.

The software is written for PC/XT/AT compatible micro-computers using MS-DOS version 3.0 (at least). It is fully interactive and has two main objectives : first a normal data management function, whose statistical and graphical utilities use TURBO C language; second a guided selection of the appropriate model showing the information path. This part of the model uses an inference engine written in TURBO PROLOG. It applies about one hundred rules which are interactive with the informations provided by :

- Questions to the user on the stock, independently from the set of data (for example : the species life span)
- Statistics on the set of data (for example : the ratio of effort range on minimum effort value)
- Graphic deduction from the set of data (for example : does this time series look unstable ? Is there a decreasing relationship on this plot ?)
- Answering "I don't know" is allowed. The program is structured and does not necessarily use the whole set of questions. An example of order in the application of the rules is presented in figure 6.

From the main menu, the user is allowed to open or select a data file, to update it with a full screen editor, to search for the most suitable model, or to choose one directly, to validate the model (assess the fit), to plot the model function, predicted values and residuals, to see the path of the expert decisions and finally to use the model for prediction.

It should be noted that in order to choose among 30 multivariate models (see appendix 1), the program first performs a regression using the CPUE as the dependent variable and the effort (or the environment in some cases) as the independent variable. From the graphic display of the residuals of this regression versus the environmental variable the user may determine which kind of relationships will link environment and CPUE in the final multivariate model. This procedure provides an easy interpretation and visualization of the process to choose the model and allows an interactive dialogue with the user who can make use of additional information. Nevertheless, recent statistical techniques of optimal transformation for multiple regression (Breiman and Friedman, 1985; Cury and Roy, 1989) could be more powerful and optimal for choosing the model from a strictly statistical point of view. As this technique only uses the multi-variate time series (which is often too short for its optimal use) it should be a useful complementary help in the model selection.

6.2 Data entry and update

The basic data set used by CLIMPROD includes time series of catch (**Y**), fishing effort (**E**), CPUE (**U=Y/E**) and an environmental variable (**V**). A full screen editor allows for data entry, correction and updating.

6.3 Monovariate statistics and graphs of raw data

The following statistics are computed for each variable : sample size, average, variance, standard deviation, coefficient of variation, coefficient of skewness and kurtosis, minimum and maximum values, range, median. The data distribution is shown on a frequency histogram allowing eventual outlier values to be detected. Although no fishery data could be used if normality was strictly required for modeling, this results may give an idea of the data-structure. CLIMPROD stops the analysis and/or displays advice or warnings, according to the distribution of the values in the different variables, or if the range/minimum ratio of the effort values is lower than 40%.

6.4 Examination of time-series

Each variable is plotted against time (years) in order to detect any strong instability in the series which would sometimes hinder the interpretation of the results. In the case of strong instability of **E** or **V** for instance, if the retained model requires an averaging one of these variables over several years to approximate an equilibrium state, the results will be of little value.

6.5 Bivariate graphics

The following relations are plotted : **Y** versus **E**, **Y** versus **V**, **U versus E**, **U** versus **V** and **V** versus **E**. These graphs reveal any outlier points which can structure the data-set or any strong relationship (linear or not) between the two independent variables **E** and **V**. It must be underlined that at present the program does consider potential lag-effects between variables at this graphical stage.

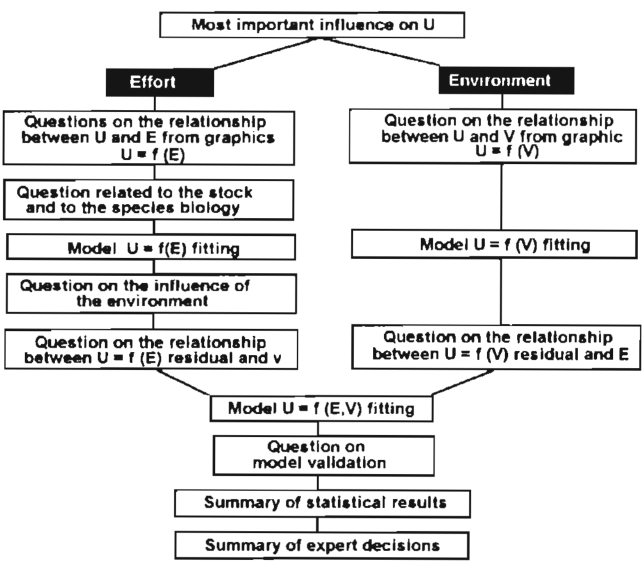


Figure 6

PARTIAL AND SIMPLIFIED FLOW DIAGRAM OF CLIMPROD, WHERE U IS THE CPUE, E THE FISHING EFFORT AND V AN ENVIRONMENTAL VARIABLE

SKHEMA CLIMPROD YANG DISEDERHANAKAN, DIMANA U ADALAH UPAYA PER UNIT PENANGKAPAN, E UPAYA PENANGKAPAN DAN V PEUBAH LINGKUNGAN

6.6 Questions guiding the choice of model

Four questions on basic assumptions of surplus production models are systematically asked, and the program is stopped if these assumptions are not met. The following questions are also systematically asked :

- Do you think that the effort influence on CPUE is more important than the environmental one (if unknown, yes is assumed) ? The answer, guided by statistical and graphical help, first orients the program either to **U=f(E)** or to **U=f(V)** models;

- Does the environment influence the abundance, the catchability or both ? At this moment the program does not provide any help for answering this question. It is supposed that the user knows the mechanism of action of the environment on the stock.

Between these two questions, the program will ask one or several questions in order to determine which relationship is more suitable between **U** and **E** (Schaefer's linear model, Fox and Garrod's exponential model or Pella and Tomlinson's generalized model), and between **U** and **V** (linear, exponential, general or quadratic).

6.7 Model fitting

In case of non-equilibrium conditions (transitional cases) a weighted average of **E** and/ or **V** is computed. In case of delayed influence of the environment on abundance a lag is inserted between the weighted average of **V** and **U** (see Fréon, 1988, for further details). The Marquardt's algorithm is used for least-square estimation of non linear parameters. According to the model the initial values of the parameter are 1,0 or computed from the original data set before running the algorithm. As first result, the percentage of variation explained by the model ($\mathbf{R^2}$) is given. The following steps depend on the quality of the fit, that is :

- After the step of bivariate model estimation, if $\mathbf{R^2}$<40%, the program stops or invites the user to give new answers to the previously unanswered questions. If $\mathbf{R^2}$>90% a validation of the bivariate model can be tried. If 40<$\mathbf{R^2}$<90%, the program will try to find a multivariate **U=f(E,V)** model providing a better correlation than the bivariate one;

- After a multivariate model estimation, a validation attempt is possible if $\mathbf{R^2}$>70%.

6.8 Statistical test of robustness (validation)

The fit assessment is mainly based on a jackknife estimation of the parameters and of $\mathbf{R^2}$. It also takes into account the residual analysis and the data set characteristics. From the graphical presentation of the predicted values of the model and of its residuals, the user's own opinion is finally required.

6.9 Summary of expert decision

At the end of every step of the main menu the user may display the path followed by the program at each level of decision with the corresponding rule number.

7. EXAMPLE

An example of application is presented in figures 7 and 8 which corresponds to the Senegalese sardine fishery (Fréon, 1983; 1988). A tentative new abundance index has been used, i.e., the mean annual weight per set when a single successful set is performed per trip (Fréon, 1989). The environmental variable influencing the stock abundance is the mean wind speed during the upwelling season.

According to stock and species knowledge, CLIMPROD first chooses to fit the exponential model for the function **U=f(E)** and find R^2= 86%. The relationship between the residuals of this model and **V** is linear (fig. 7). Therefore the linear-exponential model is fitted and provides an R^2 value equal to 95% (fig. 8) The jack-knife validation indicates that all parameters are significant at a 5% level and that no single year contributes to more than 35% of any coefficient estimation which is relatively satisfactory. The residuals of the model are not auto-correlated.

8. DISCUSSION

Although the results obtained on the Senegalese stock seem satisfactory, further studies are necessary before accepting the catch per set as a representative index of abundance. Therefore this particular example -given only as an illustration of the program capabilities- will not be further discussed here. Of greatest interest is the discussion on improvements, limitations and risks brought by the expert-system approach.

