Appendix I

Alternative Management Strategies for Small pelagic Fish

ALTERNATIVE MANAGEMENT STRATEGIES FOR SMALL PELAGIC FISH

A Case Study on Anchovy Fishery in the Gulf of Thailand

Kungwan Juntarashote
Methee Kaewnern
Pirochana Saikliang

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Kungwan Juntarashote

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CHAPTER 1

INTRODUCTION

1.1. *Introduction*

Fishery industry of Thailand has played a major role in the social and economic development of the country. In the last two decades, this industry has produced a sufficient supply of good quality animal protein, as well as creating employment for the people and foreign exchange earning for the country. In 1994, the export of fishery products attained the value of 400 million US$.

Based on the GNP data for the year 1970s, the contribution of fishery to the national economy was almost nil. However, it grew to 3 per cent by 1970 owing to the remarkably rapid development of marine fishery during the 1960s. Thereafter, percentages declined significantly to1.6 per cent in 1985 and around 1 per cent in the 1990s. The same downward trend was seen for agriculture as well. The decline in the relative importance of fishery to the national economy was due mainly to the faster growth of the industrial and service sectors, and the comparatively slow growth of the fishery sector.

The fisheries of Thailand are broadly divided into marine fishery and inland fishery. Until the 1950s, Thai fishery was generally considered to be inland fishery, as fish then available in the markets came mainly from inland waters, and freshwater fish were preferred by the consumers.

Since the Second World War, the marine capture fishery of Thailand has developed at a steady stage. In the 1950s, the majority of fishing boats were non-powered boats, and the fishing gears used were mainly traditional ones such as bamboo stake trap, set bag net, cast net, and hook and lines. In 1959 there were 1,490 bamboo stake traps, 192 Chinese purse seines and 187 Thai purse seines in operation throughout the country, with total landed catch of slightly less than 150,000 MT (Panayotou and Jetanavanich, 1987).

During the 1960s, Thai marine fishery underwent radical changes owing to the development of both otter board trawl and pair trawl fisheries. As a result of the increase in fishing effort and the expansion of fishing grounds, marine fishery production rose sharply from 148,000 MT in 1960 to 1.3 million MT in 1970. During the 1960s the average annual growth rate of marine fishery reached the surprisingly high percentage of about 25 per cent (Juntarashote, 1990)

During the 1970s marine fishery production increased by 23.4 per cent from 1.3 million MT in 1970 to 1.6 million MT in 1980. However, the annual average increase rate declined to 2.1 per cent, which was far below the approximate 25 per cent for the 1960s. Such a slow increase in marine fishery production was due mainly to the depletion of demersal resources in Thai waters and partly to the hike in fuel prices, which took place twice as a result of the world oil crises.

Marr et al. (1976) mentioned that, in the early 1970s, approximately 60 per cent of the total demersal fish catch by Thai trawlers was taken outside Thai waters. i.e.. the sea waters of Bangladesh, Myanmar, India, Indonesia, Cambodia, Malaysia and Viet Nam.

To meet the demand for tuna by rhe rapid development of the canning industry, a new type of light luring purse seine fishery was developed in the early 1980s. As a result, during the first half of the 1980s, marine fishery production increased by 24 per cent from 1.6 million MT in 1980 to slightly over 2 million MT in 1985. Marine fishery production reached its peak in 1987 when it accounted for 2.5 million MT.

The pelagic fish is of grat importance to the Thai people. It has been utilized from the early stages of Thai fishery development up to the present. The main species caught are mackerels, sardines, pomfret, scads and anchovies.

However, the rapid development of marine fishery, has given rise to two severe problems, i.e., depletion of the fisheries resources problem and conflicts among fishermen. As these two problems have become more serious, there is an urgent need to solve them, otherwise the marine fishery of Thailand will very soon face a struggle for survival.

Anchovy fishery can be sited as an example of conflicts arising among fishermen. During the last decade, the demand for boiled-dried anchovies, particularly the small sized ones, has increased. Japan and Taiwan are the major countries that import the small-sized boiled-dried anchovies offering a high price. This has resulted in a change in fishermen's fishing activities: some fishermen have changed their fishing gear from other purse seines to anchovy purse seine; while trawl operators have modified their gear in order to catch anchovy. At the same time, the anchovy purse seine fishing techniques have been improved by using a light luring device. The efficiency of each fishing effort has thus been improved, with a consequant increase in total fishing effort. Hence, given the limited anchovy resource, fishermen are competing with each other in harvesting anchovy, leading to conflicts among them. Furthermore, by using the light luring device, the catches of anchovy purse seine catches comprise many young economically important species. Thus, the conflicts have extended from fishermen who exploit the anchovy resource to fishermen who exploit other pelagic resource. The number of conflicts and their extended are increasing day by day. The Department of Fisheries (DOF) is the only governmemt agency responsible for solving these problems.

Since the development of anchovy fishery in the last decade, the total catch of anchovy has accounted for 10 per cent of total edible marine fishery production. The anchovy catches are used as raw material for fish sauce, dried and boiled-dried anchovy. Thus, with the increase in production, the number of anchovy processing plants has also increased and created employment in rural areas. In terms of foreign exchange, Thailand is earning more than 900 million Baht a year from exporting anchovy products, with the potential of even higher earnings in the future.

Sofar, no management program specifically for anchovy fishery has been developed. The reasons are: firstly, the study on the biology of anchovy is still incomplete; secondly, the accuracy of some of the data and information on catch and effort are unreliable; and thirdly, no study on the economics of anchovy fishery has yet been made. Failing more comprehensive data, only some indirect measures to regulate the anchovy fishery have so far been implemented.

This paper is an attempt to describe the present situation of anchovy fishery in its various aspects; and suggesting mangement program that would ensure its sustainable development.

1.2 *Objectives*

The objectives of the study are as follows:

1) to clarify the present situation of anchovy fishery in the Gulf of Thailand;
2) to clarify the economics of anchovy fishery; and
3) to propose an appropriate fishery management program based on the analysis of the available data on the biological and economics aspects.

1.3 *Data Source*

The data that used in this paper can be divided into;

1) *Primary data.* These comprise cost and return of anchovy fishery and the social cost created by this fishery. The data were collected from interviews and observation using prepared questionnaires.

The primary data, especially the economic data, were obtained from the fishery households on the eastern coast of the Gulf of Thailand that were engaged in anchovy fishery. The anchovy fishery households are located mainly in this area but move to other fishing grounds according to the monsoon season.

2) *Secondary Data.* These comprise data on the biology of anchovy and catch and effort statistics. They were collected from the available research papers and statistical records of the DOF.

CHAPTER 2

THE ANCHOVY FISHERY OF THAILAND

The Gulf of Thailand is a shallow part of the South China Sea. Its total area is 304,000 sq. km., which can be divided into three sub-areas, i.e., Inner Gulf, Eastern Gulf and Western Gulf. The total length of coast line is 1,875 km. The seabed consists mainly of muddy sand with an average depth of 58 m, the deepest being 84 m. Several rivers carrying rich nutrients flow into the Gulf.

Because of the above characteristics of the Gulf, Thai fishermen have enjoyed an abundance of fisheries resources. The pelagic resource was the first to be exploited by Thai fishermen. Anchovy is a species that has been exploited for several decades. At the early stage, anchovy purse seine was the major fishing gear used for catching anchovy and was operated only during daytime. The other gears were bamboo stake trap, push net and pair trawl. The Eastern Gulf is the main fishing ground, the production from this area being around 60 per cent of the total.

With the rapid increase in demand for anchovy by the fish sauce industry, the light luring fishing technique was adopted by fishermen in 1981. In addition, electronic equipment such as echo sounder and sonar, was introduced, which resulted to a tremendous increase in fishing efficiency. Thus, from 1981 onwards, the anchovy resource has been heavyily exploited, which has led to its depletion.

However, the night-time operation of anchovy purse seine fishery has created problems for other groups of fishermen. Since the anchovy catch from night-time operations is composed of many young economic fish that are the target species of other fishermen once they have grown to marketable size.

2.1 *Biology of Anchovy*

Anchovy is a species belonging to Engraulidae family which is divided into five genera, i.e., *Engraulis, Lycothrissa, Setipinna, Stolephorus and Coilia*. Wongrat (1985) reported that the following 10 species of anchovy are found in the Gulf:

1) *Stolephorus heterolobus* (Ruppell, 1837)
2) *S. buccaneeri* (Strasburg, 1960)
3) *S. bataviensis* (Hardenberg, 1960)
4) *S. indicus* (Van Hasselt, 1823)
5) *S. macrops* (Hardenberg, 1933)
6) *S. andraensis* (Babu Rao, 1966)
7) *S. tri* (Bleeker, 1852)
8) *S. commersonii* (Lacepede, 1803)
9) *S. chinensis* (bleeker, 1852)

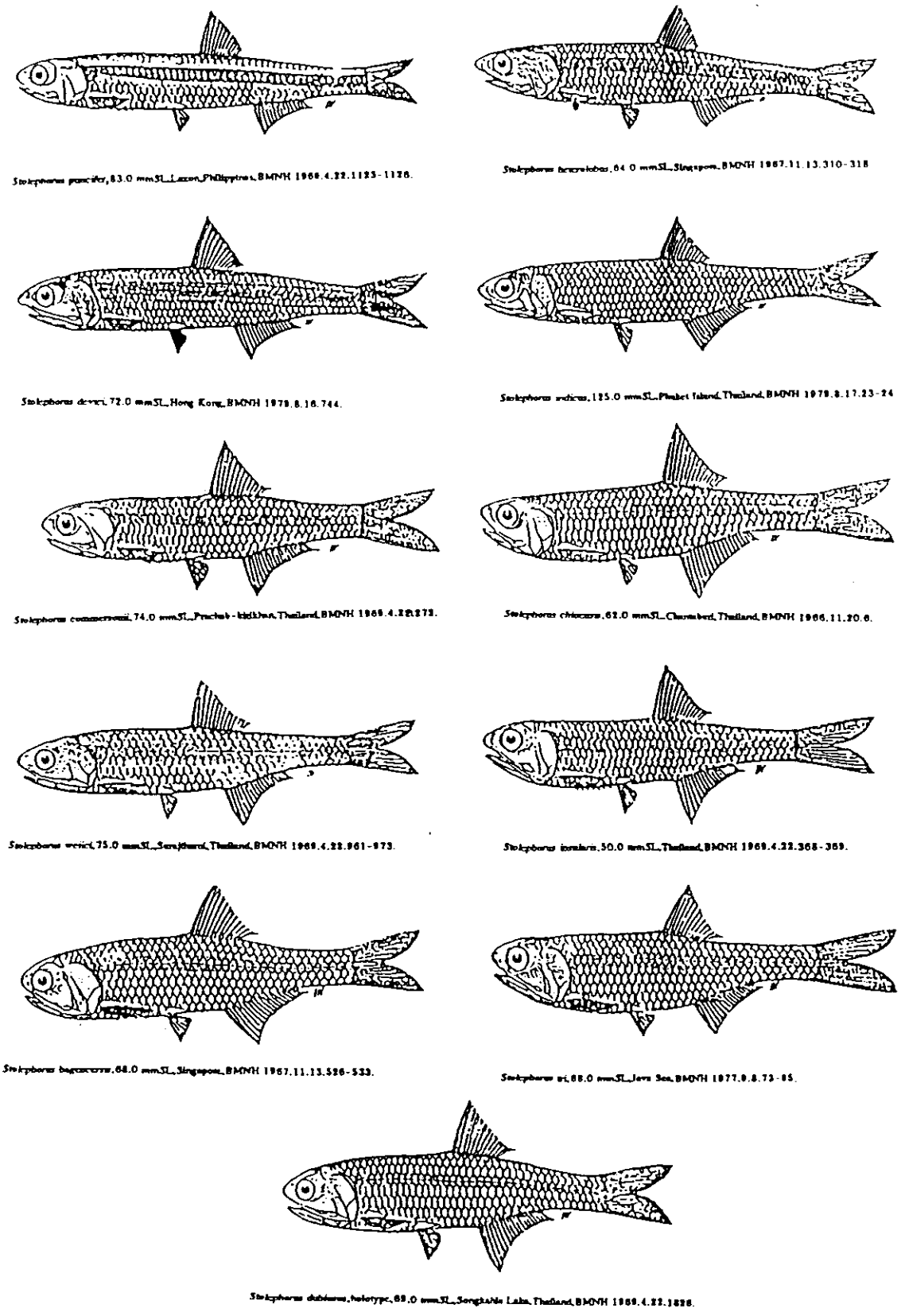

Fig. 2.1. Anchovy species found in the Gulf of Thailand.
Source : Wongrat, 1985.

