Socioeconomic Assessment of Marine Fisheries of Thailand

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Abstract

Thailand is currently one of the ten largest fishing nations in the world. In 1996, fish production reached 3.7 million t with 90% of the production coming from the marine fisheries sector and 10% from inland fisheries. Thai fishing operates in four fishing grounds namely, the Gulf of Thailand, the Andaman Sea, the South China Sea and the Bay of Bengal. However with the establishment of the Exclusive Economic Zone (EEZ) in 1977, Thailand lost over 300 000 km^2 of traditional fishing grounds.

Gross domestic product (GDP) of Thailand was estimated at 4 598 billion Baht (US$ 181 billion at 1 US$ = 25.36 Baht) in 1996 with 87.8 billion Baht (US$3.46 billion) (1.9%) coming from the fish industry. In 1997, fishery product exports reached 138 624 million Baht (US$4 million at 1 US$ = 31.18 Baht) or 69% (200 795 million Baht including fish) of the total agriculture exports and 7.3% (1 898 276 million Baht) of total exports. However, the rapid growth of manufacturing and service sectors has diminished the contribution of the fisheries sector to GDP in the recent years.

Of the estimated 35.6 million labor force in Thailand in 1998, 43% were employed in the agricultural sector including fisheries. The 1995 Census of Marine Fishery showed that the total number of fishery households including fisheries employees' households in the country was 109 635. No census was conducted for inland fisheries. The fisheries sector also supports a substantial level of employment in industries like fish processing, cold storage, fishmeal, ice making, boat construction and the like. The labor force of these industries was estimated to be at 211 682 in 1995.

Fish is the primary source of animal protein for most of Thailand's population, particularly in the coastal and near-coastal provinces. The average per capita fish consumption is 24 kg annually.

Marine capture fisheries can be broadly divided into commercial and small scale sub-sectors. Commercial vessels are those vessels over 10 m in length or 5 GT, that use modern fishing gear and have the capacity to fish offshore for several days. Small scale vessels are usually less than 10 m in length and either employ outboard- or inboard-engines, or are non-motorized and operate in near shore areas. From

1985 to 1995, the number of small scale fishing boats increased by 7.5%, while the commercial boats increased by 11%. One reason for the change has been the creation of a boat-tenure system within the commercial fishing sector, resulting in a decrease in the number of boats per household.

The major fishing gear used by the small scale fishers are gillnets, small push nets, lift nets or other modern small scale gear, set traps, bagnets and other stationary gear in estuaries or protected inshore waters. In the fishing household of Songhkla Province, Southern Thailand, shrimp gillnets, cuttlefish trammel nets, Indo-Pacific mackerel gillnets, other gillnets and Acetes trawl nets are the major fishing gear. The fishers direct their effort towards high value species like shrimp, cuttlefish, pomfret fish and crabs, but they also obtain by-catch low value fish species. The most important determinant of profit for small scale fisheries is the interaction between types of gear and fishing ground.

Commercial fishing vessels utilize otter trawls, pair trawls, beam trawls, push nets, purse seines and king mackerel gillnets as the major fishing gear. The analysis of investment, cost, revenue and return on demersal and pelagic fishing operations shows that (a) returns differ markedly among size of fishing boats and types of fishing gear; (b) ability to generate profit is greater in large fishing boats than small due to their higher ability to adjust to both economic (investment) and biological (fishing ground) changes; and (c) among the trawlers, medium and large boats can best adapt to maintain continuous profit, while for push nets, all size of boats show declining net profit. In pelagic fishing operations, purse seiners have been developed to make high profits and yield a higher return than trawlers and gillnet fishing operations.

The Schaefer Model was applied to estimate the maximum sustainable yield (MSY) and maximum economic yield (MEY) for demersal fish and trash fish in the Gulf of Thailand. Results indicated that the present catch and the corresponding effort of demersal fishing in the Gulf of Thailand surpassed both MEY and MSY. In order to obtain the maximum net benefit in the long run, the present fishing effort of catching demersal fish must be reduced to about 50% of present levels. This would lead to the rehabilitation of marine resources and minimize the by-catch.

Socioeconomic Profile

Review of the Status of Marine Fisheries

Introduction

The production from fishery industries in Thailand has demonstrated remarkable growth over the last three decades. Thailand is now ranked among the top ten fishing nations of the world. Its fisheries production exceeded 2 million t for the first time in 1977, after which a decline followed. Production recovered to over 2 million t by 1983, and increased to 3.6 million t in 1995. Ninety per cent of total production comes from marine fisheries.

Before the 1977 proclamation of an Exclusive Economic Zone (EEZ) by the neighbouring countries, the Thai fishing fleet operated in four major fishing grounds: the Gulf of Thailand, the Andaman Sea, the South China Sea and the Bay of Bengal. Thailand lost over 300 000 km^2 of traditional fishing grounds due to the establishment of EEZs. Among the marine fishing grounds that fall within Thailand's EEZ, the Andaman Sea is an important one, with a total area of about 316 000 km^2, and a coastline of 2 630 km.

In 1995, the total marine catch was 2.8 million t, (Table 1) valued at 45 183 million Baht (US$1 737 807)[1]. Compared with 1990 figures, it had increased 42% in volume but 2.2 times in value. Of the total marine catch, about 70% is caught in Thai waters and the rest from other countries' zones.

[1] 1US$ = Baht 26 at 1995 exchange rate.

Table 1. Fisheries production of Thailand by subsectors, 1977 – 98.

Year	Total		Capture				Culture			
			Marine		Inland		Coastal aquaculture		Freshwater culture	
	1 000 tons	%	1 000 tons	%	1 000 tons	%	1 000 tons	%	1 000 tons	%
1977	2 189.9	100.0	2 064.4	94.3	89.2	4.1	3.2	0.1	33.1	1.5
1978	2 099.3	100.0	1 947.7	92.8	102.1	4.9	10.1	0.5	39.4	1.9
1979	1 946.3	100.0	1 802.3	92.6	103.7	5.3	10.9	0.6	29.4	1.5
1980	1 792.9	100.0	1 587.9	88.6	110.4	6.2	60.1	3.4	34.5	1.9
1981	1 989.0	100.0	1 756.9	88.3	116.5	5.9	67.5	3.4	48.1	2.4
1982	2 120.1	100.0	1 949.7	92.0	87.7	4.1	36.9	1.7	45.8	2.2
1983	2 255.4	100.0	2 055.2	91.1	108.4	4.8	44.8	2.0	47.0	2.1
1984	2 134.8	100.0	1 911.5	89.5	111.4	5.2	61.5	2.9	50.4	2.4
1985	2 225.2	100.0	1 997.2	89.8	92.2	4.1	60.6	2.7	75.2	3.4
1986	2 536.3	100.0	2 309.5	91.1	98.4	3.9	39.1	1.5	89.3	3.5
1987	2 779.1	100.0	2 540.0	91.4	87.4	3.1	61.9	2.2	89.8	3.2
1988	2 629.7	100.0	2 337.2	88.9	81.5	3.1	108.9	4.1	102.1	3.9
1989	2 740.0	100.0	2 370.5	86.5	109.1	4.0	168.7	6.2	91.7	3.3
1990	2 786.4	100.0	2 362.2	84.8	127.2	4.6	193.2	6.9	103.8	3.7
1991	2 967.7	100.0	2 478.6	83.5	136.0	4.6	230.4	7.8	122.7	4.1
1992	3 239.8	100.0	2 736.4	84.5	132.0	4.1	229.3	7.1	142.1	4.4
1993	3 385.1	100.0	2 752.5	81.3	175.4	5.2	295.6	8.7	161.6	4.8
1994	3 523.2	100.0	2 804.4	79.6	202.6	5.8	345.8	9.8	170.4	4.8
1995	3 572.6	100.0	2 827.4	79.1	191.7	5.4	357.5	10.0	196.0	5.5
1996*	3 489.7	100.0	2 769.0	79.3	203.5	5.8	311.3	8.9	205.9	5.9
1997**	3 412.2	100.0	2 666.3	78.1	212.5	6.2	317.2	9.3	216.2	6.3
1998**	3 665.4	100.0	2 867.5	78.2	235.4	6.4	333.2	9.1	229.2	6.3

Source: Fisheries Economics Division, Department of Fisheries 1972 – 97.
Note: * Preliminary data
**** Estimated data**

Historical Development of Marine Fisheries

Historically, Thai marine fisheries were small scale fisheries along the coast of the Gulf of Thailand and Andaman Sea. The most popular fishing gear was fixed gear such as trap and set bag, which operated in river mouths and along the coast at a depth of not more than 20 m. Most catches landed were pelagic species. In 1925, the Chinese purse seine from China was introduced, and was used experimentally at a depth of less than 50 m. After the end of the 2nd World war (1951), the drift gillnet was introduced, which was effective in catching pelagic species and was widely accepted among Thai fishers. In 1960, there was a major development with the introduction of the otter trawl. This gear drew attention towards demersal species, and away from labor-intensive fishing to commercial fisheries with heavy investments in modern technology. There was a rapid increase in trawlers both in size and efficiency. Hence, over the decades two different fisheries - pelagic and demersal - have emerged in the Thai fishing industry.

Development of Pelagic Fisheries

The development of pelagic fisheries up to the present can be divided into three phases. The final phase is complex and involves management necessary to control its development.

Phase 1 (1925 - 64). The most important fishing gear for pelagic species was fixed gear such as traps, while Thai purse seine, Chinese purse seine and mackerel gillnet became widely used (Table 2). Eighty percent of pelagic species landed were mackerel.

Phase 2 (1965 - 73) was the period of growth for pelagic fisheries. Thai purse seine and mackerel encircling gillnet vessels increased, both in number and size, and these replaced trap fishing. Production from pelagic fisheries doubled that of Phase 1, and led to the expansion of the fish processing industry such as canning. The management techniques of pelagic fisheries changed from searching for more fishing grounds to the study of population dynamics and stock assessment to be used subsequently.

Phase 3 (1974 - present) witnessed the highest level of pelagic fisheries development. New fishing gear, such as luring purse seine, was introduced during this phase. This replaced Thai purse seine and mackerel encircling gillnet used during Phase 2. The number of luring purse seiners increased dramatically both in terms of size and quantity from 1 in 1972 to 730 vessels in 1981. During 1974 to 1977 catching methods were developed from searching for fish schools to aggregation methods using electrical equipment. Since 1977, there has been another major development with the introduction of sonar and power block. Concurrently, medium size trawlers, which were affected by fuel price increases, were converted to purse seiners, and fishing vessels became larger in size and capable of offshore fishing.

The development of pelagic fisheries was clearly demonstrated by a four-fold increase in production[2] from 223 900 t in 1974 to 953 900 t in 1994 (Table 2). Almost all pelagic fish resources in the Gulf of Thailand are fully exploited and there is some sign of stock depletion.

Table 2. Number of selected types of gear (fishing unit) registered and marine fish caught in Thailand, 1957 – 98.

	Pelagic fishing gear				Demersal fishing gear		Marine catch (1 000 tons)		
Year	Stake traps	Purse[1/] seines	Mackerel encircling gillnet	King mackerel drift gillnet	Trawlers[2/]	Push nets	Demersal[3/] species	Pelagic species	Total
1957	1 287	324	N/A	N/A	N/A	N/A	133.7	37.2	170.9
1958	1 344	392	N/A	N/A	N/A	N/A	94.9	50.1	145.0
1959	1 470	379	N/A	N/A	N/A	N/A	89.4	58.4	147.8
1960	1 409	323	48	N/A	99	N/A	82.8	63.7	146.5
1961	918	251	233	N/A	201	N/A	110.2	123.1	233.3
1962	792	228	386	N/A	976	N/A	118.3	151.4	269.7
1963	662	212	537	N/A	2 026	N/A	95.9	227.5	323.4
1964	602	144	890	N/A	2 360	N/A	128.1	371.0	499.1
1965	697	226	634	N/A	2 393	N/A	148.3	392.7	541.0
1966	663	228	409	N/A	2 695	N/A	202.5	445.0	647.5
1967	447	278	417	N/A	3 077	N/A	601.0	161.1	762.1
1968	457	361	329	N/A	3 182	N/A	792.5	211.5	1 004.0

[2] including catch from outside Thai waters.