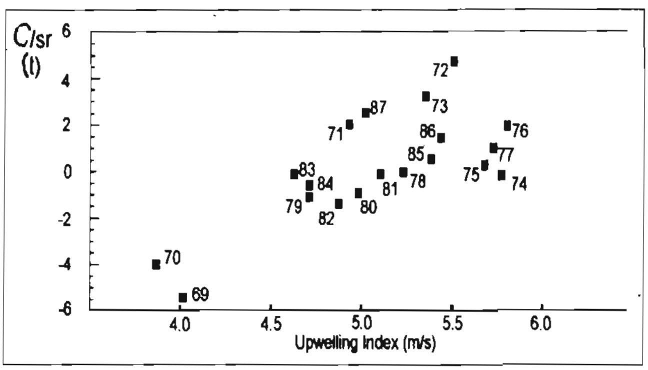


Figure 7

Coded scatterplot between upwelling index (two years weighted average of wind speed during the upwelling season) and the catch per set residuals (C/sr from a conventional surplus production model; see text); numbers represent years

Diagram pencar antara indeks upwelling (rata-rata tertimbang kecepatan angin selama musim upwelling selama dua tahun) dan hasil tangkapan setiap "set residuals" (C/sr dari model produksi konvensional, lihat teks); nomor adalah tahun

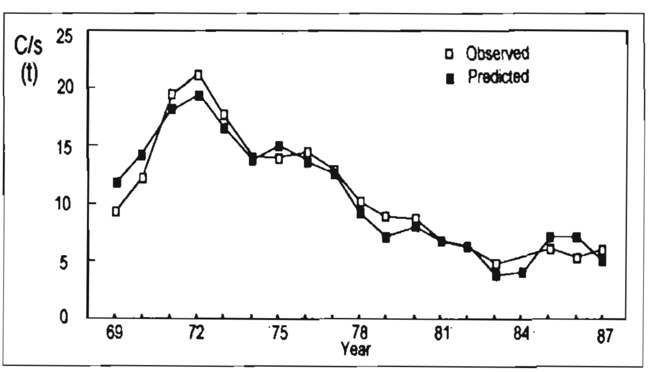


Figure 8

Predicted and observed catches per set (C/s) when introducing an environmental variable in surplus production model

Hasil tangkapan berdasarkan pengamatan dan dugaan setiap set dengan memasukan peubah lingkungan kedalam model surplus produksi

The introduction of an environmental variable into global production models increases in the number of parameters in the final formulation and consequently there are four main difficulties:

- Although fitting is easier, confidence limits of the parameters are often high and the fitting procedure may be unstable.
- It is sometimes difficult to estimate the real contribution of each variable (**E** and **V**) in the models, owing to their interaction and/or colinearity.
- The problem of transitional states becomes more difficult to solve, especially when the environmental influence is described by a shaped function (in such cases CLIMPROD does not provide a satisfactory solution).
- By increasing the number of explanatory variables one also increases the probability of getting randomly good correlations independently of any real biological phenomena (Ricker, 1975). The literature provides many examples of good historical fits which breakdown as soon as the model is used for forecasting.

These difficulties common for any multi-regression can be overcome by an objective choice of variables (supported by biological observations as far as possible). As underlined by Bakun and Parrish (1980) the selection of the environmental variable to be introduced into the model must, as far as possible, be *a priori* and not only empirical (they present a list of likely variables).

In addition, those models still have the usual limitations of conventional surplus production models, linked to their basic assumptions, as discussed by Fox (1974). Even after their modification they remain an empirical procedure for assessing fish stock responses (in terms of biomass and yield) to changes in the fishing rate and environmental conditions. Therefore they represent a blind approach for investigating recruitment variability.

When causal environmental factors and/or processes cannot be forecasted and have a short term effect, the proposed approach can only be used for assessing the range of environment-induced fluctuations and for comparing it to that of fishing effects. This would already be useful for it could improve management strategy particularly when stocks are at the upper and lower ranges of their biomass and/or catchability.

Simple surplus production models have been criticized because they suffer from lack of biological realism. Nevertheless, in many instances more sophisticated age-structured models, as proposed by Deriso (1980), do not better perform owing to difficulties in the estimation of additional parameters (Ludwig and Walters, 1985). CLIMPROD only uses one additional variable and zero to three (but often one) additional parameters to the conventional surplus production models. Moreover, the artificial intelligence allows for using additional quantitative or qualitative data which are not included in the model as variables but help the user to choose the best model equation according to the stock characteristics and not only to the criterion of the best fit. This last criteria has been demonstrated to not necessarily provide a more realistic policy prescription (Uhler, 1980). The present approach can provide better assessment and management of the stock by taking into account the user's knowledge of stock biology or structure and the expert's experience with other stocks.

Some negative aspects of CLIMPROD must also be pointed out. This tool will be made available to fishery biologists or fishery managers and can be used to fit any model without special knowledge of population dynamics. The program asks the user to respond to various questions regarding the basic assumptions underlying the model and it stops in case of insufficient knowledge. Nevertheless, the user remains free and is responsible for other errors. Moreover, the objective choice of an environmental variable (including its spatio-temporal window and its lag on production) is often the key factor to avoid spurious correlations. In general, even in the case of surplus production models, a minimum knowledge of the stock and of the species biology is required.

CONCLUSION

Few studies on the relationships between the marine species and their environment allow an estimation of combined effect of the environment and the fishing effort on the stock in term of actual production and MSY.

The models here outlined allow to take into account the effect of environment on yields and therefore to overcome the difficulties caused by two underlying requirements of the conventional surplus production models, namely : the data set must concern a period when the environmental factors influencing the stock abundance were stable (or fluctuated randomly over a long enough period of observation) and the catchability must also be independent from the environment. This advantage allows an increase of the usable data series but requires more parameters to be estimated. The decision whether to use the traditional models or their modified versions here proposed will result from the balance between such considerations.

As these models are still global they retain the limitations of such models and require the other usual basic assumptions. Despite such constraints these models are often a more acceptable solution than the traditional ones, especially in tropical areas where environmental factors are the predominant influence on production of short lived species. In such areas fish ageing is often difficult and requires expensive intensive sampling owing to the high variability of the fish length within the cohorts associated with a special type of aggregation in the case of small pelagic species (Fréon, 1985). Under such circumstances the usual analytic methods are hardly usable. Although environmental production models do not need quantitative biological data, it is necessary to possess a minimum knowledge of the species ecology for their proper use. One of the aim of CLIMPROD expert-system is to force the user to take into account this knowledge for selecting and fitting an appropriate model.

This experience in artificial intelligence, through the necessary dialogue between computer and biology sciences, leads to the formulation of modeling rules which are often empirical and crude. Such a simplification of the biologist's way of thinking is not devoid of interest. It allows for the exchange of ideas between the experts. Moreover, the software itself could be an interesting pedagogical tool either when used with real data sets or with simulated ones.

The utilization of these models for predictions is not risk-free. It requires a forecast of fishing effort and in some cases a forecast of one environmental factor (when there is not enough lag between this factor and its effect on the fishery). This latter forecast is often imprecise, as underlined by Walters (1978). Moreover, the confidence limits of the parameters are sometimes so high that the predictions within the observed range of the variables would be hazardous and of course it would be even worse to forecast using input values outside the observed range.

Nevertheless, the MSY concept, despite its epitaph (Larkin, 1977), can still be used but in a plural sense with the present models which can be considered as a final development. They provide different MSYs for each state of the environmental variable, or at least a different **fmax** when only the catchability is modified. Application examples were presented in upwelling areas (Fréon, 1988; Fréon *et al.*, 1992) showing that CLIMPROD models can provide a fairly good interpretation of fishery history. They can explain how some large fluctuations of the catches (and sometimes collapses) may occur, without any increase of the nominal effort, as a result of environmental changes. Such an eventuality has already been catered in stochastic models (Laurec *et al.*, 1980) but only in a statistical way. A deterministic tool is proposed here for the use of fishery managers. Despite imprecise catch predictions it allows to understand, and sometimes to forecast, the fishery tendencies. In this last case, the goal is not only to preserve the resource, but also to optimize the surplus production provided by favorable environmental situations.