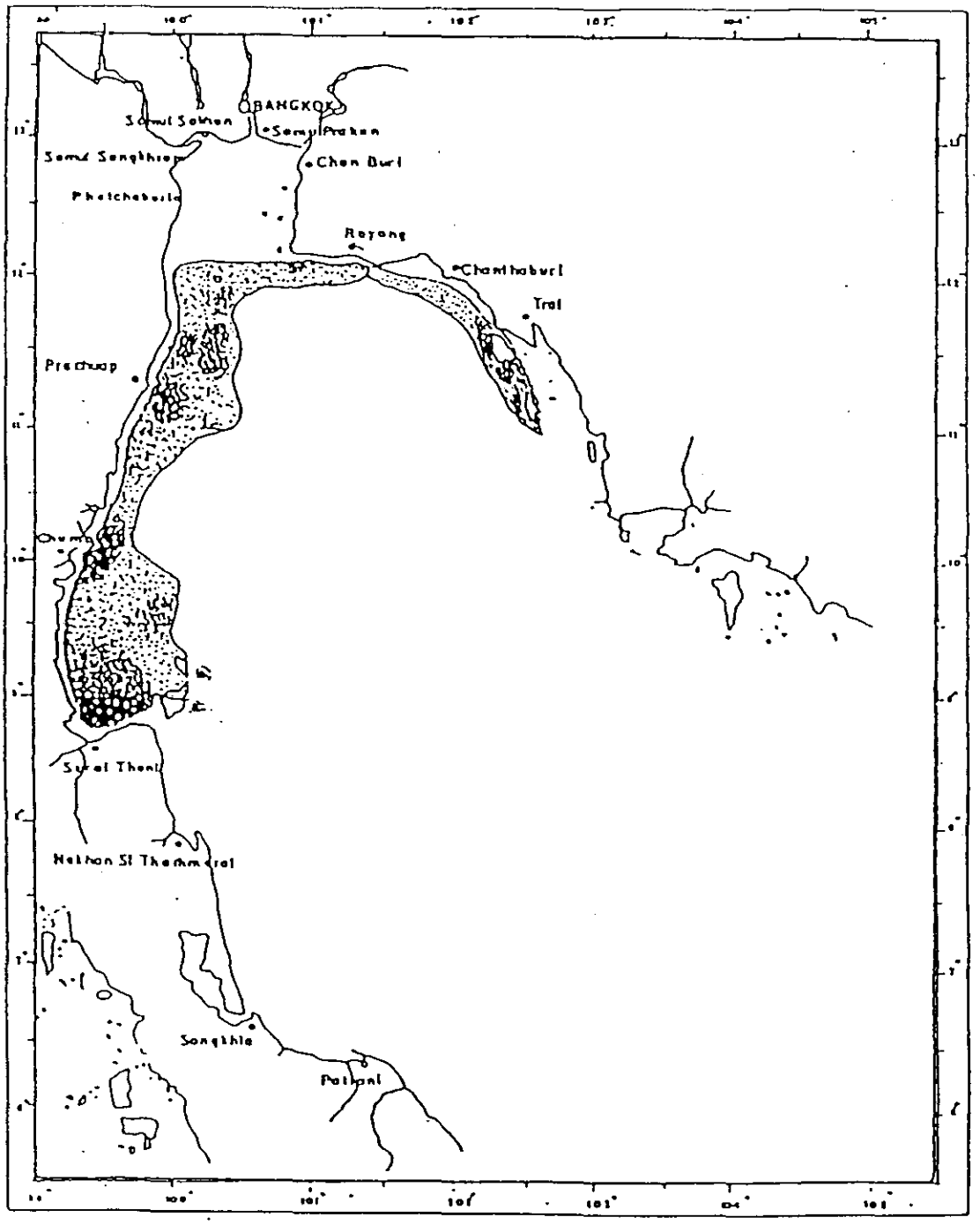

Fig. 2.2. Spawning ground of anchovy in the Gulf of Thailand.

10) Stolephorus species A (Ronquillo, 1968)

Illustrations of the ten species are shown on Figure 2.1. Among these species, *S. heterolobus* accounted for about 90 per cent of the total anchovy production from the Gulf.

In the Andaman Sea, from Ranong to Satun provinces, Thaveesit (1968) found six species, i.e., *S. heterolobus, S. indicus, S. commersonii, S. bataviensis, S. baganensis* and *S. zollingeri*. Around 80 per cent of the total anchovy production from this area consisted of *S. heterolobus*.

Distribution

Anchovy is a small pelagic fish commonly found in coastal areas and around islands in Thai waters. In the Indo-Pacific region it can be found from Hawaii, Japan, Tahiti, Korea, Australia, Papua New Guinea, to around islands of ASEAN countries. In Thailand, anchovy can be found both of the eastern and southern coasts. Trat, Rayong, Prachuap Khiri Khan, Chumphon and Surat Thani provinces are the areas where the stock density of anchovy is very high.

On the eastern coast, the eggs and larvae are distributed mainly near Chang and Kut islands of Trat province; and in the Sattahip district, Chon Buri province (Wattanachai, 1978). On the western coast, as reported by Chayakul (1990), the eggs and larvae of anchovy were found in Prachuap Khiri Khan and Surat Thani provinces the peak periods being February to April, and July to August (see Fig. 2.2).

Reproduction and Growth

This small pelagic fish reaches a mature size 6 to 8 cm; it can lay 1,600 eggs at a time. There is evidence that it spawns the whole year round but the peak seasons are February to April, and July to August. The hatching period is not less than 24 hrs.

Calanids, Harpacticids, Copepods, Gastracods, Decapods and Polychaetes are the main food of anchovy. Its predators are Spanish mackerel, bonito, wolf herring, travally, hair-tail, threadfin breams and cuttlefish.

At their early stage, anchovy larvae grow rapidly, reaching a size of 3 cm within 56 days. On average 1 to 6 month-old anchovyshow an increasein length of 8.1 mm per month, and from age 6 to 12 months, an increase per month of 3.8 mm. The average life span of anchovy is 12 months and its fishing age is 7 to 9 months. Its maximum size is 8.89 cm (Suphongphan and Issara, 1984).

2.2 *Fishing Gears*

At present, there are four groups of fishing gear that are used to catch anchovy, as follows:

1) Purse seines
   a. Without purse line
   b. With purse line
2) Scoop net and lift net
3) Push net
4) Pair trawl

Anchovy purse seine is the main gear employed by fishermen, the other gears being seldom used.

Anchovy purse seine

Anchovy purse seine is divided into two categories, i.e., without purse line and with purse line.

Without purse line

This type of gear is employed by fishermen in Klang District of Rayong province only. It operates with boat of 8-14 m in length and a 16-180 hp engine; the length and depth of net vary from 200 to 400 m and 15-30 m. Theboat is operated by a crew 6 to 10 men. The net is knotless and mesh size is 6.3 mm to 8.3 mm.

The fishermen operate fishing during day-time, from dawn to dusk. The depth of the fishing grounds is not more than 15 m. Thus the fishing grounds are generally close to the shores of the mainland or islands.

With purse line

The anchovy purse seine with purse line can be divided into two groups, i.e., daytime and night-time operation.

a) Daytime operation

This type of gear is employed in the Gulf by fishermen in Rayong, Prachuap Khiri Khan, Chumphon, Surat Thani, Nakhon Si Thammarat, Songkhla and Narathiwat provinces.

In the Andaman Sea, it can be found in Phangnga and Satun provinces. The size of fishing boat that operates this gear is classified into three groups:

a. small size (outboard powered boat with a length of 8 to 10 m);
b. medium size (inboard powered boat with a length of 10 to 14 m); and
c. large size (inboard powered boat with a length of 18 to 22 m).

The catches of small and medium sized boats are kept fresh by mixing in or salt, whereas the catches of big boats are boiled after hauling.

b) Night-time operation

Night-time operation is practiced by the fishermen in Trat, Rayong, Prachuap Khiri Khan and Chumphon provinces. They operate an inboard powered boat of 14 to 24 m in length using an 90-250 hp engine together with two small electricity generating boats of 9 to 14 m in lenght which can generate 12 to 20 kilowatt of electricity per boat. The catching boat has a crew of 16 to 25, and the electricity generator boats are manned by one or two fishermen. The size of net is 300 to 500 m in length and 60 to 80 m in depth; the net is of the knotless type with mesh size of 8.3 mm. The catching boat is equipped with electronic equipment; such as., echo sounder, sonar and radio transmission, for increasing its fishing efficiency.

The fishermen leave for the fishing ground in the late afternoon. Once a fish school has been detected, the first electricity generator boat will anchor and start to generate electricity for light luring and the second one will do the same for the second fish school that has been located. The catching boat will then fishing starting near the first boat and then going on the second boat.

Number of Anchovy Purse Seines

Most Thai fishing boats are wooden boats with inboard engine. In the early days of inboard powered boats, the second-hand truck engine was installed because of its relatively low cost compared with that of a marine engine. This was practised only as long as the price of fuel oil was inexpensive. Since 1977, most fishing boats have changed from road truck engines to marine engines owing to the rapid increase in the price of fuel.

Presently, the precise number of fishing boats that harvest the anchovy resource is not available, because of some non-registered fishing boats also engaging in anchovy capture. In addition, some purse seines that are registered as Thai purse seine or Chinese purse seine have modified their gear to enable them to catch anchovy. From the fishing boat records of the DOF, the number of anchovy purse

seines in 1977 was only 19, increasing to 155 in 1984. With the rising demand for anchovy, the number of anchovy purse seines increased to 199, 348 and 367 in 1988, 1989 and 1990, respectively. The majority were operating in the Gulf of Thailand, but from 1987 onwards the number of registered anchovy purse seines in the Andaman Sea was more than half of the total. The size of boat was varied from less than 14 m in length to more than 25 m. The size of the majority was less than 14 m (see Table 2.1).

Fishing Grounds

The fishing grounds of anchovy in the Gulf of Thailand can be divided into the following four areas: (see Fig. 2.3)

1) *The eastern coast of the Gulf.* This area covers the fishing grounds from Trat to Rayong provinces. An abundance of resources can be found around Kut, Chang, Rung and Klum islands of Trat province; Lam Singha and Khung Kraben bay in Chantaburi province; and Mun and Samet islands, Makam Pom bay, Laem Mae Phim, and Rayong bay in Rayong province.

2) *The inner Gulf.* It covers the area from Chon Buri to Phetchaburi provinces. The resources are richest around the islands in Chon Buri province, the coastal areas of Chachoengsao, Samut Sakhorn, Samut Songkhram and Phetchaburi provinces.

3) *The upper west coast of the Gulf.* This covers the fishing grounds from Prachuap Khiri Khan province to Surat Thani province. The major fishing grounds are the coastal areas of Prachuap Khiri Khan and Chumphon provinces; and Ang Thong, Phangan and Samui islands of Surat Thani province.

4) *The lower west coast of the Gulf.* This covers four provinces, i.e., Nakhon Si Thammarat, Songkhla, Pattani and Narathiwat. The main fishing grounds in Nakhon Si Thammarat are Khanom, Sichol and Tasala bays. The other three provinces, fishing grounds are along the coastal area of each province. The fishing density in these provinces is lower than in the above three areas.

Fishing Season

The fishing season of anchovy fishery in the Gulf depends on the influences of the south-west monsoon and the north-east monsoon. The fishermen on the eastern coast operate fishing from October to May, with December to February being the peak period. From May to September, the fishermen on the eastern coast who operate light luring anchovy purse seines move from the eastern coast to the upper west coast. However, the grounds in Trat province can be fished the whole year round at a water depth of 15 to 40 m. There are other gears that operate fishing according to the season.

Table 2.1 Number of registered boats by type of fishing gear, 1977 - 1990

Unit : Boat

Year	Anchovy purse seine	Luring purse seine	Pair trawl	Push net
1977	19	505	906	1,177
1978	31	578	854	1,426
1979	51	547	1,172	1,923
1980	34	620	1,230	2,262
1981	32	730	1,008	1,216
1982	56	728	1,406	1,899
1983	97	696	1,266	1,326
1984	155	321	1,166	960
1985	197	237	1,218	759
1986	143	268	1,084	664
1987	117	399	1,164	624
1988	199	503	1,132	531
1989	348	523	2,193	1,907
1990	367	393	2,193	1,879

Source : Fishery Statistics Section , Department of Fisheries.

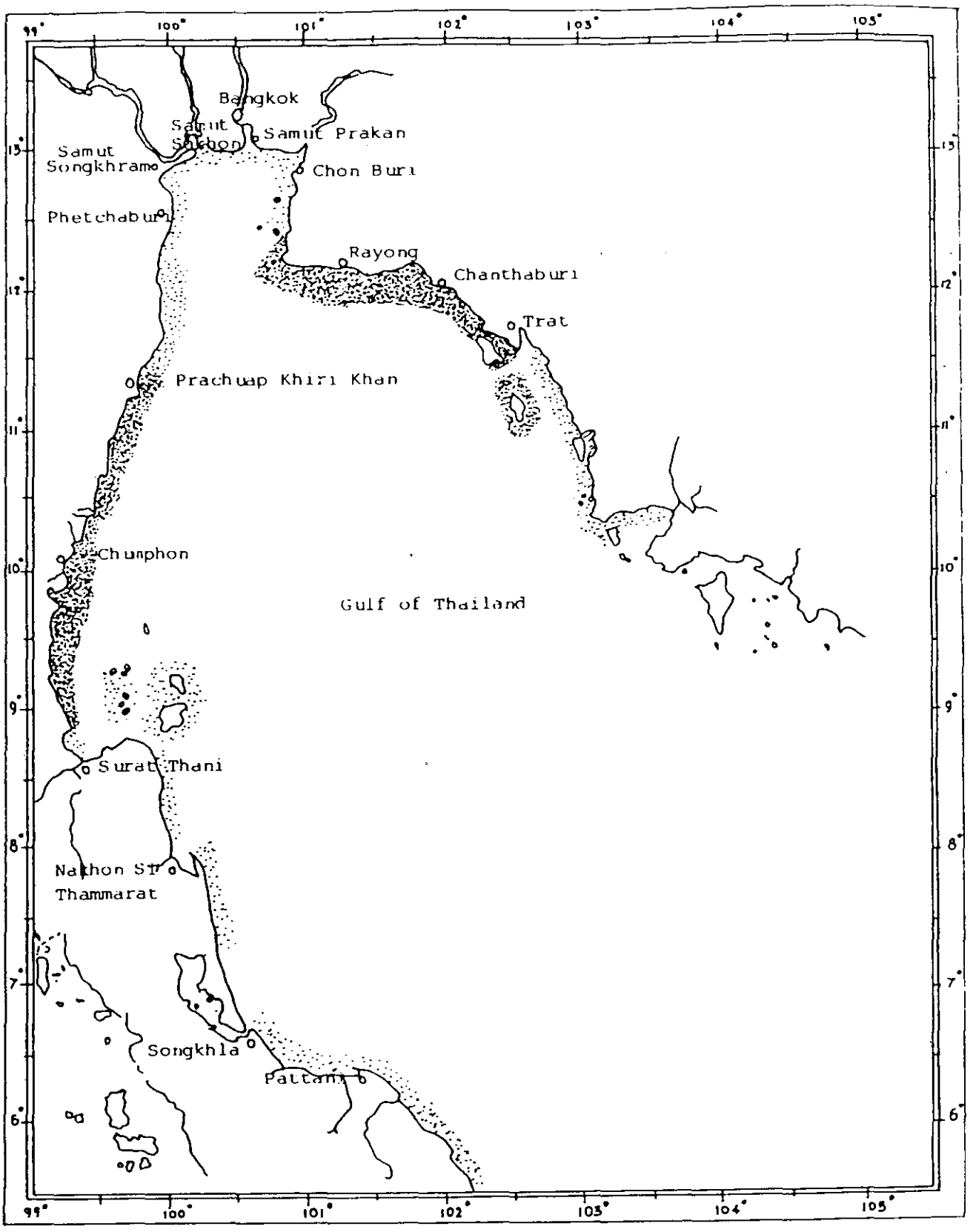

Fig. 2.3. Fishing grounds of anchovy in the Gulf of Thailand.

