HARNESSING THE LIVING FRESHWATER AND MARINE RESOURCES OF SOUTHEAST ASIA

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ABSTRACT.The freshwater and marine resources in Southeast Asia, with emphasis on those in the Philippines, are described. Strategies for sustainable use, some of them already tested to be effective in the Philippines, are discussed. In general, these strategies aim to conserve biodiversity, to maintain the integrity of the environment, to protect fishery stocks, to involve fishing communities in the management, and to use environmentally friendly technologies for enhancing fishery production.

INTRODUCTION

Southeast Asia is one of the world's centers of biodiversity. In this area are tropical rainforests and coral reefs, two major tropical ecosystems with the highest species diversity (Wilson, 1988; Ray, 1988). A major challenge to science in the twenty-first century is how to conserve this biodiversity and to make it work for the benefit of humankind.

This paper discusses the living aquatic resources in Southeast Asia, with particular reference to those in the ASEAN countries, and the activities and strategies of utilizing them at sustainable levels.

Oceanographic and Ecological Features of Southeast Asia

The land and the surrounding marine waters of Southeast Asia and the prevailing currents are shown in Figures 1, 2 and 3. The bodies of marine water bounded by the Pacific Ocean and the Indian Ocean, including the Andaman Sea, Timor Sea, and Arafura Sea, are considered as a distinct unit, the Southeast Asian Seas, covering an area of 8.94 million square kilometers, and containing nearly all types of oceanographic and geologic features, such as continental shelves, continental slopes, deep sea basins, troughs, trenches, and volcanic and coral islands (Soegiarto, 1985). So distinct is the Southeast Asian Seas that the United Nations Environment Program has developed the East Asian Seas Action Plan to deal with environmental problems in the region (Snidvongs, 1985).

The marine ecosystems or marine habitats in these waters are the estuaries, mangroves, seagrass beds, coral reefs, soft-bottom areas, and open water. One consequence of this diversification of habitats in the Southeast Asian Seas region is the high species richness. For example, Briggs (1974) described as a fertile triangle or area of highest species richness that portion of the Southeast Asian Seas formed by the Philippines, New Guinea, and the Malay Archipelago. In the Philippines alone, there are an estimated more than 2,000 species of fish (Herre, 1953), over 3,200 species of mollucs (Springsteen and Leobrera, 1986), over 400 species of corals in about 70 genera (Nemenzo, 1981), and 971 species of benthic algae in 209 genera (Silva, Meñez and Moe, 1987).

On land are freshwater habitats for aquatic organisms composed of rivers, lakes, marshes, and impoundments. There are extensive freshwater habitats in Thailand, Malaysia, and Indonesia inhabited by many freshwater fishery species. These are exploited for food and for aquarium purposes (Encyclopedia Britannica, 1971). Similarly, in the Philippines, where species richness is lower compared to Thailand, Malaysia, and Indonesia, lakes like Laguna de Bay (area 86,000 ha), rivers such as the Pampanga River (PCARR, 1981), and swamps such as the Liguasan marsh on Mindanao, supply fishery products.

The challenge is to manage the rich and varied aquatic resources of Southeast Asia, in the face of increasing human population pressure, for sustained productivity. In many cases, management requires rehabilitation and protection of the stocks in order to bring them back to their optimum productive levels.

Strategies for Sustainable Use of Living Aquatic Resources

Freshwater Ecosystems. Threats to the water quality of freshwater habitats must be minimized, if not removed, if these habitats are to work for humankind. These threats are pollution and flooding (Alcala, 1991). Sedimentation (a form of pollution) and flooding are generally caused by forest denudation in the uplands, although excessive sedimentation is sometimes the result of mining activities. Other sources of pollutants are waste effluents from agriculture, industries, and aquaculture (Alcala, 1991; Primavera, in press). It is obvious that the solution to this problem includes reafforestation of denuded area and programs in flood control and pollution control.

A bonus of massive reafforestation is the restoration of the normal water flow in rivers which in the past harbored many species of prawns and food fish (e.g. gobies and mullets; see Herre, 1927 and Roxas, 1934) and other animals yielding other products (e.g., crocodiles; see Alcala and Dy-Liacco, 1989). Dried up river systems could be rehabilitated to become productive again.

