

FAO Fisheries Report No. 700

FIPP/R700 (En)

ISSN 0429-9337

FAO/JAPAN GOVERNMENT COOPERATIVE PROGRAMME

GCP/INT/788/JPN

Report and documentation of the

**INTERNATIONAL WORKSHOP ON THE IMPLEMENTATION OF
INTERNATIONAL FISHERIES INSTRUMENTS AND FACTORS OF
UNSUSTAINABILITY AND OVEREXPLOITATION IN FISHERIES**

Mauritius, 3-7 February 2003



DISCUSSION PAPER 7**THE GULF OF THAILAND TRAWL FISHERIES**

by

*Ratana Chuenpagdee and Daniel Pauly⁹⁶***Summary**

The Gulf of Thailand (GoT) has long been overfished – a well-known fact that shapes many of the fisheries policies developed by the Department of Fisheries (DoF), the Thai government lead agency responsible for fisheries management. Numerous measures have been taken that were intended to reign in the trawl fisheries, the major cause of overfishing in the GoT, to restore and protect the fisheries resource base, to provide food security for coastal and other communities through aquaculture development and to improve livelihood in the fishing communities. The effectiveness of these measures, in their application to the trawl fisheries in the GoT, is reviewed and difficulties and obstacles in the management of these fisheries are presented.

The DoF developed fisheries policies that largely correspond to those that are accepted within the global fishery management community, and which are related to bio-ecological, social, economic and institutional components of sustainability. Moreover, in support of the DoF's mission, the Thai Government has endorsed numerous international treaties and conventions, notably the United Nations Convention on the Law of the Sea, the United Nations Fish Stocks Agreement and the FAO Code of Conduct for Responsible Fisheries. As a member of the Association of Southeast Asian Nations (ASEAN), Thailand also has endorsed various regional fisheries agreements, besides serving as host for several important fisheries-related meetings, such as the NACA/FAO Conference on Aquaculture in the Third Millennium, February 2000; the ASEAN-SEAFDEC Conference "Fish for the People" in November 2001; and most recently the first Coastal Zone Asia-Pacific Conference in May 2002.

The problems with trawl fisheries in the Gulf of Thailand continue. While the number of trawlers has been reduced to about 8 000 during the past 10 years their cumulative fishing capacity is still well in excess of what is needed for maximum sustainable yield or maximum employment in the industry. Further, their catch per effort continues to decline, while the bulk of the catches now consist of "trash fish."

The government policies to protect and restore the fisheries resources of the GoT are not effective. Notably, they are not followed by implementing legislation and enforcement (and the corresponding budget allocations). Moreover, they often exacerbated existing conflicts between large-scale and small-scale fishers. Overall, the difficulties of and obstacles for management of the trawl fishery in the GoT are due to inappropriate incentives, absence of policy implementation, poverty in fishing communities, and lack of alternative employments for fishers.

⁹⁶ The views expressed in this paper are solely those of the authors, Ratana Chuenpagdee, Department of Coastal and Ocean Policy, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point Virginia, USA, ratana@vims.edu; and Daniel Pauly, University of British Columbia, Vancouver, British Columbia Canada, d.pauly@fisheries.ubc.ca.

1. INTRODUCTION

This contribution reviews the difficulties and obstacles faced by the Thailand Department of Fisheries (DoF), the lead agency for the management of Thai fisheries, in the implementation of existing fisheries instruments in order to meet fishery management aims. The review is conducted with respect to major factors of unsustainability and overexploitation in trawl fisheries of the Gulf of Thailand (GoT). It also addresses lessons learned from the implementation of various policies, identifies gaps and suggests paths to their solutions. The fisheries in question have been distinguished from a set of six different types of fisheries, by the following description, “these fisheries are really multispecies and multigear. [...] These fisheries occur in South East Africa, off West Africa and off Eastern South America. In these fisheries, it may be illusory to consider bio-ecological sustainability at the scale of individual species” (Gréboval, 2002). The mixed trawls emphasized in this review are demersal trawls, such as otter board trawls, pair trawls, and beam trawls, which are the predominant gears in the GoT.

With an area of about 350 000 km², the GoT is a typical Large Marine Ecosystem (LME) in term of its size (Sherman and Duda 1999). However, it differs from a number of other LME in being, to a large extent, part of the EEZ of a single country (Fig 1), thus minimizing straddling stocks issues. Moreover, the GoT appears largely unaffected by the massive regime shifts that beset other areas of the Pacific, e.g., the Central/North Pacific (Polovina *et al.* 1995). These features lead to a situation where ecosystem effects of fishing can be evaluated in ‘pure’ form, as it were, without having to account for the confounding effects of, e.g. foreign fleets operating within the GoT, or environmental fluctuations. This review is therefore focused on Thai trawl fisheries operating in the GoT.

Four main aims of fishery management were identified at the Bangkok Workshop⁹⁷ i.e., bio-ecological, social, economic, and institutional. Following the suggested framework from the Bangkok Workshop, we review the trawl fisheries of the GoT in terms of the implementation of the existing fisheries instruments, by addressing three main questions.

Is management of trawl fisheries of the GoT successfully achieving the four main aims?

Why is fishery management successful (or not)?

How can the difficulties and obstacles be overcome?

The review is structured into five sections. First, we describe the key features and development of the GoT fisheries, with an emphasis on the trawl fisheries. Next, we provide a brief overview of the main organizations in Thailand responsible for, or playing critical roles in, fishery management. This is followed by the assessment of difficulties and obstacles to effective implementation, using the suggested framework mentioned above. Examples are given with respect to major factors of unsustainability and overexploitation identified at the Bangkok Workshop, including inappropriate incentives, high demand for limited resources, poverty and lack of alternatives, complexity and lack of knowledge, lack of governance and interactions with other sectors, and with relation to major international instruments, such as the United Nations Convention for the Law of the Sea (UNCLOS), the Code of Conduct for Responsible Fisheries (CCRF), etc. The next section addresses how these factors of unsustainability interact with the achievement of fishery management aims, as well as describes lessons learned from the implementation. The final section suggests some paths to address these difficulties and obstacles.

⁹⁷ Gréboval, 2002. FAO/Japan Government Cooperative Programme International Workshop on Factors Contributing to Unsustainability and Overexploitation in Fisheries, held in Bangkok, Thailand, 4-8 February 2002. Report and Documentation in FAO Fisheries Report No. 672, FIPP/R672.

1.1 Key features and development of the Gulf of Thailand fisheries⁹⁸

The GoT, as defined on Fig. 1, consists of three subsystems: the shallow 'Inner Gulf' ($\approx 10\,000\text{ km}^2$); a band of shallow grounds (down to 50 m), bordering the East and West coasts, reaching to the

Cambodian coast on the East, to the border of Peninsular Malaysia on the West ($\approx 150\,000\text{ km}^2$), and supporting the bulk of the demersal trawl fishery; and a Central Basin ($\approx 190\,000\text{ km}^2$), with depths ranging from 50 to 80 m, and a shallow sill (about 50 m) that limits water exchanges with the open South China Sea (Piyakarnchana 1989; Eiamsa-Ard and Amornchairojkul 1997).

Primary production prevailing in the GoT is known to be relatively high, with a recent boost by increased nutrients from rivers and shrimp farms, which in turn leads to increasing occurrences of harmful algal blooms, oxygen depletion events ('dead zones'), food poisonings and other pollution effects, particularly in the Inner Gulf (Eiamsa-Ard and Amornchairojkul 1997; Longhurst 1998; Piyakarnchana 1999).