Table 2. Number of selected types of gear (fishing unit) registered and marine fish caught in Thailand, 1957 – 98. (continued)

Year	Pelagic fishing gear				Demersal fishing gear		Marine catch (1,000 tons)		
	Stake traps	Purse seines[1/]	Mackerel encircling gillnet	King mackerel drift gillnet	Trawlers[2/]	Push nets	Demersal species[3/]	Pelagic species	Total
1969	374	314	224	N/A	3 185	N/A	948.5	231.0	1 179.5
1970	371	716	260	235	3 082	354	998.0	337.6	1 335.6
1971	313	475	244	151	3 608	610	1 265.9	204.2	1 470.1
1972	236	506	254	138	4 486	1 327	1 428.7	119.4	1 548.1
1973	189	680	228	231	5 837	1 628	1 338.2	199.8	1 538.0
1974	229	657	188	148	5 271	1 213	1 127.7	223.9	1 351.6
1975	262	625	187	177	4 962	1 075	1 130.7	263.9	1 394.6
1976	222	726	226	157	5 204	844	1 197.5	345.3	1 542.8
1977	242	706	314	244	6 288	1 177	1 552.1	515.5	2 067.6
1978	250	843	359	151	6 453	1 426	1 515.9	441.9	1 957.8
1979	258	681	256	227	8 747	1 923	1 386.1	416.2	1 802.3
1980	225	781	307	287	10 421	2 262	1 259.7	328.2	1 587.9
1981	277	833	258	327	7 525	1 216	1 368.5	388.4	1 756.9
1982	233	840	238	281	11 475	1 899	1 554.2	395.5	1 949.7
1983	225	846	144	264	9 390	1 326	1 542.6	512.6	2 055.2
1984	254	961	245	265	9 131	960	1 338.9	572.6	1 911.5
1985	234	951	227	269	8 325	759	1 409.1	588.1	1 997.2
1986	258	996	203	329	7 407	664	1 739.4	570.1	2 309.5
1987	253	1 174	223	365	7,343	624	1 910.4	629.6	2 540.0
1988	231	1 456	146	461	6,950	531	1 699.2	638.0	2 337.2
1989	208	1 443	114	282	13 113	1 907	1 666.9	703.6	2 370.5
1990	188	1 629	101	299	12 905	1 879	1 643.0	719.2	2 362.2
1991	188	1 614	88	338	10 298	1 047	1 752.5	726.1	2 478.6
1992	204	1 452	72	362	9 465	818	1 895.2	841.2	2 736.4
1993	190	1 509	94	271	9 086	808	1 896.9	855.6	2 752.5
1994	190	1 511	99	280	8 346	651	1 850.5	953.9	2 804.4
1995	139	1 397	82	330	7 995	634	1 858.7	968.7	2 827.4

Source: Fisheries Economic Division, Department of Fisheries 1972 – 97.
Note: [1/] Chinese purse seine, Thai purse seine, Luring purse seine and Anchovy purse seine.
[2/] Otter trawl, Pair trawl and Beam trawl.
[3/] Demersal fish, Trash fish, Cephalopod, Crab, Shrimp, Mollusc and others.
N/A = Not available.

Development of Demersal Fisheries

Demersal fisheries were not popular prior to 1960. There was an unsuccessful introduction of trawl by private companies in 1952. This type of fishing requires experienced and skilled crews and the demersal species caught had yet to find a market. Nevertheless, some fishers were successful in converting the trawl into beam trawl by using smaller-size vessels and harvesting shrimp along the coast. In 1960, the Government of the Republic of Germany rendered technical assistance in marine fisheries development by surveying fishing grounds and providing suitable fishing gear for harvesting marine resources. The otter trawl was the most effective gear and became widely deployed. The number of fishing vessels increased rapidly from 99 in 1960 to 13113 in 1990, and decreased to 7 995 in 1995. During this time, Thai trawl fisheries went through both expansion and crisis, in three distinct phases.

Phase 1 (1960 - 73) had the same rapid development of demersal fisheries as Phase 2 of pelagic fisheries. This was the period of great expansion of trawl such as pair trawl and beam trawl, and especially otter trawling. The number of trawlers increased 59 - fold from 99 in 1960 to 5 837 in 1973. Since demersal resources were abundant and newly discovered, and the financial return from trawling higher than from other fishing gear at that time, investment in trawlers became attractive. Investment in trawling increased both in terms of the number and size of fishing boats, which ventured into international waters for the first time.

Concurrently in 1967 - 71, the Department of Fisheries discovered fishing grounds in the Bay of Bengal, the best grounds for trawling, and large fishing boat construction began. The increase in fishing boats resulted in an increment in demersal catch of 2.1 - fold, from 63 700 t in 1960 to 1 338 200 t in 1973 (Table 2). However, crises immediately followed. Demersal fisheries resources especially in the Gulf of Thailand, began to suffer from over-exploitation. Sustainable yield of this fishery is about 768 000 t with a fishing effort of 8 x 10^6 hours (Boonyubol and Pramokchutima, 1984). At the same time, fuel prices increased by four times in 1973 and 1974. The rise in fuel price also had implications on the world economy, causing a drop in demand by importers of Thai fisheries products, and eventually affecting the domestic price.

Phase 2 (1974 - 81). The number of trawlers and demersal catches landed in 1974 dropped by 34% and 16% respectively compared with 1973. Another fuel price increase during 1979 - 80 forced many fishers to operate the more fuel-efficient purse seine. Landings of pelagic species consequently showed an increase against the decline of demersal species (Table 2). The final crisis affecting trawl fisheries, especially the medium and large size trawlers, came with the declaration of EEZs. Neighbouring countries, particularly the archipelagic ones benefited from this declaration. However, Thailand as a shelf-locked state, surrounded by EEZs of other nations, cannot expand its economic zone. Coupled with little shelf area, the division of territorial waters based on the equidistance principle generated a great loss to Thai fisheries resoures. Other countries claimed parts of the high seas that were formerly utilized by the Thai fishers, thus decreasing fishing grounds by about 300 000 km^2. The number of trawlers in the Gulf increased, thereby depleting the resources. These additional fishing vessels raised the fishing effort and the effort levels of individual trawlers also increased. Fishing boats that continued to fish outside the Gulf needed additional investment for more effective engines and navigational aids, such as radar, to avoid arrest.

This situation led to a recommendation to reduce the number of trawlers and initiate control measures in 1981. In the final period of this phase, negotiations were started on joint ventures in fisheries with other nations, with the main objective to seek sectional new fishing grounds and to settle the problems of intrusion of Thai vessels. A Joint Venture Agreement between Thailand and Bangladesh was signed in 1980. This was the first time that Thai fishing vessels could legally operate in international waters after the proclamation of the EEZs of the neighbouring countries.

Phase 3 (1981 - present). Various crises brought about the decline of trawlers during the early period of fuel price adjustment. However after the adjustment, growth in fishing effort and fishing gear with small mesh size cod-ends, along with inshore fishing increased the catch of trash fish and thus fishers' incomes. This practice created problems with the artisanal fishers. Catching the fingerlings as trash fish leads to a decline in the population of demersal fish. At the same time, medium and large trawlers were not profitable since improvement in efficiency was needed, by increasing engine capacity and introducing navigational aids such as radar to operate along the boundary or sometimes in the neighbouring waters. The problems of arrests increased. Nonetheless, the number of trawlers reached 9 393 in 1983 due to newly constructed fishing vessels (Table 2). The Department of Fisheries issued measures to control the construction of new trawl vessels, including issuance of fishing licenses for trawl fishing. However, these measures were not strictly enforced due to lack of coordination among concerned agencies. The fishers had more interest in the negotiation of joint ventures, charter vessels and hire purchase agreements with Australia, Indonesia, Myanmar, Bangladesh and India. Fish, thus caught are brought back to Thailand, resulting in a slight increment in marine fishery production at the present time.

Contribution of the Fisheries Sector to Economic Growth and Welfare

Contribution of Fisheries Sector to Gross Domestic Product (GDP)

Thailand's gross domestic product (GDP) was estimated at 4 598 billion Baht in 1996, of which the fishing industry contributed 87.8 billion Baht or 1.9% of GDP, a decline from the average of 3% of GDP during the period 1994 to 1996. The main reasons for the diminished contribution to GDP by the fisheries sector in recent years were the rapid growth of manufacturing and service sectors and the comparatively slow growth of the fisheries sector. These factors were partially offset by increases in real fish prices. In constant (1983) price terms, the aggregate value of fish production peaked in 1978 at 21 000 million Baht. Furthermore, although the fisheries sector makes a relatively small contribution to Thailand's GDP, it makes an important contribution to export earnings and employment, and provides the Thai people with the principal source of animal protein in their diet (Table 3).

Contribution of Fishing Industry to Income and Employment

The labor force of Thailand was estimated at 35.6 million in 1998, of which some 15.4 million (43%) were employed in the agricultural sector (including fisheries).

The 1995 Census of Marine Fishery revealed that the total number of fishery and fishery employees' households in the country was 109 635. They are comprised of 50 312 households exclusively engaged in capture fishery; 27 388 households engaged in coastal aquaculture; 3 001 engaged in both marine capture fishery and coastal aquaculture; and 28 934 households of fishery employees. The population engaged in marine fisheries was 535 210 persons (Table 4).

The inland fisheries census was not conducted, however most rice-growing farmers know how to catch fish, i.e. they are part-time fishers. Millions of farmers routinely catch freshwater fish for their own consumption.

A survey on freshwater fish-farm production since 1974 was conducted, but unfortunately not all aquaculturists and employees were recorded. The survey showed that the number of freshwater fish farms continuously increased from 61 980 farms in 1990 to 161 504 farms in 1994. This indicates that at least 300 000 persons were involved in freshwater aquaculture in 1994.

Additionally, the fisheries sector supports substantial employment in industries such as fish processing, cold storage, fish meal, ice making, boat construction, etc. The labor force of these industries was estimated at 211 682 in 1995.

Contribution of Fisheries Sector to Foreign Exchange Earning

The contribution to Thailand's export earnings by the fishing and fish processing industries has increased steadily in recent years (Table 5). The positive trade balance in fish and fish products increased from 11 584 million Baht to 111 185 million Baht (US$3 566 million at 1 US$ = 31.18 Baht in 1997) between 1983 and 1997. Although the industry relies on imported inputs such as diesel fuel and netting, material earnings remain substantial, particularly in relation to the level of employment in the industry. Fishery product exports in 1997 totaled 138 624 million Baht (US$4 446 million), equivalent to 69% of total agriculture exports (200 795 Baht million including fish) and 7.3% of total exports (1 898 276 million Baht).

Table 3. Gross domestic product (GDP) and national income at current market prices by industrial sectors in Thailand, 1989 - 96.