The small daytime anchovy purse seine can be operated 12 months a year. The beach seines that are used in Rayong province do fishing from April to June.

In the Andaman Sea, the fishing grounds can be divided into four areas, as follows;

1) the fishing ground from Kai island to Kam and Phayam islands in Ranong province;

2) the western coast of Phangnga and Phuket provinces;

3) the eastern coast of Phuket including Phangnga bay, and the western coast of Krabi province; and

4) the western coast of Trang and Satun provinces.

Fishing Season

The fishing season of the above areas 1 and 4 starts in November to end of April. In areas 2 and 3, the fishermen can operate fishing 12 months a year; but during heavy rain they stop operating because all catches have to be sun-dried after boiling.

2.3 *Production*

More than 90 per cent of the total production of anchovy was caught from the Gulf and the remaining from the Andaman Sea. Anchovy purse seine is the major gear to catch anchovy; the minor gears are push net, bamboo stake trap, pair trawl and light luring drift net. Table 2.2 shows the production of anchovy from 1971-1991 by type of gear, and achovy production by fishing area is shown in Table 2.3.

In the past, bamboo stake trap and push net were the major gears for catching anchovy, when production from anchovy purse seine was less than 30 per cent of the total. Production from the eastern coast was mainly by anchovy purse seine and pair trawl; whereas, in the Inner Gulf, anchovy were caught by light luring drift net, bamboo stake trap and push net. Anchovy and push net were the main gears for catching anchovy on the western coast. However, following improvement of the anchovy purse seine, its efficiency increased rapidly. The production from anchovy purse seine reached to more than 74 per cent of the total; and from 1898 onwards it accounted for more than 90 per cent.

Table 2.2 Anchovy production from the Gulf of Thailand by type of gear, 1971-1991.

Unit : MT

Year	Total	Type of Gear					
		Anchovy purse seine	Bamboo stake trap	Other purse seines	Push net	Pair trawl	Others
1971	15,315	7,692	7,173	-	-	-	450
1972	18,894	6,784	6,001	-	-	-	6,109
1973	49,092	10,093	7,644	-	-	-	31,355
1974	27,424	3,108	13,496	466	2,446	-	7,908
1975	18,740	3,071	6,764	3,047	1,131	678	4,049
1976	17,277	3,854	5,564	1,940	2,208	1,773	1,938
1977	11,658	2,011	4,869	1,820	320	894	1,744
1978	10,177	2,492	567	3,635	1,024	802	1,657
1979	16,872	7,540	5,228	210	-	1,121	2,773
1980	20,225	4,490	5,049	2,833	3,342	983	3,528
1981	14,471	5,185	4,260	608	687	1,355	2,376
1982	24,617	13,553	6,027	121	2,806	701	1,409
1983	40,551	32,667	4,124	133	494	723	2,410
1984	90,039	79,158	4,183	5,149	35	279	1,235
1985	104,166	79,752	5,199	17,226	596	328	1,065
1986	59,175	39,689	3,338	13,269	770	893	1,216
1987	57,768	22,003	2,996	29,289	589	589	2,302
1988	69,378	53,232	2,105	8,779	1,508	1,051	2,703
1989	96,970	86,894	4,335	1,716	908	460	2,657
1990	123,958	114,942	2,361	432	467	518	5,238
1991	115,082	106,017	1,875	842	673	680	4,995

Source : Department of Fisheries, 1973-1992.

Table 2.3 Anchovy production by fishing area , 1971-1991.

Unit : MT

Year	Total	Fishing Area						
		Area 1	Area 2	Area 3	Area 4	Area 5	Area a	Area b
1971	15,315	7,536	7,171	2	606	0	0	0
1972	18,894	6,079	6,704	2	0	0	0	0
1973	49,092	10,157	26,962	4,623	2,753	0	0	0
1974	27,424	2,610	16,863	42	444	0	0	0
1975	18,740	3,800	10,930	130	180	0	0	0
1976	17,277	6,599	8,361	1,123	325	0	0	0
1977	11,658	5,261	4,570	1,502	322	0	0	0
1978	10,177	4,337	1,407	242	175	276	2,916	0
1979	16,872	9,170	5,028	1,116	447	0	0	0
1980	20,225	8,924	9,148	1,235	229	0	0	0
1981	14,471	8,722	5,167	90	57	0	0	0
1982	24,617	14,409	8,705	1,044	346	0	0	0
1983	40,551	34,264	4,629	107	1,198	7	0	0
1984	90,039	85,130	4,219	102	186	2	0	0
1985	104,166	94,774	8,040	40	929	0	0	0
1986	59,175	54,351	3,671	307	843	0	0	0
1987	57,768	29,835	23,692	2,187	596	42	4	0
1988	69,378	50,073	7,442	9,575	1,822	9	26	180
1989	96,970	80,522	6,824	8,206	1,356	0	3	59
1990	123,958	109,022	3,336	9,845	1,715	40	0	0
1991	115,082	54,765	3,036	54,719	2,523	0	0	39

Source : Department of Fisheries, 1973-1992.

The production of anchovy from 1971 to 1973 increased rapidly from 15,315 MT to 49,092 MT. However, the oil crises in 1973 and 1974 resulted in fall in production. It dropped to 27,424 MT in 1974 and decreased continuously to 10,177 MT in 1978. From 1980 onwards, to meet the rising demand for boiled-dried anchovy in the world market, the fishermen developed new fishing techniques and adopted a method by which fish could be process on board. Since the light luring fishing technology was applied to anchovy fishery, the fishermen are able to operate fishing during both daytime as well as night-time. Thus, production increased to 40,551 MT in 1983 then skyrocketed to 90,039 MT in 1984 and reached 104,166 MT in 1985. From 1986 to 1989, production was less than 100,000 MT owing to the strict law enforcement on mesh size limit. However, in 1990 and 1991 production increased to 123,958 MT and 115,082 MT, respectively, because the fishermen expanded their fishing grounds from coastal to deeper areas and increased night-time operations.

2.4 *Utilization*

As anchovy is a small-sized species, covered with fine scales, it spoils in a very short time after harvesting. Thus, anchovy is limited in its use to raw material for fish sauce and for processing as boiled-dried fish. The fish sauce from anchovy is the best quality fish sauce, containing the highest protein content, i.e., 21.23 per cent (Phongphen et, al., 1987).

Prior to 1982 anchovy was used mainly for fish sauce production. However, since then, the demand for boiled-dried anchovy increased rapidly in the world market. Therefore, the anchovy catch used for boiling and drying increased from 6,114.1 MT in 1982 to 22,989.9 MT in 1983 and reached 92,025.1 MT in 1990. The anchovy catch used for fish sauce was around 20,000 MT from 1982 to 1985; it increased to around 30,000 MT from 1986 to 1991 (see Table 2.4). A minor portion of the catch is processed into fermented fish, which is popular only in the southern part of Thailand.

The DOF reports that there are three species of fish, i.e., anchovy, sardine, and Indo-Pacific mackerel, from which fish sauce is commonly used. Anchovy is the main raw material accounting for 61.20 per cent in 1982, then increasing to 84.80 per cent in 1985 and reaching 92.13 per cent in 1991 (see Table 2.5). The fish sauce that uses anchovy as raw material is cosidered to be the best quality. Production in 1980 was 5,432 MT and increased to 10,710.6 and 18,966 MT in 1986 and 1992, respectively. Table 2.6 shows the cost of production, revenue and net profit of fish sauce from anchovy. Fish sauce production is a labour-intensive activity, thus labour cost constitutes the major item of total cost, followed by raw material cost. The price of fish sauce is determined by the negotiation between producer and middleman. In the case of large-scale fish sauce production, the producer will determine the price. The price of fish sauce varies according to its quality. Apart from domestic consumption, fish sauce is exported to many countries, inter alia, the USA, France, Hong Kong, Saudi Arabia, Canada, and Australia (see Table 2.7). Thailand earned foreign exchange from this product amounting to over 100 million Baht from 1982 to 1986 and over 300 million baht in 1991. It was estimated that the export of Thai fish sauce

Table 2.4 Utilization of anchovy in Thailand, 1982-1991.

Unit : MT

Year	Utilization of anchovy		
	Fish sauce	Fermented fish	Others
1982	18,393.7	118.2	6,114.1
1983	17,492.1	137.0	22,989.9
1984	18,431.8	175.5	71,479.7
1985	16,168.2	355.8	87,672.0
1986	33,762.5	368.3	24,869.2
1987	31,057.6	254.1	26,488.3
1988	23,977.9	250.9	45,171.2
1989	27,775.2	347.3	68,977.5
1990	31,615.6	359.3	92,025.1
1991	34,595.0	368.7	75,188.3

Source : Department of Fisheries, 1984-1993.

Table 2.5 Quantity of fish used for fish sauce production, 1982 - 1991.

Unit : MT

Year	Total	Anchovy	Sardine	Mackerel	Miscellaneous
1982	30,055.00	18,393.56	6,616.79	3,319.15	1,728.56
		(61.20)	(22.02)	(11.04)	(5.75)
1983	28,516.61	17,491.81	7,274.45	2,312.75	1,428.60
		(61.34)	(25.51)	(8.11)	(5.01)
1984	24,226.88	18,431.96	3,906.18	894.70	994.04
		(76.08)	(16.12)	(3.69)	(4.10)
1985	19,066.28	16,169.56	1,095.46	447.71	1,353.55
		(84.81)	(5.75)	(2.35)	(8.37)
1986	47,246.72	33,765.83	3,731.82	8,253.07	1,492.00
		(71.47)	(7.90)	(17.47)	(3.16)
1987	41,755.28	31,057.98	3,519.03	3,346.27	3,832.00
		(74.38)	(8.43)	(8.01)	(9.18)
1988	27,345.80	23,977.90	1,996.40	570.50	801.00
		(87.68)	(7.30)	(20.9)	(2.93)
1989	31,466.51	27,775.22	2,267.49	602.45	821.35
		(88.27)	(7.21)	(1.91)	(2.61)
1990	35,989.43	31,615.59	2,294.76	532.78	1,546.30
		(87.85)	(6.38)	(1.48)	(4.30)
1991	37,549.50	34,595.00	1,003.50	1,251.00	1,546.30
		(92.13)	(2.67)	(3.33)	(1.87)

Table 2.6 Costs . Revenue and Benefit of fish sauce processing (40,000 Kg./tank),1990.

Items	Baht
1. Costs	121,348
1.1 Fresh Fish	39,600
1.2 Salt	13,920
1.3 Labour	52,000
1.4 Interest (15 %)	15,828
Cost / Kg.	3.03
2. Revenue	
2.1 Fish sauce from 40,000 Kg. of fish	340,000
Grade 1	120,000
Grade 2	100,000
Grade 3	80,000
Grade 4	40,000
Revenue / Kg.	8.50
3. Net benefit	
3.1 Net benefit / tank	218,652
3.2 Net benefit / Kg.	5.47

Table 2.7 Export of fish sauce by country of destination, 1990-1992.

Volume : MT

Value : 1,000 Baht

Country	1990		1991		1992*	
	Volume	Value	Volume	Value	Volume	Value
Australia	855	20,673	913	21,731	984	23,702
Canada	785	15,236	853	16,081	669	13,148
France	1,859	34,967	1,587	32,948	1,645	34,848
Hong Kong	1,455	15,698	1,795	19,026	2,693	27,866
Japan	347	8,183	496	12,486	835	19,414
U.S.A.	6,107	130,158	6,553	136,995	7,100	151,326
Others	4,594	63,494	4,955	69,410	5,040	75,208
Total	16,002	288,409	17,152	308,677	18,966	345,512

Source : Department of Customs.

* Estimated.

will increase year by year owing to a growing demand by Thai restaurants abroad and by Thai and Indo-Chinese households who have settled in North America and Europe.

Prior to 1980, the bulk of the catch was either dried in the sun or boiled and then dried, and sold mainly in the domestic market. only a small amount being exported to neighbouring countries. Since 1981, because of the rising demand for boiled-dried anchovy in the world market, fishermen have produced more boiled-dried than dried anchovy. The survey on cost and earning of dried anchovy production amounting to a total of 310 kg. per day on the eastern coast showed that raw material was the main cost followed by labour and transportation costs. Labour cost was rather low because the producers seldom employed labour from outside, using family members for the drying process. The dried anchovy is sold to the local collectors at a average price of 18 Baht per kg.. the producers making a profit of 3.19 Baht per kg. (see Table 2.8). For boiled-dried anchovy, calculation of cost and earnings for a producing capacity of 110 kg. per day. It revealed that raw material cost was the highest portion, followed by labour cost. Labour cost was higher than for the dried anchovy process because the boiled-dried process needs labour skilled in boiling the anchovy. The producers sold their product at 40 Baht per kg.. The price increased if the size of the fish was small. The producers made a profit of 18 Baht a kg., which was nearly six times that earned from dried anchovy (see Table 2.9). Thus, most of the producers now prefer to produce boiled-dried anchovy rather than dried anchovy if the raw material is fresh.