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APPENDIX 1 : CLIMPROD AVAILABLE MODELS

U=f(E) models

U=a.exp(b.E)	(exponential)
U=a+b.E	(linear)
U=(a+b.E)^(1/(c-1))	(generalized)

U=f(V) models

U=a+b.V	(linear)
U=a.V^b.	(exponential)
U=a+b.V^c	(general)
U=a.V+b.V^2+c	(quadratic)

U=f(E,V) models;influence of V on abundance

U=a.V+b.E	(linear-linear)
U=a+b.V+c.E	(linear-linear)
U=a.V^b+c.E	(linear-exponential)
U=a.V+b.V^2+c.E	(linear-quadratic)
U=(a+b.V).exp(c.E)	(exponential-linear)
U=a.V.exp(b.E)	(exponential-linear)
U=a.exp(b.E)+c.V+d	(exponential-linear)
U=a.V^b.exp(c.E)	(exponential-exponential)
U=a.V^b.exp((c.V^d.E) without constraints	(exponential-exponential)
U=(a.V+b.V^2).exp(c.E)	(exponential-quadratic)
U=((a.V^b)+c.E)^(1/(d-1))	(generalized-exponential)
U=((a+b.V^2)^(d-1)+c.E)^(1/d-1)	(generalized-quadratic)

U=f(E,V) models;influence of V on catchability

U=a.V+b.V^2.E	(linear-linear)
U=a+b.V-c.(a+b.V)^2.E	(linear-linear)
U=a.V^b+c.V^(2.b).E	(linear-exponential)
U=a.V.exp(b.V.E)	(exponential-linear)
U=(a+b.V).exp(-c.(a+b.V).E)	(exponential-linear)
U=a.V^b.exp(c.E.V^b)	(exponential-exponential)
U=a.V.(b-c.V)-d.V^ 2.(b-c.V)^2.E	(linear-quadratic)
U=a.V.(1+b.V).exp(c.V.(1+b.V).E)	(exponential-quadratic)

U=f(E,V) models;influence of V on both abundance and catchability

U=a.V^(b+c)+d.V^(2.b).E	(linear-exponential-exp.)
U=a.V^(1+b)+c.V^(2+b)+d.V^(2.b).E	(linear-quadratic-exp.)
U=a.V^b.exp(E.c.V^d)	with sign constraint (exp.-exp.-exp.)
U=(a.V^(1+b)+c.V^(2+b)).exp(d.V^b.E)	(exp.-quadratic-exp.)

FISAT AND STOCK ASSESSMENT

F. C. GAYANILO, JR.

ABSTRACT

The development and structure of FiSAT (FAO-ICLARM Stock Assessment Tools) are presented; this software stems from the need to standardize common length-based methodologies for research in fish stock assessment, FiSAT includes all rou-

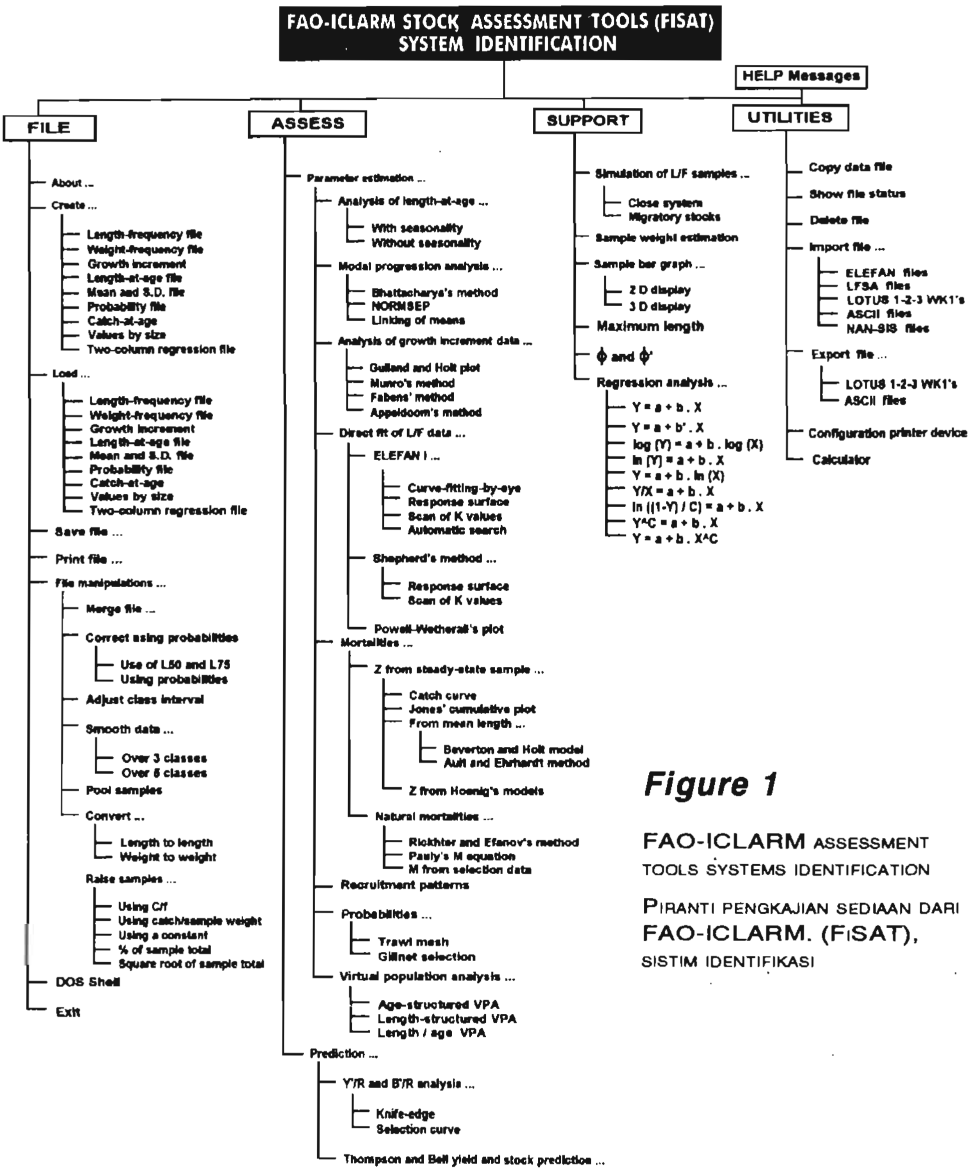

Figure 1

FAO-ICLARM ASSESSMENT TOOLS SYSTEMS IDENTIFICATION

PIRANTI PENGKAJIAN SEDIAAN DARI FAO-ICLARM. (FiSAT), SISTIM IDENTIFIKASI tines of the complete ELEFAN (**E**lectronic **LE**ngth Frequency **AN**alysis) package developed by ICLARM and of the LFSA (**L**ength-based **F**ish **S**tock **A**ssessment) package developed by FAO, along with some new routines also found useful for analysis of length frequencies.

Requiring only a minimum of 512K of RAM, 7.5 MBytes of free disk space for the programs and EGA or VGA graphic displays for high-resolution graphic outputs on an IBM PC (or its compatibles), FiSAT now includes 90 different routines for fish stock assessment and supports data types other than length frequencies. It is envisioned that both ICLARM and FAO will distribute FiSAT in the form of three 3.5" disks with a User's Guide in the second half of 1994 to over 800 registered users of both ELEFAN and LFSA. An edited detailed Reference Manual, outlining the theory behind each routine, will also be made available by late 1994.

Perkembangan dan struktur dari pada FiSAT (FAO-ICLARM Stock Assessment Tools) disajikan; piranti lunak ini disesuaikan menurut kebutuhan untuk menstandisasi metodologi berdasarkan ukuran panjang yang biasa untuk penelitian didalam pengkajiaan sediaan. Didalam FiSAT terdapat semua rutin dalam Compleat ELEFAN yang dikembangkan masing-masing oleh ICLARM dan LFSA yang dikembangkan oleh FAO, bersama-sama dengan rutin yang baru yang berguna untuk analisis.frekuensi panjang.

