THE JAVA SEA ECOSYSTEM

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ABSTRACT

A global connection between the ecosyatem of the Java Sea and small pelagic resources was studied. A hydroacoustic survey was performed to obtain information on stock behavior and its biomass. Special attention was given to some ecobiological features that could be of importance for harvesting and management issues.

KEYWORDS : Java Sea, ecobiology, fish behavior, biomass, management.

ABSTRAK

Hubungan menyeluruh antara ekosistem Laut Jawa dan sumber daya ikan pelagis kecil telah diteliti. Survei hidroakustik telah pula dilakukan untuk mengungkap lebih dalam tentang perilaku dan biomassa ikan pelagis kecil. Selanjutnya perhatian khusus diberikan kepada sejumlah keragaan ekobiologi yang penting bagi berbagai perumusan strategi pemanfaatan serta pengelolaan sumber daya ikan.

KATA KUNCI : Laut Jawa, ekobiologi, perilaku ikan, biomassa, pengelolaan.

The management of natural aquatic resources has to be based on knowledge in various fields. The corresponding studies have to be more or less connected in a multidisciplinary approach. Multidisciplinarity, as defined here, means that all disciplines aim to analyse and understand the same object. It means too, that they have at least some common constraints, time and space scales and observation units. Managing the fisheries in Java Sea context requires the understanding of the whole system (Widodo and Durand, 1996). Fish distribution and its variability depend on the physical and climatic environment on one hand, on the other hand, we have to deal with human societies and their cultures. Being able to operate a synthesis of the whole requires a multidisciplinary approach, including technological issues and institutions. One will find more detailed information in PELFISH final report (Durand and Widodo, 1997).

In this paper, we will give a brief presentation of the main results, and some comments on difficulties and constraints in the field of environment. First, on the global features of the Java Sea ecosystem and consequencies for pelagic resources. Then some information on the results obtained through acoustic studies : behaviour and biomass. In third place, a special attention is given to some bioecological features which could be of importance for harvesting and management issues. We will then introduce a more general discussion on the approach needed to give sound diagnosis on renewable resources management system.

ENVIRONMENT GENERAL FEATURES

A thorough understanding of the ecosystems functioning is necessary to conduct the management of renewable living resources. It means that, beyond the description of an average scheme, the variability which occur at every level, from climatic variations and primary productivity to species recruitment and fish availability for fishermen must be taken into account.

The need for concomitant data on environment is obvious and the corresponding studies have been identified, but such programs required specific means and skills and could not be conducted in the frame of the present project. The solution was to extrapolate ancient results - mainly gathered before World War II - and to use scarce and scattered recent data (Durand and Petit, 1995). A more specific utilisation was done also for relations between climatic factors and seine fishing (Potier and Boely, 1990). In addition, we performed salinity and temperature measurements during acoustic cruises in Java Sea, from 1991 to 1994 (Petit *et al.*, 1995). The acoustic team has acquired this data, using a thermosalinometer and a quantameter. A profiler probe measured the salinity and the temperature at each hydrological station made repeatedly along the transects. The water turbidity was also analysed. Many stations have been probed from June 1993 until May 1995 (about 40 stations per survey).

The most important points of the environmental issues are :

- The Java Sea is a huge collection of waters : some 450,000 sq. kilometres. Morphologically, it is well delimited on three sides, namely Sumatra, Java and Kalimantan islands. The eastern boundary is wide open towards deep Indonesia seas. Its average depth is about 40 meters with its bottom sloping from west to east, 20 to 100 meters.
- The general climatic scheme is clear. Winds are seasonally reversing and so are the currents in the Java Sea : westward flow during the south-east monsoon (dry season), eastward during the north-west monsoon (rainy season).
- The general importance of fresh water impacts through rivers' discharge and rain at sea is distinctly demonstrated, even if a long term quantification remains impossible, owing to the lack of pertinent data.
- The year to year variability of the system is mainly explained through the changing balance of oceanic eastern waters with coastal and neritic waters from the Java Sea. There is a lack of description of environmental conditions for rainy season and subsurface waters.