Dried and boiled-dried anchovies are exported to the following countries: Japan, Malaysia. Singapore, Hong Kong. Taiwan and Sri Lanka, the latter importing by far the largest quantity. Japan and Taiwan imported mainly small and very small boiled-dried anchovies and the remaining countries mainly the medium and large sizes. This in accordance with taste preferences and purpose of consumption (see Table 2.10).

2.5 *Stock Size of Anchocy*

Every coastal state has tried in various ways to estimate the stock size of its fishery resources. Thailand is likewise trying to estimate the stock size of its important economic species for the sustainable development of the fishery industry. Its pelagic resources are the target of such a study since these are a staple ingredient of the Thai people's daily diet. The first species regarding which the DOF conducted a study on stock assessment is Indo-Pacific mackerel (*Rastrelliger neclectus*), this species being the favourite fish of Thai people. Anchovy is the other species on which the DOF study has concentrated because of the increase in market demand. The estimation of anchovy stock size requires statistics on several parameters as well as statistics on catch and effort to calculate surplus production model. Although, the DOF has collected data covering more than a decade, it has been found that these are not sufficiently reliable and complete to carry out a comprehensive analysis. There are several reasons for this: firstly, the fishermen gave little cooperation in supplying data because they feared that the information would be used for taxation purposes; and secondly, the officers responsible for data collection were not always very efficient in carrying out their duty.There have also been instance of researchers who were

Table 2.8 Costs and earnings of dried anchovy at the capacity of 310 Kg. / day,1993.

Items	Baht / day
1. Fixed costs	
Drying mat	12.50
Round crate	16.60
Subtotal	29.10
2. Variable costs	
Fresh fish (3.8:1)	4,320.00
Labour	126.00
Thatched shelter Rent	75.00
Transportation	120.00
Subtotal	4,641.00
3. Total cost	4,613.10
4. Revenue	5,688.00
Benefit	1,074.90
5. Price (Baht / Kg.)	18.00
Benefit (Baht / Kg.)	3.19

Table 2.9 Costs and earnings of boiled - dried anchovy at capacity of 110 Kg. / day, 1993.

Items	Baht / day
1. Fixed costs	
Brazier and boiling pan	8.30
Thatched shelter	6.90
Crate	3.75
Drying mat	14.58
Subtotal	33.53
2. Variable costs	
Fresh fish (4.5:1)	3,000.00
Labour	600.00
Cooking gas	16.00
Thatched shelter Rent	25.00
Subtotal	3,641.00
3. Total cost	3,674.53
4. Revenue	4,400.00
Benefit	725.50
5. Price(Baht / Kg.)	40.00
Benefit (Baht / Kg.)	18.00

Table 2.10 Export of dried anchovy and boiled - dried anchovy by country of destination, 1990-1992.

Volume : MT

Value : 1,000 Baht

Country	1990		1991		1992*	
	Volume	Value	Volume	Value	Volume	Value
Hong Kong	470	32,772	377	26,363	844	44,568
Japan	1,480	117,571	1,565	222,890	165	15,157
Malaysia	5,796	49,513	5,480	49,050	6,857	239,995
Singapore	192	25,445	156	20,780	283	15,624
Taiwan	316	21,735	236	15,965	174	9,287
Sri Lanka	11,747	217,650	14,135	272,774	11,050	224,196

Source : Department of Customs.

* Estimated.

handling the collected data considering them as their own property and withholding from other researchers, thus preventing proper analysis for the benefit of Thai anchovy fishery.

Data on anchovy fishery were collected and kept mainly by two researchers of the Marine Fishery Division; one worked for the Eastern Marine Fishery Development Center and the other for the Bangkok Marine Fishery Development Center. This analysis is therefore based mainly on the biological data supplied by these two researchers; and the catch and fishing effort data from the Fishery Statistics Section of the DOF.

In this analysis, it is assumed that anchovy purse seine is the standard gear because of its the high efficiency in catching anchovy and its common use by fishermen. The Shaefer and Gulland-Fox models have been used for the analysis.

The statistics obtained from the DOF showed that, from 1971 to 1990,there was a wide variation in the number of registered anchovy purse seines and in the total amount of fishing effort (see Table 2.11). In order to reduce such variation for the purpose of this analysis, the regression method was applied. Taking the figures in Table 2.11, the regression equation is:

$$\ln Y = 7.65404 + 0.02954 X$$
$$r = 0.81976$$

when,

Y = Total fishing days
X = Number of registered anchovy purse seines

From this equation and its correlation coefficient (r), it may be assumed that the estimated fishing effort is the non-bias figure. The estimated fishing effort figures and total catch from Table 2.12 were used to calculate the estimated CPUE of standard gear. The estimated CPUE was then used to estimate the maximum sustainable yield of the anchovy stock in the Gulf of Thailand by the **Schaefer model** which assume that the fishery is at a steady stage.

From the equation,

$$CPUE = a + bF$$

then, multiplied by the total fishing effort of standard gear, the catch can be calculated by the equation,

$$Y = aF + bF^2$$

when,

Y = Total catch

Table 2.11 Number of registered boats and fishing effort of anchovy purse seine in the Gulf of Thailand, 1971-1990.

Year	No. of boats	No. of fishing days	Ln No. of days	Calculated [1/] No. of days
1971	42	5,844	8.67317	7,294
1972	48	5,903	8.68322	8,709
1973	66	7,062	8.86248	14,821
1974	46	4,416	8.39299	8,209
1975	30	6,215	8.73472	5,117
1976	45	5,497	8.61196	7,970
1977	14	1,832	7.51316	3,190
1978	28	2,671	7.89021	4,823
1979	43	4,992	8.51559	7,513
1980	28	3,191	8.06809	4,823
1981	13	3,488	8.15708	3,097
1982	22	7,562	8.93089	4,040
1983	37	16,827	9.73074	6,292
1984	53	29,084	10.27794	10,095
1985	118	37,983	10.54489	68,871
1986	91	21,954	9.99670	31,019
1987	47	14,026	9.54867	8,455
1988	69	28,096	10.24338	16,195
1989	76	47,911	10.77710	19,915
1990	105	65,525	11.09019	46,908

Source : Department of Fisheries, 1972; 1974; 1975; 1977-1980; 1982-1983; 1989-1994.

Note : [1/] Calculated from the equation Ln Y = 7.65404 + 0.02954 X

Y = No. of anchovy purse seine fishing days

X = No. of anchovy purse seine boats

Table 2.12 Catch , fishing effort, calculated no. of days and catchability of anchovy purse seine fishery in the Gulf of Thailand , 1971-1990.

Year	Catch (MT)	Fishing effort (days)	Calculated [1/] No. of Days	Catchability [1/] (Kg / day)
1971	7,536	5,844	7,294	1,033.18
1972	6,784	5,903	8,709	779.01
1973	10,093	7,062	14,821	680.99
1974	3,108	4,416	8,209	378.61
1975	3,071	6,215	5,117	600.17
1976	3,854	5,497	7,970	483.57
1977	2,011	1,832	3,190	630.50
1978	2,492	2,671	4,823	516.66
1979	7,540	4,992	7,513	1,003.64
1980	4,490	3,191	4,823	930.90
1981	5,185	3,488	3,097	1,674.37
1982	13,553	7,562	4,040	3,354.84
1983	32,667	16,827	6,292	5,191.52
1984	79,158	29,084	10,095	7,841.54
1985	79,752	37,983	68,871	1,157.99
1986	39,689	21,954	31,019	1,279.50
1987	22,003	14,026	8,455	2,602.36
1988	53,232	28,096	16,195	3,287.01
1989	86,894	47,911	19,915	4,363.23
1990	114,942	65,525	46,908	2,450.36

[1/] Calculations based on Table 2.11.

F = Total fishing days of standard gear
a = Constant
b = Fishing effort coefficient

the value of a and b calculated from equation

$$b = \frac{\sum X_i Y_i - \overline{X} \sum Y_i}{\sum X_i - \overline{X} \sum Y_i}$$

$$a = \overline{X} - bX$$

$$\overline{X} = \sum X_i / N$$

$$\overline{Y} = \sum Y_i / N$$

when,

X_i = Fishing effort from year 1 to N
Y_i = CPUE from year 1 to N
$\overline{X}$ = Average fishing effort
$\overline{Y}$ = Average CPUE
N = Number of years

From the above equations, the maximum sustainable yield and the optimum amount of fishing effort were estimated from the following equations:

$$Y_s = - a^2 / 4b$$
$$f_s = - a / 2b$$

when,

Y_s = Maximum sustainable yield
f_s = Optimum amount of fishing effort

Thus, by the Schaefer model, the MSY of anchovy in the Gulf of Thailand and the optimum amount of fishing effort of standard gear were estimated by the equation:

$$Y = 3{,}928.076 - 0.0367940\ X$$

r^2 = 0.1850092
DF = 10
Std Err Coef. = 0.0244206
t-cal. = -1.507
t-tab. = -1.895
Confident limited = 95 %

From the above value, the estimated MSY of the anchovy in the Gulf of Thailand was 104,839 MT and the estimated number of optimum fishing days of

standard gear was 53,379 days. Total anchovy production by all gears, estimated fishing effort and CPUE are shown in Table 2.13

The stock size of anchovy in the Gulf of Thailand can also be estimated by **Fox's model** that applies the Gompertz equation for this analysis.

$$Y_E = k\,\overline{B}\,(\ln B_m - \ln \overline{B})$$

when,

$$\overline{B} = U/q \quad \text{and}$$
$$B_m = U_m/q$$

then,

$$U = U_m e^{-bf}$$

and multiplied by total fishing effort,

$$Y_E = U_m f e^{-bf}$$

From this equation, the MSY was equal to $0.37\ U_m / b$ and the total optimum amount of fishing effort was equal to $-1/b$.

From,

$$\ln U = a - bx$$

when,

U = CPUE
X = Total amount of fishing effort of standard gear
a = Constant
b = Coefficient of fishing effort.

The MSY and optimum fishing effort were derived by,

$$Y_s = -e^{-a-1} / b$$
$$f_s = -1/b$$

then,

$$\ln U = 8.10949 - 0.0000127\ X$$

r^2 = 0.1970385
DF = 10
Std Err Coef. = 0.0000081

Table 2.13 Fishing effort and catch per unit of effort and total catch of anchovy in the Gulf of Thailand, 1971-1990, by Schaefer Model.

Year	Total production of all gears (MT)	Fishing rate [1/] (Kg / day)	Calculated [2/] No. of fishing days (standard gear)
1971	15,315	1,033.18	14,823
1972	18,894	779.01	24,254
1973	49,092	680.99	71,090
1974	27,424	378.61	72,433
1975	18,740	600.17	31,224
1976	17,277	483.57	35,728
1977	11,658	630.50	18,490
1978	10,177	516.66	19,698
1979	16,872	1,003.64	16,811
1980	20,225	930.90	21,726
1981	14,471	1,674.37	8,643
1982	24,617	3,354.84	7,338
1983	40,551	5,191.52	7,811
1984	90,039	7,841.54	11,482
1985	104,166	1,157.99	89,954
1986	59,175	1,279.50	46,249
1987	57,768	2,602.36	22,198
1988	69,378	3,287.01	21,107
1989	96,970	4,363.23	22,224
1990	123,958	2,450.36	50,588

Note : [1/] Fishing rate calculated from the equation

Ln Y = 7.65404 + 0.02954 X

Y = No. of anchovy purse seine fishing days

X = No. of anchovy purse seine boats

[2/] Total production of all gear / fishing rate

t-cal. = -1.566
t-tab. = -1.895
Confident limited = 95 %

Thus, from Fox's model, the estimated MSY of anchovy in the Gulf of Thailand was 96,210 MT and the optimum fishing effort was 78,634 fishing days of standard gear.

Table 2.14 Fishing effort and catch per unit of effort and total catch of anchovy in the Gulf of Thailand, 1971-1990, by Fox Model (1970).

Year	Total production os all gears (MT)	Fishing rate [1/] (Kg / day)	Calculated day (standard gear)	Ln Fishing rate (Kg/ day)
1971	15,315	1,033.18	14,823	6.94040
1972	18,894	779.01	24,254	6.5802
1973	49,092	680.99	71,090	6.52354
1974	27,424	378.61	72,433	5.93652
1975	18,740	600.17	31,224	6.39921
1976	17,277	483.57	35,728	6.18119
1977	11,658	630.50	18,490	6.44651
1978	10,177	516.66	19,698	6.24738
1979	16,872	1,003.64	16,811	6.91139
1980	20,225	930.90	21,726	6.83615
1981	14,471	1,674.37	8,643	7.42319
1982	24,617	3,354.82	7,338	8.11815
1983	40,551	5,191.52	7,811	8.55478
1984	90,039	7,841.54	11,482	8.96719
1985	104,166	1,157.99	89,954	7.05444
1986	59,175	1,279.50	46,249	7.15422
1987	57,768	2,602.36	22,198	7.86418
1988	69,378	3,287.23	21,107	8.09773
1989	96,970	4,363.23	22,224	8.38097
1990	123,958	2,450.36	50,588	7.80399

Note : [1/] Fishing rate of Anchovy calculated from the equation

Ln Y = 7.65404 + 0.02954 X

Y = No. of anchovy purse seine fishing days

X = No. of anchovy purse seine boats

CHAPTER 3

ECONOMICS OF ANCHOVY FISHERY

3.1 *Cost and Earnings of Anchovy Fishery*

Anchovy purse seine is the main fishing gear employed by fishermen to catch anchovy. Therefore, it is this gear that has been taken for the analysis of cost and earnings.

Anchovy purse seine fishery in Thailand can be divided into two groups according to whether it is operated in daytime or at night-time. However, the cost components,i.e., fixed costs and variable costs of these two groups are similar. Fixed cost comprises hull, engine, fishing gear and electronic equipment. Variable cost includes fuel and engine oil, ice, salt, labour, maintenance and others.

The straight line method has been applied for the calculation of depreciation of all fixed cost items. From the references of the Department of Fisheries, the life span of the hull, engine and fishing gear is set at 15, 10 and 5 years, respectively.