Program ini hanya memerlukan RAM 512 K, 7,5 MBytes dari hard disk dan untuk penyajian grafik resolusi tinggi diperlukan monitor EGA dan VGA pada IBM PC atau yang compatibel, sekarang FiSAT mencakup 90 rutin yang berbeda untuk pengkajian suatu sediaan dan dapat mendukung penggunaan jenis data yang lain selain frekuensi panjang. Telah dipertimbangkan bahwa ICLARM dan FAO akan menyebar luaskan FiSAT dalam bentuk tiga disket 3,5 inci yang dilengkapi dengan buku petunjuk menjelang akhir tahun 1994 kepada lebih dari 800 pengguna ELEFAN dan LFSA. Reference Manual yang lengkap, yang menjelaskan teori dari masing-masing rutin akan tersedia pada akhir tahun 1994.

INTRODUCTION

"Future life scientist may be characterized more by their ability to use the computer for data analysis and simulation than by their ability to use the traditional microscope" (Spain 1982). Indeed, it has become apparent in recent times that more and more fisheries scientists are knowledgeable in using microcomputers, and to a certain degree, in programming as well.

A fishery stock assessment should provide scientific advice about the state of the fish stock which ultimately should be managed for the benefit of the fishermen. This, however, is not the direct procedure as it would be for a farmer to manage a domestic stock or for a forester to manage a forest. The major difference is that fishes are usually not seen, counted or weighed before they are caught, thus the need to assess fish stocks through mathematical inferences. However, as noted by the late John Gulland, classical methods are inappropriate for two reasons; **(i)** fisheries have the capacity to develop and reach a critical level in a much shorter time than required for their scientific assessment, which leads to *post mortem* results rather than useful advice and **(ii)** a much greater accuracy is more often expected than obtained when computational difficulties are circumvented through approximation (Gayanilo, 1993; Garcia *et al.*, 1993).

Recent developments in the microcomputer industry have brought powerful number-crunching abilities to the desks of most researchers which may, in some ways, diminish the 'inappropriateness' of the classical procedures. The renewed interest in biomathematics resulted in the development of new algorithms being implemented on microcomputers, improving the accuracy and speed of the assessment procedures.

One of ICLARM's early contributions to this emerging trend was the development of the ELEFAN (**E**lectronics **LE**ngth **F**requency **AN**alysis) (Pauly and David, 1981; Brey and Pauly 1986; Gayanilo *et al.*, 1989) suite of routines. This software package provided an alternative to fisheries scientists working in the tropics to assess fish stocks incorporating methods that could be used and for which data was available and/or readily collected (Pauly *et al.*, in press). The staff of FAO (**F**ood and **A**griculture **O**rganization) has also contributed to the development of methodologies applicable to the tropics and much of this effort is incorporated in the LFSA (**L**ength-based **F**ish **S**tock **A**ssessment) software package (Sparre, 1987).

ELEFAN and LFSA were developed in response to the same needs, hence, both packages included a number of similar routines. Things could have been left at that: FAO and ICLARM continue to maintain and distribute their respective software and the interested colleagues can choose. Practical experiences made during various training courses especially the FAO/ DANIDA Training Courses in Tropical Fish Stock Assessment showed, however, that the simultaneous offering of "competing" software had an inhibiting effect on the course participants. Also, the costs of maintaining and documenting a complex software package are rather high, especially if one's mission is global and hence, involves producing documentation in languages other than English (Pauly and Sparre 1991).

For all these reasons, FAO and ICLARM have signed a Letter of Agreement covering the development of a joint software which will supersede FAO's LFSA and ICLARM's Complete ELEFAN. The new software is now called FiSAT (**FAO-ICLARM** **S**tock **A**ssessment **T**ools). It includes all routines of the Complete ELEFAN and LFSA as well as new promising models/methodologies.

THE FISAT SOFTWARE

The first version of FiSAT contains over 90 modules and supports several data types (but mainly length frequencies). Following some of the standards set by commercial software for its user interface, it will be distributed on three 3.5" disks, with a User's Guide to the software and Reference Manual, to be printed and distributed through FAO. The software package will require 7.5 Mbytes of free disk space for a minimum of 512K of RAM and a graphic adapter (EGA or VGA) for its high-resolution graphic displays. FiSAT has four main groups of routines, FILE, ASSESS, SUPPORT and UTILITIES (fig.1)

The FILE Menu

The FILE set of routines provides functions to :

- Create, edit, save and print (length or weight frequency, growth increment, length-at-age, mean and standard deviation, selection, catch-at-age, value by size and two-column regression) files;
- Manipulate the data files : merge different files, correct length frequencies using probabilities of capture, adjust the class interval of grouped frequencies, pool samples, convert data forms, raise samples, etc...

Most of these routines are for manipulating length frequencies, as the package as a whole emphasizes the analysis of for length frequency data, the key data (besides catches) in the tropical fisheries.

The ASSESS Menu

The routines in the ASSESS menu include procedures to **(i)** estimate growth parameters from length-at-age, growth increments and length frequencies, **(ii)** estimate mortalities and related parameters, **(iii)** identify seasonal pulses of recruitment **(iv)** compute fishing patterns (F. array) and recruitment using Virtual Population Analysis (VPA), and **(v)** predict yield and biomass per recruit (Y/R; B/R) from the Beverton and Holt and Thompson and Bell models for various fishing scenarios (single and multispecies).

The SUPPORT Menu

This set of routines includes various ancillary functions: estimating sample weights given length-weight relationships, plotting of length-frequency histograms, estimation of expected maximum size from observed extreme values, estimating growth indices (o) and performing linear regression analysis. This menu also offers a routine for the simulation of length frequencies from either a closed-system (where it is assumed that fish do not migrate to other areas) or from a system that allows sequential migration of fish from one area to the next (up to four areas can be linked by migrating fish).

The UTILITIES Menu

The set of routines included in the UTILITIES menu serve purposes such as copying of data files, deleting files, importing ELEFAN, LFSA, LOTUS 1-2-3, ASCII and NANSIS files, exporting length frequencies to LOTUS 1-2-3 or ASCII files and configuring printer devices. A calculator is also included for convenience.

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WORKSHOP AND ROUND TABLE

BIODYNEX WORKSHOP

23-25 MARCH 1994

REPORTER : M. POTIER

INTRODUCTION

This workshop was held, from the 23th to the 25th March in Jakarta. Scientists of the project, Indonesian institutions and ASEAN countries attended this workshop (see list of participants). Under the supervision of the experts invited, some particular aspects underscored during the seminar were studied. To achieve these tasks, basic data available at the project were used and four working groups, each coordinated by an expert, were formed. After two days of analysis, the conclusions of each group were discussed during a general meeting and recommendations were given.

Group I : J. WIDODO

Bio-geography analysis of the main species found in the fishery. Bibliographic comparison of some biological and ecological parameters among the same or related species in different parts of the world..

Group II : F.C. GAYANILO

Analysis of length-frequencies with FiSAT software. Case study: *Decapterus macrosoma, Rastrelliger kanagurta, Amblygaster sirm.*

Group III : P. FREON

Analysis of catch and effort data.

Group IV : S.B. SAILA

Environment. Based on the study of historical data.

GROUP I : Bio-geography

This group analyzed the growth rate and the natural mortality parameters of the main species caught by the fishery and compared them to the same or related species in other parts of the world in order to estimate some richness indexes and exploitation rates of the Java Sea and to confirm the ecological status of the studied species (coastal or oceanic, migrant or sedentary).

These comparisons were based on results (tab. I) found prior to the project by some Indonesian scientists on *Decapterus spp.* (Sadhotomo and Atmaja, 1985; Widodo, 1988), *Rastrelliger kanagurta* (Sujastani, 1974; Nurhakim 1993), on *Selar crumenophthalmus* and *Sardinella gibbosa* (Dwippongo *et al.*, 1986) in the Java Sea, in the Indo-Pacific region (Ingles and Pauly, 1984) and in other parts of the world (Van Nierop and Nhwani, 1986).