Another threat to the freshwater resources is over- exploitation, often with the use of destructive fishing methods. Rivers have been dynamited or poisoned with chemicals. Lakes are generally used for fishfarming, and it is not unusual to find overcrowding of water space by fish cages. Laguna de Bay in Luzon is a classic example (PCARR, 1981; SEGREAH UNDP/ADB, 1974). In this lake, species richness and fish yields have been reduced as a result of overexploitation and deterioration of water quality. Another example in the Philippines is Lake Lanao, which had lost most of its dozen species in eight genera of endemic cyprinid fishes (Herre 1924) before scientists were able to study them. Still another Philippine example is Lake Buhi in the Bicol region, home of the *sinarapan* (gobies), which are disappearing (see publications of Philippine Council for Aquatic and Marine Research and Development, Los Baños [PCAMRD]).

Aside from protection, research activities are very much needed. One research area is the study of culture ranching or aquarium potential of endemic fish species. Another is the genetic improvement of introduced species currently being used in aquaculture. Something is being done in determining potentials by research bodies such as PCAMRD, but more effort is needed. With regard to the genetics problem, the International Center for Living Aquatic Resources Management (ICLARM), the University of the Philippines-Marine Science Institute (UP-MSI), and the Central Luzon State University are involved in the genetic improvement of farmed tilapias (Pullin *et al.*, 1991).

Many species of finfish and shellfish in the freshwater habitats of Southeast Asia can be managed and protected to benefit human populations in the region.

Shallow-Water Marine Ecosystems. These productive ecosystems comprise estuaries, mangroves, seagrass beds, coral reefs, soft-bottom areas (in part), and open water (in part). Most marine production readily available to the larger mass of the human population occurs in shallow waters. Resources in these waters bear the brunt of human exploitation and pollution with the consequent depletion of fishery stocks and degradation of the environment (Yap and Gomez, 1985). In the case of mangroves, these have been logged for fuelwood and/or converted into fishponds (Fortes, 1988, Ruhabhorn and Phantumvanit, 1988). In recent years several management strategies have been implemented to address environmental problems.

Protective Management. One of these management strategies is protective management. Reserves, sanctuaries, and marine parks have been set up all over Southeast Asia. Thus, portions of coral reefs, or even whole reef areas have been temporarily or permanently closed to fishing (Johannes, 1978; Ruddle and Johannes, 1985). Coral reefs have also been used for multiple purposes (Kenchington, 1988). The concept of marine fishery reserves (MFRs), as applied to coral reefs, is gaining

acceptance as a viable option for sustainable coral reef fisheries (Plan Development Team, 1990). MFRs are reef areas permanently closed to human exploitation. They provide protection from fishing mortality to portions of reef fish populations which serve as spawning stock to ensure recruitment supply to the entire reef system as well as reefs elsewhere. The effectiveness of an MFR in the maintenance of species richness, abundance, and community structure within the reserve and of high fish yields outside of the reserve has been demonstrated by experiments in the central Visayas, Philippines. In brief, protective management through an MFR resulted in higher species richness, higher abundance, and higher fish yields on Sumilon Island (Russ, 1985; Alcala, 1988; Russ and Alcala, 1989; Alcala and Russ, 1990). Fish yields during the period of protection were higher than those during the period with no protection. There was obviously an export of fishes from the MFR to the fished area.

MFRs located throughout the Southeast Asian Seas region could be sources of fish larvae for coral reefs situated downstream of prevailing currents (Roberts and Polunin, unpubl.). This may be true of Palawan Island fisheries which could be replenished by fish larvae from the Tubbataha National Marine Park moving westward with the prevailing currents in the Sulu Sea (Figures 2 and 3).

Protection of mangrove ecosystems appears successful in some countries of Southeast Asia, such as Malaysia and Brunei (pers. comm.) but is being beset by problems in such countries as the Philippines, where mangroves are protected only on paper but not in reality. From our experience, there are probably only a few small mangrove patches that have been afforded some degree of protection in the country.

The seagrass beds are still neglected, despite the heroic efforts of seagrass workers like Fortes (1988, 1990). As far as the author knows, there are no protected seagrass beds in the country.