Daytime operation

There are two classes of fishing boat that used for daytime operation, i.e., less than 14 m and 14 to18 m in length. The analysis has been done for each class separately as follows.

a. Less than 14 m in length

This class of boat comprises the majority of anchovy purse seines. The average size of boat was 8 m in length with an engine of 40 hp. The average number of crew members was seven. They operated 18 days per month and 8.8 months a year (see Table 3.1).

Total production cost was 52, 263 Baht per month; 459,623 Baht per year and 4.20 Baht per Kg. Within this cost, fixed cost accounted for 15.9 per cent of the total, depreciation of fishing gear being the highest (6.8%) followed by opportunity cost, and depreciation of boat, engine and equipment. This revealed that the anchovy purse seine has a low fixed cost that resulting in an increase in the number of boats because of the very low initial investment required.

Variable cost was the major cost of the total. It accounted for 84.1 per cent. Labour cost was 44 per cent of the total, representing more than half of the total variable cost. Materials, maintenance and other costs accounted for 23.7, 20.0 and 16.4 per cent of the total, respectively. Labour cost is thus shown to be the largest portion of total cost. It was high owing to the shortage of labour for the fishery industry despite the fact that Thailand has an unemployment problem. At present, Thai labour will choose to work at sea as a last resort because of the hard work and

Table 3.1 Cost , Revenue and Benefit of daytime anchovy purse seine fishery ,size of boat < 14 m.

1. Average length of boat	8 m.			
2. Average engine Power	40 hp.			
3. Average number of crew	7 persons			
4. Number of Fishing days per month	18 days			
5. Number of Fishing months per year	8.8 months			
	per month	per year	per Kg.	%
6. Total costs	52,263	459,623	4.20	100.0
6.1 Fixed costs	8,316	73,183	0.67	15.9
1) depreciation of boat, engine and equipment	1,288	11,338	0.10	2.5
2) depreciation of net and equipment	3,564	31,365	0.29	6.8
3) opportunity cost of boat and engine	3,464	30,480	0.28	6.6
6.2 Variable costs	43,914	386,440	3.53	84.1
1) Equipment	13,379	108,935	1.00	23.7
- fuel and engine oil	10,731	94,435	0.86	20.5
- ice	511	4,500	0.04	1.0
- salt	1,136	10,000	0.09	2.2
2) Labour	22,991	202,325	1.85	44.0
- wage	18,259	160,675	1.47	35.0
- food	4,733	41,650	0.38	9.1
3) Maintenance	10,429	91,778	0.84	20.0
- vessel	3,442	30,287	0.28	6.6
- engine	2,503	22,027	0.20	4.8
- net and equipment	4,485	39,464	0.36	8.6
4) Others	8,543	75,180	0.69	16.4
7. Catch (Kg.)	12,429	109,375		
8. Total revenue (Baht)	50,024	475,415	4.35	
9. Operating benefit (Baht)	10,110	88,975	0.81	
10. Net benefit (Baht)	1,794	15,792	0.14	

Note : Operating benefit = Total revenue - Variable cost

Net benefit = Total revenue - Total cost

risk involved. Therefore, fishing vessels wanting to engage crews have to offer a good salary as well as a benefit sharing system.

The average total catch of this class of fishing boat was 12,429 and 109,375 Kg per month and per year, respectively. The average landing price was 4.35 Baht/Kg which was high because the production was used mainly as raw material for boiled-dried products (70%). Total revenue was 50,024 and 475,415 Baht per month and per year, respectively.

Gross profit of this class of anchovy purse seine was 0.81 Baht per Kg and net profit 0.14 Baht per Kg.

b. 14 to18 m in length

The average size of boat was 15.5 m in length with an engine of 150 hp on average. For a boat of this size, a crew of 18 is required to carry out fishing operations. The fishermen operated 20 days a month and 7 months in a year (see Table 3.2).

Total fishing cost was 118,155 Baht per month; 827,087 Baht per year and 2.95 Baht per Kg. Fixed cost was 0.94 Baht per Kg or 31.7 per cent of total cost, which was higher than for the smaller class of fishing boats, and 2.02 Baht per Kg or 68.3 per cent was variable cost (see Table 3.2). Among the variable costs, labour cost, and fuel and engine oil cost were the highest accounting for 43.5 and 8.8 per cent, respectively.

Average total catch was 40,000 and 280,000 Kg per month and per year, respectively. The whole production was used as raw material for fish sauce that fetched a lower price of 3.00 Baht per Kg. Thus, the revenue of the fishermen who operated this size class of boat was 120,000 Baht per month or 840,000 Baht per year. Gross profit was 0.98 Baht per Kg and net profit 0.05 Baht per Kg.

The question arises why fishermen still engage in fishing operations despite the fact that this net profit is extremely low. The reasons are; 1) fishermen tend to take this gross profit into account and seldom consider take their net profit; and 2) fishermen have very limited job opportunities in other sectors..

Night-Time Operation

Night-time operation is a new fishing method that was introduced to Thai fishermen recently. This new technique has improved the efficiency of anchovy purse seine and resulted in a rapid increase in the total amount of fishing effort.

The fishing boats that operate at night-time have an average length of 17.82 m, with an average engine power of 300 hp. A fishing unit is composed of one fishing boat and two electricity generator boats. A fishing unit requires a crew of 21. The average fishing time was 22 days a month and 10.2 months a year.

Table 3.2 Cost , Revenue and Benefit of daytime anchovy purse seine fishery , size of boat > 14 m

1. Average Length of boat	15.5 m.			
2. Average Engine Power	150 hp.			
3. Average number of crew	18 persons			
4. Number of Fishing days per month	20 days			
5. Number of Fishing months per year	7.0 months			
	per month	per year	per Kg.	%
6. Total cost	118,155	827,087	2.95	100.0
6.1 Fixed costs	37,438	262,067	0.94	31.7
1) depreciation of boat, engine and equipment	12,581	88,067	0.31	10.6
2) depreciation of net and equipment	7,143	50,000	0.18	6.0
3) opportunity cost of boat and engine	17,714	124,000	0.44	15.0
6.2 Variable costs	80,717	565,020	2.02	68.3
1) Equipment	15,589	109,120	0.39	13.2
- fuel and engine oil	10,389	72,720	0.26	8.8
- ice	-	-	-	0.0
- salt	5,200	36,400	0.13	4.4
2) Labour	51,357	359,500	1.28	43.5
- wage	39,643	277,500	0.99	33.6
- food	11,714	82,000	0.29	9.9
3) Maintenance	13,000	91,000	0.33	11.0
- vessel	2,143	15,000	0.05	1.8
- engine	2,286	16,000	0.06	1.9
- net and equipment	8,571	60,000	0.21	7.3
4) Others	771	5,400	0.02	0.7
7. Catch (Kg.)	40,000	280,000		
8. Total revenue (Baht)	120,000	840,000	3.00	
9. Operating benefit (Baht)	39,283	274,980	0.98	
10. Net benefit (Baht)	1,845	12,913	0.05	

Note : Operating benefit = Total revenue - Variable cost

Net benefit = Total revenue - Total cost

Total production cost was 3.87 Baht per Kg, of which 0.57 Baht (16.9%) was fixed cost and the remaining 3.31 Baht (83.1%) was variable cost. Labour was the main cost, accounting for 1.22 Baht per Kg (36.28%) followed by the fuel and engine oil that accounted for 0.63 Baht per Kg (18.6%).

The average total catch was 71,781 Kg per month or 732,168 Kg per year. The fishermen sold their catches at 3.43 Baht per Kg, whicp provided them with a total revenue of 246.209 Baht per month or 2,511,336 Baht per year.Thus, the fishermen were able to earn a gross profit of 0.65 Baht per Kg and a net profit of 0.08 Baht per Kg. (see Table 3.3)

3.2 *Social Cost of Anchovy Fishery*

The study of the Department of Fisheries (DOF) on the species composition of anchovy catches reveals that some juveniles of economically important species have been caught by anchovy purse seine. These juveniles, after landing, were used as raw material for fish meal and therefore fetched a relatively low price. This is a severe loss in terms of economics and biology. It is treated as social cost because of the lost opportunity of utilizing these resources at a later time.

In this analysis, it has been assumed that the length at first capture of fish (L_c) caught by a purse seine with a mesh size of 2.5 cm is of marketable size (L_m) because the number of these purse seines is the highest. With a 2.5 cm. mesh size, 50 per cent of the fish having reached length at first capture can be caught while 50 per cent of smaller sized fish will be able to escape.

The study of the Marine Fishery Division of the DOF on the species composition of the catches by anchovy purse seine in 1989, reveals that there were juvenile fish of five species, i.e., anchovy, mackerels, sardines, caranx and squid (see Table 3.4). Juveniles of other economically important species were also caught but, owing to the difficulties encountered in classifying juveniles of certain species, no estimate of their numbers could be made. The distinction between Indo-Pacific mackerel and Indian mackerel for instance, is very difficult if the size of the fish is less than 10 cm. DOF (1991) reported that the total catch of Indo-Pacific mackerel in 1989 was 3.7 times that of Indian mackerel. As the price of these two species differs widely, a distinction between them would have to be made for closer calculation of the social cost resulting from their capture. If it had been possible to take this price difference into account in the present analysis, the social cost would probably be shown to be higher than calculated here.

Based on the above assumption, the social cost was calculated as follows.

1. From the length-weight relationship equation of Sparre (1985), the weight of juveniles of economically important species caught by anchovy purse seine was calculated by the equation;

$$W_{in} = aL^{\alpha}_{in} \quad \ldots\ldots(1)$$

Table 3.3 Cost and revenue of nighttime anchovy fishery (light luring).

1. Average length of boat	17.82	m.
2. Average engine power	300	hp.
3. Average number of crew	21	persons
4. Average number of fishing days per month	22	days
5. Average number of months per year	10.2	months
6. Average number of electricity generator boats	2	boats

Items	per month	per year	per Kg.	%
1. Total cost	240,570	2,453,809	3.87	100.0
1.1 Fixed costs	40,689	415,023	0.57	16.91
1) depreciation of boat ,engine and equipment	12,940	131,990	0.18	5.38
2) depreciation of net and equipment	6,915	70,533	0.10	2.87
3) opportunity cost of boat and engine	20,833	212,500	0.29	8.66
1.2 Variable costs	199,881	2,038,786	3.31	83.09
1) Equipment	62,596	638,479	0.87	26.02
- fuel and Engine oil	44,870	457,674	0.63	18.65
- ice	9,797	99,929	0.14	4.07
- salt	7,929	80,876	0.11	3.30
2) Labour cost	87,285	890,307	1.22	36.28
- wage	73,343	748,099	1.02	30.49
- food	13,942	142,208	0.19	5.80
3) Maintenance	37,429	381,776	0.52	15.56
- vessel	10,095	102,969	0.14	4.20
- engine	6,084	62,057	0.08	2.53
- net and equipment	21,250	216,750	0.30	8.83
4) Others	12,571	128,224	0.18	5.23
Catch (Kg)	71,781	732,168		
Total revenue (Baht)	246,209	2,511,336	3.43	
Operating benefit (Baht)	46,328	472,549	0.65	
Net benefit (Baht)	5,640	57,527	0.08	

Note : Operating benefit = Total revenue - Variable cost

Net benefit = Total revenue - Total cost

Table 3.4 Catch composition of anchovy purse seine fishery, 1989.

Unit : Kg / day / boat

Month	Catch composition of daytime operation							Catch composition of nighttime operation						
	Total	Anchovy	Mackerel	Sardine	Caranx	Squid	Others	Total	Anchovy	Mackerel	Sardine	Caranx	Squid	Others
January	2,430.47	2,329.85	34.03	25.03	0.24	1.94	39.37			Data not	available			
February	2,695.34	2,485.37	11.32	149.05	0.81	4.31	44.47			Data not	available			
March	2,986.50	2,782.52	16.72	90.49	4.18	12.54	80.03			Data not	available			
April			Seasonal	closure						Seasonal	closure			
May	2,007.50	1,844.29	42.76	27.10	0.00	0.60	92.75	2,175.00	1,061.62	91.35	724.93	12.61	7.83	276.66
June	2,266.95	2,136.83	13.38	79.57	0.00	1.36	35.82	3,738.00	2,238.69	325.21	384.27	17.94	5.98	765.92
July	2,898.58	2,579.16	20.29	267.25	0.29	1.74	29.86	2,171.67	1,305.17	505.13	165.26	1.95	6.73	187.41
August	2,183.77	2,091.18	4.80	41.49	0.22	1.31	44.76	5,252.00	1,879.69	671.21	2,470.54	2.63	6.83	221.11
September	2,023.51	1,962.00	12.14	18.82	0.20	3.24	27.12	2,830.00	1,383.59	75.84	1,226.81	0.00	55.75	88.01
October	2,804.77	2,669.30	13.46	74.89	7.85	15.99	23.28	3,410.00	2,052.82	31.03	1,276.36	14.32	0.00	35.46
November			Data not	available						Data not	available			
December	1,300.45	1,110.84	10.53	38.62	0.00	0.78	139.67			Data not	available			
Average	2,359.78	2,193.89	18.64	75.75	11.80	4.01	55.69	3,262.78	1,705.78	285.82	973.61	8.81	15.99	272.77

Source : Department of Fisheries.

when,

W_{tn} = total weight of young economic fish (gram)
L_t = size of young economic fish (cm)

2. The total number of young economic fish were calculated by the equation:

$$N_{tn} = \text{Total weight of young economic fish} / W_t \quad \ldots\ldots(2)$$

when,

N_{tn} = total number of young economic fish that are caught by anchovy purse seine
W_{tn} = weight of young economic fish that are caught by anchovy purse seine

3. The total number of young economic fish that can survive and grow to marketable size was calculated by the equation

$$N_{tD} = N_{tn} \cdot e^{-Z \Delta t} \quad \ldots\ldots(3)$$

when,

N_{tD} = total number of surviving economic fish
N_{tn} = total number of young economic fish at early stage
Z = mortality rate (natural and by fishing)
Δt = growth period from the length of fish that were caught to the length at first capture (L_c)

4. The growth period of young economic fish from their size at capture to marketable size was calculated by the von Bertalanffy (1938) equation.

$$L_t = L_\alpha \left(1 - e^{-K (t - t_0)} \right) \quad \ldots\ldots(4)$$

5. The total weight of surviving economic fish was calculated by equation (1).

6. The value of surviving economic fish was derived from the total weight of surviving economic fish multiplier by their average prices.