Industrial Sectors	1989		1990		1991		1992		1993		1994		1995		1996	
	Bahts (millions)	%	Bahts (millions)	%	Bahts (millions)	%	Bahts (millions)	%	Bahts (millions)	%	Bahts (millions)	%	Bahts (millions)	%	Bahts (millions)	%
Gross Domestic Product (GDP)	1 620 882	100.0	1 895 034	100.0	2 506 635	100.0	2 830 914	100.0	3 170 258	100.0	3 630 805	100.0	4 188 929	100.0	4 598 288	100.0
Agriculture	279 094	17.2	273 973	14.5	317 085	12.6	348 127	12.3	329 878	10.4	390 233	10.7	464 171	11.1	507 339	11.0
Crops	174 809	10.8	159 992	8.4	181 918	7.3	197 058	7.0	166 564	5.3	206 264	5.7	258 432	6.2	289 570	6.3
Livestock	29 797	1.8	32 770	1.7	37 430	1.5	35 001	1.2	32 275	1.0	35 802	1.0	42 599	1.0	44 457	1.0
Fisheries	27 449	1.7	32 214	1.7	43 139	1.7	55 764	2.0	67 410	2.1	76 138	2.1	83 097	2.0	87 800	1.9
Forestry	8 181	0.5	6 665	0.4	7 110	0.3	6 705	0.2	6 443	0.2	6 145	0.2	6 098	0.1	6 291	0.1
Agricultural Services	10 678	0.7	10 795	0.6	10 958	0.4	11 525	0.4	11 149	0.4	12 477	0.3	12 779	0.3	13 519	0.3
Simple Agricultural and Processing Products	28 180	1.7	31 537	1.7	36 530	1.5	42 074	1.5	46 037	1.5	53 407	1.5	61 166	1.5	65 702	1.4

Source: NESDB

Table 4. Fisheries sector employment in Thailand, 1995.

Type of employment	No. of Fishers, Fish farmers and Employees
Marine capture[1]	157 377
Coastal aquaculture[2]	45 898
Inland culture[3]	404 344
Related fisheries industry[4]	220 370
TOTAL	827 989

Sources: [1, 2] 1995 Marine Fishery Census.
[3] No. of farmer = (no. of fishfarm x 2 persons).
[4] Ministry of Labor and Social Welfare.

Table 5. Trade balance in the fisheries sector of Thailand, 1983 - 97.

Year	Import		Export		Trade Balance	
	Q (tons)	V (M. Baht)	Q (tons)	V (M. Baht)	Q (tons)	V (M. Baht)
1983	58 942	1 093	344 899	12 677	285 957	11 584
1984	119 064	2 119	411 722	15 081	292 658	12 962
1985	152 707	3 857	466 219	18 528	313 512	14 670
1986	268 089	7 590	602 486	26 829	334 397	19 239
1987	227 327	7 017	663 650	32 654	436 323	25 637
1988	347 666	14 713	798 572	44 437	450 906	29 724
1989	455 755	19 067	875 293	53 705	419 538	34 638
1990	507 737	20 653	904 973	61 070	397 236	40 418
1991	724 668	27 353	1 087 395	78 463	362 727	51 110
1992	714 012	24 569	1 106 141	82 469	392 129	57 901
1993	760 919	21 629	1 115 078	91 018	354 159	69 389
1994	893 588	21 329	1 214 946	110 285	321 358	88 956
1995	872 818	21 924	1 192 560	116 578	319 742	94 654
1996	797 389	22 425	1 146 949	110 781	349 560	88 356
1997	710 115	27 439	1 181 255	138 624	471 140	111 185

Sources: Custom Department, Ministry of Finance.

Contribution of Fishery Sector to Domestic Nutrition

The contribution of fish and other food to the Thai diet during 1995 is reported in Table 6a. Fish is the primary source of animal protein for most of Thailand's population, particularly in the coastal and near-coastal provinces. Over the period 1978 to 1997, the per capita consumption of fish in Thailand averaged 24 kg annually and fluctuated between highs of about 32.8 - 33.8 kg in 1994 and 1995 and lows of about 18.8 -18.9 kg in 1987 - 88 (Table 6b).

Table 6a. Per capita food intake in Thailand, 1995.

Items	Whole Country		Urban Area		Rural Area	
	Grams/day	%	Grams/day	%	Grams/day	%
Cereals, Roots and Tubers	305.7	41.4	281.4	37.4	312.3	42.4
Sugar and Honey	13.7	1.9	14.6	1.9	13.4	1.8
Pulses, Nuts and Oilseeds	17.1	2.3	19.7	2.6	16.3	2.2
Vegetables	113.2	15.3	101.4	13.5	116.7	15.9
Fruit	76.8	10.4	93.9	12.5	72.0	9.8
Oils and Fats	14.0	1.9	12.3	1.6	14.4	2.0
Meats	71.4	9.7	83.4	11.1	68.1	9.3
Fish	46.6	6.3	47.3	6.3	46.5	6.3
Eggs	21.4	2.9	17.2	2.3	22.5	3.1
Milk	29.3	4.0	44.6	5.9	25.1	3.4
Others	29.9	4.0	35.8	4.8	28.4	3.9
TOTAL	739.1	100.0	751.6	100.0	735.7	100.0

Table 6b. Apparent consumption of fish in Thailand, 1970 - 97.

Year	Total Production (1 000 tons)	Fish used for fishmeal (1 000 tons)	Trade		Apparent Consumption		
			Imports (1 000 tons)	Exports (1 000 tons)	Total consumption (1 000 tons)	Population (Million)	Consumption per capita (Kg)
	(1)	(2)	(3)	(4)	(5) = (1) - (2) + (3) - (4)	(6)	(7) = (5) / (6)
1978	2 099	887	114	237	1 088.7	45.2	24.1
1979	1 946	808	364	250	1 251.9	46.1	27.1
1980	1 792	773	140	227	932.3	47.0	19.8
1981	1 989	797	152	269	1 076.1	47.6	22.6
1982	2 121	813	128	338	1 098.4	48.4	22.7
1983	2 255	803	116	405	1 162.4	49.5	23.5
1984	2 135	758	166	547	996.4	50.5	19.7
1985	2 225	776	207	639	1 015.8	51.5	19.7
1986	2 536	976	362	847	1 074.2	52.5	20.4
1987	2 779	1 106	220	881	1 012.7	53.5	18.9
1988	2 630	956	343	993	1 023.8	54.6	18.8
1989	2 740	980	436	1 095	1 100.7	55.2	19.9
1990	2 786	978	475	1 174	1 108.7	56.1	19.8
1991	2 958	982	664	1 359	1 281.0	56.9	22.5

Table 6b. Apparent consumption of fish in Thailand, 1970 - 97. (continued)

Year	Total Production (1 000 tons)	Fish used for fishmeal (1 000 tons)	Trade		Apparent Consumption		
			Imports (1 000 tons)	Exports (1 000 tons)	Total consumption (1 000 tons)	Population (Million)	Consumption per capita (Kg)
	(1)	(2)	(3)	(4)	(5) = (1) - (2) + (3) - (4)	(6)	(7) = (5) / (6)
1992	3 240	1 001	637	1 393	1 482.6	57.6	25.7
1993	3 385	1 027	788	1 438	1 708.5	58.5	29.2
1994	3 523	930	883	1 535	1 940.5	59.1	32.8
1995	3 573	916	864	1 510	2 010.7	59.5	33.8
1996	3 500	900	737	1 438	1 899.5	60.1	31.6
1997*	3 460	900	728	1 645	1 642.7	60.8	27.0
Average	2 684	903	426	911	1 295.4	53.5	24.0

Source: Fisheries Economic Division, Department of Fisheries 1972 - 97.
Note: * Preliminary data.

Socioeconomic Analysis of the Small Scale Fishery Sector

Assessment of Status of Fishing Households and Communities

The coastline of Thailand is 2 614 km in length. Twenty-three provinces are situated along the coast. The Department of Fisheries has divided the provinces into five coastal fishing regions. Regions 1 - 4 cover the Gulf of Thailand and the fishing gear of these regions is given in Figure 1. Region 5 covers the coastal areas of the Andaman Sea.

According to a Preliminary Report on Marine Fishery Census in 1995 (National Statistics Office (NSO), 1992a; National Statistics Office (NSO), 1992b), there are 80 701 marine fishing households that can be classified into three types. Households that engage exclusively in fisheries account for 62.3%; those in coastal aquaculture account for 35%; and those engaged in both fisheries and aquaculture account for 3.7%. In 1995, about 53 112 fishing households were engaged in marine fisheries, of which 85.5% can be classified as small scale fishing households[2] and 15.5% can be classified as commercial-scale fishing households (Table 7a).

A structural change in Thailand's fisheries has taken place during the last 10 years. From 1985 - 90, the number of fishing households and fishing boats decreased by 6.7% and 2.3% respectively (Tables 7a - b). Small scale fishing households and small scale fishing boats decreased by 5.9% and 0.6% respectively whereas commercial-scale fishing boats decreased by 9.8%. The decrease in the number of small scale fishing boats was largely due to the decrease in coastal fishing resources on the one hand, and conflicts between small scale and the commercial-scale fishers on the other.

During 1990 - 95, the number of fishing households and fishing boats in Thailand increased by 11.0% and 5.4% respectively (Tables 7a - b). The increase in fishing households has largely been in commercial fisheries.

The increase in fishing boats has been in the small scale sector. Small scale fishing boats account for 8.1% of the total increase while commercial boats have actually decreased in number by 3.7%. One reason for the change in commercial boats has been the creation of a boat-tenure system within the commercial fishing sector, which resulted in a decrease of the number of boats per household.

Three major factors have led to the increase in small scale fishing households and small scale fishing boats during the last five years. First, the

[2] Small scale fishing households are defined as those which use non-powered boats or outboard-powered boats or inboard-powered boats with less than 5 gross ton (GT) engine is fishing operations.

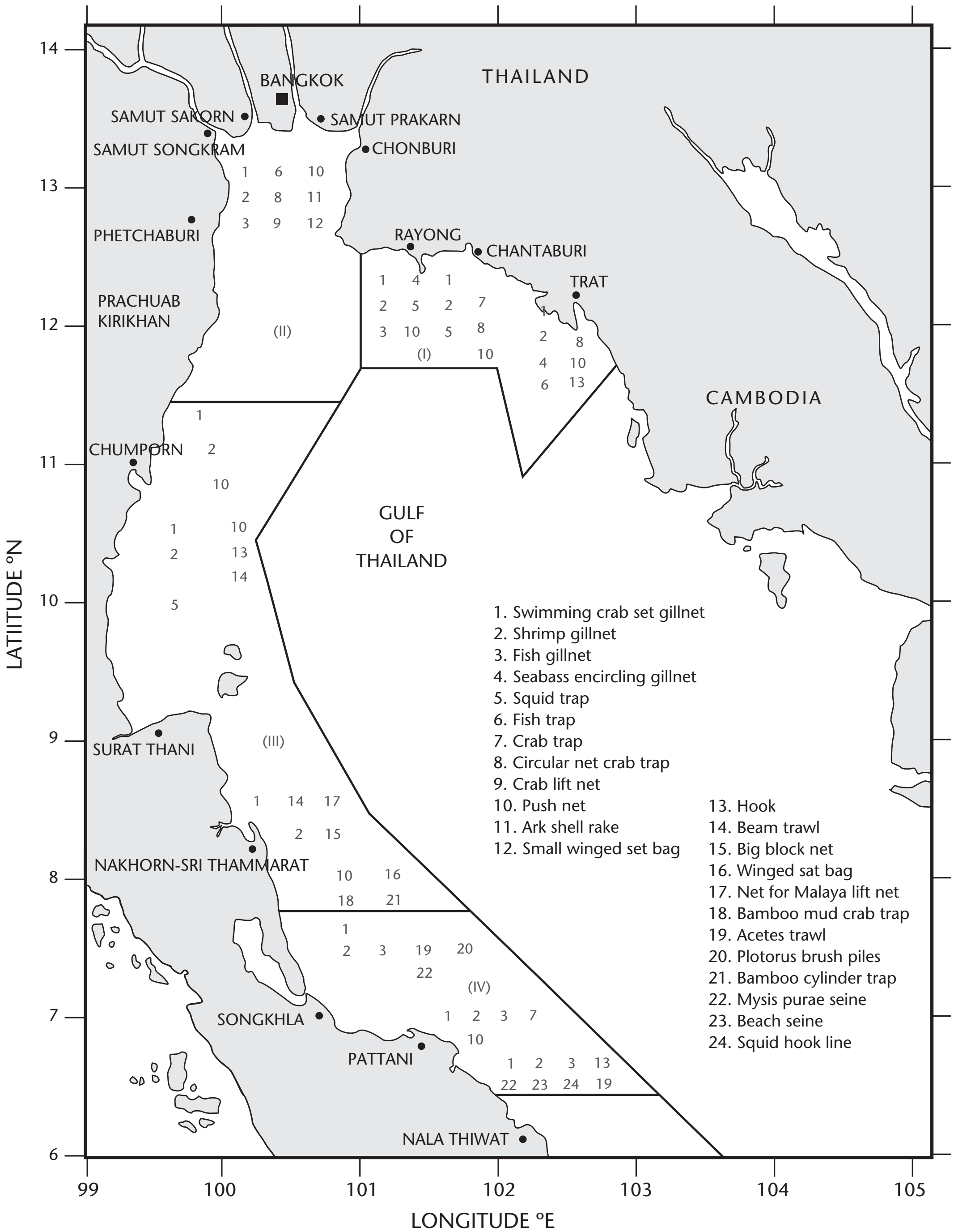

Fig. 1. Map of coastal fishing region.