Similarly, no soft-bottom areas are strictly protected. However, occasional closure of certain bays to trawlers automatically protects the soft-bottom benthos. The important role of soft-bottom benthos in the overall productivity of shallow-water ecosystems has been reviewed by Alongi (1989).

The fishery production of shallow water environments is one cogent reason for protecting them. Coral reefs, for example, produce in excess of 30 tons of fish per square kilometer per year (Alcala, 1988; Alcala and Russ, 1990; Alcala and Gomez, 1985). Mangroves through their leaf litter have an important role in fisheries by supplying 13-47% of the carbon requirement of demersal food chains (Robertson *et al.*, 1988).

In Malaysia, Jothy (1984) estimated that 40% of fish landings are associated with mangroves. Many fish species are found in mangroves (Robertson and Duke, 1987). The currently accepted idea is that mangroves are nursery areas for fish. Seagrass beds have also been found to harbor a number of fish species, and also serve as fishery nursery sites. Fortes (1990) summarized the information from Southeast Asia. They may also export organic matter; this idea is being looked at by researchers such as Fortes (1991) and Oñate-Pacalioga and Estacion (1991).

Estuaries are generally productive areas, serving as fish nursery areas, but bear the brunt of pollution, especially sediment from upstream areas, chemicals from industries, and domestic wastes. The estuarine portions of Manila Bay are examples of polluted waters. Elsewhere in the country, mouths of rivers to which mine tailings find their way are additional examples. There are no protected estuaries in this country. Protection would appear to be one of the urgent needs of shallow- water marine ecosystems.

Protection should be extended to small island ecosystems that are as yet almost pristine. In Malaysia, small thickly forested islands, such as Pulau Tioman and Pulau Redang, have been converted into recreational or resort islands. It is important to maintain the balance between development and conservation to assure the survival of both marine and terrestrial components of these island ecosystems.

Rehabilitation Schemes. The other strategy to make our coastal ecosystems work for humankind is to rehabilitate degraded environments to allow the restoration of the original associated biota. Mangrove reafforestation, coral transplantation, and artificial reef establishment are examples of these schemes. In the Philippines, the Department of Environment and Natural Resources (DENR) has embarked on a national reafforestation program. In coastal areas, one result of this activity is to increase the amount of organic matter which will serve as base of food chains for organisms. This would increase the species diversity of these ecosystems and make available sources of proteins to the dependent human populations. Long before the DENR program of reafforestation, some island communities in the Visayas, Philippines had already started planting mangrove trees for use in building construction and to attract fishery species (pers. obs.). Other Southeast Asian countries, such as Malaysia, Indonesia, and Brunei, probably do not need to replant mangrove trees, as they still have large areas of primary mangrove swamps.

Coral transplantation has been shown to be feasible, and some species of economic importance (e.g., blue coral) have been observed to grow well. Gomez (1991) has summarized the work in this area at the UP-MSI. The purpose of coral transplantation is to rehabilitate denuded bottom areas to attract reef-associated organisms, including fish. In view of the widespread destruction of coral reefs throughout South-

east Asia and their importance as source of valuable products for man and as recreation areas for local populations and tourists, coral transplantation is one way of ensuring their usefulnesss to humankind.

The establishment of artificial reefs has been recommended with some precautions as a management tool for artisanal fishery and as a means of habitat enhancement (Polovina, 1991; Chou, 1991; Vande Vusse, 1991). Our experience with the first artificial reef in the Philippines (Alcala, 1979) has shown that it can indeed yield a reasonable biomass of fish with a relatively small economic effort. There is currently a widespread interest in artificial reefs in Southeast Asia (White *et al.*, 1990).

At the experimental stage is transplantation procedure for seagrasses to hasten the consolidation of loose bottom substratum. In the Philippines, the UP-MSI, Diliman, has been transplanting certain species of seagrass off Marinduque Island (pers. obs.).

Sea Ranching and Seafarming Schemes. Seagrass beds and coral reef areas may be utilized for sea ranching and seafarming activities. Normally, seagrass beds abound in several species of sea urchins and sea cucumbers, some of which are used for food. In addition, seagrass beds have turned out to be reasonably good sites for ranching giant clams and possibly abalone (Alcala, 1990).

Both seagrass beds and coral reefs can be used to farm the red alga *Eucheuma*, provided the floating method is used to prevent trampling on the corals (pers. obs.).