Until the early 1960s, Thai fisheries had been driven mainly by their own, internal dynamics. This was reflected in an emphasis on small pelagics (mainly Indian mackerels, *Rastrelliger* spp. and anchovies, *Stolephorus* spp.), caught by artisanal fishers using mainly Chinese purse seine and Thai purse seine, and supplying local markets. Most important among these was the supply of anchovies for making 'fish sauce' (Nam Pla; Ruddle 1986, Pauly 1996).

In the early 1960s, a Thai-German bilateral project introduced and widely demonstrated the use of light 'Engels' trawl for catching demersal fish, i.e., a gear much more suited to the bottom type and demersal resources of the GoT than the gear used in previous, unsuccessful attempt in the area (Tiews 1965, 1972; Butcher 1996). Contrary to the belief that the Thai trawl fishery was a 'North-South' transfer of technology, detailed analysis (Butcher 1996, 1999) reveals that the technological 'package' that was transferred had been perfected in the Philippines, notably in Manila Bay, at the end of the Second World War (Tiews and Caeces-Borja 1959; Silvestre *et al.* 1987). Thus, the developed-country contribution here consisted mainly of facilitating a 'South-South' technology transfer, i.e., overcoming the isolation of developing-country scientists and managers.

The rapid build-up of trawling effort in the GoT was fuelled from two sources:

- extremely high rates of profit by the first trawl operators, quickly reinvested into more trawlers; and perhaps more importantly;
- cheap loans for further fisheries development, mainly from the Manila-based Asian Development Bank, and which markedly reduced the cost of entry into the fishery (Mannan 1997).

A detailed economic analysis of the GoT demersal trawl fishery is given in Panayotou and Jetanavanich (1987), providing details on the various 'market failures' involved. Also this study analyses the exacerbating effect of the global fuel increases of 1973, which jointly with the declaration of EEZ by neighbouring countries, gradually forced the return into the GoT of a large numbers of trawlers that had been operating outside (Butcher 1999).

An important point to stress is the ecological impact of the massive increase in trawling effort that occurred from the early 1960s on, and which resulted, in the early 1980s, in a strong decline in catch per effort, from about 300 kg/hour in 1961 to about 50 kg/hour in the 1980s, and 20-30 kg/hour in the 1990s (Eiamsa-Ard and Amornchairojkul 1997), as well as in a strong form of 'Fishing down marine

⁹⁸ There is an enormous literature on the history and development of the Gulf of Thailand fisheries and on the interactions with other sectors (partial reviews in Pauly, 1979; Pope, 1979; Hongskul, 1979). This brief account, adapted from Pauly and Chuenpagdee (*in press*), provides key references, serving as a basis for discussion of the issues addressed in this review.

food webs' (Pauly *et al.* 1998; Christensen 1998; Pauly and Chuenpagdee, in press). Similarly, demersal catches, which had earlier increased in response to the build-up of effort, began to stagnate, and to slowly decrease, while the catch composition changed both within species (toward smaller individuals; Pope 1979; Pauly 1980), and between species (toward small, short-lived species; Pauly 1979, Beddington and May 1982), i.e., toward an ill-named mix of "trash fish." As reported by Chullasorn and Chotiyaputta (1997), 30 to 40 percent of the catch from trawl surveys consists of "trash fish," 30 percent of which comprised of juveniles of economically importance species (Ibrahim, 1999). In addition to the traditional Nam-Pla factories, the simultaneous development of the Thai aquaculture industry provided a ready outlet for the "trash fish" landed by trawlers (Hayase and Meemeskul 1987; Csavas 1993). Sumaila (1999) discusses the now global phenomenon of rapid value increases in small fishes 'subsidizing' the overfishing of larger fishes, a phenomenon which classical economists may view as yet another market failure.

The seminar on the 'Future of Thai Fisheries' (FTF) in October 1987 was an important stepping-stone for the management of Thai fisheries (SEAFDEC, 1987). For the first time, government and private sectors formally discussed fisheries trends in the GoT and suggested some constructive solutions. Interestingly, the FTF seminar participants assigned the deteriorating conditions of fisheries resources in the GoT to the lack of interests from the government sector in promoting effective management and focused research. They urged the government to tighten control in some fisheries, particularly demersal trawls and push nets, in addition to encourage small-scale fisheries and to develop outreach program to increase public awareness about resource conservation (SEAFDEC, 1987)

1.2 Key players in the management of the Gulf of Thailand fisheries

The key player in the management of the GoT fisheries is the Government of Thailand, specifically through its Department of Fisheries (DoF), which is presently undergoing a restructuring process, involving the transfer of some sub-divisions to a newly established ministry, as detailed below.

The DoF plays a major role in the management of marine and freshwater fisheries, notably through its own research centres and fishery stations, distributed along the coasts on the GoT and Andaman Sea, and in major coastal cities. As well, the DoF is responsible for setting and implementing national fisheries policies embedded in the National Economic and Social Development Plan of the Government of Thailand. Until late 2002, the DoF was a unit within the Ministry of Agriculture and Cooperatives; within the new governmental structure, many sub-divisions of the DoF have been transferred to the newly established Ministry of Natural Resources and Environment. Nevertheless, the roles and responsibilities of the DoF remain largely the same, viz:

- enforcement of fisheries laws, pertaining to fishing rights in the Thai EEZ, the fish marketing system, and the conservation and protection of wildlife;
- research on the development of aquaculture, on stock enhancement, feed development, animal health, and fishing gears;
- research and survey of fishing grounds within the Thai EEZ and for distant water fleets;
- designing fishing regulations and operating a system of monitoring, control and surveillance;
- research and development on fish storage and processing, quality control and inspection;
- research and development on transfer of fishing technology, promote aquaculture and other fisheries-related occupations; and
- developing databases and distributing information to interested parties.

Fishery policies are developed for a period of five years corresponding to the National Economic and Social Development Plan. During the Eight Plan, covering the years 1997-2001, policies were intended to resolve the problems of over-exploited status of fisheries resources, degraded habitats, ineffective fishery management in addressing conflicts and high fishing costs. During this period, the production target set by the DoF was 1.73 million metric tonnes per year. As well, the DoF was to promote effective and sustainable management, restore the resource base of the fisheries, and improve

living conditions in fishing communities. The DoF attempted to achieve these goals through several measures, such as controlling the number of fishing boats and gears, protecting fish spawning and nursery areas, implementing seasonal closure of the fisheries, promoting allocation of fishing rights to local communities, mitigating the impact of environmental problems, etc.

The fisheries policies developed for the period from 2002 to 2005 largely reiterate these goals, but include, in addition, a focus on the involvement of all stakeholder groups in the management and development of fisheries, in the integration of scientific and traditional knowledge, and in promoting export of fisheries products through quality control and implementation of health and safety regulations.

Although this not discussed here, we must also allude to the role of the Southeast Asian Fisheries Development Center (SEAFDEC), a major regional organization shaping the intellectual context within which the Thai fisheries are managed. Through training, research and information services, SEAFDEC aims at improving the food supply by rational utilization and development of fisheries resources in Southeast Asia. It acts as a catalyst in encouraging regional collaboration through sharing of technical experts and providing forum for discussion between policy makers. Additionally, SEAFDEC provides technical assistance in formulation and implementation of common fisheries policies for the region. Most recently, jointly with ASEAN, SEAFDEC organized a major regional fisheries conference on “Fish for the People” in November 2001, in Bangkok, Thailand.