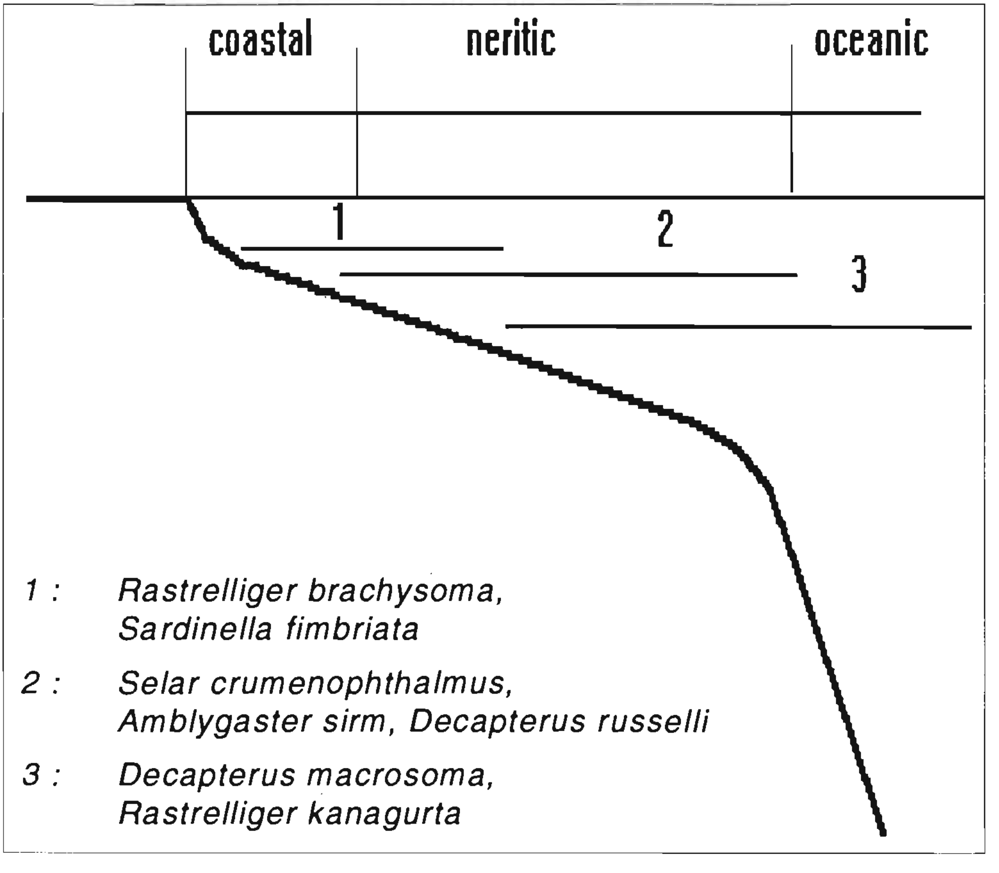


Figure 1

ECOLOGICAL DISTRIBUTION OF THE MAIN PELAGIC SPECIES CAUGHT BY THE SEINERS

DISTRIBUSI GEOGRAFIS DARI SPESIES IKAN-IKAN PELAGIS UTAMA YANG TERTANGKAP OLEH PURSE-SEINE

Table I

NATURAL MORTALITY AND GROWTH RATE FOR DIFFERENT SPECIES IN THE JAVA SEA AND OTHER PARTS OF THE WORLD.

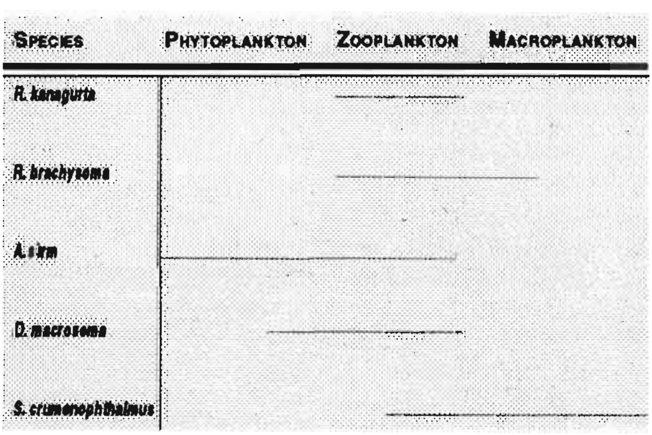
MORTALITAS ALAMI DAN LAJU PERTUMBUHAN DARI BEBERAPA SPESIES YANG BERBEDA DI LAUT JAWA DAN PADA BEBERAPA TEMPAT DI DUNIA.

SPECIES	REGION	M	K
Decapterus russelli	Java Sea	.65< M <1.19	.39
	Java Sea	2.0	1.18
	Java Sea	1.8	.95
	Philippines	1.1< M <1.19	.54
Decapterus macrosoma	Java Sea	62< M <1.73	.73
	Java Sea	1.86	.98
	Philippines	1.1< M <2.3	1.25
Rastrelliger kanagurta	Java Sea	1.625	
	Java Sea	.64< M <1.04	.68
	Java Sea	2.58	1.63
	Malacca Strait	.78	
	Mozambique	84	
	Philippines	2.43	1.55
Selar crumenophthalmus	Java Sea	2.17	1.25
	Hawaii	2.57	
	Philippines	.89	
	Mariana Islands	.61	.89
Sardinella gibbosa	Java Sea		
	South China Sea	2.29	1.2
	Mozambique	1,46	,58

Table II

FEEDING HABITS OF THE MAIN PELAGIC SPECIES CAUGHT BY THE SEINERS IN THE JAVA SEA.

KEBIASAAN MAKAN DARI SPESIES IKAN PELAGIS UTAMA YANG TERTANGKAP OLEH PURSE SEINE DI LAUT JAWA



The heterogeneity of the methods used to estimate these parameters in the various analyzed studies don't allow us to find clear conclusions. Nevertheless the values of M and K seem relatively high in the Java Sea.

Pelagic species caught by the seiners are tropical species with a worldwide distribution (*S. crumenophthalmus*), Indo-Pacific (*R. kanagurta, Amblygaster sirm, S. gibbosa*) or a more restricted South-East Asia (*Rastrelliger brachysoma, Sardinella fimbriata*).

Most of them are typically shoaling fish which live mostly over continental shelves and make migrations across deep waters (*R. kanagurta, Decapterus macrosoma*). Their dispatch over the continental shelves (fig. 1) is conditioned by the tolerance to salinities, some of them being euryhaline (*R. brachysoma, S. gibbosa, Sardinella fimbriata*) some others stenohaline being unable to live in waters less than 32 ‰ (*R. kanagurta, D. macrosoma, Decapterus russelli*).

They are predominant zooplankton and macroplankton feeders, showing different diet behaviors according to their life stage (tab. II).

Most of these species due to their feeding diet are not dependent on a major seasonal upwelling system with its associated phytoplankton bloom. Nevertheless, relationship exists between regions of high plankton abundance and scads fishing grounds (Longhurst and Pauly, 1987).

Some species (*S. crumenophthalmus*, *Decapterus spp.*) show different behavior being epipelagic fish during their juvenile phase and bentho-demersal fish during their adult phase (Tiews *et al.*, 1970).

This group noted that a systematic bibliographic research has to be started to get better knowledge on the biology of these species or related ones through their extension area and as many of them have a large South-East Asia dispatch, some regional studies could be implemented.

GROUP II: Length Frequencies analysis.

Starting in May 1991, the project set a sampling scheme on the large and medium seiners fisheries in the main landing places (Boely *et al.*, 1990; Potier and Sadhotomo, 1991). Length frequencies measurements are made every day on the main species and by fishing grounds. Five species represent 90% of the total catch. Among them, *D. russelli* and *D. macrosoma* which form the bulk of the catch (60%) as well as *R. kanagurta* which is the most valuable species were chosen for the study.

In first approach the data were pooled in two groups (Java Sea, South China Sea) corresponding to the best assumptions in terms of stocks units. The analysis was performed using the FiSAT software developed by ICLARM and which is a synthesis of ELEFAN and FSAS systems (Gayanilo, 1994).

The results obtained were compared to previous results on the same species in the Java Sea and other areas (tab. III). Most of the results are expressed in TL (Total Length). As the measurements made in the project are in FL (Fork Length), a relationship between these two parameters would be useful to compare the different studies.