Fish farming with the use of floating cages over seagrass beds and coral reefs is being practiced in some parts of the country (pers. obs.). A simple technology of fish ranching on seagrass beds which are covered and uncovered daily by tides is practiced by residents of one small island off northern Negros, Philippines. The technology consists of piling dead coral rocks over an excavated seabed to form rock mounds which are colonized by fishes. Harvesting occurs at low tide.

Alternatives to Destructive Fishing and Overfishing. Over 300 species of fish, mostly from coral reefs, are highly desired for use in home aquaria abroad. Unfortunately, most of these fishes are caught with dip nets after exposure to poisonous cyanide chemicals underwater (pers. comm.). The result is that the fishes do not live long. But the more lasting effect is on the corals which die as a result of exposure to the chemicals, precluding sustainable harvests in the future. To address this problem, the HARIBON Foundation, an environmental non-governmental organization, has conducted community-based programs to persuade cyanide fishermen to use barrier

nets instead of poisonous chemicals. The program also educates the fishermen on the ecological importance of coral reefs and the need for environmental protection.

A study of the demersal (bottom) fishery resources of Manila Bay has shown that the resources have suffered from massive biological and economic overfishing (Silvestre *et al.*, 1987). These authors suggest as a solution the reduction in the number of fishing boats and the increase of the mesh size of nets from 2 cm to at least 5-6 cm. Pauly (1989) maintains that Philippine fisheries in general are already overexploited.

Community Participation. It has become clear that fisherfolk participation in the management of shallow-water marine resources is necessary. Management requires the cooperation and active participation of user communities. Fisherfolk organizations are often the key to successful protective management in relation to the strategies discussed earlier. This is amply demonstrated by the experience in the central Visayas (Savina and White, 1986; Abregana and Alcala, 1991). However, management of off-shore resources, such as atolls in the Sulu Sea, would require a strong enforcement component backed up by patrol craft.

Sustained Use for Recreation. Coral reefs are the most attractive ecosystems to tourists because of their natural beauty and also because coral reefs are new to them. An increasing number of tourists visiting Southeast Asia are expected to snorkel or scuba dive in coral reefs. This development is expected to bring substantial income into the country. However, many travel agencies and resort hotels serving tourists do not have educational or environmental programs to protect fragile corals from damage, accidental or intentional, in the course of diving operations. Or if they do, some of them are indifferent to their implementation (e.g., use of spearguns by their diving customers). It is obvious that those involved in the tourist trade should help protect the coral reef resources on which their business depends in the long-term.

Sea Tenure Issues. With increasing mariculture activity of fisherfolk in coastal ecosystems, questions on their sea rights have been raised. Cordell (1989, p. 5) defines sea tenure as referring to "...any system of informal, relatively closed, communal, shared, joint, collective, or even private property in fishing. Whether tenure is legal or illicit, more or less overt or covert, more or less secure, spoken or unspoken, these customs usually carry a special weight or legitimacy that can only be imposed from within, by a group on its members." Governments should address the issues of sea tenure before conflicts arising from the use of nearshore marine resources erupt and threaten the peace and harmony prevailing in fisherfolk communities.

Oceanic Fishery Resources

To this group belong the fishery resources at the sea bottom and in the water column of marine waters more than 200 m deep. Included here are the resources in the Exclusive Economic Zone (EEZ). The fishery species are pelagic, highly mobile fishes like tuna, tuna-like fishes, and squids. Marine mammals (dugong, porpoises, and whales), though not part of fishery resources, are mentioned here only because of the urgent need to protect most of them (Dolar 1992, in press).

Some Southeast Asian fishery authorities believe that the tuna fishery resources in the EEZ are under-exploited (Anonymous, 1987; Aprieto, 1990). However, Dalzell and Corpus (1990) presented evidence of biological overfishing of small pelagics, some of which are caught in nearshore waters. The *payao*, which is a fish-attracting device widely used in the Southeast Asian Seas, appears to be one of the reasons for this overfishing because it facilitates the capture of juveniles. At any rate, more research is indicated to settle the issue for the large tuna species being exploited in southern Philippines, for example.