2. DIFFICULTIES AND OBSTACLES TO EFFECTIVE IMPLEMENTATION

An assessment of the difficulties and obstacles that impede the implementation of fishery management in the GoT is presented below, based on the four components of sustainability, i.e., bio-ecological, social, economic and institutional. Under each component, we assess whether the DoF understands the issues described in Gréboval (2002). Evidence to support our evaluation is provided, using various factors of ‘unsustainability’ as illustrations.

2.1 Bio-ecological component of sustainability

The main bio-ecological aim of fishery management can be divided into three sub-aims, as follows.

2.1.1 To protect, conserve, and restore fishery resources, the environment, the habitat, the ecosystem and bio-diversity

The GoT is part of the Southeast Asia Center of marine biodiversity. For example, as of December 2002, FishBase listed 598 fish species for the GoT Large Marine Ecosystem (see www.fishbase.org). Basic biological parameters (e.g. growth, natural mortality, size at first maturity, etc.) have been published for a small fraction of these species (see e.g., Chomjurai and Bunag, 1970; Hongskul, 1974; Boonwanich and Amornchairojkul, 1982).

As an active member of ASEAN, Thailand has endorsed ASEAN Agreement on the Conservation of Nature and Natural Resources whose parties “agree to preserve genetic diversity by ensuring the conservation and preservation of all species in their jurisdiction especially by protecting endangered species and conserving endemic species”. One of the primary tasks, identified by the government of Thailand, was to bring the laws and regulations into line with relevant international fisheries instruments, such as the Convention relating to the Conservation and Management of Straddling Stocks and Highly Migratory Fish Stocks and the FAO Code of Conduct for Responsible Fisheries (Chullasorn and Chotiyaputta, 1997).

Several measures have been taken for protection and conservation of marine resources in the GoT. Since 1972, trawlers are prohibited from an area within 3 km from the shoreline, and within a perimeter of 400 m of any stationary fishing gear. In 1984, an area of about 26 400 km² in the GoT was declared as a conservation area, prohibiting fishing by all gear types during spawning season from

15 February to 15 May (Phasuk, 1994). Enforcement of these regulations is far from effective, however, because of socio-economic considerations for small-scale fishers (Phasuk, 1994), whose poverty and lack of alternatives are the cause for this unsustainability.

To provide protection of endangered and threatened species, the DoF issued regulations prohibiting the catching of sea turtles, the collection of their eggs and the export of sea turtle shells. A marine turtle nesting area of about 1.6 km² in Trat Province, GoT, has been protected (during the breeding season) for the past ten years. Catching of dugongs and collection of corals are also prohibited. The DoF also emphasizes the rehabilitation of fishing grounds, and promotes artificial reef projects to create protected habitats for marine life. The DoF has not, however, established any stringent program to prevent the extirpation of species of long-lived large fishes, such as sharks, rays, groupers, etc., from the GoT.

The Royal Forestry Department (RFD) has also established and managed several marine national parks, and prohibited some fishing activities in certain areas. Predictably, these measures have been contested in the affected fishing communities, whose members often feel marginalized by government policies and regulations. Although RFD attempts to promote community-based management and to provide appropriate incentives to small-scale fishers, particularly through promotion of sustainable tourism in marine national parks (Coastal Development Centre, 2002), it is unable to successfully protect marine resources, due to lack of effective enforcement.

2.1.2 *To prevent overfishing*

As mentioned above, the GoT trawl fisheries suffer from overcapacity, due to their uncontrolled growth in the late 1960s - early 1970s. This was further aggravated when the Thai Government encouraged the construction of distant water fleet, which in its heyday reached all the way to Oman in the west and Eastern Indonesia in the east. Upon declaration of EEZ by UNCLOS, this fleet had to return to the GoT, adding to the excess effort that was already there (Panayotou and Jetanavanich, 1987).

Another, if indirect, source of overfishing was the build up of coastal aquaculture and poultry industries, which readily absorbed the so-called "trash fish" that the fleet generated (Csavas 1993, Pauly 1996). Similar to the development of trawl fisheries, the DoF had earlier promoted coastal aquaculture, in particular the intensive farming of giant tiger prawn (*Penaeus monodon*) through loans, subsidies and research and development for feed and culture techniques. This was considered an important initiative to support the government policy in increasing fisheries production to meet domestic demand and to increase income from export (Prohmanon, 1987).

In general, overfishing in the GoT, caused particularly by trawl fishing, is well recognized. The urgent measure agreed upon at the FTF seminar was to increase monitoring, control and surveillance, to ensure conservation of fisheries resources and to protect parental stocks and nursery areas. Additionally, through a Ministerial-level agreement, Thailand has jointly conducted survey of fisheries resources with Vietnam in 1997, and has teamed up with Cambodia to perform joint EEZ patrols to enforce regulations and to promote joint assessment of marine resources (Ibrahim, 1999). All these efforts were meant to help keep fisheries resource base from further deterioration.

Clearly, the two examples above, i.e., the development of distant water fleet and of coastal aquaculture, represent inappropriate incentives by the Thai government, which counteract its attempt to prevent overfishing. The issue with the former has now taken a new form, as the government is currently exploring joint venture programs for distant water fisheries with foreign nations. Most likely, Thai trawlers will continue to fish in other countries' EEZ, ultimately causing ecological impacts to the host countries similar to those in the GoT. However, joint ventures should bring more benefits to the host countries than bilateral fishing agreements, where the only benefit to the host country is access fee (K. Juntarashote, personal communication).

The issue of coastal aquaculture development, which is still viewed, an important means of food production, supplementing declining catches from captured fisheries, is discussed further below.

2.1.3 To restore the resources, the habitat and the ecosystems to conditions capable of producing the Maximum Sustainable Yield (MSY), taking into account multispecies and ecosystem considerations

Although the Thai government acknowledges the need for restoration of fisheries resources and habitats, it has not yet incorporated multispecies and ecosystem considerations into fisheries management. This is not surprising, as the ecosystem-based management concept is fairly new and is difficult to implement, even in developed countries. Thai universities and government researchers have so far lacked the skills and knowledge to apply such approach. This is slowly changing, however, as some DoF researchers have recently received training on the use of a major ecosystem modelling software, Ecopath with Ecosim (EwE), now widely used to address marine ecosystem management issues, and developed by a group of researchers at the University of British Columbia. As a result, a EwE model has been developed for the GoT, which builds on an earlier effort by Christensen (1998; see www.ecopath.org). Ecosystem-based management was also promoted at the first Coastal Zone Asia-Pacific Conference (CZAP), organized by the Coastal Development Centre (CDC) in Bangkok in May 2002, jointly with several partners in the region, North America and Europe, however, (see Conference Proceedings: www.vims.edu/czap).

2.2 Social component of sustainability

Two major social aims of fishery management included in this review are described below.

2.2.1 To achieve optimum utilization of the resource, ensure safe, healthy and fair working environments and conditions

Poverty and lack of alternatives lower the opportunity cost of labour, thus allowing seemingly unprofitable fisheries to still earn a positive rent. This is the case in the small-scale fisheries, which compete for resources with large scale trawl fisheries, and whose social and economic conditions have been stagnating at best, if not deteriorating (Nagalaksana, 1987; Pauly, 1987; Juntarashote, 1994). Poverty and lack of alternatives manifest themselves in the large-scale fisheries as well, via the employment of landless farmers from the hinterland and the highlands (Panayotou and Jetanavanich, 1987; Pauly, 1997; National Statistical Office, 2001).