Table 7a. Change in fishing households in Thailand, 1985, 1990 and 1995.

Year	Small scale			Commercial-scale			Total		
	Number	%	% of change	Number	%	% of change	Nuumber	%	% of change
1985[1/]	41 592	81.2		9 653	18.8		51 245	100.0	
1990[2/]	39 127	81.8	-5.93	8 709	18.2	-9.78	47 836	100.0	-6.65
1995[3/]	44 867	84.5	14.70	8 245	15.5	-5.33	53 112	100.0	11.00

Table 7b. No. of fishing boats classified by type of fishing operations, 1985, 1990 and 1995.

Year	Small scale			Commercial-scale			Total		
	Number	%	% of change	Number	%	% of change	Number	%	% of change
1985[1/]	40 095	86.2	–	12 855	13.8	–	52 950	100.0	–
1990[2/]	39 870	84.9	-0.56	11 887	15.1	-7.53	51 757	100.0	-2.25
1995[3/]	43 092	86.7	8.10	11 446	13.3	-3.71	54 538	100.0	5.40

Source: [1/] National Statistics Office and Department of fisheries (1987)
[2/] National Statistics Office and Department of Fisheries (1992)
[3/] National Statistics Office (1996)

population in coastal fishing communities has increased. Second, coastal fishery resources have partly recovered because of artificial reefs. The reefs have become additional fishing areas and have also been able to inhibit coastal trawl fishing. Third, fishing communities are enthusiastic in locating more fishing areas by themselves.

Socioeconomic Conditions of Small Scale Fishing Communities

Most small scale fishing communities are located in the coastal areas of Thailand. In 1992, there were 2 562 fishing communities in Thailand (National Statistics Office (NSO) and Department of Fisheries (DOF), 1992). Of these, 76% are situated on the coast of the Gulf of Thailand and 24% are on the Andaman Sea coast. Of the small scale fishing households in the coastal fishing communities 61.7% are Buddhists and 38.3% are Muslims (Panayotou 1985).

Structure of the Small Scale Fishing Households

According to the 1990 survey, the average size of small scale fishing households is 5.5 persons. Fishing households in Region 4 are the largest with 7 persons per household. In Regions 5, 2, 1 and 3, the average size are 5.5, 5.3, 5.1 and 5.1 persons per household, respectively. Custom and religion affect the size of fishing households. For instance, in Region 4 (consisting of Nakorn Sri Thammarat, Songkhla, Pattani and Narathiwas Provinces) and in Region 5 (Ranong, Phang-nga, Phuket, Krabi, Trang and Satun Provinces) where most of the fishing households are Muslim, the average household size is larger (Adulavidhaya 1980).

Occupational Structure of Small Scale Fishing Households

Some members of the fishing households may earn additional income depending on the location of village or fishing community. Examples include jobs in marine animal culture, marine animal processing, fishing boat crew, processing factories and shrimp culture. Activities in agriculture include rice growing, horticulture, crop growing and animal raising. Other jobs include those of technician, and small scale merchant. Reasons for supplementary occupations are: (a) low income from fisheries; (b) instability in fisheries; (c) unemployed labor in households, especially women; (d) off-season unemployment.

Income Structure of Fishing Households

Income of small scale fishing households comes from various sources, although fishing generates the main income. According to a 1992 income and expenditure survey (National Statistics Office (NSO), 1992b), the annual national average income was 58 776 Baht. Fisheries income accounts for 77.3% of the total. For small scale fishing households on the Andaman Sea coast and those in the Gulf of Thailand, fisheries income accounts for 75.2% and 78.3% respectively of the total income (Table 8a). Therefore, the condition of coastal resources is a major factor that determines the income and living conditions of small scale fishing households.

Living Conditions of Small Scale Fishers

The living standard of small scale fishing households can be calculated using two approaches. The first is comparison of the per capita income. The second is estimation of Engel's coefficient (ratio of the household's food expenditure to the total expenditure). A ratio greater than 50% indicates that food expenditure is a major household expense and that such households have a low standard of living. This is based on the principle that household income will be spent on food as a priority and that any remaining surplus will be spent for other purposes.

In 1990, the annual national average per capita income of small scale fishers was 10 687 Baht. Average per capita income on the Andaman Sea coast was 9 836 Baht and 11 953 Baht for the Gulf of Thailand (National Statistics Office (NSO) and Department of Fisheries (DOF), 1992). Annual national per capita income of all sectors was 16 463 Baht and 14 054 Baht in southern Thailand (National Statistics Office (NSO), 1992a). The per capita income of small scale fishers on the Andaman Sea coast was not only less than the national and the southern per capita income but also less than that of small scale fishers nationwide. Small scale fishers in the Gulf of Thailand have the lowest per capita income compared to small scale fishers nationwide and people living in the southern region (Table 8a).

In 1990, Engel's coefficients of the small scale fishing households were 60.4 for the whole country, 61.3 for the Andaman Sea coast and 59.1 for the Gulf of Thailand. Comparing these figures with the national coefficient of 39.2 and the southern coefficient of 42.4, the living standard of small scale coastal fishers is lower than the national average and that of southern Thailand. The living standard of small scale coastal fishers on the Andaman Sea coast is not only lower than the national and the regional average in southern Thailand, but also lower than that of the nationwide average of small scale fishers (Table 8b).

Occupational and Geographical Mobility

The open-access theory assumes perfect factor mobility in and out of fishing. Fishers, especially small scale fishers, are occupationally and geographically immobile for reasons which include: attachment to fishing as a way of life, gambling behavior, socio-cultural constraints, sunk capital costs, low education, ignorance of alternative opportunities, unresponsiveness to economic incentives, etc.

Panayotou and Panayotou (1986) in surveys taken five years apart in a number of villages in Chumporn (Gulf of Thailand) and Phang Nga (Andaman coast), and employing different methods of analysis, showed that fishers are responsive to economic incentives and do move between occupations and locations; less so between locations. Capital tends to be less mobile than labor, at least in the short run. Fishers do not admit to having an emotional attachment to fishing, but they like the freedom and independence of being one's own boss. For this reason they reject employment in factories, but are prepared to take up crop or fish farming if given land or other assistance.

Fishers admit attachment to their own areas and they distrust unknown, far-away places. Given a choice, they prefer to move to rural areas than to the big city. This is true especially of fishers who live in more isolated fishing communities, such as those of the Andaman Sea coast. Both religion and distance appear to constrain geographical mobility. Muslim fishers and their families travel less than Buddhist and, when they do, they visit neighbouring Muslim provinces.

Mobility in and out of fishing is lower than mobility in and out of non-fishing occupations. Mobility of labor out of fishing is greater than mobility into fishing. Fishing is losing ground as an occupation while the population of fishing communities stabilizes as a result of (a) the drying-up of the permanent in-migration of the sixties and the seventies, and (b) the reduction in population growth.

Table 8a. Annual income of Thai household and small scale fishing households, 1990.

Types of Income	Whole country (Baht·yr^{-1})	Southern region (Baht·yr^{-1})	Small scale Fishing Households					
			Total Average		Gulf of Thailand		Andaman Sea Coast	
			(Baht·yr^{-1})	%	(Baht·yr^{-1})	%	(Baht·yr^{-1})	%
Total Income	67 500	61 836	58 776	100.0	63 351	100.0	54 098	100.0
1. Cash Income			43 333	73.7	50 856	80.3	42 257	78.1
1.1 Fisheries Income:								
- Fishing Income			37 501	63.8	40 652	64.2	33 765	62.4
- Fish Culture			139	0.2	216	0.3	417	0.8
- Fish Processing			1 567	2.7	2 201	3.5	1 008	1.9
1.2 Non-fisheries Income:								
- Salary and Wage			3 749	6.4	4 623	7.3	3 051	5.6
- Farming Income			1 656	2.8	1 271	2.0	2 279	4.2
- Small scale Business			1 301	2.2	1 226	1.9	1 577	2.9
- Others			420	0.7	667	1.1	160	0.3
2. Non-cash Income:			12 443	21.2	12 495	19.7	11 841	21.9
2.1 Fishing Income			6 216	10.6	6 528	10.3	5 484	10.1
2.2 Goods and Services			1 764	3.0	1 401	2.2	2 227	4.1
2.3 Housing Rent			4 463	7.6	4 566	7.2	4 130	7.6
Family Size (persons)	4.1	4.4	5.5		5.3		5.5	
Income per Capita (Baht·yr^{-1})	16 463	14 054	10 687		11 953		9 836	

Source: National Statistics Office 1992b.

Table 8b. Annual expenditures of Thai household and small scale fishing household, 1990.

Items	All Household in Thailand[1]				Small scale Fishing Household[2]					
	Whole Country		Southern Region		Total Average		Gulf of Thailand		Andaman Sea Coast	
	(Baht·yr^{-1})	%	(Baht·yr^{-1})	%	(Baht·yr^{-1})	%	(Baht·yr^{-1})	%	(Baht·yr^{-1})	%
Total expenditure	65 244	100.0	61 920	100.0	49 474	100.0	54 347	100.0	44 798	100.0
- Food and Drink	25 584	39.2	26 268	42.4	29 885	60.4	33 307	61.3	26 489	59.1
- Clothing	3 816	5.8	3 768	6.1	1 695	3.4	1 637	3.0	1 761	3.9
- Housing rent	14 628	22.4	11 616	18.8	8 147	16.5	8 906	16.4	7 267	16.2
- Medical care	2 220	3.4	2 100	3.4	818	1.7	948	1.7	758	1.7
- Others	18 996	29.1	18 168	29.3	8 929	18.0	9 549	17.6	8 523	19.0
Engel's coefficients	39.2		42.4		60.4		61.3		59.1	

Source: [1] National Statistics Office 1992a.
[2] Small scale fishing households are defined as those which use non-powered boats or outboard-powered boats or inboard-powered boats with less than 5 gross ton (GT) engine is fishing operations.

Out-migration is temporary and usually in response to economic incentives, such as fishing activities elsewhere. In-migration is more permanent and socially rather than economically induced.

In Chumporn Province (Gulf of Thailand), occupational mobility narrowed the gap between the fishing and non-fishing wage rate from 33 Baht (US$1.05 at 1 US$ = 31.18 Baht in 1997) to 2 Baht (US$0.06), but in Phang Nga province (Andaman Sea Coast) the gap widened from 4 Baht (US$0.13) to 50 Baht (US$1.60). However, Phang Nga was in temporary imbalance as a result of a decline in non-fishing activities, especially offshore tin mining. In Phang Nga, there were temporary resource rents created partly by a recovery of the fishery, and partly by the fall in the opportunity cost of labor, following the decline in non-fishing activities.