The EEZ tuna resources are believed able to withstand more exploitation, but to exploit these resources modern fishing and oceanographic vessels are required. If this assessment is correct, the Philippines, which lags behind Indonesia and Malaysia in studies and exploitation of its EEZ resources, should be prepared to invest heavily in equipment in order to catch up with its ASEAN neighbors.

The bottom fisheries are not well known, and there is a need for more exploration of deep waters. One deep water species that is probably already extinct because of overexploitation is the chambered nautilus in Tañon Strait, between Negros and Cebu Islands, Philippines (pers. obs.). The author observed shark fishing by long line in the Sulu Sea at depths of 1,000- 2,000 m some years ago, but this activity is apparently seasonal.

Summary

The strategies and most of the activities suggested in this paper are ongoing. What are needed for the twenty-first century are the intensification of these activities and in some cases the institutionalization of the strategies. We can expect to continue to harness our shallow-water marine resources only if we simultaneously institute protective management and rehabilitation of these resources. There is a need to develop simple environmentally friendly technologies that will increase nearshore production. There is also a need for fisherfolk communities to participate in the management and protection of these resources. To make use of our deep sea ma-

rine resources in the EEZ, the Philippines has to invest in seaworthy oceanographic and fishing vessels.

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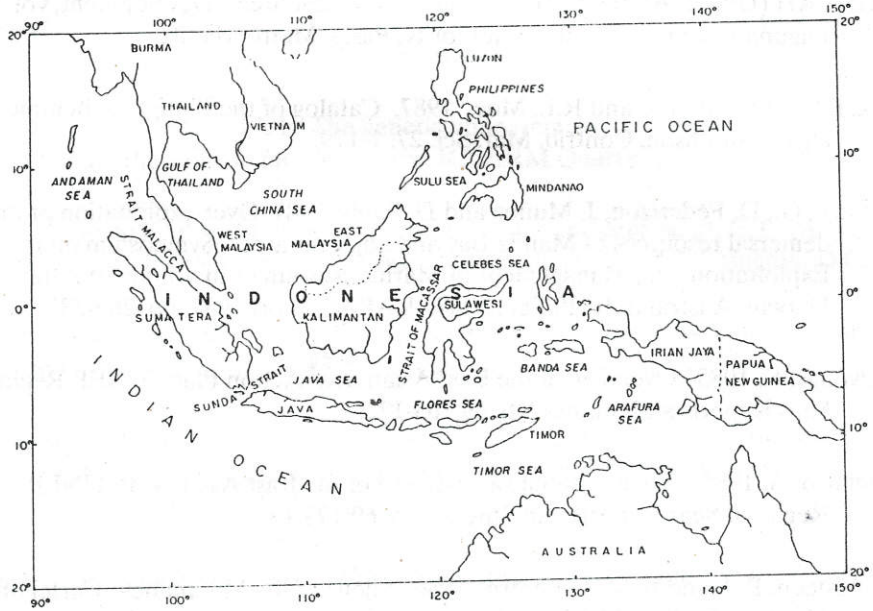

Figure 1. Map of the South-East Asean Seas. Taken from: Soegiarto, A. 1985. Oceanographic assessment of the East Asian seas. In: UNEP: Environment and Resources in the Pacific. UNEP Regional Seas Report and Studies No. 69. UNEP 2985. pp. 173-184.