As small-scale fishers saw their catch per effort drop, some of them turned to illegal fishing practices, such as using nearshore push nets, causing damages to seafloor habitats for several organisms and juvenile fish (Nagalaksana, 1987). Although the DoF has given priority to minimize conflicts between small-scale and commercial fishers, conflicts, particularly between push net fishing and other small-scale gears, have accelerated, and in some cases resulted in loss of properties and even lives.

2.2.2 To consider aquaculture a means to promote diversification of income and diet

As stated above, the Government of Thailand has strongly supported aquaculture development as a means to increase food production, supplementing production from the sea. Through its Ninth National Economic and Social Development Plan, the Thai government hopes to diversify aquaculture through practices and environmental friendly technologies, as well to improve the quality of fisheries and marine products to meet human health standard. These initiatives are seen as contributing, if indirectly, to a reduction of excessive fishing effort and to help resolve conflicts between trawlers and small-scale fishers.

The Network of Aquaculture Centres in Asia-Pacific (NACA), situated in Bangkok, together with FAO, organized a “Conference on Aquaculture in the Third Millennium” in Bangkok, in February 2000. The resulting ‘Bangkok Declaration’ acknowledges the importance of aquaculture industry for

developing countries, as it contributes to people's livelihood, food security, poverty alleviation, income generation, employment, and trade, as well as complements other food production systems (NACA/FAO, 2000). However, it also stresses the need for successful national institutional arrangements and capacity, responsible policies and goals, and effective regulatory frameworks supporting sustainable aquaculture development. The declaration supports continued development of aquaculture through transparent processes, and co-operation between States, private sector and other stakeholders.

The price of coastal aquaculture development, mostly of giant tiger prawns in the GoT, is particularly high. Rapid expansion of intensive shrimp farming along the coast, some of which involved clear-cutting of mangrove forests, has caused many environmental problems such as poor coastal water quality, deteriorating of marine resources, and saltwater intrusion into nearby agricultural areas. These impacts are poorly understood and, when quantitatively assessed, are usually much lower than the profits that the shrimp farmers have enjoyed. These high profits resulted in the increase in the number of shrimp farms and culture areas from about 6 000 farms in 1987, taking up an area of 45 000 hectares, to 28 000 farms covering 79 000 hectares in 1999 (DOF, 2001). The catastrophic collapses of several shrimp farms in the Upper Gulf of Thailand in 1989 were attributed to poor water quality originated from industrialization within the watersheds and to pollution from the farms (Dierberg and Kiattisimkul, 1996). Many shrimp ponds are abandoned after they become unprofitable, leaving vast areas unsuitable for agriculture or other aquaculture activities.

In sum, continued support for development of coastal aquaculture can bring about both positive and negative impacts, and the latter will predominate in the absence of regulations. Particularly, the interactions of this sector with other economic sectors and coastal environment must be regulated, such as to avoid unsustainable practices. Other types of culture should also be promoted, particularly traditional, less intensive and less polluting systems.

2.3 Economic component of sustainability

The main economic aims of fishery management include two major categories, as follows.

2.3.1 To match fishing capacity to the productive capacity of the resources, the environment and the ecosystem

One major reason for the rapid development of the trawl fisheries in Thailand was subsidies from the Asian Development Bank (ADB; Mannan, 1997), which provided low-cost loans that fuelled an extreme rapid build up of the Thai trawler fleet at a time where profits would have been high enough, in any case, to allow for fleet size increase (Panayotou and Jetanavanich 1987).

Following on its adoption of the FAO Code of Conduct for Responsible Fisheries, the DoF issued licensing regulations aiming to control the number of trawlers and push nets, and thus bringing down the effort extended to catch demersal fishes to optimum, sustainable level. The regulations are considered effective, as the number of registered trawlers gradually decreased from about 10 500 units in 1980 to 7 000 in 1988 (Phasuk 1994). The current number of registered trawlers is reported at 8 000 units (DoF 2002).

In practice, the decrease in the number of trawlers is due mainly to voluntary exit from fisheries by fishers who no longer wish to continue operating. The government policy, while not issuing 'new' license, does allow renewal of license for current license holders, provided that they follow zoning and mesh size regulations (Boonyaratpalin 2002).

The only actual program devoted to matching fishing capacity to the productive capacity of the resources encourages small trawlers to convert themselves as gill-netters, through buy-back program and financial assistance for gear purchase (K. Juntarashote, personal communication). However, as gill

nets are allowed to operate within three kilometres from shore, they end up also contributing to excess capacity in the GoT, as well as cause conflicts with other fishers using smaller gill nets.

Considering that not all trawlers operating in the GoT actually have licenses, and, that the current level of effort is still in excess of what will produce maximum sustainable yield, or even maximum employment in the industry (Christensen and Walters 2002), it is inescapable that the Thai government still has a long way to go to match fishing effort to the productive capacity of the resources.

2.3.2 *To conduct trade according to the World Trade Organization (WTO) rules, including the elimination of subsidies and to prevent illegally caught fish from reaching their markets*

According to the DoF draft fisheries policy for 2002 to 2006, exports of Thai fishery products have steadily increased (at an average of about two percent by volume and nine percent by value per year) from 1997 to 2001, thus providing a basis for continued support of the export industry by the Thai government. This high demand contributes to unsustainability through the increase of catches of extremely valuable invertebrates, especially penaeid shrimp and squids (mainly *Loligo chinensis*), which benefits from the extermination of their piscine predators (Pauly 1984, 1988). The high value of the shrimps and squids thus ‘subsidizes’ and biologically ‘justifies’ continued high fishing pressure on finfishes. The use in aquaculture operations of the small (‘trash’) fishes that result from overfishing, moreover, encourages further fishing pressure in the GoT (James *et al.* 1991). As well, Thailand, having become a major exporter of seafood, is plugged into what is essentially an insatiable global market, in which prices have been rapidly increasing, thus subsidizing what in some cases would otherwise be unprofitable operations.

Technically, only the small-scale fishery sector is subsidized, through low-cost fuel and infrastructure developments. The large-scale sector, however, while not directly subsidized by the government, has access to cheap, tax-free fuel beyond the 12 miles zone (K. Juntarashote, personal communication).

Finally, landings of fishery products are generally not controlled, except when they are for export markets. In such case, WTO rules are strictly followed to ensure that the products can be certified as meeting regulations.

2.4 Institutional component of sustainability

In terms of institutional aims, several components are included in the review, as follows.

2.4.1 *To use the best scientific information*

DoF regularly conducts fishery surveys and produces annual fisheries statistics. Scientific information from research is used to set management measures such as seasonal and area closures, mesh size limit.

However, the vanishingly small contribution of Thai fisheries scientists to the international peer-reviewed literature (as can be assessed, e.g. via a comparative analysis of the Aquatic Science and Fisheries Abstracts), and the rudimentary stock assessment published by DoF personnel in regional technical reports suggest that the available database on GoT fisheries is underutilized. Or put differently: the GoT fisheries are not managed on the basis of the best available scientific information.