The work of Panayotou and Panayotou (1986) suggests the potential for new activities such as fish farming and cottage industries. However, fishers are already engaged in a variety of non-fishing activities and they are quite responsive to differential earnings between these and fishing. What is needed is the support for the activities that have been neglected in the past because of a bias towards fisheries development. Such support may be in the form of infrastructure, credit and dissemination of information on employment opportunities, new technologies and markets. Geographical mobility should be encouraged especially out of the isolated communities of Phang Nga, but not in other large urban centers like Bangkok. To forestall an influx of new entrants into fisheries as resource rents are created, it would be necessary to accompany the promotion of non-fishing alternatives with effective controls on entry, perhaps through the granting to the small scale fishing communities of exclusive territorial rights to the coastal fisheries.

Competition and Conflicts in a Dualistic Sector

The last 30 years have revolutionized Thailand's coastal fishing industry. Rapid and often unfettered development, however, has degraded the coastal resources and encouraged conflicts between large- and small scale fishing fleets and among small scale communities themselves. At the root of these inter- and intra-sectoral conflicts are uncontrolled development of land and water concessions surrounding small scale communities, increasing competition, and the introduction of environmentally-destructive technology.

Land Encroachment

Many of Thailand's small scale fishing communities live in marginal areas and they conduct most of their fishing activities within close proximity to where they live. This creates two types of problems. Firstly, small scale fishing communities tend to be highly dependent on local resources; when not fishing, they work in local, resource-intensive industries, such as rubber extraction and processing, rice farming or aquaculture.

Secondly, small scale fishing communities are extremely vulnerable to the negative effects of environmental degradation. In particular, encroachment from land developers and environmentally-destructive technologies pose a substantial threat to small scale communities. Rubber plantations, for instance, take up land that could otherwise be used for farming, landing fish or home-steading. Likewise, shrimp farms occupy large areas of land, employ little labor and discharge harmful chemicals into coastal areas.

These encroaching activities provide local communities with few economic benefits or opportunities and impose significant economic and environmental costs. Because of the lack of land title and power, local communities are often at the mercy of local entrepreneurs and government officials. The latter are particularly important as they are responsible for defining and enforcing regulations regarding land use. The policy of local land departments seems to be one of *laissez-faire*, permitting a wide array of private concessions such as rubber plantations and shrimp farms.

Over-exploitation of Coastal Fisheries

A second type of conflict stems from escalating competition between small scale and large scale fishing communities, and among the small scale communities themselves. Conflicts between small scale and large scale fleets generally occur when the latter enter the fishing areas used by the small scale communities, degrading local fishing grounds, depleting local fish stocks, or tearing up stationary gear. Conflicts among the small scale communities tend to follow the same general pattern, whereby fishing communities use destructive gear (such as push net or cyanide).

There are many destructive technologies pursuing fewer fish, creating persistent and violent conflicts within Thailand's coastal zones. Surveys by the

Department of Fisheries show that catch per unit of effort (CPUE) rates have been declining since the 1960s (Table 9).

Fleet Operational Dynamics

The State of the Fishing Fleets

Fishing Fleet Classification

The marine capture fisheries can be broadly divided into commercial and small scale sub-sectors. Vessels over 10 m in length or 5 GT which use modern fishing gear and have the capacity to fish offshore for several days, are classified as commercial vessels. They typically operate from the larger ports and commonly use ice to preserve their catch. Refrigeration is employed on some of the larger vessels. Small scale vessels are usually less than 10 m in length and either employ an outboard-engine or inboard-engine or are non-motorized. Most small scale fishers operate from fishing villages.

According to the Marine Fisheries Census, a structural change in Thailand's fisheries took place between 1985 and 1995. The overall number of fishing boats increased by 3.0% (Table 10); small scale fishing boats increased by 7.5% whereas commercial fishing boats decreased by 11.0%. One reason for the change was the creation of a boat-tenure system within the commercial fishing sector, which resulted in a decrease in the number of boats per household.

Fishing Methods and Gear

Small scale vessels typically employ gillnets, small push nets, lift nets or other modern small scale gear, or alternatively set traps, bag nets and other stationary gear in estuaries or protected inshore waters. They rarely spend more than 12 hours at sea and generally fish within 5 km of the shore. Some fishers employ cast nets or hand-lines from the shore or from non-powered boats. The composition of the commercial fleet since 1958 is provided in Table 11. In theory, mechanized vessels using active gear must be licensed but in practice a significant proportion of vessels are unlicensed. Trawlers and purse seiners are the most important components of the fleet. Push nets and gillnets also take significant catches.

Table 9. Effort and CPUE in the Gulf of Thailand, 1986 - 85.

Year	Fishing effort (1 000 hours)	CPUE (kg·hr^{-1})
1961	358	279
1962	515	199
1963	672	295
1964	114	288
1965	1 147	233
1966	2 051	177
1967	2 773	158
1968	3 493	147
1969	3 621	143
1970	3 875	137
1971	6 065	100
1972	7 362	97
1973	8 644	85
1974	6 382	93
1975	9 273	77
1976	7 726	92
1977	10 265	75
1978	8 806	81
1979	8 923	80
1980	8 847	62
1981	11 470	50
1982	12 296	49
1983	13 351	46
1984	10 390	60
1985	11 928	54

Source: Somporn et al. citing Phasuk and Boobyubol and Pramok-Chutima, 1990.

Table 10. Number of fishing boats classified by type of fishing operations, 1985 and 1995.

Year	Small scale			Commercial scale			Total		
	Number	%	% of change	Number	%	% of change	Number	%	% of change
1985[1/]	40 095	86.2		12 855	13.8		52 950	100	
1995[2/]	43 092	86.7	7.5	11 446	13.3	-10.96	54 538	100	3.0

Sources: [1/] National Statistics Office and Department of Fisheries 1987.
[2/] National Statistics Office 1996.

Table 11. Number of selected types of gear (fishing units) registered and marine fish caught in Thailand, 1957 - 95.

Year	Pelagic fishing gear				Demersal fishing gear	
	Stake traps	Purse seines[1/]	Mackerel encircling gillnet	King mackerel drift gillnet	Trawlers[2/]	Push nets
1957	1 287	324	N/A	N/A	N/A	N/A
1958	1 344	392	N/A	N/A	N/A	N/A
1959	1 470	379	N/A	N/A	N/A	N/A
1960	1 409	323	48	N/A	99	N/A
1961	918	251	233	N/A	201	N/A
1962	792	228	386	N/A	976	N/A
1963	662	212	537	N/A	2 026	N/A
1964	602	144	890	N/A	2 360	N/A
1965	697	226	634	N/A	2 393	N/A
1966	663	228	409	N/A	2 695	N/A
1967	447	278	417	N/A	3 077	N/A
1968	457	361	329	N/A	3 182	N/A
1969	374	314	224	N/A	3 185	N/A
1970	371	716	260	235	3 082	354
1971	313	475	244	151	3 608	610
1972	236	506	254	138	4 486	1 327
1973	189	680	228	231	5 837	1 628
1974	229	657	188	148	5 271	1 213
1975	262	625	187	177	4 962	1 075
1976	222	726	226	157	5 204	844
1977	242	706	314	244	6 288	1 177
1978	250	843	359	151	6 453	1 426
1979	258	681	256	227	8 747	1 923
1980	225	781	307	287	10 421	2 262

Table 11. Number of selected types of gear (fishing units) registered and marine fish caught in Thailand, 1957 - 95. (continued)

Year	Pelagic fishing gear				Demersal fishing gear	
	Stake traps	Purse seines[1/]	Mackerel encircling gillnet	King mackerel drift gillnet	Trawlers[2/]	Push nets
1981	277	833	258	327	7 525	1 216
1982	233	840	238	281	11 475	1 899
1983	225	846	144	264	9 390	1 326
1984	254	961	245	265	9 131	960
1985	234	951	227	269	8 325	759
1986	258	996	203	329	7 407	664
1987	253	1 174	223	365	7 343	624
1988	231	1 456	146	461	6 950	531
1989	208	1 443	114	282	13 113	1 907
1990	188	1 629	101	299	12 905	1 879
1991	188	1 614	88	338	10 298	1 047
1992	204	1 452	72	362	9 465	818
1993	190	1 509	94	271	9 086	808
1994	190	1 511	99	280	8 346	651
1995	139	1 397	82	330	7 995	634

Source: Fisheries Economic Division, Department of Fisheries 1981 - 95.
Note: [1/] Chinese purse seine, Thai purse seine, Luring purse seine and Anchovy purse seine.
[2/] Otter trawl, Pair trawl and Beam trawl.
N/A = Not available.

Costs, Earnings and Profitability of Small Scale Fishing Operations

The study unit I was the fishing household in Songkla Province, Southern Thailand. Eight major fisheries in six villages along the coastal gulf of Thailand were selected. The major types of gear are shrimp gillnets, cuttlefish trammel nets, Indo-Pacific mackerel gillnets, other gillnets and Acetes trawl nets. The survey was made in May 1999, using the cross-sectional data for the previous year. The 33 sample fishing households were selected in six villages. These households were grouped according to the major types of fishing gear used.

Characteristics of Fishing Operation

Fishing Boats and Engines

Table 12 shows the details of fishing boats by type and size. About 93% of the boats were powered with outboard engines (long-tail). The boats' average length was 7.0 m. About 94% of the engines were diesel and the average HP was 8.3 HP.

Type of Gear and Definition of Gear Group

Fishing units were classified by the type of gear employed. Some fishing units use a two-gear combination, three-gear combination, or a four-gear combination. Based on these criteria, three groups of single gear, four of two-gear combination, one of three-gear combination and one four-gear combination were identified.

Initial Investment and Variable Input Use

Initial Investment

The initial investment in fishing assets (boat, engine and gear) by type of gear group is given in Table 13a. Small scale fishing units had average

Table 12. Boats and engine used of small scale fishing operation, Southern Thailand, 1998.

Items	Number of sample	%
Type of boats:	33	100.0
Outboard	32	97.0
Inboard	1	3.0
Length of boat:	33	100.0
Less than 6 meters	4	12.1
6 - 8 meters	27	81.8
9 - 10 meters	2	6.1
Average boat length:	7.0 meters	
Type of engine:	33	100.0
Benzene	2	6.1
Diesel	31	93.9
Engine power:	33	100.0
Less than 6 HP	11	33.3
6 - 10 HP	21	63.6
More than 10 HP	1	3.0
Average engine power:	8.29 HP	

investment assets worth 63 316 - 201 000 Baht (US$ 1 531 - 4 861 at 1 US$ = 41.35 Baht in 1998). The highest initial investment was in the OA (other gillnets and Acetes trawl net) gear, while the lowest was in shrimp gillnets.

Variable Input Use

The main variable inputs used were labor, nets and fuel, with the operator's household providing the main source of crew. Among the fishing villages they were all similar in family labor, with an average of 1.0 - 1.7 persons per fishing unit, using all types of fishing gear. There were significant differences in person-days (based on an 8-hour day) of family labor and wider differences between gear groups (Table 13b).

Cost Structure

Fixed cost is the cost that does not depend on the level of fishing operations but on the value of fishing assets. This may be 28.9% of total costs for shrimp gillnets, 35.0% for cuttlefish trammel nets and 31.9% for Indo-Pacific mackerel gillnets (Table 14a), all of which are single gear. There was a significant difference in the share of fixed costs between two-gear combination, three-gear and four-gear combination operations.

Table 13a. A16 Initial investment of small scale fishing by types of fishing gear, Southern Thailand, 1998.

Types of fishing gear	Initial Investment (Bahts)			
	Boat	Engine and equipment	Fishing gear and equipment	Total
Single gear:				
Shrimp gillnets	24 833	16 667	21 817	63 316
Cuttlefish trammel nets	42 000	27 800	27 400	97 200
Indo-pacific mackerel gillnets	36 500	10 000	17 500	64 000
Two-gear combined:				
SC	37 143	13 857	19 932	70 932
SI	35 000	12 000	41 000	79 000
CI	40 000	10 000	70 950	120 950
OA	100 000	20 000	81 000	201 000
Three-gear combined:				
SCO	38 750	26 750	83 500	149 000
Four-gear combined:				
SCIO	46 000	34 750	102 250	183 000

Table 13b. Labor input use by types of small scale fishing gear, Southern Thailand, 1998.