Nevertheless, the values of L_∞ found with the project data do not vary much from previous results in the Java Sea. Values of L_∞ found in the Java Sea are generally smaller than the L_∞ found on the same species in other areas.

The project samples purse seiners which catch fish over the continental shelf in water no more than 100 m deep. As the increasing mean size of fish with depth is common (Johannes, 1981) and as sometimes size specific migration into deeper water can occur for lowering maintenance metabolism (Longhurst and Pauly, 1987) the largest sizes may be not accessible to this gear.

Another explanation can be found in the conditions prevailing in the Java Sea. Marchal (1992) noted than the most part of coastal species off the Ivory Coast and Ghana present nanism phenomena (*Sardinella aurita, Decapterus ronchus*) due to sedentary behavior and to the low productivity of these waters. As the productivity of the Java Sea seems low, the same phenomena could occur.

Table III

L∞ AND K VALUES FOUND FOR DIFFERENT SPECIES IN THE JAVA SEA AND OTHER AREAS

NILAI L∞ DAN K YANG DIPEROLEH DARI BEBERAPA SPESIES YANG BERBEDA DI LAUT JAWA DAN DAERAH LAIN

SPECIES	REGION	L∞	K
Decapterus russelli	Jakarta Bay	27.0 (TL)	1.18
	Java Sea	28.3 (TL)	0.39
	Java Sea*	24.5 (FL)	0.90
	Philippines		
Decapterus macrosoma	Java Sea	25.4(TL)	0.98
	Java Sea	24.4 (TL)	0.73
	Java Sea *	19.6	2.50
	Philippines	24.4 (TL)	0.95
Rastrelliger kanagurta	Java Sea		
	Java Sea*	26.3 (FL)	0.68
	Malacca Strait	28.7 (TL)	0.78
	India	22.4 (FL)	4.32
	Red Sea	42.0 (TL)	0.30
	Mozambique	22.1 (FL)	0.81

TL: Total Length
FL: Fork Length
*** Project values***

To deal with these hypothesis, as the sampling of the large and medium seiners covers a limited part of the population (fish between 10 to 19 cm) it has to be extended to fisheries which catch other parts of the last one (juveniles or old individuals) and the analysis of the data has to be performed with more than one method.

GROUP III : Analysis of catch and effort data.

When comparing with some temperate stocks, the catch and effort data for large seiners appear to cover a short period, twelve years. But such a database is quite noticeable in tropical fisheries. Catch data are available by commercial category and by fishing grounds for the large and medium seiners fisheries. Most of the work consisted to study these data using time series analysis which helped us to find tendencies and to try to standardize the effort in order to get a representative index of the abundance. Mini purse seiners and Danish seines data (catch, effort) covers three years only and comes from one landing place located in West Java (Tuti *et al.*, pp. 185-194).

The series show a high variability (seasonal and inter-annual) (fig. 2), a great instability and the interaction between them is strong. The CPUE (catch per unit of effort) series of the large and medium seiners fleets show a similar pattern and the differences between them tend to decrease from 1987 to 1992 (fig. 3) as these two categories of vessels tend to overlap (Potier and Sadhotomo, pp. 195-214). The CPUE of the mini and Danish seiners present trends which are not so different from large and medium seiners. Since 1990, the CPUE increases slightly in every fishery (fig. 4).

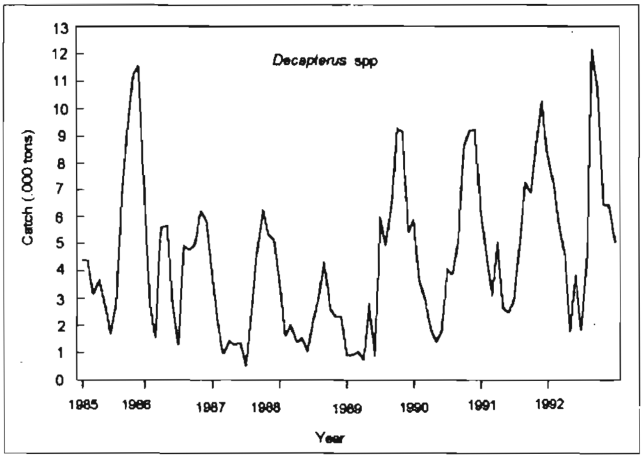


Figure 2

MONTHLY LANDINGS OF SCADS (*DECAPTERUS SPP.*) BY THE SEINERS FISHERIES FROM 1985 TO 1992

JUMLAH IKAN LAYANG, SCAD (*DECAPTERUS SPP.*) YANG DIDARATKAN SETIAP BULAN OLEH PERIKANAN PURSE SEINE DARI TAHUN 1985 SEMPAI DENGAN 1992

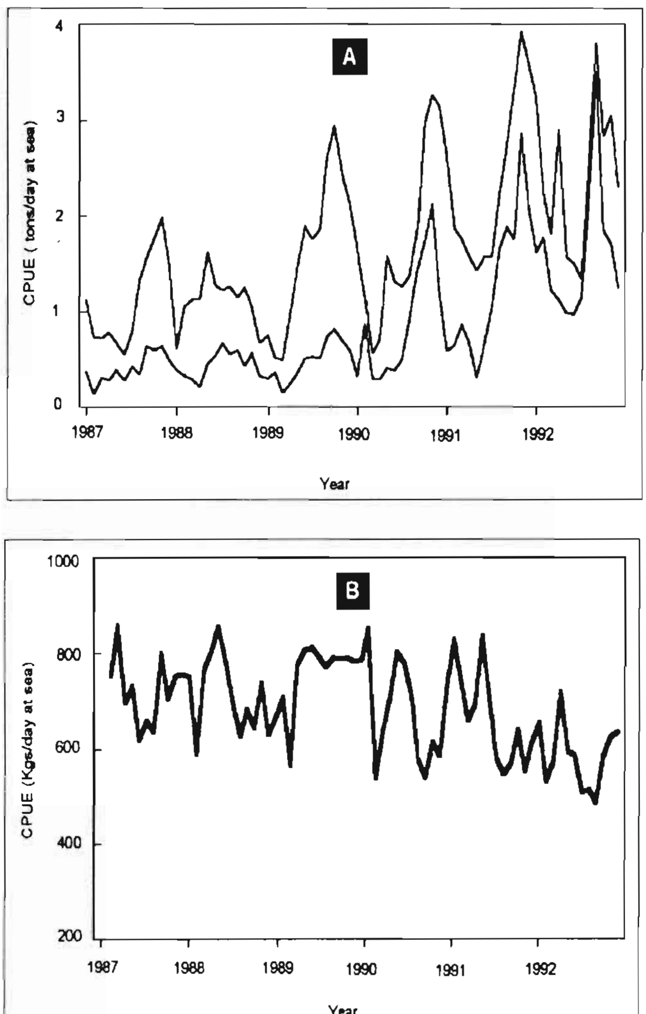


Figure 3

EVOLUTION OF THE LARGE AND MEDIUM SMOOTHED CPUE (A) AND OF THE RELATIVE DIFFERENCE BETWEEN THEIR CPUE (B) FROM 1987 TO 1992.