2.4.2 *To apply the precautionary approach to conservation and management*

As for ecosystem-based management, the concepts and principles of the Precautionary Approach are not well understood and are not considered in the management of Thai fisheries. The fact that large-scale trawler operators organized themselves as a strong ‘Fisheries Association’ may have made it difficult for the government to apply the Precautionary Approach. Indeed, this association has already complained that the current regulations to limit the number of trawlers do not take into consideration the high amount of capital invested in these vessels.

On the other hand, small-scale fishers have participated strongly in conservation and protection of marine and coastal ecosystems. Through support from the government and non-governmental organizations, they have been able to organize themselves, and work together in community projects such as mangrove reforestation, and protection of coral reefs.

2.4.3 To do monitoring, control and surveillance in their areas of jurisdiction but also for those vessels flying their flags on the high seas or of foreign vessels using their ports

Foreign vessels do not generally operate or land their products in the GoT. The only foreign fleets that land their catches in Thai ports are tuna boats from Taiwan, which use the fish markets in Phuket, Andaman Sea, Thailand, i.e. outside of the GoT. Their products are inspected by the DoF officer and certified for quality and regulatory control.

On the other hand, many Thai fishing vessels operate in foreign waters, and not all of them are illegal. A recent report revealed that 1 800 licensed Thai trawlers operate in other States' jurisdiction, while another 2 200 trawlers illegally fish in foreign waters (GMT Corporation Ltd., 2003). One of the strategies commonly used by Thai fishing vessels is to change the flag that they fly depending on whose jurisdiction they enter.

2.4.4 To cooperate with other States to promote conservation and responsible fishing and to resolve disputes peacefully

The Government of Thailand has hosted several meetings relating to the FAO Code of Conduct for Responsible Fishing, which has been translated into Thai and distributed to fishers all over the country.

As stated above, some Thai fishing fleets have long been operated illegally in foreign water and many have been caught. From 1982 to 2001, a total of over 3 000 fishing boats and nearly 30 000 crews have been caught by Vietnam, Burma, India, Indonesia, Bangladesh, Malaysia, Cambodia and Australia (GMT Corporation Ltd., 2003). The ensuing disputes are generally resolved peacefully, at least in those cases where the vessel owners are willing to pay for compensation.

2.4.5 To implement transparent decision-making process and involved interested parties

There is a general acceptance of community-based fishery management system as a participatory approach to ensure effective conservation of resources and sustainable fishery development, and fishery cooperatives and other fishers' organizations are considered one of the options for an establishment of co-management mechanism (FAO/RAP, 1998). One of the priorities among the fishery policies for the period from 2002 to 2006 is to promote participation of fishers in fishery management through establishment of fisher groups and fishery cooperatives and through education and training in production and marketing, as well as in raising environmental awareness.

Public hearings are one of the current forms of public participation encouraged by the DoF, although the participants are often passive. Thai people are not accustomed to open discussion, and thus do not always show up at the public hearing, except when they are directly affected by the discussed issues. Environmental NGOs are useful in this context, as they can help articulate issues, provide support to fishing communities and often encourage them to engage in a dialogue with the government.

2.4.6 To promote the awareness of responsible fisheries through education and training

The DoF has extension services and training departments whose roles are to promote education and understanding about marine resources and responsible fisheries to fishers and public. Training for fishers include transferring of knowledge to improve fishing techniques and marketing capacity, and promoting conservation of fisheries resources through informal and formal education program,

information sharing system and local activities to raise awareness of resource importance and environmental values. In addition to the DoF, several academic institutes, including technical school and teachers' colleges, offer degree programs in fisheries management, marine conservation and environmental studies.

2.4.7 *To duly take into account the interest of fisheries in planning the multiple use of coastal areas*

Although the need to integrate fisheries in the management of coastal areas, where multiple and conflicting uses occur, is widely acknowledged, such planning has yet to materialize (Suraswadi, 1996). This situation might improve, however, with the newly established Ministry of Natural Resources and Environment (MNRE), which now incorporates most of the DoF, and will be in charge of managing fisheries and coastal resources.

Coastal ecosystems of the GoT have been greatly degraded due to factors such as coastal pollution from industrial, tourism and urban development, clear-cutting of mangrove forests for coastal aquaculture and coastal development, ecological impacts of fishing, in particular trawling, on habitats and seafloor, tourism impacts on coral reefs (e.g., through boat anchoring, physical damage by divers) (Chuenpagdee *et al.* 2001, Kuijper, 1999). Lack of integrated planning in the coastal zone is identified as one of the reasons for the multi-faceted problems in the coastal areas. It is anticipated that MNRE will play a major role in addressing these problems.

3. LESSONS LEARNED

We have discussed thus far inappropriate incentives, high demand for limited resources, poverty and lack of alternatives, lack of knowledge, and interactions of the fishery sector with other sectors, and the environment as factors of unsustainability for management of trawl fisheries in the GoT. These factors largely undermine the well-intended government fisheries policies, and impede their success, especially when lacking effective mechanisms for implementation. In most cases, the problems are properly identified and directions to address such problems are broadly described. The difficulties and obstacles yet remain in the determination of what specific actions are to be implemented, how and by whom. Framework for implementation must also include monitoring and evaluation to gauge success and to make necessary adjustment.

Is it realistic to expect that multispecies and multi-stakeholders such as trawl fisheries of the GoT be managed to meet numerous fisheries objectives? The case study of the GoT suggests that, while long-term and global vision for management is needed, an effective strategy might involve setting small, practical objectives that correspond well with the local communities' interests and societal values. The new fisheries policies emphasizing the importance of public participation in fisheries management and the education and training program to encourage stewardship of marine resources will eventually lead to decentralized management system where resources are co-managed by the government and the local communities through transparent and collaborative processes.

Contrary to the widespread opinion, we do not believe that high biodiversity and the ensuring complexity are the major factors that "make it hard to identify proper courses of action" (Gréboval 2002). By the standard prevailing in the late 1970s, when simple surplus production models were routinely applied to the entire catch of trawl fisheries (Brown *et al.* 1976), the declining catch per effort in the excellent series of annual scientific trawl surveys conducted by DoF since the 1960s (Eiamsa-Ard and Amornchairojkul. 1997) had made it abundantly clear that the GoT demersal fisheries were overfished (Pauly 1979, Pope 1979). This inference was confirmed by more detailed analyses, involving simulations based on food web models of the GoT ecosystems (Larkin and Gazey 1982; Christensen 1998). The latter study, using the Ecopath with Ecosim modelling approach, showed that the GoT demersal fisheries had strongly depleted its resources base by the early 1970s. Also, Christensen and Walters (2002) showed that this overfishing impacted catches, rents or even jobs.

In other words, high biodiversity and biological complexity were not objective factors for unsustainability of fisheries in the GoT, though subjectively they may have played that role by suggesting that more knowledge was needed before acting. Already, existing information on the exploited species of the GoT available through databases (www.fishbase.org; www.cephbase.org, etc.) can be used with tools, such as Ecopath with Ecosim, to explore ecosystem responses under different management regimes (Pauly *et al.* 2000, Christensen 1998, Christensen and Walters 2002, Walters *et al.* 1997, 1998).

4. PATHS TO SOLUTIONS

Bio-ecological component of sustainability will require rolling back the excessive effort prevailing in the GoT fisheries. This is a path that at present inconceivable, but which if not implemented will eventually lead to destruction of the resource base of the fisheries, currently hovering at about less than five percent of its original biomass (Eiamsa-Ard and Amornchairojkul 1997). This path could become easier to conceive once the direct and indirect subsidies contributing to pseudo-profitability of the fleets are identified (see Munro and Sumaila, 2002 for a critical list of such subsidies in the case of the North Atlantic).