Types of fishing gear	No. of fishing day (days)	No. of family labors (persons)	No. of person-day		
			Family labor	Hired labor	Total
Single gear:					
Shrimp gillnets					
Cuttlefish trammel nets	118	1.6	140	126	266
Indo-pacific mackerel gillnets	141	1.2	138	138	276
	110	1.5	49	30	79
Two-gear combined:					
SC	234	1.4	230	203	433
SI	135	1.0	132	132	264
CI	280	1.0	280	280	560
OA	218	1.0	213	213	426
Three-gear combined:					
SCO	254	1.7	302	127	429
Four-gear combined:					
SCIO	291	1.2	301	248	549

Note: SC = Shrimp gillnets, and Cuttlefish trammel nets
SI = Shrimp gillnets, and Indo-pacific mackerel gillnets
CI = Cuttlefish trammel nets, and Indo-pacific mackerel gillnets
OA = Others gillnets, and Acetes trawl nets
SCO = Shrimp gillnets, Cuttlefish trammel nets, and Other gillnets
SCIO = Shrimp gillnets, Cuttlefish trammel nets, Indo-pacific mackerel gillnets, and Other gillnets

Variable costs ranged from 65.0% to 71.1% of total fishing costs for single gear groups. This included hired labor, which is the main cash cost component. It accounted for about 25.9% - 48.7% of total costs in the case of two-gear combinations, and as much as 42.7% in the case of three-gear combinations.

In general, fixed costs consisted of interest on debt, depreciation of fishing assets and the opportunity cost of owned capital. Variable costs consisted of payment to hired labor, fuel, opportunity cost of family labor and nets, ice, fees and maintenance. Total cost and its components varied considerably among gear types (Table 14b). Single gear groups averaged a total cost of 36 263 - 98 873 Baht (US$ 877 - 2 391 in 1998) per year whereas two-gear combined operations ranged between 120 588 and 240 510 Baht (US$2 916 - 5 816 in 1998). In addition, three-gear combined operations averaged a total cost of 196 548 Baht (US$4 753) per year, whereas four-gear combined operations averaged 232 162 Baht (US$5 615). CI gear groups (cuttlefish trammel nets with Indo-Pacific mackerel gillnets) had the highest total cost with an average cost of 240 510 Baht (US$5 816) per year while Indo-Pacific mackerel gillnets had the lowest, with an average total cost of 36 263 Baht (US$877) per year. This is an indication of the dualism in coastal fisheries, i.e. one type of gear group has annual expenses over 10 times higher than that of another gear group. As noted, the latter is more than 10 times more profitable than the former, although profitability is not always correlated with the scale of operations, as reflected in total fishing costs or in the capital cost of the fishing assets.

Species Composition of Catch and Revenue Structure

The catch consists of a variety of species commanding such widely diverging prices that aggregate catch figures make little sense. This is due to the multi-species nature of the fisheries in coastal areas and the non-discriminating gear employed. Although total value of catch is more meaningful than quantity, the relative contribution of different species to value, as well as the individual catch and unit price of these important fish species, is important.

The fishers direct their effort toward high value species such as shrimp, cuttlefish, pomfret fish and crab but they obtain as by-catch low-value species called trash fish. There is considerable variation among gear groups in both the catch of individual species per year and the price obtained (Table 15).

The OA groups, on the average, obtain larger quantities and receive lower prices than shrimp gillnetters and other groups. The former's less valuable catch, such as trash fish, contributes sufficiently to total revenue to be considered more of a target catch than a low-price fish. For example, mackerel fish and edible fish contributed almost 94.1% of the total (Table 15)

Table 14a. Cost structure of small scale fishing operation by types of fishing gear, Southern Thailand, 1998.

Type of gear combination	Fixed costs (%)			Variable costs (%)					Total cost (%)
	Depreciation	Opp. cost of capital	Sub-total	Cash cost: Hired labor	Cash cost: Fuel	Cash cost: Others	Opp. Cost of family labor	Sub-total	
Single gear:									
Shrimp gillnets	24.6	4.3	28.9	16.9	4.5	13.5	36.3	71.1	100.0
Cuttlefish trammel nets	29.4	5.6	35.0	27.6	6.1	10.2	21.1	65.0	100.0
Indo-pacific mackerel gillnets	17.2	14.7	31.9	4.7	10.0	29.2	24.2	68.1	100.0
Two-gear combined:									
SC	29.5	3.1	32.5	25.9	9.9	10.1	21.6	67.5	100.0
SI	20.9	4.0	24.9	48.7	5.7	11.6	9.1	75.1	100.0
CI	19.3	1.8	21.2	46.8	6.9	10.0	15.1	78.8	100.0
OA	15.8	7.8	23.6	46.3	12.5	11.9	5.8	76.4	100.0
Three-gear combined:									
SCO	11.7	3.0	14.7	42.7	8.3	6.6	27.8	85.3	100.0
Four-gear combined:									
SCIO	19.7	2.2	22.0	30.5	14.5	13.2	19.8	78.0	100.0

Table 14b. Major cost items (Baht/year) per fishing unit by types of fishing gear, Southern Thailand, 1998.

Type of gear combination	Fixed costs (Bahts·year^{-1})		Variable costs (Bahts·year^{-1})				Cash cost (Bahts ·year^{-1})	Imputed cost (Bahts ·year^{-1})	Total cost (Bahts ·year^{-1})
	Depreciation	Opp. cost of capital	Cash cost: Hired labor	Cash cost: Fuel	Cash cost: Others	Opp. Cost of family labor			
Single gear:									
Shrimp gillnets	20 626	3 600	14 181	3 742	11 322	30 415	29 244	54 641	83 885
Cuttlefish trammel nets	29 087	5 520	27 261	6 060	10 080	20 865	43 402	55 472	98 873
Indo-pacific mackerel gillnets	6 244	5 340	1 703	3 630	10 572	8 775	15 904	20 359	36 263
Two-gear combined:									
SC	40 203	4 166	35 379	13 521	13 741	29 491	62 642	73 860	136 502
SI	25 167	4 800	58 763	6 930	13 960	10 969	79 653	30 935	120 588
CI	46 457	4 440	112 500	16 613	24 100	36 400	153 213	87 297	240 510
OA	35 100	17 400	103 040	27 747	26 400	12 968	157 187	65 468	222 654
Three-gear combined:									
SCO	22 999	5 850	83 850	16 300	12 934	54 616	113 083	83 465	196 548
Four-gear combined:									
SCIO	45 820	5 160	70 700	33 757	30 657	46 069	135 113	97 049	232 162

Note: SC = Shrimp gillnets, and Cuttlefish trammel nets
SI = Shrimp gillnets, and Indo-pacific mackerel gillnets
CI = Cuttlefish trammel nets, and Indo-pacific mackerel gillnets
Opp = Opportunity
OA = Others gillnets, and Acetes trawl nets
SCO = Shrimp gillnets, Cuttlefish trammel nets, and Other gillnets
SCIO = Shrimp gillnets, Cuttlefish trammel nets, Indo-pacific mackerel gillnets and Other gillnets

Table 15. Annual catch fishing unit and composition of catch by types of small scale fishing gear, Southern Thailand, 1998.

Types of gear combination	Catch per unit (kg)	Value of catch per kg. (Baht·kg^{-1})	Catch composition (%)					
			Mackerel fish	Edible fish	Trash fish	Shrimp	Crab	Cephalopods
Single gear:								
Shrimp gillnets	637	117.8	23.6	28.7	0.2	32.4	8.2	6.9
Cuttlefish trammel nets	2 119	42.3	2.8	30.6	0.1	0.0	16.5	49.9
Indo-pacific mackerel gillnets	3 024	25.8	27.6	71.6	0.0	0.4	0.3	0.2
Two-gear combined:								
SC	2 782	48.4	4.5	30.5	0.1	2.6	15.9	46.4
SI	6 129	27.5	27.5	70.8	0.0	1.0	0.4	0.3
CI	10 077	32.8	17.1	54.2	0.0	0.2	7.2	21.3
OA	28 724	8.4	39.5	54.6	0.0	5.8	0.0	0.0
Three-gear combined:								
SCO	8 306	28.6	22	46.2	0.0	1.5	7.8	22.1
Four-gear combined:								
SCIO	6 846	37.5	18	55.1	0.0	2.2	6.9	18.0

Note: SC = Shrimp gillnets, and Cuttlefish trammel nets
SI = Shrimp gillnets, and Indo-pacific mackerel gillnets
CI = Cuttlefish trammel nets, and Indo-pacific mackerel gillnets
OA = Others gillnets, and Acetes trawl nets
SCO = Shrimp gillnets, Cuttlefish trammel nets, and Other gillnets
SCIO = Shrimp gillnets, Cuttlefish trammel nets, Indo-pacific mackerel gillnets and Other gillnets

Fishing Income and Profit

Gross Revenue

As expected, the highest value of catch or gross revenue was found in the CI gear groups with 330 495 Baht (US$7 993 in 1998) per year followed by the SCIO gear group (shrimp gillnets, cuttlefish trammel nets, Indo-Pacific mackerel gillnets and other gillnets) at 256 652 Baht (US$6 207) per year (Table 16). The lowest gross revenues were observed among the single gear groups and averaged between 75 017 - 89 584 Baht (US$1 814 - 2 166) per year. This indicates that the value of catch by fishing gear group reflects the availability of fisheries resources.

Gross Family Income

Gross family income is obtained by subtracting cash costs from gross revenues and is the maximum income from fishing that the household can consume in the short-run. It is not, however, sustainable over the long run, because no allowance is made for depreciation of fishing assets. There were several gear groups (e.g. shrimp gillnetters) that earned gross incomes that would not have allowed bare subsistence without supplementary income from non-fishing sources (Table 16).

Net Family Income

Net family income is obtained by subtracting depreciation from gross family income and can be consumed in its entirety without impairing the household's ability to continue fishing in the future. Net family income consists of returns to the family on factors such as capital, family labor and management, and rents, such as resource rent and rents from ability (e.g. rent is a 'wage' for some fixed resource like land). All households had positive net family incomes. However, the single gear groups (shrimp gillnetters) had extremely low net family incomes. The CI fishing unit group was the highest income group (Table 16).

Operating Profit

Operating profit (or gross economic profit), is defined as the difference between gross revenues and operating (or variable) costs. The importance of this measure of profitability lies in the economic principle that zero operating profits forms the dividing point between operation and close-down in the short-run. As long as operating (or variable) costs are covered, the fishing unit can continue operating until either the situation improves or fixed assets can be liquidated. Again, single gear groups

Table 16. Profitability (Baht/year) by types of small scale fishing gear, Southern Thailand, 1998.

Types of gear combination	(Baht·year^{-1})				
	Gross revenue	Gross family income	Net family income	Operating profit	Net profit
Single gear:					
Shrimp gillnets	75 017	59 112	38 486	15 358	(8 869)
Cuttlefish trammel nets	89 584	89 584	60 498	25 318	(9 289)
Indo-pacific mackerel gillnets	78 079	62 642	57 302	53 400	41 816
Two-gear combined:					
SC	134 663	72 021	31 818	42 530	(1 839)
SI	169 160	89 508	64 341	78 539	48 572
CI	330 495	330 495	284 038	140 881	89 985
OA	242 659	208 127	173 027	72 505	20 005
Three-gear combined:					
SCO	237 552	124 469	101 470	69 852	41 004
Four-gear combined:					
SCIO	256 652	256 652	210 832	75 470	24 490

Note: SC = Shrimp gillnets, and Cuttlefish trammel nets
SI = Shrimp gillnets, and Indo-pacific mackerel gillnets
CI = Cuttlefish trammel nets, and Indo-pacific mackerel gillnets
OA = Others gillnets, and Acetes trawl nets
SCO = Shrimp gillnets, Cuttlefish trammel nets, and Other gillnets
SCIO = Shrimp gillnets, Cuttlefish trammel nets, Indo-pacific mackerel gillnets and Other gillnets

(shrimp gillnetters) had very low operating profits. The five most profitable types of gear were CI, SI, SCIO, OA and SCO, respectively (Table 16).