The length-weight relationship, growth coefficient (K), infinity length (L_α), marketable size (L_m) or length of first capture (L_c), mortality coefficient (Z) and t_0 values were obtained from the study of various research papers of the DOF. The value of these parameters and their sources are shown in Table 3.5. The CPUE and catch composition are shown in Table 3.6. The analysis of the social cost of anchovy purse seine is done separately for daytime operation and nighttime operation.

Table 3.5 Length weight relationship, mortality coefficient (Z) , infinity length (L_α) , growth coefficient (K) , length at first capture (L_c) and t_o value.

Species	L/W Relationship	Source	Z	L_α	L_c	K	t_o	Source
Anchovy	F : $W= 0.000007089*L^{2.9329}$	Yoo Sook Swat (1990)	10.69	10.54	5.64	1.81	-0.0106	Yoo Sook Swat (1990)
	M : $W= 0.000002064*L^{3.2494}$							
Mackerel	$W= 0.006138*L^{3.213}$	Dumri Somjaiwong (1990)	1.18	21.24	13.37	0.31	-0.030	Dumri Somjaiwong (1990)
Sardine	$W= 0.000006264*L^{3.0985}$	Dumri Somjaiwong (1991)	0.84	18.65	10.85	0.28	-0.045	Dumri Somjaiwong (1990)
Caranx	$W= 0.014631*L^{2.8884}$	Bhatia (1979)	6.22	25.79	5.49	0.11	-0.146	Piensiri Piyatheerathitivorakul (1983)
	$W= 0.00438*L^{3.30647}$	Likhit Hnupetch (1984)	8.64	12.53	12.53	0.13	-0.080	Piensiri Piyatheerathitivorakul (1983)
Squid	$W= 0.420666044*L^{2}$	Mala Supongpun (1987)	1.20	40.90	10.36	0.49	-0.310	Mala Supongpun (1987)

Table 3.6 Catch per unit of effort and catch composition (%) of daytime anchovy purse seine fishery.

Month	CPUE (Kg./ day / boat)	Catch composition (%)					
		Anchovy	Mackerel	Sardine	Caranx	Squid	Others
January	2,430.47	95.86	1.40	1.03	0.01	0.08	1.62
February	2,695.34	92.21	0.42	5.53	0.03	0.16	1.65
March	2,986.50	93.17	0.56	3.03	0.14	0.42	2.63
April	Seasonal closure						
May	2,007.50	91.87	2.13	1.35	-	0.03	4.62
June	2,266.95	94.26	0.59	3.51	-	0.06	1.58
July	2,898.58	88.98	0.70	9.22	0.01	0.06	1.04
August	2,183.77	95.76	0.22	1.90	0.01	0.06	2.03
September	2,023.51	96.96	0.60	0.93	0.01	0.16	1.34
October	2,804.77	95.17	0.48	2.67	0.28	0.57	0.83
November	Data not available						
December	1,300.45	85.42	0.81	2.97	-	0.06	10.74
Average	2,359.78	92.97	0.79	3.21	0.05	0.17	2.81

Source : DOF survey ,1989.

Daytime operation

By the length-weight relationship equation, and the figures in Table 3.7 of average size of young economic fish (mackerel, sardine, caranx, common Jack and squid) that were caught by anchovy purse seine, the average weight (gram/fish) of fish (W_{tn}) was calculated. From the total catch per boat per day (C_{tn}), the number of fish that were caught by a boat in one day (N_{tn}) was estimated. The weights of marketable size fish (W_m) that were calculated from L_c are given in column 6 of Table 3.8. Table 3.9 shows the economic loss of daytime operations.

These calculations showed that the social cost created by an anchovy purse seine was 1,581.03 Baht per day. This comprises squid (1,020.51 Baht), scad (388.16 Baht), mackerel (139.07 Baht), caranx (25.62 Baht) and common Jack (7.67 Baht).

Night-time operation

From the length-weight relationship equation of each species shown in Table 3.4 and data in Tables 3.10 and 3.11, the social cost created by light luring anchovy purse seine was estimated.

The same procedure was followed as for daytime operation. The number of fish caught by a boat in one day was estimated, then the expected weight of fish having reached marketable size and their value were calculated.

The social cost of light luring anchovy purse seine operation was 5,914.92 Baht per boat per night, which was nearly four times that of daytime operation. This social cost comprises the loss from sardines (3,745.79 Baht), mackerels (2,013.53 Baht), squid (125.72 Baht), caranx (20.31 Baht) and scad (7.67 Baht) (see Table 3.12).

In conclusion, light luring anchovy purse seine created a higher social cost than the daytime anchovy purse seine. This was due to the high catch of sardines and mackerels during nighttime operation. Thus, it may be concluded that the light luring anchovy purse seine is a fishing method that is destroying the pelagic fish stock. Moreover, there may be juvenile economic fish mixed in the anchovy catch. If it were possible to identify these juvenile fish, the total social cost would be higher than estimated in the present analysis.

3.3 *Marketing of Anchovy*

As mentioned in the previous chapter, the anchovy catches accounted for 10 per cent of the total edible marine fishery production, with a value of more than 400 million Baht. The fishermen sell their catches through several channels, i.e., to processing vessels at sea, and to middlemen and fish sauce plants on shore. Some fishermen keep a portion of their catch for processing at home if manpower is available.

Table 3.7 Length frequency of major commercial fish caught by daytime anchovy purse seine fishery in the Gulf of Thailand.

Length	Sardine		Mackerel		Common Jack		Caranx	
(cm)	Number	%	Number	%	Number	%	Number	%
2.50	2	0.09	-	-	-	-	-	-
3.00	7	0.33	-	-	-	-	-	-
3.50	38	1.77	-	-	-	-	-	-
4.00	78	3.63	12	1.08	-	-	1	7.69
4.50	116	5.40	40	3.62	-	-	-	-
5.00	201	9.36	77	6.96	-	-	-	-
5.50	277	12.90	101	9.13	3	11.11	-	-
6.00	349	16.25	117	10.58	4	14.81		-
6.50	326	15.18	86	7.78	-	-	-	-
7.00	200	9.31	89	8.05	-	-	-	-
7.50	143	6.66	98	8.86	2	7.41	1	7.69
8.00	82	3.82	76	6.87	-	-	-	-
8.50	84	3.91	63	5.70	-	-	-	-
9.00	83	3.86	67	6.06	1	3.70	-	-
9.50	82	3.82	64	5.79	-	-	1	7.69
10.00	49	2.28	53	4.79	1	3.70	1	7.69
10.50	16	0.74	47	4.25	3	11.11	-	-
11.00	4	0.19	38	3.44	6	22.22	1	7.69
11.50	6	0.28	24	2.17	4	14.81	3	23.08
12.00	4	0.19	16	1.45	1	3.70	-	-
12.50	1	0.05	11	0.99	-	-	2	15.38
13.00	-	-	11	0.99	-	-	1	7.69
13.50	-	-	8	0.72	-	-	-	-
14.00	-	-	4	0.36	-	-	-	-
14.50	-	-	1	0.09	-	-	-	-
15.00	-	-	-	-	-	-	-	-
15.50	-	-	-	-	-	-	-	-
16.00	-	-	1	0.09	-	-	-	-
16.50	-	-	-	-	-	-	-	-
17.00	-	-	1	0.09	1	3.70	1	7.69
17.50	-	-	-	-	-	-	-	-
18.00	-	-	-	-	-	-	-	-
18.50	-	-	-	-	-	-	-	-
19.00	-	-	1	0.09	1	3.70	1	7.69
19.50	-	-	-	-	-	-	-	-
20.00	-	-	-	-	-	-	-	-
Total	2,148	100	1,106	100	27	100	13	100
Average	6.49		7.74		9.85		11.58	

Source : DOF survey ,1989.

Table 3.8 Weight of fish by species caught by daytime anchovy purse seine fishery ; calculated from relationship between length and weight .

Species	W_{tn} 1/ (gram / piece)	C_{tn} 2/ (Kg / boat / day)	N_{tn} 3/ (piece/ boat / day)	L_m 4/ (cm)	W_m 5/ (gram / piece)
Anchovy		2,193.89			
F	0.868119	1,096.95	1,263.588	5.64	0.970312
M	0.894887	1,096.95	1,225.791	5.64	1.012316
Mackerel	4.401002	18.64	4.235	13.37	25.485144
Sardine	2.582807	75.75	29.329	10.85	12.694944
Caranx	17.285813	5.90	341	15.49	40.051476
Common Jack	8.438033	5.90	699	12.53	18.698914
Squid	2.629163	4.01	1,525	10.36	45.149918
Others	-	55.69	-	-	-

Note : Fish length = TL ; Squid length = Body length (tentacles not included)

1/ W_{tn} : Average weight of fish at time of capture ; calculated from the equation of L/W relationship

(L = Average length at time of capture (cm)).

2/ C_{tn} : Weight of economic fish species which caught and sold, by catch.

3/ N_{tn} : Number of fish caught and sold as fresh fish ; calculated from C_{tn} / W_{tn}

4/ L_m : Marketable size (Lm)

(use length at first capture (cm))

5/ W_m : Weight at Marketable size, calculated from the equation of L/W relationship

(L = Marketable size (Lm))

Table 3.9 Economic loss caused by daytime anchovy purse seine fishery,1989.

Species	t [1/]	Z [2/]	Nt [3/]	Weight [4/]	Price [5/]	Revenue [6/]
			(id. / boat)	(Kg. / boat)	(Baht / Kg.)	(Baht / boat)
Mackerel	1.74075	1.18	543	13.84	10.05	139.07
Sardine	1.58581	0.84	7,741	98.27	3.95	388.16
Caranx	2.92547	0.52	75	2.82	9.08	25.62
Common Jack	2.64883	0.72	104	1.94	3.95	7.67
Squid	5.60866	0.10	870	39.30	25.97	1,020.51
Others	1.47641	-	-	-	1.99	0.00
Total economic loss (Economic Species)						1,581.03

Note : $L_t = L_\infty (1-e^{-k(t-t0)})$

[1/] : time taken to grow from at time of capture to marketable size

[2/] : Total mortality rate (Natural morality + Fishing mortality)

[3/] : Number of live fish ; calculated from the equation $Nt = Nt * e^{-z*\Delta t}$

[4/] : Estimated weight when fish grow up to marketable size

[5/] : Price of fish at Fish Marketing Organization (FMO) in 1989

[6/] : Estimated revenue when fish grow up to marketable size

Table 3.10 Catch per unit of effort and catch composition (%) of nighttime (light luring) anchovy purse seine fishery in the Gulf of Thailand .

Month	CPUE (Kg./ day/boat)	Catch composition (%)					
		Anchovy	Mackerel	Sardine	Caranx	Squid	Others
January	Data not available						
February	Data not available						
March	Data not available						
April	Seasonal closure						
May	2,175.00	48.81	4.20	33.33	0.58	0.38	12.68
June	3,738.00	59.89	8.70	10.28	0.48	0.16	20.49
July	2,171.67	60.10	23.26	7.61	0.09	0.31	2.63
August	5,252.00	35.79	12.78	47.04	0.05	0.13	4.21
September	2,830.00	48.89	6.68	43.35	-	1.97	3.11
October	3,410.00	60.20	0.91	37.43	0.42	-	1.14
November	Data not available						
December	Data not available						
Average	3,262.78	52.28	8.76	29.84	0.27	0.49	8.36

Source : DOF survey ,1989

Table 3.11 Length frequency of major commercial fish caught by nighttime anchovy purse seine fishery in the Gulf of Thailand.

Length	Sardine		Makerel		Common Jack		Caranx	
(cm)	Number	%	Number	%	Number	%	Number	%
2.50	-	-	-	-	-	-	-	-
3.00	-	-	-	-	-	-	-	-
3.50	1	0.11	6	0.36	-	-	1	0.40
4.00	4	0.45	7	0.41	4	1.6	-	-
4.50	14	1.57	20	1.18	-	-	-	-
5.00	39	4.38	63	3.73	2	0.73	1	0.40
5.50	33	3.70	94	5.57	2	0.73	4	1.59
6.00	20	2.24	153	9.06	2	0.73	1	0.40
6.50	4	0.45	226	13.38	3	1.09	2	0.80
7.00	11	1.23	249	14.74	8	2.92	8	3.19
7.50	2	0.22	120	7.10	9	3.28	2	0.80
8.00	11	1.23	42	2.49	3	1.09	1	0.40
8.50	12	1.35	35	2.07	-	-	-	-
9.00	23	2.58	63	3.73	2	0.73	2	0.80
9.50	39	4.38	81	4.80	1	0.36	5	1.99
10.00	71	7.97	113	6.69	5	1.82	3	1.20
10.50	100	11.22	114	6.75	14	5.11	78	31.08
11.00	114	12.79	94	5.57	54	19.71	10	3.98
11.50	108	12.12	81	4.80	71	25.91	36	14.34
12.00	92	10.33	55	3.26	49	17.88	32	12.75
12.50	78	8.75	28	1.66	23	8.39	9	3.59
13.00	39	4.38	9	0.53	9	3.28	4	1.59
13.50	18	2.02	8	0.47	5	1.82	4	1.59
14.00	16	1.80	10	0.59	3	1.09	7	2.79
14.50	10	1.12	3	0.18	3	1.09	8	3.19
15.00	32	3.59	1	0.06	2	0.73	13	5.18
15.50	-	-	6	0.36	-	-	6	2.39
16.00	-	-	4	0.24	-	-	11	4.38
16.50	-	-	1	0.06	-	-	1	0.40
17.00	-	-	1	0.06	-	-	1	0.40
17.50	-	-	1	0.06	-	-	1	0.40
18.00	-	-	1	0.06	-	-	-	-
18.50	-	-	-	-	-	-	-	-
19.00	-	-	-	-	-	-	-	-
19.50	-	-	-	-	-	-	-	-
20.00	-	-	-	-	-	-	-	-
Total	891	100	1,689	100	274	100	251	100
Average	10.55		8.24		11.05		11.55	

Source : DOF survey, 1989.