We suggest that the required reduction of effort should be based on zoning of the marine ecosystem, with the coastal areas consisting of zones opened to small-scale fishing only, plus a number of 'no-take' areas wherein the stocks could rebuild themselves, and only a small band of depth, perhaps between 50-100 m, open to a much reduced trawling fleet. The current three km ban of trawlers and push nets is a good basis for the design of these protected areas, where enforceability will be brought about through participation of local small-scale fishers. Allocation of rights to fishers should not be only to harvest the resources, but also to protect, conserve and restore resources for current and future generations.

The rapid development of the Thai economy (including the tourism sector), only briefly interrupted by the 1999 financial crisis, combined with the decline of population growth rate, should help address the above issue, as well as reduce poverty and lack of alternatives problem, by providing employment options, i.e., by increasing the opportunity cost of labour. A focus on education would also help, as it has been shown to strongly increase mobility out of fisheries under conditions similar to those around the GoT (Bailey, 1982).

The outlook for shrimp farming industry is noteworthy, as the importance of this sector for the Thai economy is strongly emphasized in the new fishery policies. Sustainable management of shrimp farming is feasible through environmental friendly technology and good aquaculture practices. For example, the use of semi-closed system, where minimal exchange of water is required, or complete closed system (no water exchange), for shrimp culture is now considered as a feasible technique that brings about higher yield and less problems with diseases and water quality than the current intensive system (Y. Musig, personal communication).

In addition to promoting the aquaculture industry, other measures to promote economic diversification include improved infrastructure facilities for fish landing, storage, processing and marketing, all of which enhance the quality and competitiveness of marine products in the domestic and export markets (but which also, like all subsidies, contribute to reducing costs, and hence to encourage overfishing). Production of value-added products such as surimi has also been promoted. As a result, fishing communities enjoy higher standard of living and improved social well-being (Phasuk, 1994).

Finally, we believe that an integrated management approach should be employed for the GoT trawl fisheries. While ecosystem effects of trawling in the GoT have already been identified, we lack comprehensive assessment of the social and economic importance of the GoT, which considers total values of fisheries, coastal aquaculture, tourism, and other resources and activities in the GoT.

Research addressing this issue will help formulate appropriate policy measures leading to sustainability of trawl fisheries in the GoT.

ACKNOWLEDGMENTS

We sincerely thank Dr Kungwan Juntarashote, Faculty of Fisheries, Kasetsart University for providing references and insightful information on some of the issues addressed in this review, and Dr Yont Musig, from the same institute, for information about shrimp farming.

REFERENCES

- Bailey, C.** 1982. Small-scale Fisheries of San Miguel Bay, Philippines: *Occupational and Geographic Mobility*. ICLARM Technical Reports No. 10. Manila: International Center for Living Aquatic Resources Management.
- Beddington, J.R. & May R.M.** 1982. The harvesting of interacting species in a natural ecosystem. *Scientific American* 247: pp. 42-49.
- Boonwanich, T. & Amornchairojkul, S.** 1982. *Length composition of Saurida undosquamis and S. elongata in the western coast of the Gulf of Thailand*. Marine Fisheries Division, Department of Fisheries. Publ. No. 13, Bangkok, Thailand. 8 pp.
- Brown, B. J., Brennan, M., Grosslein, E., Heyerdahl & Hennemuth, R.** 1976. *Effects of fishing on the marine fish biomass in the Northwest Atlantic from the Gulf of Maine to Cape Hatteras*. ICNAF Research Bulletin 12: pp. 49-68.
- Boonyaratpalin, M.** 2002. *New Concepts for Thai Marine Capture Fisheries Management*. Department of Fisheries. Document Number 1/2002. [in Thai]
- Butcher, J.G.** 1996. *The marine fisheries of the Western Archipelago: toward an economic history, 1850 to the 1960s*. pp. 24-39. In: D. Pauly and P. Martosubroto (eds). *Baseline Studies of Biodiversity: the Fish Resources of Western Indonesia*. ICLARM Studies and Reviews 23.
- Butcher, J.G.** 1999. *Why do Thai trawlers get into so much trouble?* MS, presented at a Symposium on "The Indian Ocean: Past, Present and Future", Western Australian Maritime Museum, Fremantle, Western Australia, Nov. 1999. 18 pp.
- Chomjuraj, W. & Bunag, R.** 1970. Preliminary tagging studies of demersal fishes in the Gulf of Thailand, pp. 517-524. In: J. C. Marr (ed.) *The Kuroshio: a Symposium on the Japan Current*. East West Center Press. Honolulu.
- Christensen, V.** 1998. *Fishery-induced changes in a marine ecosystem: insights for models of the Gulf of Thailand*. *J. Fish Biol.* 53 (Suppl. A): pp. 128-142.
- Christensen, V. & Walters, C.** 2002. Ecosystem-scale optimization policies: the nature of the beast. Presentation at the Fourth William R. and Lenore Mote International Symposium in Fisheries Ecology, Confronting Trade-offs in the Ecosystem Approach to Fisheries Management, 5-7 November 2002, Sarasota, Florida
- Chuenpagdee, R., Knetsch, J.L. & Brown, T.C.** 2001. *Coastal management using public judgments, importance scales, and predetermined schedule*. *Coastal Management* 29 (4): pp. 253 – 270.
- Chullasorn, S. & Chotiyaputta, C.** 1997. The Fishing Status of Thailand. In: *Proceedings of the Regional Workshop on Responsible Fishing*. Bangkok, Thailand. 24-27 June 1997.
- Coastal Development Centre**, 2002. *Issues and Solutions in Coastal Zone Management of Thailand: Conflicting uses and overlapping jurisdiction in the coastal areas*. Summary of a joint workshop between the Department of Fisheries and the Royal Forestry Department, held in Hua Hin, 16-17 June 2001. [in Thai]
- Csavas, I.** 1993. *Aquaculture development and environmental issues in the developing countries of Asia*. pp. 74-101 In: R.S.V. Pullin, H. Rosenthal and J. Maclean (eds). *Environment and Aquaculture in Developing Countries*. ICLARM Conference Proceedings 31.
- Dierberg, F. E. & Kiattisimkul, W.** 1996. Issues, impacts, and implications of shrimp aquaculture in Thailand. *Environmental Management* 20(5): pp. 649-666.
- DOF**, 2001. *Statistics of Shrimp Culture 1999*. Department of Fisheries, Ministry of Agriculture and Cooperatives. Bangkok, Thailand. Document No. 15/2001.