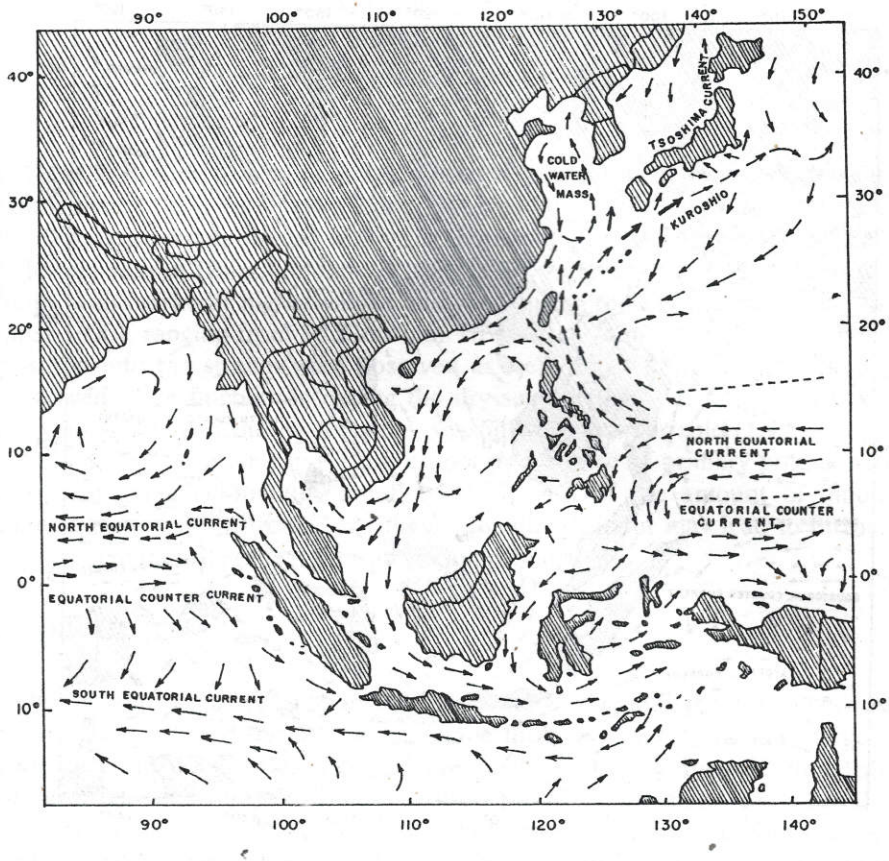

Figure 2. Surface current patterns of South-East Asian waters during the northeast monsoon (December-May).

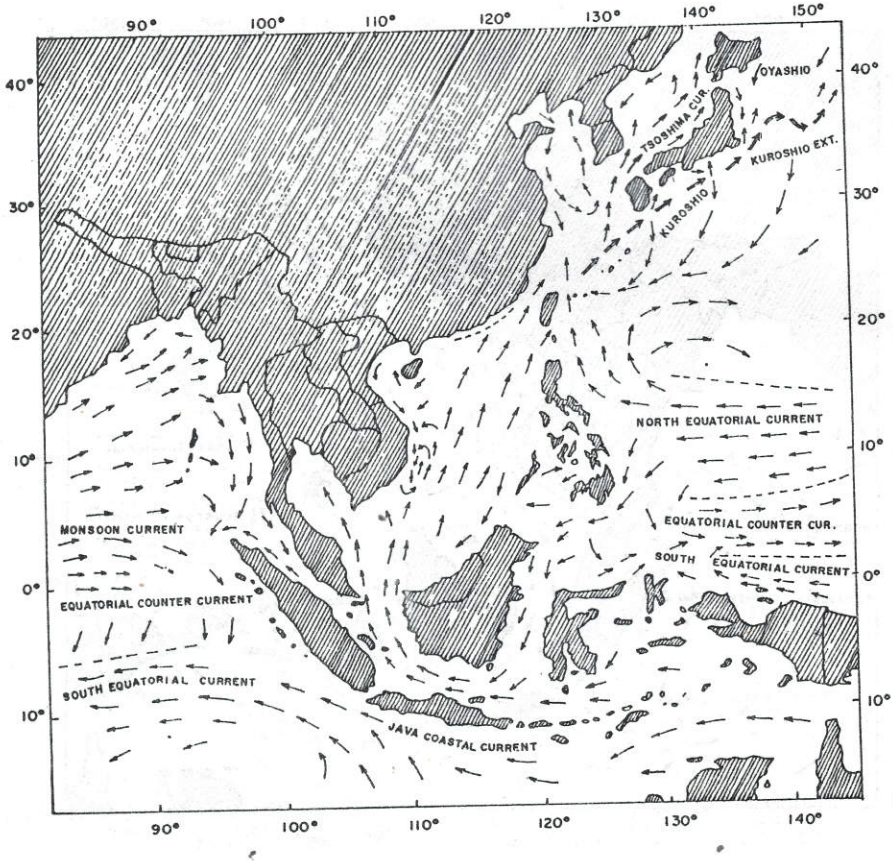

Figure 3. Surface current patterns of South-East Asian waters during the southeast monsoon (June-November).