Table 3.12 Economic loss caused by nighttime anchovy purse seine fishery,1989.

Species	t [1/]	Z [2/]	Nt [3/]	Weight [4/]	Price [5/]	Revenue [6/]
			(id. / boat)	(Kg. / boat)	(Baht / Kg.)	(Baht / boat)
Mackerel	1.61900	1.18	7,862	200.35	10.05	2,013.53
Sardine	0.13479	0.84	74,699	948.3	3.95	3745.79
Caranx	2.94465	0.52	56	2.24	9.08	20.31
Common Jack	1.54783	0.72	130	2.42	3.95	9.57
Squid	5.60866	0.10	107	4.84	25.97	125.72
Others	1.47641	-	-	-	1.99	0.00
Total economic loss (Economic Species)						5,914.92

Note : $L_t = L_\alpha (1-e^{-k(t-t0)})$

[1/] time taken to grow from at time of capture to marketable size

[2/] : Total mortality rate (Natural morality + Fishing mortality)

[3/] : Number of live fish ; calculated from the equation $Nt = Nt * e^{-z*\Delta t}$

[4/] . Estimated weight when fish grow up to marketable size

[5/] : Price of fish at Fish Marketing Organization (FMO) in 1989

[6/] : Estimated revenue when fish grow up to marketable size

Calculation for the present analysis show that 30 per cent of anchovy catch is used for fish sauce; 47 per cent for dried anchovy, 17.5 per cent for boiled-dried anchovy, and the remaining 5 per cent for fish meal and other purpose.

The anchovy catches that are to be used for fish sauce are mixed with salt at sea and off-loaded directly at the fish sauce plant. Of total production 86.3 per cent is sold in the domestic market and 13.7 per cent is exported. The fish sauce for export is a good quality product, meeting the standards of the importing countries. The Department of Business Economics, of the Ministry of Commerce has conducted a survey on the fish sauce consumption of the Thai people and found that average consumption is approximately 20 ml per day. Assuming that there aere 50 million people who consume fish sauce, the amount of fish sauce required would be approximately 1,330,000 bottles of a 750 ml capacity.

Dried anchovy is processed mainly by fishermen because the process is simple and enable them to sell an added value product. Some middlemen also process dried anchovy or, if they have a surplus of anchovy they may sell a portion to processing households. Hence, the dried anchovy can be produced by fishermen, middlemen or processing households. The product is then collected by local collectors or exporters. Of total production, 54 per cent is exported and 46 per cent retained for local consumption.

The processing of boiled-dried anchovy requires a higher initial investment as well as the availability of skilled workers, of which there is a shortage. Therefore, fishermen do not engage in this activit but sell their catches to the processors. The local collectors collect the products and resell them to the exporters. The quantity exported was 52 per cent of the total, 48 per cent being consumed within the country.

The above figures indicate that there is a world market for processed anchovy, especially dried and boiled-dried anchovies. Therefore, the fishing activities have changed to meet the requirements of the world market: for instance when the world market began to offer a high price for small-sized processed anchovy, the fishermen immediately changed their net to the very fine mesh size to catch more small-sized anchovy. Efforts to manage the anchovy resource may therefore fail because of the world market's specific requirements.

Chapter 4
Fishery Management Programme

4.1 *Fishery Management in Thailand*

Fishery resources are treated as common property that anyone in the country can exploit without hindrance. However, in order to maintain the fisheries resources, there must be agencies that have responsibility for conserving and managing the resources.

In Thailand, the Fisheries Conservation Division (FCD) of the DOF is the main agency responsible for conserving the resources by means of surveillance. Following the recommendations of several divisions of the DOF, i.e.; Marine Fishery Division, Inland Fishery Division, Fisheries Economics Division and others; the DOF or the Ministry of Agriculture and Cooperatives has issued rules and regulations for governing fisheries resources management. The FCD, under these issued rules and regulations, has the authority to practice law enforcement. The fishery officials of the Patrol Boat Unit are empowered to arrest the fishermen who violate the rules and regulations and refer them to the Police. The courts will then impose the appropriate penalty. In addition, in order to strengthen law enforcement, provincial and district fishery officials are also authorized to arrest the offending fishermen.

In the past, the objective of fisheries management in Thailand was to manage the fisheries resources not the fishermen. Regulations were issued based to the fishery biological aspects, and the socio-economic conditions of the fishermen were not considered by the agencies concerned. Recently, there has been some improvement in establishing fishery management measures in that the social and economic factors are taken into account by the policy makers.

The role of the DOF under the fishery management programme, now being implemented, is similar to that of a game keeper's duty on land. However, because of several limitations. its success of the programme is in doubt. These limitations are firstly, the number of personnel engaged in law enforcement is very limited compared with the wide-spread fishing grounds. Secondly, the number of patrol boats is inadequate. There are fewer than 50 patrol boats for the whole country's water areas, both inland and of shore., of the country. Thirdly, the enforcement cost is very high and it is doubtful whether the benefits derived from the enforcement programme justify the cost. Fourthly, the fishermen lend very little cooperation to the fishery management programme.

Owing to the above limitations and the fact that fisheries resources are common property, the resources have declined year by year. Statistics on marine fishery production in Thailand do not reflect this decline. On the contrary, they show an increasing trend annually, the reason for this being that Thai fishing fleets operate fishing in neighbouring countries under fishing agreements, joint venture fishery or other programmes. If their catches are landed at any landing places of Thailand, they are treated as Thai marine fishery production regardless of where they were caught, in

accordance with the fishery data collection system established by the Food and Agriculture Organization of the United Nations.

Therefore, owing to the poor success of the fishery management programme in the past, it is essential to seek other alternatives for fisheries resources management.

4.2 *Anchovy Fishery Management Programme*

In the absence of a fishery management programme directed specifically to anchovy fishery. DOF applied to anchovy fishery the management programme relating to other species (pelagic fish). Before night-time anchovy fishery was started, the regulations issued for fishery management in general were adequate for managing anchovy fishery. However, after the introduction of light luring anchovy fishery, the DOF became aware that anchovy fishery needed a more specific fishery management programme.

In 1983, the DOF revealed that modification of the fishing operation by using a light luring device with small mesh size net was a destructive fishing method. Many juveniles of economical fish were caught by this fishing technique. Hence, on 14 February 1983 the MAC issued a regulation aimed at conserving these fisheries resources. The intent was to ban the fishing method using a light luring device with a net of less than 2.5 cm mesh size in Thai waters. Thus, if night-time anchovy fishery was to be continued, the fishermen would have to change their nets from small mesh size (less than 2.5 cm) to mesh size 2.5 cm and above.

After the issue of the above regulation, the fishermen who engaged in night-time anchovy fishery with nets of mesh size less than 2.5 cm declared that they could not accept the regulation. They petitioned the DOF to the postpone implementation for two years. The reason given was that they had invested considerable capital in fishing vessels and they needed two years to that recover their investment and then turn from anchovy fishery to other types of fishery. In conclusion, the fishermen requested the DOF to start implementing this regulation in 1985. The DOF, however, turned down the fishermen's request.

Although fishery officials have carried out strict enforcement, some fishermen found ways of bypassing the regulations. They modified their fishing boats by moving out the electric light generator to a small boat and declared that the small boat did not belong to them. Thus, they were fishing with a less than 2.5 cm mesh size net without a light luring device on their boat so that the DOF patrol boats had no right to arrest them. Therefore, in order to put an end to this practice, the MAC issued a regulation on 14 November 1991 prohibiting fishermen from operating with a less than 2.5 mesh size net in Thai waters both during the day and at night-time. Thus, fishermen who operate fishing with or without a light luring device would be unable to use a net with a mesh size of less than 2.5 cm and the DOF patrol boats could enforce the regulation effectively.

Again, the fishermen expressed their disagreement with the regulation and proposed that the DOF conduct biological studies on destructive effects of anchovy

purse seine with a less than 2.5 cm. mesh size net on young economical species. The DOF accepted the fishermen's proposal and issued seven announcements for biological studies on the following dates: 24 November 1992, 4 December 1992, 21 January 1993, 13 May 1993, 11 June 1993, 9 July 1993 and 6 August 1993. The studies were confined to the fishing boats that were using a less than 2.5 cm mesh size net and operated fishing with and without a light luring device. The conclusion of the studies were:

1) For daytime operations, a little over 90 per cent of the total catches was composed of anchovy .

2) Anchovy caught by daytime operations were of mature size.

3) The fishermen who sold their catches to the boiled-dried anchovy processors or processed the catch themselves at sea, operated mainly in the daytime. Because the species composition of the anchovy catches from daytime operations includes fewer other species than the catches from night-time operators, processors had no difficulties in processing the catch.

Based on the outcome of the studies, the DOF has allowed the fishermen to operate the anchovy purse seine with a less than 2.5 cm mesh size net for daytime operation only, from 15 February to 31 March.

The fishery management regulations for anchovy fishery

There are now many regulations applying to anchovy fishery. Before 1983, the problems arising from anchovy fishery were not as serious as at present, thus there were no specific regulations on the management of anchovy fishery. However, owing to the increasing demand for boiled-dried anchovy in the world market in 1980s, the anchovy fishing fleets suddenly increased their fishing effort to catch more anchovy. Therefore, from 1983 onwards specific regulations were issued for the management of anchovy fishery. These regulations are:

1) No fisherman may operate any type of fishing gear that uses a less than 2.5 cm mesh size net with light luring device(s). This regulation was issued by the MAC on 14 February 1983.

2) Anchovy purse seiners are prohibited to fishing in the waters off Prachuap Khiri Khan, Chumphon and Surat Thani provinces from 1 April to 15 May. The MAC issued this regulation on 28 November 1984, with amendments on 11 January 1988.

3) Fishermen are prohibited from fishing by using any type of purse seiners with light luring device(s) in specified areas of Trat Province. This regulation was issued by MAC on 24 January 1985.

Enforcement

The Thai's waters (Gulf of Thailand and the Andaman Sea) total 316,017 sq. km. Therefore, with the limited number of personnel and fishery patrol boats of the DOF, it is very difficult to enforce the rules and regulations effectively. Many fishermen still violate the regulations which results in a decline in anchovy resources in the sea areas. The fishermen are obliged to fish further and further from their former fishing grounds, the cost of production thus increasing day by day. In addition, the conflicts between the fishermen who engage in anchovy fishery and those who exploit pelagic resources have increased both in terms of the severity of the conflicts and the number of cases.

In 1994, the DOF had 40 fishery patrol boats for law enforcement and a further number are under construction in 1995. There are 5 marine fisheries resources conservation units and 4 marine fisheries resources reservation units that responsible for enforcement.

Marine Fisheries Resources Conservation Unit

1. Marine Fisheries Resources Conservation for the Upper Gulf Unit. This unit is located in Samut Prakhan Province. There are 11 patrol boats for enforcement in the sea areas off Phet Buri, Samut Sakhon, Samut Songkram, Samut Prakarn, Chachoengsao and Chon Buri provinces.

2. Marine Fisheries Resources Conservation for the Eastern Coast Unit. It is located in Rayong Province. The unit has 4 patrol boats for enforcement in the sea areas off Rayong, Chantha Buri and Trat provinces.

3. Marine Fisheries Resources Conservation for the Upper South Unit. It is located in Chumphon Province. This unit has 6 patrol boats for enforcement in the sea areas off Prachuap Khiri Khan, Chumphon and Surat Thani provinces.

4. Marine Fisheries Resources Conservation for Lower South Unit. It is located in Songkhla Province and equipped with 7 patrol boats. This unit is responsible for the sea areas off Songkhla, Pattani and Narathivat provinces.

5. Andaman Marine Fisheries Resources Conservation Unit. This is located in Phuket Province. Two patrol boats belong to the unit and carry out enforcement operations in the sea areas off Ranong, Phuket, Phangnga, Krabi, Trang and Satun provinces.

Marine Fisheries Resources Reservation Unit

1. Tao (Turtle) Island Marine Fisheries Resources Reservation Unit. It is located in Surat Thani Province and equipped with 2 patrol boats.

2. Chang (Elephant) Island Marine Fisheries Resources Reservation Unit. It is located in Trat Province and equipped with 3 patrol boats.

3. Surin Island Marine Fisheries Resources Reservation Unit. It is located in Phangnga Province and equipped with 2 patrol boats.

4. Lee Pe Island Marine Fisheries Resources Reservation Unit. It is located in Satun Province and equipped with 2 patrol boats.

Although, the DOF put in practice place several fishery management measures governing anchovy fishery, conflicts among fishermen still arise the DOF has not been able to achieve the objectives of the management system, for the following reasons:

1. Personnel and the number of fishery patrol boats are limited compared with the almost 3,000 km of coast line. Enforcement can be carried out only in specific areas.

2. There are some loopholes in the law and regulations. Fishery patrol boats can arrest the poachers only while they are operating the fishing gear. Thus, very few poachers are arrested and taken to court.

4.3 Alternative Strategies for Management

Since the DOF's fishery management programme, which is based on the centralized management concept cannot implemented effectively and the enforcement costs are considerable, the DOF must seek alternatives for the management of anchovy fishery. In the past, the DOF devised its fishery management programme solely on the basis of the anchovy stock and the information furnished by fishery officers. The fishermen had no chance of participating in the drafting process of any law and regulations. This is no doubt the reason why the fishermen have always been opposed to the law and regulations issued by the DOF.