- DOF**, 2002. *Thai Fishing Vessels Statistics 2000*. Department of Fisheries, Ministry of Agriculture and Cooperatives. Bangkok, Thailand. Document No. 16/2002.
- Eiamsa-Ard, M. & Amornchairojkul, S.** 1997. *The marine fisheries of Thailand, with emphasis on the Gulf of Thailand trawl fishery*. pp. 85-95 In: G. Silvestre and D. Pauly. (eds.). Status and Management of tropical coastal fisheries in Asia. ICLARM Conference Proceedings 53.
- FAO/RAP**, 1998. *The Role of Fishery Cooperatives in Promoting Sustainable Coastal Fisheries in Thailand*. FAO Regional Office for Asia and the Pacific. RAP Publication 1998/26. 115 pp.
- GMT Corporation Ltd.** 2003. *Report on Strategies for Joint Venture and Cooperation in Distant Water Fleets*. Applied Economics Research Center, Kasetsart University.
- Gréboval, D.** (comp.). 2002. *Report and documentation of the International Workshop on Factors Contributing to Unsustainability and Overexploitation in Fisheries. Bangkok, Thailand, 4-8 February 2002*. FAO Fisheries Report No. 672. Rome, FAO. 2002. 173 pp.
- Hayase, S. & Meemeskul, Y.** 1987. Fluctuations of trash fish landed by Thai trawlers. *Bulletin of the Japanese Society for Fishery Oceanography* 51(2): pp. 124-133.
- Hongskul, V.** 1974. *Population dynamics of pla-tu *Rastrelliger neglectus* (van Kampen) in the Gulf of Thailand*. In: 15th Proceedings of the Indo-Pacific Fisheries Commission. Vol. III, pp. 297-350.
- Hongskul, V.** 1979. *Multispecies systems in fisheries*. *Thai Fisheries Gazette* 32(1): pp. 85-95. [In Thai]
- Ibrahim, H. M.** 1999. *Overfishing in the Gulf of Thailand: Issues and Resolution*. In: D. M. Johnson (ed). SEAPOL Integrated Studies of the Gulf of Thailand, Volume 2. Southeast Asian Programme in Ocean Law, Policy and Management (SEAPOL). Bangkok.
- James, D., Garcia, S., Newton, C. & Martosubroto, P.** 1991. Studies of Thailand, Malaysia, Indonesia, the Philippines and the ASEAN Region. p. 31-70. In: Fisheries and aquaculture research capabilities in Asia. The World Bank Technical Paper No. 147, Washington, D.C.
- Juntarashote, K.** 1994. Possible Development of Community-Based Management in Thailand with the Advent of Fishing Right System. In: Proceedings of the 7th IIFET Conference, 18-21 July 1994, Taipei, Taiwan.
- Kuijper, M.** 1999. *Ocean Science Policy Issues on the Gulf of Thailand and the Prospect of Large-Scale Co-operative Research*. In: D. M. Johnson (ed). SEAPOL Integrated Studies of the Gulf of Thailand, Volume 2. Southeast Asian Programme in Ocean Law, Policy and Management (SEAPOL). Bangkok.
- Larkin, P.A. & W. Gazey** 1982. Application of ecological simulation models to management of tropical multispecies fisheries. p. 123-140. In: D. Pauly & G.I. Murphy (eds). Theory and management of tropical fisheries. ICLARM Conference Proceedings 9, Manila.
- Longhurst, A.R.** 1998. *Ecological geography of the sea*. Academic Press, San Diego. 398 pp.
- Mannan, M. A.** 1997. Foreword: Asian Development Bank. p.v. In: G. Silvestre and D. Pauly. (eds.). *Status and Management of tropical coastal fisheries in Asia*. ICLARM Conference Proceedings 53.
- Munro, G. & U.R. Sumaila**, 2002. *The impact of subsidies upon fisheries management and sustainability: The case of the North Atlantic*. *Fish and Fisheries* 3: pp. 233-290.
- NACA/FAO**. 2000. *Aquaculture Development Beyond 2000: the Bangkok Declaration and Strategy. Conference on Aquaculture in the Third Millennium, 20-25 February 2000. Bangkok, Thailand*. NACA, Bangkok and FAO, Rome. 27 pp.
- Nagalaksana, C.** 1987. *Thailand Country Experience. Paper presented at the Symposium on the Exploitation and Management of Marine Fishery Resources in Southeast Asia held in conjunction with the Twenty-second Session of the Indo-Pacific Fishery Commission, Darwin, Australia, 16-26 February 1987*. RAPA/REPORT: 1987/10.
- National Statistical Office**, 2001. *The 2000 Intercensal Survey of Marine Fishery. Statistical Data Bank and Information Dissemination Division, National Statistical Office. Bangkok, Thailand*. [in Thai]
- Panayotou, T. & Jetavanich, S** 1987. The Economics and Management of Thai Marine Fisheries. ICLARM Studies and Reviews 14, 82 pp.
- Pauly, D.** 1979. Theory and Management of Tropical Multispecies Stocks: a Review, with Emphasis on the Southeast Asian Demersal Fisheries. ICLARM Studies and Reviews 1, 35 pp.
- Pauly, D.** 1984. Reply to comments on pre-recruit mortality in Gulf of Thailand shrimp stocks. *Transactions of the American Fisheries Society*. 113: pp. 404-406.

- Pauly, D.** 1987. *Theory and Practice of Overfishing: A Southeast Asian Perspective*. ICLARM Contribution No. 356. Paper presented at the Symposium on the Exploitation and Management of Marine Fishery Resources in Southeast Asia held in conjunction with the Twenty-second Session of the Indo-Pacific Fishery Commission, Darwin, Australia, 16-26 February 1987. RAPA/REPORT: 1987/10.
- Pauly, D.** 1988. *Fisheries research and the demersal fisheries of Southeast Asia*, pp. 329-348. In: J.A. Gulland (ed.) *Fish Population Dynamics* (2nd ed.). Wiley Interscience, Chichester.
- Pauly, D.** 1996. Fleet-operational, economic and cultural determinants of by-catch uses in Southeast Asia. P. 285-288 In: *Solving By-catch: Considerations for Today and Tomorrow*. University of Alaska, Sea Grant College Program, Report No. 96-03, Fairbanks.
- Pauly, D.** 1997. *Small-scale fisheries in the tropics: marginality, marginalization and some implications for fisheries management*. pp. 40-49 In: E.K. Pikitch, D.D.; Huppert & M.P. Sissenwine (eds.) *Global trends: Fisheries Management*. American Fisheries Symposium 20, Bethesda, Maryland.
- Pauly, D., Christensen, V. & Walters, C.** 2000. *Ecopath, Ecosim and Ecospace as tools for evaluating ecosystems impact of fisheries*. ICES Journal of Marine Science 57: pp. 697-706.
- Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. & Torres, F.C. Jr.** 1998. *Fishing down marine food webs*. Science 279: pp. 860-863.
- Pauly, D. & Chuenpagdee, R.** *Development of Fisheries in the Gulf of Thailand Large Marine Ecosystem: Analysis of an Unplanned Experiment*. In: G. Hempel & K. Sherman (eds). *Large Marine Ecosystems of the World: Trends in Exploitation, Protection, and Research*. Elsevier Science [in press]
- Phasuk, B.** 1994. *Fishing Effort Regulations in the Coastal Fisheries of Thailand*. In: *Proceedings of the IPFC Symposium on "Socio-Economic Issues in Coastal Fisheries Management. Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations. Bangkok, Thailand. 23-26 November 1993*. RAPA Publication: 1994/8.
- Piyakarnchana, T.** 1989. *Yield dynamics as an index of biomass shifts in the Gulf of Thailand*. pp. 95-142. In: K. Sherman and L.M. Alexander (eds.). *Biomass yield and geography of large marine ecosystems*. Westview Press, Boulder.
- Piyakarnchana, T.** 1999. *Changing state and health of the Gulf of Thailand Large Marine Ecosystem*. pp. 240-250 In: K. Sherman and Qisheng Tang (eds.) *Large Marine Ecosystems: Assessment, Sustainability and Management*. Blackwell Science, Malden.
- Polovina, J.J., Mitchum, G.T. & Evans, G.T.** 1996. *Decadal and basin-scale variations in mixed-layer depth and the impact on biological production in the Central and North Pacific*. Deep-Sea Research. 42(10): pp. 1701-1716.
- Pope, J.A.** 1979. *Stock assessment in multispecies fisheries. South China Sea Fisheries, with special reference to the trawl fishery in the Gulf of Thailand*. South China Sea Development and Coordinating Programme. SCS/DEV/79/19. Manila, 109 pp
- Prohmanon, P.** 1987. *Status of coastal aquaculture in Thailand and future trend*. In: *Future of Thai Fisheries: A report from a joint seminar between government and private sectors*. 4-6 June 1987. SEAFDEC, Bangkok, Thailand. [in Thai]
- Ruddle, K.** 1986. *The supply of marine fish species for fermentation in Southeast Asia*. *Bulletin of the National Museum of Ethnology*. 11(4): pp. 997-1036.
- SEAFDEC** 1987. *Future of Thai Fisheries: A report from a joint seminar between government and private sectors*. 4-6 June 1987. SEAFDEC, Bangkok, Thailand. 583 pp. [in Thai]
- Sherman, K. & Duda, A.M.** 1999. *An ecosystem approach to global assessment and management of coastal waters*. Marine Ecology Progress Series. 190: pp. 271-287.
- Silvestre, G.T., Federizon, R., Muñoz, J. & Pauly, D.** 1987. *Overexploitation of the demersal resources of Manila Bay and adjacent areas*, pp. 269-287. In: *Proceedings of the 22nd Session of Indo-Pacific Fisheries Commission, Darwin, Australia, 6-26 February 1987, RAPA*. Bangkok.
- Sumaila, U. R.** 1999. *Pricing down marine food webs*. pp 13-15 In: **Pauly, D., Christensen, V. & Coelho L.** (eds.). *Proceedings of the EXPO '98 Conference on Ocean Food Webs and Economic Productivity*, Lisbon, 1-3 July 1998. ACP-EU Fisheries Research Report. (5).
- Suraswadi, P.** 1996. *The Policy of the Department of Fisheries for Community-based Coastal Fisheries Management*. In: *Community-based Fisheries Management in Phang-nga Bay, Thailand*.