EVOLUSI HASIL TANGKAPAN PER UNIT UPAYA DARI PURSE SEINE BESAR DAN SEDANG (A) SERTA PERBEDA RELATIF ANTARA KEDUA HASIL TANGKAPAN PER UNIT UPAYA (B) DARI TAHUN 1987 SEMPAI DENGAN 1992

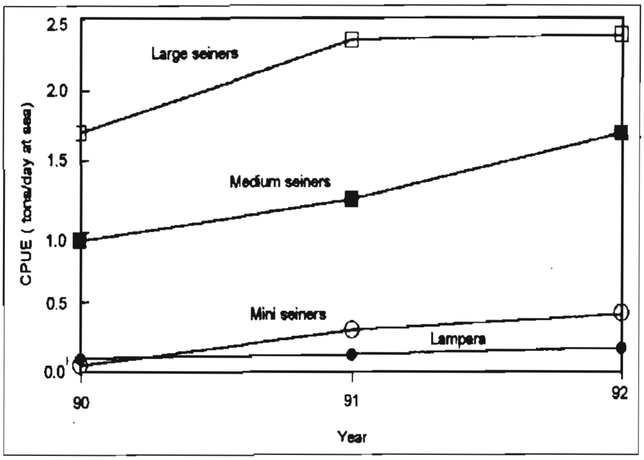


Figure 4

EVOLUTION OF THE ANNUAL AVERAGE CPUE FOR DIFFERENT FLEETS FROM 1990 TO 1992

EVOLUSI RATA-RATA TAHUNANA HASIL TANGKAPAN PER UNIT UPAYA UNTUK JENIS ARMADA YANG BERBEDA DARI TAHUN 1990 SEMPAI DENGAN 1992

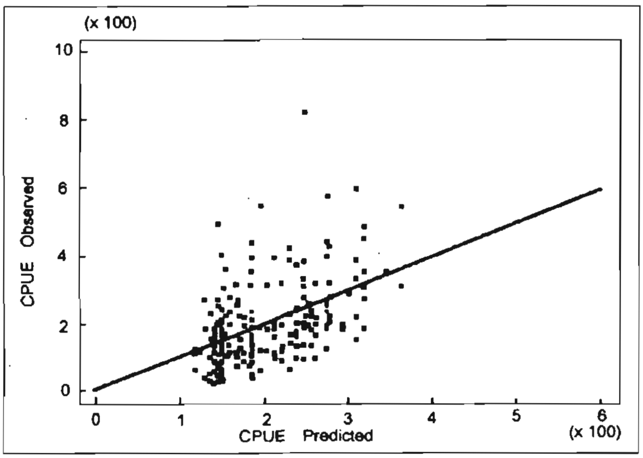


Figure 5

RELATIONSHIP BETWEEN CPUE AND SOME CHARACTERISTICS (LENGTH, CAPACITY) OF THE PURSE SEINERS

HUBUNGAN ANTARA HASIL TANGKAPAN PER UNIT UPAYA DAN BEBERAPA KARAKTERISTIK KAPAL PURSE SEINE (PANJANG, KAPASITAS)

In order to use surplus models, an essay of standardization of the effort was implemented. Some fleets qualitative parameters (spatial, temporal, changes in fishing techniques) as well as quantitative (length, horse power and vessel capacity) were compared to the CPUE by means of a global linear model. The sample used was too small (60 large and 25 medium seiners with data covering three months of CPUE) and no relationship between CPUE and different parameters was found (fig. 5).

Thus, the surplus models we used, even those including environmental variables, explain only a small part of the variance. Two explanations can be given to this poor result. First the starting point of the year for the series must follow the biological cycle of the fish in the Java Sea and cannot coincide with the civil year. Secondly, the estimation of the effort must be improved. A study of the characteristics of the vessels must be done and the changes in the fishing techniques (Potier and Petit, pp. 171-184) have to be taken into account. The logistic model suggest a robustness of the stocks to exploitation (Widodo, 1988 ; Nurhakim, 1993), but this could be due to the mixture of species.

Even if the analysis does not show a relationship between environment and fishing, the high variability of the fishing data seems coming from external factors to the fishery.

A synthesis of the knowledge on the environment of the Java Sea has been given by Durand and Petit (pp. 14-38). As noted by these authors, there are no long time series on environmental parameters except for rainfall. Salinities series cover a short scale time (1950-1954, Veen 1953), or are given for the time of cruises. Winds and productivity parameters are scarcely known on limited geographical areas. More, most of these series were collected before the second world war or immediately after. Since 1960, studies on the environment lack for the Java Sea area.

Available series were studied with the same manner as catch and effort data. Salinities give a good picture of the mean annual pattern of the water masses dispatch in the Java Sea with low salinities (30-32 ‰) during the first part of the year (North-West monsoon) and higher salinities (34-35 ‰) during the second one (South-East monsoon). A well established West-East gradient occurs along the year. Rainfalls show the same pattern as catch and effort with a great spatio-temporal variability.

Primary productivity is high along the southern coast of Kalimantan (Nontji, 1977) during April-May when large runoffs of the Kalimantan rivers occur. This type of situation is often associated to spawning grounds and a detailed study of this area would be useful. We can notice that the fishing grounds are located in the East-southern part of Kalimantan during that period. Satellite imagery could be helpful to follow the intensity of the rivers runoffs and chlorophyll a dispatch.

CONCLUSIONS AND RECOMMENDATIONS

Some conflicting piece of information are obtained from the Java Sea. Referring to the surface of the prospected area (Nurhakim *et al.*, pp. 145-155) which is entirely located in waters comprised between 50 and 100 m deep the total landings are rather low. The exploitation area of the stocks does not cover the whole biomass area of the populations and taking the production per km^{-2} as an index of the biomass is only a last resort. Nevertheless, comparing with similar fisheries existing in other parts of the world, the value found in the Java Sea (2tons/km^{-2}) seems low, against 5 tons/km^{-2} in Ivory Coast (Marchal 1993), 7 tons/km^{-2} in Senegal (Samba et Laloe, 1986) and 15 tons/ km^{-2} in Ghana (Marchal 1993).

Even if the comparison of the catch rate among fisheries harvesting different ecosystems is difficult the observed values can give us some informations on the exploitation. The mean catch rate in the Java Sea is 3 tons/day, as in Senegal it is 30 tons/10 hours and in Chile 500 tons/day. Different factors can explain such differences;

- The exploitation does not concern species living at the same trophic level, mainly *Decapterus spp.* zooplanktonophageous species in the Java Sea and anchovies planktonophageous species in Chile. It can explain the great differences in the abundance among these species.
- The biological productivity of the Java Sea which is low compared to the upwellings regions.
- The scarcity of the resource revealed by the small number of shoals encountered in the Java Sea during the acoustic cruises. The fish is scattered in the whole water column and this spatial dispatch explains the use of rafts and lights by the seiners which have to aggregate the fish to catch it.

■ The technical stage reached by the Javanese fishermen whose fishing techniques (wood vessel, no mechanical assistance to haul the net....) do not allow a high yield.

In conclusion, it is premature to make any exclusive statement on management. In the stage of the project the use of surplus and analytical models is not really convenient and the time series analysis, even if they do not explicitly model population processes and cannot provide information on optimal harvesting policies, can however provide valuable forecasts to guide short-term management decisions.

All the recommendations have consequences in terms of management (tab. IV). Nevertheless, three are important;

- study the life cycle on one or two year classes,
- find the most accurate estimate of the effort,
- Implement a regional approach as some stocks seem shared between different countries (round scads).

Table IV

CONCLUSIONS AND RECOMMENDATIONS ISSUED BY EACH GROUP AT THE END OF THE WORKSHOP SESSION

KESIMPULAN DAN REKOMENDASI YANG DIBUAT OLEH SETIAP KELOMPOK PADA AHKIR LOKAKARYA

	GROUP I BIO-GEOGRAPHY	GROUP II LENGTH FREQUENCY	GROUP III CATCH	GROUP IV ENVIRONMENT
RESULTS	* Low richness index of the Java Sea * Relatively fast growth * Natural mortality relatively high	* Too few small and big sizes in the samples * Difficult to establish the growth curve	* High seasonal variations * No relationship cpue-environment * Surplus models do not fit well * Standardisation of effort	* Data too scarce and too old * High variability of the environment
RECOMMENDATIONS	* Age of the fish * Early life stages Spawning grounds Nursery grounds	* Sampling other fisheries in order to find small and big sizes * Analysis with more than one method * FL(fork length) TL (total length) relationship	* Characteristics of the fleet * Improvment fishing effort index * Use of GLM for standardisation of effort * Research of the beginning of year cycle	* Search for actual data * Use of climatic factors as rainfall, wind and rivers runoff * Satellite imagery
	* Bibliography * Stock limitations. Joint studies with Asean countries			

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ROUND TABLE

Java Sea fisheries, a provisional approach

CHAIRMAN : DR. J.R. DURAND
REPORTER : DR. J. WIDODO

AGENDA

1. **General Presentation**
   1.1. General picture of the Java Sea fisheries (pelagic and demersal)
   1.2. Some definitions

2. **Preliminary Results of the Project**
   2.1. Production models
   2.2. Multispecies Analytic Models
   2.3. Migrations

3. **Regulations**
   3.1. Kind of regulations
   3.2. Existing and planned regulations

A round table session was carried out and all the participants had opportunity to participate in the discussion on the Java Sea fisheries. Presentations on the overall picture of the fisheries and some definitions used, preliminary results on biology, population dynamics and exploitation, and regulations practiced in the Java Sea were delivered.