SMALL PELAGIC FISHES BIOECOLOGY

Seine fisheries in open waters mainly catch six pelagic species : *Decapterus russelli* and *D. macrosoma* (scads), *Selar crumenophthalmus* (big eye scad), *Rastrelliger kanagurta* (Pacific mackerel), *Sardinella gibbosa* (sardine) and *Amblygaster sirm* (spotted sardine). The fish caught are mostly immature or in recovery stage (Atmaja *et al.*, 1995). Most of the fish seem to reach sexual maturity from April to June, at the end of the rainy monsoon. The small number of encountered ripe and spent individuals in the catch sample may indicate that their spawning grounds are beyond the fishing areas, or they are not available for purse seine fishing.

From preliminary observations of growth parameters, it appears that most of the catch consist of young fishes (Suwarso *et al.*, 1995). As a rough estimation, we could say that the average age of fish caught is less than one year. Several cohorts were detected for some species, especially those of Carangids. Each of the cohort has its own characteristics, consequently, for analytical approach, they should be treated separately.

An exploratory scheme has been given for recruitment and migration (Sadhotomo and Potier, 1995) mainly from reproduction data and catch length frequency. In general the size distribution tends to follow west-east direction : the average length increase from West to East. Obviously, the spatial distributions of sizes are related to hydrographic conditions.

More generally, three types of life cycle may be distinguished. Based on the catches of seiners, Potier and Sadhotomo (1995) showed that three groups of species more or less coexist in Java Sea: coastal, neretic and oceanic. The oceanic populations (*Decapterus macrosoma* type) live near the continental shelf edge and are found in waters where salinity is never less than 34 %; they are caught during the dry monsoon, when the oceanic waters enter the Java Sea. The neritic populations (*D. russelli* type) live on the continental shelf in waters with salinity between 32 to 34 %°, they are caught all along the year. The coastal species (*Sardinella gibbosa* type) live near the coasts e.g. with highly fluctuating salinity; they are found all the year in small quantities.

It is worthy to note that whether those fish are originating from unit stocks is still questionable. The difference on average length could be due to environmental factors and/or to the existence of different unit stocks. A preliminary study on stock identification, using mitochondrial-DNA analysis is in progress and a proposal on a more intensive study is on the verge of implementation between ORSTOM and RIMF.

SPATIAL EXTENSION

The geomorphological concept of Java Sea has been useful but no longer fits with the system which supports the medium and big seiners exploitation. It is clear now that the bioecological links with South China Sea should not be overestimated. Some exchanges exist, as stated by Hardenberg (1938), but it would mainly imply coastal species. There are seasonal exchanges through the Sunda Strait, but they have an influence only on the south-west waters of Java Sea. The influence of oceanic waters through the wide and deep eastern opening - even if it is modulated owing to inter-annual climatic variability - is much more important. It can be said that, for some of the small pelagic species, the Flores Sea to South Sulawesi and Makassar Strait up to Banda Sea are probably parts of the system.

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

BIOECOLOGICAL SAFEGUARDS

The examination of the open waters pelagic stocks exploitation in its present state, shows that there are specific characteristics which lead to some safeguards to surexploitation :

- The combination of different life cycles for the main target species mean that their vulnerability is only partial, coastal and neritic species being protected in shallow waters (but their catches by small scale fisheries is not well known) and oceanic species being out of reach, at least for their adult components in eastern waters.
- Owing to acoustic studies results, the biomass distribution seems to be scattered and fish overspread when comparing with other pelagic ecosystems in the world. This original feature has to be related to Java Sea specific environment characteristics which lead to specific fish behaviour. Usually, small pelagic fishes are found in shoals which represent natural concentrations easier to find and to fish. It could explain why the fishing occurs mainly at night and why the operations of concentration (with aggregating device and/or light) are quite long, enabling generally only one seine haul, sometimes two, during the night. Even with nets and lights improvements it means that the individual effort for a given boat should not rise very much. It seems to be a natural constraint limiting fishing effort.
- Safeguards have been placed on the size of vessels. There are two limits to the size of the vessels : on the one hand, coastal waters along Java Coast are shallow and the harbours are built round river estuaries in Central Java. The draught is low and already larger seiners have problem to enter the harbour when coming back from fishing cruises. On the other hand, traditional keels building with one wood piece does not seem able to adapt to bigger boats. From this two points of view, the present seiners seem to have reached their maximum size (36 to 37 meters in total length).