Net Economic Profit

Net profits were calculated by deducting fixed costs from operating profit to determine the long-run profitability of various types of fishing gear. On strictly economic criteria, fishing units not covering their total costs (i.e. having negative net profits) leave the fisheries in the long-run, switching to the next best alternative from which, by definition, they could earn more. If net profits are made, new fishing units are attracted into open-access fisheries, until all pure profits (net profits minus management costs) disappear due to competion.

The most profitable types of gear were CI gear groups making a profit 89 985 Baht (US$2 176 in 1998) per year, followed by SI gear groups, Indo-Pacific mackerel gillnets and SCO gear groups, at an average 48 572 Baht (US$1 175) per year, 41 816 Baht (US$1 011) per year and 41 004 Baht (US$992) per year, respectively. Cuttlefish trammel net, shrimp gillnets and SC gear groups suffered greater losses than other groups, due to high operating costs and small catches. SCIO and OA gear groups also earned a reasonable profit, slightly more than 24 490 Baht (US$592) per year and 20 005 Baht (US$484) per year respectively. (Table 16).

Factor Returns

In terms of returns to labor, OA gear groups paid the highest wage rate at 272 Baht (US$6.58) per person-day mostly by share, followed by CI gear groups, 266 Baht (US$6.43), shrimp gillnet, 146 Baht (US$3.53) and SI gear groups, 264 Baht (US$ 6.38). The returns to labor for three types of gear groups namely, SC, SCO and Indo-Pacific mackerel gillnets were below the national minimum wage rate of 164 Baht (US$3.97) per person-day in 1998 (Table 17).

The returns on capital, that is, profit as a percentage of investment cost, was highest in the case of CI and CS gear groups because of the very high profit involved. The concept of returns on capital makes little sense for small scale fishing units.

Explaining Variation in Profitability

The high returns for CI and SI gear groups reflect the fishing skills and entrepreneurial ability of their operators as well as of the abundance of fisheries

Table 17. Return to investment and labor by types of small scale fishing gear Southern Thailand, 1998.

Types of gear	Return to investment (%)	Return to labor (Baht/person-day)
Single gear:		
Shrimp gillnets	(8)	168
Cuttlefish trammel nets	(4)	174
Indo-pacific mackerel gillnets	74	133
Two-gear combined:		
SC	3	150
SI	68	264
CI	78	266
OA	19	272
Three-gear combined:		
SCO	31	140
Four-gear combined:		
SCIO	16	213

Note: SC = Shrimp gillnets, and Cuttlefish trammel nets
SI = Shrimp gillnets, and Indo-pacific mackerel gillnets
CI = Cuttlefish trammel nets, and Indo-pacific mackerel gillnets
OA = Others gillnets, and Acetes trawl nets
SCO = Shrimp gillnets, Cuttlefish trammel nets, and Other gillnets
SCIO = Shrimp gillnets, Cuttlefish trammel nets, Indo-pacific mackerel gillnets and Other gillnets

resources in the Songkla coastal area. Thus, this return consists partly of rents of ability and quasi-rents for fixed factors and partly of resource rents. This is also reflected in the higher wages paid by these two gear groups. From the society's point of view, it appears that there are grounds for maintaining these gear groups and their contribution to employment and fish production.

The most important determinant of profit appears to be the interaction between types of gear and fishing grounds. Having the right type of gear at the right fishing grounds with appropriate skill and entrepreneurial spirit appears to be the recipe for high profits. These three components are present in the three most successful types of fishing group, CI gear groups, SI gear groups and Indo-Pacific mackerel gillnets. The question is how a small scale Songkla fisher with a relatively large debt and small funds of his own can take advantage of changing economic conditions by acquiring a shrimp gillnet.

The small scale fishers in the Songkla coastal area are in the worst possible situation because of the paucity of funds, of fish resources and of non-fishing alternatives. In this situation, not only credit and training are necessary but eventually relocation of the surplus fishers is inevitable, unless imaginative government projects such as small scale coastal aquaculture developments provide viable alternatives to coastal fishing.

Costs, Earnings and Profitability of Commercial Fishing Operations

This section is confined to operations of commercial fishing vessels, which use six major types of fishing gear, accounting for approximately 75% of the total quantity of marine products caught. The types of gear are otter trawls, pair trawls, beam trawls, push nets, purse seines and king mackerel gillnets. The various types of gear are applied in different sized fishing vessels. The study therefore concentrated on size of fishing vessels. Data were obtained from 100 samples. The survey was made in April - May 1996 and obtained the cross-sectional data for the previous year's activities in Thai waters.

Classification of commercial fishing operations varies. In this study, the length of fishing boats is used to be comparable with the classification used by the Department of Fisheries. (Gross tonnage and engine power have a correlation with vessel length of 0.95 and 0.75, respectively). Otter trawl boats are further classified into three categories, i.e. < 14 m, 14 - 18 m and 18 - 25 m. Pair trawls (one fishing unit comprising two vessels) are classified into the same three categories: < 14 m, 14 - 18 m and 18 - 25 m. Beam trawlers are classified into two categories, i.e. < 14 m and > 14 m. Push net boats and purse seiners are classified into three categories: < 14 m, 14 - 18 m and 18 - 25 m. Other fishing boats like king mackerel gillnetters are classified into two categories, 14 - 18 m and 18 - 25 m.

Inputs Use in Fishing Operations

In fishing operations, two major inputs are applied: labor or crew (hired labor and family labor) and materials, i.e. fuel, oil, ice and others (containers and food). Table 18 indicates that the number of crew in trawlers increases with vessel size, i.e. 3 - 14 crew are needed with otter trawls, 4 - 8 are needed with pair trawl vessels and 3 - 5 are needed with beam trawl vessels. Vessels deploying push nets require 3 - 5 crew. As for purse seiners, a large number of crew (17 - 25) is needed. Finally, vessels with king mackerel gillnets require 9 - 10 crew. Small otter trawls can work at sea for 10.6 months per year, but time spent fishing depends on the weather (monsoon), and Government measures that specify closed seasons during spawning of some resources.

The unit "person-day" measures the services of labor used in fishing operations. Otter trawlers utilize 103 - 210 person-days, pair trawlers of all sizes need 122 - 255 person-days, beam trawlers and push netters of all sizes need 43 - 120 person-days and 46 - 63 person-days respectively. The number of person-days needed in purse seiners varies from 374 - 575 while king mackerel gillnetters need 171 - 200 person-days per month.

Apart from labor, the other most important input in fishing operations is fuel, especially for trawls and push nets where the engines have to operate during harvesting. Fuel consumption per month varies depending on the types of vessels: 4 537 - 10 693 litres for otter trawls (from small to large sizes), 12 032 - 21 547 litres for pair trawls and 3 559 - 15 915 litres for push nets. While the fuel consumption is much less in purse seiners and gillnetters than trawlers, these vessels do not differ significantly in size and fishing gear. Fuel consumption per month is between 4 730 - 10 521 litres for purse seiners and 3 563 - 5 145 litres for gillnetters.

Preservation of marine products during and after harvesting is important for the quality and price of products. Currently, ice is mainly used; the amount required depends on the duration of the trip. Otter trawlers (< 14 m), beam trawlers and push netters that spend only 1 - 2 days per trip require 0.01 - 5.3 t of ice per month. Larger fishing vessels require 11.7 - 26.3 t per month; king mackerel gillnet boats need only 0.7 - 0.8 t per month (Table 18).

Composition of Catch

Species and volume of catch differ according to the type of gear, and the fish harvested with similar types of gear further differs according to boat size. Table 19 indicates that monthly catch by each otter trawler has a volume between 8 027 and 39 593 t. Most of the catch is trash fish, comprising 45.4 - 62.5% of the total catch. Edible fish comprises 14.4 - 29.1% of the total catch. Small otter trawls (< 14 m) harvest shrimp comprising 31.8% of the total catch, but most are small size. Average catch per month of pair trawlers for all boat sizes varies between 25 316 and 57 921 t. The catch is completely different among small pair trawlers (< 14 m), medium pair trawlers (14 - 18 m) and large pair trawlers (18 - 25 m). Medium and large pair trawlers have a similar ratio of catch, i.e. edible fish, trash fish and cephalopods comprising 18.1 - 24.3%, 51.5 - 59.0% and 10.9 - 18.2% of total catch respectively. Average catch per month of beam trawlers for both boat sizes varies between 817 and 4 157 t. Shrimp comprises a large proportion of beam trawl catch, but most shrimp caught are small in size and receive low prices. Medium beam trawlers also catch a large quantity of cephalopods which comprises 27% of total catch. Finally, all sizes of push netter have a similar ratio of catch, i.e. edible fish, trash fish, shrimp and cephalopods are caught in the ratios 6.5 - 8.4%, 54.5 - 60.7%, 16.5 - 21.3% and 3.1 - 5.2% of total catch respectively.

Catch obtained from purse seiners and gillnetters consists mainly of edible fish making 31.0 - 80.0% of total catch. Catch by size of purse seiner varies between 36 760 and 55 351 t per month. Most of the catch is economic pelagic species, i.e. Indo-Pacific mackerel and sardinellas. King mackerel gillnet is the fishing gear catching high quality fish of similar size, with average price per kg of about 37.49 - 41.05 Baht (US$0.91 - 0.99), while the average price of other fish caught by purse seines is between 6.86 - 9.55 Baht (US$0.17 - 0.23) per kg. Major pelagic fish caught are king mackerel and little mummy.

Table 18. Variable input use per fishing unit by type and size of vessels, 1995.

Type of fishing gear	Length of boat (meters)	No. of crews	No. of fishing days per month	No. of fishing months per year	No. of person-days per fishing month			Fuel (litre·month^{-1})	Oil (litre·month^{-1})	Ice (litre·month^{-1})
					Hired labor	Family labor	Total			
Otter trawls										
< 14 meters	12.0	4	25	10.6	85	18	103	4 537	31	5.1
14 - 18 meters	16.2	7	26	9.8	156	8	164	9 126	61	11.7
18 - 25 meters	19.3	8	25	10.0	208	3	210	10 693	95	19.2
Pair trawls										
< 14 meters	13.5	10	27	8.0	122	–	122	12 032	41	
14 - 18 meters	16.4	11	18	9.3	216	5	221	14 993	65	5.5
18 - 25 meters	18.8	14	17	10.0	255	–	255	21 547	161	18.9
										26.3
Beam trawls										
< 14 meters	12.0	3	17	9.8	17	26	43	190	7	0.1
> 14 meters	15.7	5	24	9.0	96	24	120	5 317	26	5.2
Push nets										
< 14 meters	10.0	3	20	9.3	22	24	46	3 550	16	0.9
14 - 18 meters	17.0	4	22	9.3	66	13	79	6 250	19	2.0
> 18 meters	20.7	5	25	9.8	25	38	63	15 915	40	5.3
Purse Seine										
< 14 meters	12.1	17	22	6.0	352	22	374	4 730	13	21.1
14 - 18 meters	17.1	21	23	10.0	460	23	483	8 159	53	21.5
18 - 25 meters	20.7	25	23	10.0	575	–	575	–	108	25.0
King Mackerel gillnet										
14 - 18 meters	16.6	9	19	10.0	152	19	171	3 563	27	0.7
18 - 25 meters	19.2	10	20	10.0	180	20	200	5 145	51	0.8

Investment Costs

Investment costs consist of three parts, i.e. the investment in the hull, (all wooden hulls); the investment in the engine and other navigational aids; and the investment in fishing gear and equipment. Initial investment in fishing operations varies according to type and size of fishing boat. The ratio of initial investment to number of crew indicates capital intensity of each type and category of fishing vessel (Smith and Mines 1982).