In addition, the three participants coming from Malaysia (Mr. Mansor M. Isa), Philippines (Ms. Rosita Calvello) and Thailand (Ms. Amara Cheupan) were speaking on fisheries management measures in each of their country in order to compare the situation on a regional basis.

The officials of the fisheries services (DGF and its regencial agencies), shipowners, and the economists of the Project took an active part in the discussion by delivering their experiences and their view points. In fact, it was a prelude to the coming seminar on socio-economics and innovations scheduled to be performed in November 1995.

1. General Presentation

It is believed that both inshore as well as off-shore small pelagic fish resources of the Java Sea has been intensively exploited. On the other hand, exploitation on demersal fish resources are less intensive than those of pelagics, especially the off-shore ones.

Interactions might occur between pelagics and demersals, primarily on biological and technological interactions which take place mainly in the terms of predator relationship, competition on food and/or in space, while technological interactions may occur in the terms of what some fishing gear e.g. lampara may capture pelagics as well as demersals.

In general there are three kinds of fisheries, i.e., small scale or coastal fisheries, artisanal and industrial fisheries. The term of municipal fisheries is known from the Philippines, namely fisheries that operated less than 3 GT motorized as well as non powered boats.

In tropical multi-species fisheries, overfishing on one species may occur without people involved in the exploitation, assessment or management knowing this fact, as that overfished species is replaced by another one, the level of the catch remaining the same.

2. Preliminary Results of the project

■ PRODUCTION MODELS

In using production models, standardization of effort should take into account those variables which effectively play a significant role in fishing mortality. The use of powerful light intensity in purse seine fishery should be taken into account in determining fishing effort.

■ MULTI-SPECIES ANALYTIC MODELS

Analytical models, which were originally developed for application to single species populations, can be used to predict the possible impact of changes in fishing intensity or size limit on the direction of change in overall yield of the fishery. Refinement of this estimates evidently depends upon better estimates of natural mortality **M**, fishing mortality **F**, and growth parameter **k** of the Von Bertalanffy growth formula.

■ MIGRATIONS

Spatio-temporal migrations are evidently existing for scads. The euryhaline species, e.g. *D. russelli* might have more restricted migration that the stenohaline one, i.e. *D. macrosoma*. A joint program on *Decapterus spp.* between Indonesia, Malaysia and the Philippines would be very useful, as the regional scale seem necessary.

As far as fish migrations are concerned, the use of methodologies other than analysis on length statistical data should be carried out to verify the present results.

3. Regulations

Regulations have previously been implemented in the Java Sea. Based upon ministerial decrees zoning of fishing grounds closed and opened areas, and mesh size regulation exist, but are mainly ignored by the fishermen. Since 1980 the trawling has been banned in the Java Sea to protect the small fisheries and annual fishing licences based on the boat tonnage are now obligatory. However the number of licences is not limited and whoever wants to invest in the fishery sector and can buy one is allowed on the sea.

The feasibility of mesh size regulation on purse seine fishery is questionable for the fishery based on the use of more and more powerful light so that fish of any size will be aggregated and captured.

At the present stage, as the stocks do not seem to be overfished, any modification or addition to the existing regulations are too early. If the fishing pressure increases again, then effective control on fishing efforts should be enforced.

The enforcement of the regulations should be strengthened along with the actualization of the MCS (Monitoring, Control and Surveillance).

The participation of the community in the planning, actuating and enforcing regulations should be taken into account in any fisheries management measures.

CONCLUSION

■ Java Sea Perspectives

Considering the debates during the seminar the quota solution to regulate the Javanese fisheries seems almost excluded due to the necessity to set up a heavy control system (there are many places of landing in the region) as well as the kind of fisheries which all exploit a complex of species.

The pelagic resources presenting a high annual variability it would be wiser to consider an adaptive management of the resource playing possibly on :

- Regulation of the fishing effort
- Protection of the fishing areas
- Exploitation of other species
- Minimal size of fish at landing
- Governmental subsidies to maintain temporary inactive fleet

Rare are the examples of pelagic fisheries management in developing countries. However, among these few examples, we can notice the management of the Sardines exploitation implemented in Morocco. The main measures have been :

- Transfer of part of the traditional fleet in other fishing areas
- Control of the exploitation level in the most endangered zones
- Development of a mobile fleet able to move quickly in order to take the most advantage of the occasional peaks in production

In the Java Sea, the fishery sector is an important receptacle of manpower coming from the overpopulated agricultural zones of this coast. A global management approach will be necessary and will have to take into account the constraints on the resources, on the regional economy as well as on the employment.

LIST OF ABBREVIATIONS

AARD	Agency for Agricultural Research and Development
ANALEN	Analysis of Length
ASEAN	Association of South-East Asian Nations
BPPL	See RIMF
CLIMPROD	Climate Production models
CPUE	Catch Per Unit of Effort
CRIFI	Central Research Institute for Fisheries
DGF	Directorate General of Fisheries
EEZ	Exclusive Economic Zone
ELEFAN	Electronic Length Frequency analysis
ENSO	El Nino Southern Oscillation
FAD	Fish Agregating Device
FAO	Food and Agricultural Organization
FiSAT	FAO-ICLARM Stock Assessment Tools
FL	Fork Length
GI	Gonad Index
GSI	Gonado Somatic Index
ICLARM	International Center for Living Aquatic Resources Management
IFREMER	French Institute for Research at Sea
LFSA	Length base Fish Stock Assessment
MRT	Mean Return Time
MSY	Maximum Sustainable Yield
ORSTOM	French Research Institute for Development through Cooperation
PELFISH	Java Sea Pelagic Fishery Assessment Project
POPSYS	Population Systems
RIMF	Research Institute for Marine Fisheries
SSB	Single Side Band
TL	Total Length
VBGF	Von Bertalanffy Growth Formula
VRT	Variance of Return Time

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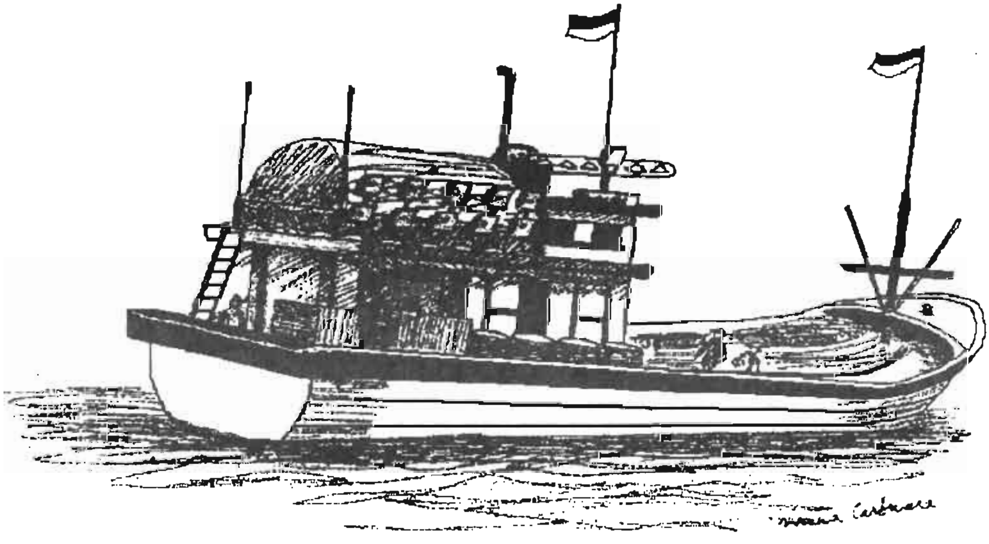

PRINTED

APRIL 1995