In order to deal with these natural constraints as well as for management purposes, it would seem sensible to limit the size of seiners. It seems that a maximum length round 30 meters - that is to say about 120 tons - would be quite suitable.

FROM ECOSYSTEM TO SYSTEM

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

We have now a basic understanding of the functioning of the system which is represented by small pelagic stocks in Java Sea open waters, their exploitation by seiners fisheries and distribution and commercialisation through North Coast harbours. The main results deal with bioecology, acoustics, exploitation system, socioeconomics. In order to reach the general objectives initially fixed, we had to build a multidisciplinary team able to describe the functioning of the whole system.

Fisheries biologists focus on population dynamics and exploitation and their major interconnection with social sciences occurs at the end of the production process with landings in harbours; the economists then take in charge the quantitative and qualitative issues through transformation and commercialisation channels. From this point of view, we think that the objectives have been reached. Nevertheless we still find weaknesses in our general knowledge, from two points of view, at least.

The environment case is a special one, as information and data collection are under the authority of other state agencies and were mainly out of reach of such a project as PELFISH. For all living marine resources monitoring and survey as well as for oceanographic studies (productivity, pollution, ...), Indonesia needs permanent means at several scales. More attention should be paid to satellite data (remote sensing) on the one hand, and on the other hand it has been suggested to install a permanent network of coastal stations, cheap and easy to manage, which would give very valuable information on the quality and dynamics of marine waters. The inter annual variability issue should be analysed and an index could be developed, accounting both for local variability and large scale variability (ENSO).

In the social sciences field - but for some aspects of innovation, adaptive processes and women part in fisheries - the sociological knowledge is very low as well as, for recent history, social life and employment.

In brief, the aquatic resources management should rely on better ecological and socio anthropological data as they are integral components of the exploitation system.

CONCLUSION

One of the major results of the Project is in depth collection of existing information on Java Sea pelagic open water fisheries and their physical and human environments. Along with the description of the exploitation scheme and the commercialisation issues they allow us to give a first synthesis on the system and its functioning. Even if it has to be completed and reinforced it gives the preliminary basis on which the fisheries management should be built.

The initial definition of this project's frame was given by the Java Sea open waters, the small pelagic stocks within this area, the so-called medium and big seiners catching these fishes in these waters and the corresponding post-harvest activities. The general postulate underneath this definition was that it was more or less an unity which could be described in itself. This assumption has proved to be a valuable working hypothesis, leading to proposals for next steps in management. Nevertheless, we have to underline that this general definition present at least two major weaknesses for a better understanding of the whole system.

The first one is related to the spatial distribution of the small pelagic stocks and the bioecology of the main species : more should be known about areas which could be important bioecological ones for some of the species caught : West Java Sea and South Kalimantan waters for neritic and coastal species, North of Makassar Strait, Sulawesi and may be further eastward for oceanic species. Understanding the Java Sea open waters small pelagic fisheries means studying also Java Sea coastal waters and links with adjacent water bodies, at least from two points of view : spatial distribution of species and populations (genetic studies) and quantitative estimates of the abundance (biomasses through acoustics but the availability of modern and adapted research vessels is a preliminary condition.

The second one concerns the exploitation scheme. The importance of the mini seiners fishery is demonstrated and their contribution to the total captures of the main small pelagic open waters stocks should be taken into account. Beyond our first study, we need to know better this fishery for its overall quantitative impact, but also for its socio-economic specificity as it is an inter-linking field towards coastal and littoral fisheries.

Thus, the Project brought up new questions, mainly outside its initial scope as it is not really satisfactory to deal with small pelagics only. Along our way, it became more and more obvious that strong interactions are found between fisheries, between fisheries products and with other next economic fields (aquaculture, transport). Even more the coastal waters present a specific landscape with high competition on coastal resources, changes of the environment through human behaviour (infrastructures, pollution). It can be concluded that, beyond the next steps the frame should be even larger, including all marine resources. It means a systemic approach of Java Sea aquatic resources exploitation and management. Such an approach will have to deal with complexity and imply involvement of co-management process. Thus the future should combine classical numerical knowledge and more modern approaches taking into account complexity linked to multispecific populations.

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