Many coastal states are, at present, implementing a fisheries co-management system for three main reasons. Firstly, to solve the problem of conflicts among fishermen; secondly, reduce the enforcement costs; and, thirdly, to enable the coastal fisheries resources to recover. Co-management is defined as the sharing of responsibility and/or authority between the government and local resource users/communities to manage the fishery or the resource (e.g., coral reefs, mangrove shoreline habitats). The degree of responsibility and/or authority that the state and various local levels have will differ and depend upon country and site specific conditions. Determining what kind and how much responsibility and/or authority should be allocated at the local level is a political decision (Pomeroy, 1994).

The results of the study appearing in Chapters 3 and 4 reveal that economic factors play the major role in the changes in anchovy fishery. Originally, fishermen caught mainly the large-sized anchovy because of the demand for this size by the fish sauce industry. With the rising demand for small-sized anchovy in the world market, the price of small-sized anchovy rapidly increased and the fishermen now attempt to catch the small-sized instead of the large-sized anchovy. They have modified their gear and fish closer to the coast for a big catch of small-sized anchovy. Therefore, in

establishing co-management of anchovy fishery, policy makers must pay more attention to the economic factors.

The key conditions for successful fisheries co-management that Ostrom (1990, 1992), Pinkerton (1989) and Pomeroy (1994) have pointed out should be considered carefully before such a programme is implemented.

The key conditions are:

1. *Clearly defined boundaries:* The physical boundaries of the area to be managed should be well defined so that the fishermen's groups can have an accurate knowledge of them. The boundaries should comprise an ecosystem that fishermen can easily observe and understand. The area should also be of a size that allows for management with available technology, i.e., transportation and communications equipment.

2. *Clearly defined membership:* The individual fisherman or household with rights to fish in the demarcated fishing area and participate in area management should be clearly defined. The number of fishermen or households should not be so large as to give rise to difficulties in effective communication and decision making.

3. *Group cohesion:* The fishermen's group or organization should have their permanent residence close to the area to be managed. There should be a high degree of homogeneity, in terms of kinship, ethnicity, religion or fishing gear type, among the group. Local ideology, customs and belief systems create a willingness to deal with collective problems. There should be a common understanding of problems and acceptance of alternative strategies.

4. *Prior experience of fishery organization:* The fishermen should preferably have had some experience of traditional community-based systems and of organizations in which where they have represented resource users interested in fishery management.

5. *Benefits exceed investment costs:* The fishermen should be made aware that the benefits to be derived from participation in and compliance with community-based management will exceed the cost of investment.

6. *Participation by fishermen:* The majority of the fishermen affected by the management arrangements should be included in the group that take decisions on these arrangements and introduces changes.

7. *Enforcement of management rules:* The management rules should be written out in simple terms. All fishermen should be involved in the monitoring and enforcement of the rules.

8. *Legal rights to the demarcated fishing area:* The fishermen's group or organization must be legally entitled to operate in the demarcated fishing area.

Legislation must be in place clearly defining the extent of local responsibility and degree of authority.

9. *Cooperation and leadership at community level:* The fishermen should be motivated to actively participate, in terms of time and effort in fishery management. A local committee set up by the fishermen should assume responsibility for the management of the programme in the field.

10. *Decentralization and delegation of authority:* The government should have established a formal policy and/or passed a law on decentralization of administrative functions and delegation of management responsibility and/or authority to the local government and local fishermen's groups.

11. *Coordination between government and the fishing community:* A coordinating body should be established, external to the local fishermen's group or organization and with representation from the fishermen group or organization for the purpose of coordinating with government, on monitoring enforcement of management arrangements and resolve conflicts.

The co-management programme seems to be the most appropriate fishery management programme for Thai anchovy fishery and capable of rectifying the shortcoming of the present fishery management measures. The Thais like other human, once they realize that something has been entrusted to them, they will use it wisely for their own benefit. At present, fishermen attempt to catch as much fish as possible in one day's operation as they are not sure that the next day's catch will be as plentiful. Since every fisherman has the same attitude, it is not surprising that the fisheries resources are declining.

Since the recovering period of fisheries resources in tropical waters is shorter than in the temperate zone, the fisheries co-management programme can be applied to the Thai anchovy fishery with a good chance of success. The anticipated result of the programme are: firstly, that the anchovy resources close to the coastal area, i.e., small-sized anchovy will be conserved by the fishermen for their future benefits; secondly, that the number of fishing boats will be limited to ensure that the average catch per fishing boat in the future will increase or at least remain the same as at present; and thirdly, that the fishermen who engage in anchovy fishery will participate actively in the co-management programme.

CHAPTER 5

CONCLUSIONS

Since 1982, the production of anchovy has increased rapidly owing to the development of fishing technology, the major development being the introduction of light luring fishery to anchovy fishery. At the same time, the anchovy is used not only for fish sauce but also as dried and boiled-dried anchovy for export. The demand for anchovy has increased year by year, resulting in fishermen extending their operations to new fishing grounds. These, there has been an increasing in total amount of fishing effort. Therefore, the anchovy resources are depleted in many fishing grounds, particularly in the coastal areas. Furthermore, many young economic species were caught as a by-catch of anchovy fishery.

The analysis on costs and earnings of anchovy fishery has shown that the day-time operation paid for the production costs at 5.14 Baht/kg; and the fishermen sold their catch at 5.07 Baht/kg wet weight; and it social cost created was 1,581.03 Baht per boat per day. For night-time operation, production costs were 3.35 Baht/kg whereas the revenue was 3.43 Baht/kg, and the social cost was 5,914.92 Baht per boat per day.

The CPUE of anchovy purse seine has declined since 1982. This indicates that the anchovy resources have been overexploited for more than ten years. Therefore, if the total amount of fishing effort is not decreased, it can be assumed that this resource will be depleted in the near future. The DOF is seeking various fishery management measures for solving the problems of this fishery.

To ensure the sustainable development of Thai anchovy fishery, the following measures should be implemented as soon as possible.

1. Since night-time anchovy fishery has created a considerably high social cost, the DOF has to limit or ban the night-time operation as soon as possible to prevent the destruction of young economical fish. In addition, the law and regulations concerning the management of anchovy fishery need urgent revision otherwise the anchovy resources in the coastal areas cannot recover in the near future.

2. The DOF has to seek new fishing grounds for anchovy fishery through research and exploration. From the present analysis, it was found that the existing fishing grounds for anchovy are limited to certain coastal areas resulting in heavy exploitation of the resources in that area. Many researchers believe that because of the biology of anchovy, a stock of large-sized anchovy may be available in offshore waters. The large-sized anchovy may not be suitable for the boiled-dried process but it is a good raw material for fish sauce.

3. The larger catches of very small-sized anchovy in the past was the result of an increase in demand for dried small-sized anchovy in the world market. The price per kg of small-sized boiled-dried anchovy is the highest and decreases as the size

increase. Therefore, in order to avoid overexploitation of the small-sized anchovy, the Thai Government should impose an export tax on small-sized boiled-dried anchovy. This tax would constitute an indirect measure for reducing fishing pressure on small-sized anchovy. Thus, the recruitment of coastal anchovy would be increased and the abundance of this resource in the coastal areas could be secured. The revenue collected from such an export tax could be allocated to the Fishery Development Fund which was established recently. The DOF is the agency which uses this fund for the development of the fishery industry as a whole. In principle, the tax on anchovy exports would be used mainly for the development of anchovy fishery.

4. A study on the stock of anchovy in Thai waters should be cover the Gulf of Thailand and the Andaman Sea. If possible, co-research with neighbouring countries should be done for the straddling stock utilization. Although, no research has so far been undertaken on the straddling stock, now is the time for cooperation between the countries in this region for their mutual benefit.

5. The DOF should establish a data and information centre for the study of stock assessment of the economic species. Each year, the DOF allocates a reasonable budget to the Marine Fishery Division for fishery data collection. Unfortunately, the collected data have not been handled properly and some of the collected data disappeared. Thus, the estimation of the stock size of some species is not precise. Therefore, in order to avoid the mistakes of the past, the collected fishery data should be recorded in standard format and stored in the main computer of the DOF so that any researcher can access the data through the network system.

6. A co-management programme should be established urgently. Although at present, Thailand has no specific law applicable to a co-management programme, some articles of the present fishery law can be applied to such a programme. However, some difficulties might arise at the initial stage of the programme, inter alia, in connection with the establishment of fishing rights for each fishermen's institution and the setting up of efficient fishermen's institutions. These difficulties can be solved by close collaboration between the fishermen and government.

7. The DOF should register all the fishing boats that catch anchovy in Thai waters. At present, the number of registered anchovy fishing boats is underestimated. There are many fishing boats registered as purse seiners catching other species that are modified as anchovy purse seiners during the anchovy fishing seasons. Thus, the total amount of fishing effort is also underestimated. Therefore, to set up an effective fishery management programme, it is essential to know the actual number of fishing boats which are exploiting anchovy resources.

References

Chantarasakul, V. 1988. Species and their juvenile distribution in the Rayong bay, Rayong province. Master degree thesis. Chulalongkhorn University. Bangkok. 194 p.

Chayakul, R. 1990. Composition and distribution of juvenile fish in the Gulf of Thailand, Chumphorn province coastal area. Marine Fishery Division, Department of Fisheries. Bangkok. 18 p.

Department of Fisheries. 1973-1993. Marine fisheries records. Fishery Policy and Planning Division, Department of Fisheries. Bangkok.

Department of Fisheries. 1991. Fishing vessels records, 1989. Fishery Policy and Planning Division, Department of Fisheries. Bangkok.

Hnuphet, L. 1984. Length frequency distribution and growth rate of *Caranx leptolpis* Valenciennes, 1833. that caught by luring purse seine in the Gulf of Thailand. Technical report no. 46. Marine Fishery Divission, Department of Fisheries. Bangkok. 21 p.

Ostrom, E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge Unversity Press, Cambridge, England.

_____. 1992. Crafting institutions for self governing irrigation systems. Institute for Contemporary Studies Press. San Francisco, USA.

Pinkerton, E., Editor. 1989. Cooperative management of local fisheries. University of British Columbia Press, Vancouver, Canada.

Piyathirathitivorakhul, P. 1983. Study on growth and length frequency distribution of *Caranx mate* Cuvier that were caught in the Gulf of Thailand. Bangkok. 21 p.

Photharot, M. and Krisana Sophaphongse.1992. Utilization of anchovy. Fishery Gazzette Vol. 45(6). Department of Fisheries. Bangkok. p. 539-546.

Pomeroy, R. S. and M. J. Williams. 1994. Fisheries co-management and smll-scale fisheries: a policy brief. International Center for Living Aquatic Resources Management, Manila. 15 p.

Rattakul, P., Predee Methathip, Narumol Sangthong and Boonsong Sirima. 1987. Time saving techniques in fish sauce fermentation. Fish Technology Division, Department of Fisheries. Bangkok. 26 pp.

Somjaiwongse, D. 1991. Study on population dynamic of *Sadinella gibbosa* (Bleeker, 1849) in the Gulf of Thailand. Technical paper no. 5/1990. Marine Fishery Division, Department of Fisheries. Bangkok. 63 p.

Suphongphan, S. and Phissamorn Issara. 1984. Study on age, growth and t_0 of *Stolephorus heterolobus* (Ruppel, 1833) in theGulf of Thailand, 1970-1973. Technical paper no. 44. Marine Fishery division, Department of Fisheries. Bangkok. 23 p.

Suphongphan, S. and Phairoj Saikliang. 1985. Anchovy purse seine fishery. Marine Fishery Division, Department of Fisheries. Bangkok. 27 p.

Suphongphan, M. 1987. The assessment of squid stock in the Gulf of Thailand. In Proceedings of Annual Fisheries Seminar, 1987. 15-17 September 1987. National Inland Fishery Institute, Department of Fisheries.Bangkok. p. 153-165.

Saikliang, P. and Pissamorn Issara. 1984. Study on anchoy (*Stolephorus spp.*) fishery in the Gulf of Thailand, 1969-1981. Technical paper no. 46. Marine Fishery Division, Department of Fisheries. Bangkok. 34 p.

Saikliang, P. 1990. Anchovy fishery. Technical paper no. 1/1990. Marine Fishery Division, Department of Fisheries. Bangkok. 45 p.

_____. 1990. Anchovy in the Gulf of Thailand. Fishery Gazzette Vol. 43 (5). Department of Fisheries. Bangkok. p. 339-348.

Saikliang, P. and Phisamrn Issara. 1984. Study on anchovy (*Stolephorus spp.*) fishery inthe Gulf of Thailand. Marine Fishery Division, Deartment of Fisheries. Bangkok. 34 p.

Sidtichokapun, S. 1976. A preliminary estimation of a parent stock of anchovy (*Stolephorus heterolobus*) from surveys on the spawning grounds off the western coast of the Gulf of Thailand, 1968-1969. Proceedings of the International Seminar on Fisheries Resources and their management in Southeast Asia, 19 Nov. - 6 Dec. 1974, Berlin. p 134-148.

Thaveesit, T. 1968. Report on anchovy in the Gulf of Thailand. Marine Fishery Laboratory, Fishery Exploratory Division, Department of Fisheies. Bangkok. 18 p.

_____. 1979. Summary of technical papers on anchovy. Technical paper no. 6. Marine Fishery Division, Department of Fisheries. Bangkok. 10 p.

Thaveesit, T. and Phismorn Thephranont. 1973. Length-weight relationship of anchovy (*Stelophorus heterolobus*) in the Gulf of Thailand. Fishery Exploratory Division, Department of Fisheries. Bangkok. 13 p.

Theptranont, P. 1972. Length frequency distribution of anchovy in the Gulf of Thailand. Marine Fishey Laboratory, Fishery Exploratory Division, Department of Fisheries. Bangkok. 14 p.

Wattanachai, S. 1978. Distribution of fish larvae in the Inner Gulf of Thailand. Marine Fishery Laboratory, Department of Fisheries. Bangkok. 23 p.

Wongrat, T. 1985. Classification of anchovy Genus *Stolephorus* (Pisces: Engraulidae) in Indo-Pacific region. Sciences Journal. Faculty of Sciences, Chulalongkhorn University. Vol. 10(1) p. 25-45.