Proceedings of the National Workshop on Community-based Fisheries Management. 14-16 February 1996. Regional Office for Asia and the Pacific, FAO. Phuket, Thailand.

Tiews, K. 1965. *Bottom fish resources investigations in the Gulf of Thailand and an outlook on further possibilities to develop the marine fisheries of South East Asia*. Archiv. FischWiss. 16(1): pp. 67-108.

Tiews, K. 1972. *Fishery development and management in Thailand*. Archiv für Fischereiwissenschaft. 24(1/3): pp. 271-300.

Tiews, K. & Caeces-Borja, P. 1959. *On the availability of fish of the Family Leiognathidae Lacepède in Manila Bay and San Miguel Bay and their accessibility to controversial fishing gears*. Philippine Journal of Fisheries. 7(1): pp. 59-85.

Walters, C., Pauly, D. & Christensen, V. 1998. *Ecospace: Prediction of mesoscale spatial patterns in trophic relationships of exploited ecosystems, with emphasis on the impacts of marine protected areas*. Ecosystems. 2: pp. 539-554.

Walters, C., Christensen, V. & Pauly, D. 1997. *Structuring dynamic models of exploited ecosystems from trophic mass-balance assessments*. Rev. Fish Biol. Fish. 7(2): pp. 139-172.

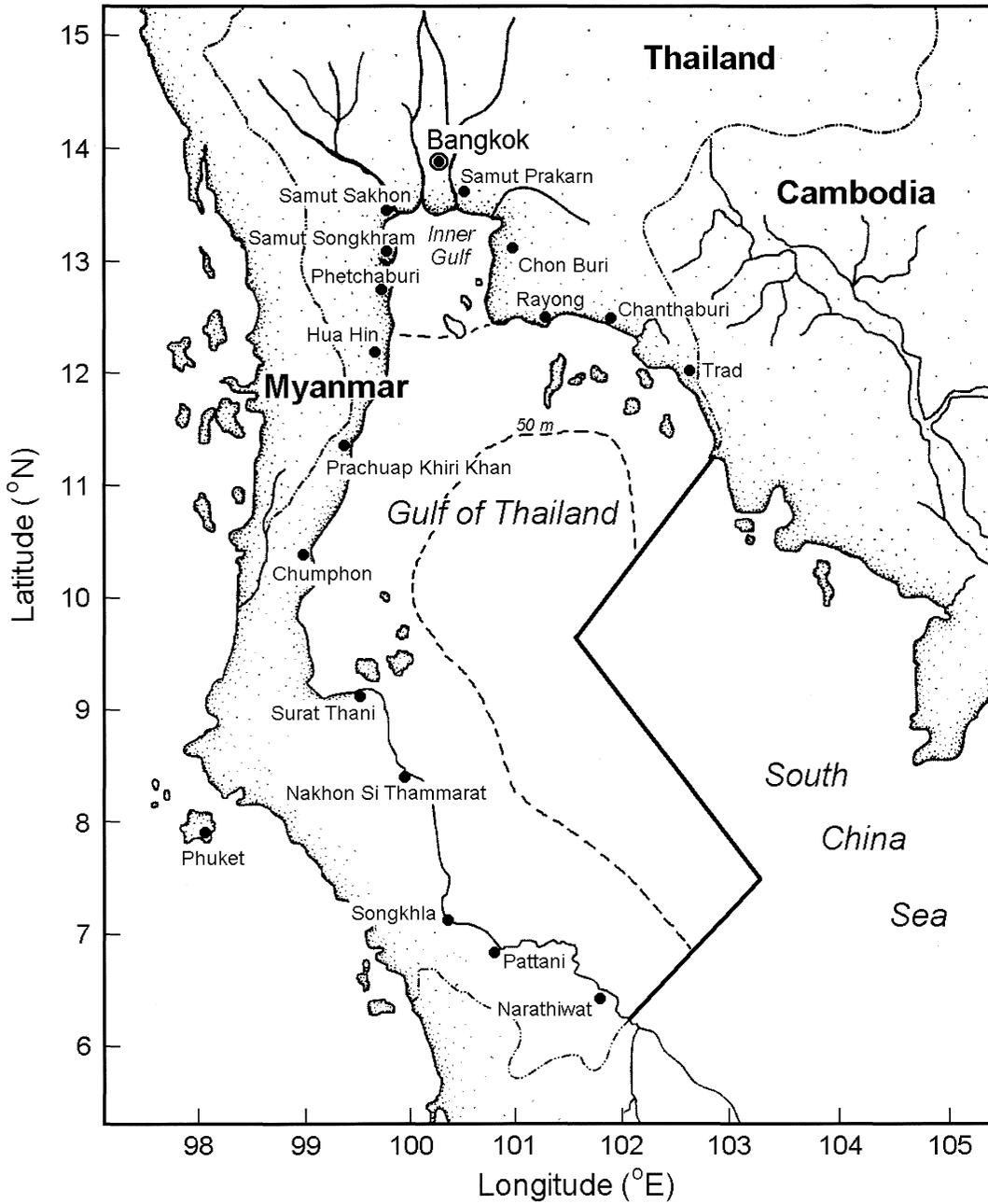


Figure 1. Gulf of Thailand, showing the three sub-systems mentioning in the text (Pauly and Chuenpagdee, in press)