Investment Costs of Demersal Fishing Gear

Capital investment for different types of trawlers primarily depends on hull construction. Thus the cost for hull construction of otter trawlers and pair trawlers comprises an average 50% and 42% of total investment, respectively. Table 20 shows that capital outlay on otter trawlers of small size differs on the average from 423 225 Baht (US$10 235 in 1998) to 2 220 907 Baht (US$53 710), a 5.2 times difference. This is because the size of < 14 m is mainly for coastal fisheries and merely needs used engines, which cost less, and the gear is also not expensive. Otter trawlers of > 18 m in length employ modern equipment, such as echo-sounder and radar, etc. The ratio of capital to number of crew, which measures capital intensity, slowly increases according to size of boat ranging from a low of 105 806 : 1 to a high of 277 613 : 1. Capital investment in pair trawlers does not differ significantly with boat size for several reasons. Fishing grounds are not far from shore, vessels can only operate during day-time and less fishing gear and equipment are needed compared with otter trawls of similar size. Capital outlay from small to large fishing boat sizes (< 14 m up to 18 - 25 m in length) is between 1 197 825 Baht (US$28 968) to 3 895 937 Baht (US$94 218) per unit, or a difference of 3.3 times. Capital intensity ranges from 119 783 : 1 to 278 281 : 1, a difference of 2.3 times.

Table 19. Catch, value of catch and catch composition per fishing unit by type and size of vessels, 1995.

Type of fishing gear	Length of boat (meter)	Total catch (Kg)	Value of catch (Baht)	Average price of catch (Baht·Kg^{-1})	Catch Composition				
					Edible fish (%)	Trash fish (%)	Shrimp (%)	Cephalopods (%)	Others (%)
Otter trawls									
< 14 meters	12.0	8 027	79 249	9.87	14.4	45.4	31.8	6.4	2.0
14 - 18 meters	16.2	22 852	196 227	8.59	25.4	62.5	4.0	7.4	0.7
18 - 25 meters	19.3	39 593	290 158	7.33	29.1	59.9	1.2	9.5	0.3
Pair trawls									
< 14 meters	13.5	25 316	245 610	9.70	24.3	51.5	2.7	18.2	3.3
14 - 18 meters	16.4	29 857	445 544	14.92	18.1	59.0	11.3	10.9	0.7
18 - 25 meters	18.8	57 921	633 668	10.94	14.4	73.4	3.7	8.1	0.4
Beam trawls									
< 14 meters	12.0	817	22 091	27.04	7.0	-	80.0	3.1	9.9
> 14 meters	15.7	4 157	125 336	30.15	18.3	14.7	39.3	27.0	0.7
Push nets									
< 14 meters	10.2	3 668	67 802	18.48	8.4	54.5	21.3	3.1	12.7
14 - 18 meters	16.7	6 861	128 690	18.76	6.5	57.4	20.8	4.0	5.2
18 - 25 meters	20.6	9 880	242 650	24.56	9.5	60.7	16.5	5.2	8.2
Purse Seines									
< 14 meters	12.1	36 760	252 137	6.86	31.0	68.5	-	-	1.0
14 - 18 meters	17.1	40 821	349 020	8.55	36.7	63.0	-	-	0.5
18 - 25 meters	20.7	55 351	528 602	9.55	49.5	48.6	-	1.0	1.0
King Mackerel gillnets									
14 - 18 meters	16.6	4 106	153 946	37.49	85.0	13.0	-	-	2.0
18 - 25 meters	19.2	6 470	265 594	41.05	80.0	19.0	-	-	1.0

Source: Fisheries Economics Division, Department of Fisheries 1995.

As for beam trawlers, capital outlay ranges from 71 881 Baht (US$1 738) to 313 383 Baht (US$7 579) on the average, a difference of about 4.4 times.

Capital outlay on small-sized push net vessels ranges from 132 357 Baht (US$3 201) to 1 031 030 Baht (US$24 934), a difference of 7.8 times. This size boat, < 14 m, is mainly used in coastal fisheries and needs only used engines that cost less. Fishing gear is not complicated and requires only low investment. On the other hand, push netters of 18 - 25 m in length employ modern equipment. The capital-labor ratio increases according to size of boat from 44 119 : 1 to 206 206 : 1.

Investment Cost of Pelagic Fishing Gear

Capital investment in pelagic fisheries such as purse seiners and king mackerel gillnetters differs from trawl fisheries, in that investment in assets for equipment is more than that for the hull. Purse seine investment in equipment and gear requires higher investment compared to other types of boat. Between 53.6 and 74.9% of total investment is for equipment and 16.0 to 30.9% is needed for the hull. Investment in gear and equipment for king mackerel gillnetters is 52.8% and 54.4% of total capital outlay respectively, while the cost of hull is between 31.5% and 33.3% of total costs. Table 20 indicates that of all pelagic fishing gear, large purse seiners (18 - 25 m) require the highest investment at an average of 4 339 790 Baht (US$104 953) per unit, followed by medium size (14 - 18 m), requiring an average capital outlay of 2 743 886 Baht (US$ 66 356) per unit. King mackerel gillnetters require an average capital investment of 1 989 489 to 2 666 849 Baht (US$48 113 - 64 494) per unit. King mackerel gillnetters have the highest capital intensity ranging from 221 054 : 1 to 266 685 : 1, while purse seiners (< 14 m) have

Table 20. Investment costs per fishing unit by type and size of vessels, 1995.

Type of fishing gear	Length of boat (meters)	Horse-power (HP)	Initial Investment								Capital Intensity*	
			Hull		Engine		Gear & equipment		Total			
			Value (Baht)	%	Value (Baht)	%	Value (Baht)	%	Value (Baht)	%		
Otter trawls												
< 14 meters	12.0	103	182 500	43.1	120 318	28.4	120 407	28.4	423 225	100.0	105 806	:1
14 - 18 meters	16.2	203	703 929	53.6	287 522	21.9	320 989	24.5	1 312 515	100.0	187 502	:1
18 - 25 meters	19.3	323	1 161 111	52.3	617 555	27.8	442 161	19.9	2 220 907	100.0	277 613	:1
Pair trawls												
< 14 meters	13.5	217	546 250	45.6	317 750	26.5	333 825	27.9	1 197 825	100.0	119 783	:1
14 - 18 meters	16.4	516	795 000	36.8	884 000	40.9	483 500	22.4	2 162 500	100.0	196 591	:1
18 - 25 meters	18.8	646	1 725 000	44.3	935 000	24.0	1 235 937	31.7	3 895 937	100.0	278 281	:1
Beam trawls												
< 14 meters	12.0	46	41 333	57.5	24 617	34.2	5 931	8.3	71 881	100.0	23 960	:1
> 14 meters	15.7	183	81 250	25.9	157 000	50.1	75 133	24.0	313 383	100.0	62 677	:1
Push nets												
< 14 meters	10.0	154	39 250	29.7	50 620	38.2	42 487	32.1	132 357	100.0	44 119	:1
14 - 18 meters	17.0	300	79 142	19.9	135 000	34.0	182 657	46.0	396 799	100.0	99 200	:1
> 18 meters	20.7	312	313 600	30.4	305 590	29.6	411 840	39.9	1 031 030	100.0	206 206	:1
Purse seines												
< 14 meters	2.1	188	292 222	16.0	166 250	9.1	1 365 771	74.9	1 824 243	100.0	107 308	:1
14 - 18 meters	17.1	249	721 429	26.3	221 429	8.1	1 801 028	65.6	2 743 886	100.0	130 661	:1
18 - 25 meters	20.7	333	1 342 105	30.9	670 553	15.5	2 327 132	53.6	4 339 790	100.0	173 592	:1
King Mackerel gillnets												
14 - 18 meters	16.6	233	627 143	31.5	311 429	15.7	1 050 917	52.8	1 989 489	100.0	221 054	:1
18 - 25 meters	19.2	268	887 273	33.3	329 000	12.3	1 450 576	54.4	2 666 849	100.0	266 685	:1

Source: Fisheries Economic Division, Department of Fisheries 1995.
Note: * Capital/crew ratio indicating investment cost per crew.

the lowest capital intensity at 107 308 : 1. This is because king mackerel gillnetters require less labor than any other type of fishing boat.

Cost Structure

Inputs in fishing operations are divided into two main groups, fixed input or fixed assets invested, and variable inputs. Fixed cost or input consists of the depreciation cost of durable assets (boats, engine, and other durable equipment), the opportunity cost of capital (measured at an interest rate of 12%) and the interest cost on debt. These costs are incurred whether there are fishing operations or not. Variable cost or input consists of three subparts, revolving cost (fuel and oil, ice and repair costs), labor cost (hired labor, family labor and food) and marketing costs (commission, transport and various fees).

The cost structure in Table 21 shows that for all types of fishing gear, the main costs are variable costs at 73.5 - 89.4% of the total cost (variable plus fixed) with 7.0 - 26.5% of total costs as fixed cost. Trawlers and push netters have high fuel and oil expenses, i.e. 32.1 - 51.0% of total costs. Variable costs of purse seiners and gillnetters differ in that the majority of expenses are for labor at 26.5 - 51.0% of total costs, and only 16.0 - 21.1% of total cost is fuel expense. Trawl and push net fisheries, with their high proportion of fuel costs, have a high degree of instability due to the possibility of fuel price changes or the introduction of fuel-saving measures during a period of scarcity.

Table 21. Cost structure by type and size of vessels, 1995.

	Fixed cost (%)				Variable cost (%)						
Type of fishing gear	Depre-ciation (%)	Opp. cost of capital (%)	Interest on debt (%)	Sub total (%)	Labor (%)	Fuel & Oil (%)	Ice (%)	Repair & main-tenance (%)	Others (%)	Sub total (%)	Grand total (%)
Otter trawls											
< 14 meters	4.0	4.8	1.9	10.6	23.6	44.1	6.1	14.0	1.6	89.4	100.0
14 - 18 meters	5.6	9.1	1.1	15.8	26.6	33.6	6.4	15.8	1.8	84.2	100.0
18 - 25 meters	6.4	9.3	3.8	19.6	19.6	32.1	6.9	11.3	10.5	80.4	100.0
Pair trawls											
< 14 meters	5.4	8.3	1.3	15.0	21.0	37.7	5.2	19.5	1.6	85.0	100.0
14 - 18 meters	5.6	7.3	2.4	15.4	19.7	37.3	5.5	20.7	1.4	84.6	100.0
18 - 25 meters	6.5	10.4	1.5	18.4	17.8	36.5	4.9	20.5	1.9	81.6	100.0
Beam trawls											
< 14 meters	2.6	3.0	1.4	7.0	46.0	33.0	1.5	11.3	1.2	93.0	100.0
> 14 meters	4.6	7.0	2.4	13.9	32.3	38.4	4.0	9.9	1.6	86.2	100.0
Push nets											
< 14 meters	4.8	7.4	2.0	14.1	29.1	39.5	1.1	8.1	4.1	81.9	100.0
14 - 18 meters	4.4	8.0	4.7	17.2	27.2	37.3	1.6	15.5	1.2	82.7	100.0
18 - 25 meters	5.7	11.2	3.2	20.0	17.6	51.0	2.1	7.6	1.7	80.0	100.0
Purse Seines											
< 14 meters	1.6	6.6	2.6	10.8	51.0	16.0	4.2	17.3	0.6	89.2	100.0
14 - 18 meters	2.1	11.4	2.5	16.0	44.8	21.1	4.8	12.0	1.2	84.0	100.0
18 - 25 meters	2.7	9.4	3.4	15.5	35.9	18.1	4.9	22.2	3.4	84.5	100.0
King Mackerel gillnets											
14 - 18 meters	4.0	15.5	7.0	26.5	34.7	20.3	3.0	15.1	0.4	73.5	100.0
18 - 25 meters	3.0	14.4	5.9	23.3	26.5	16.9	2.6	16.4	14.4	76.7	100.0

Source: Fisheries Economics Division, Department of Fisheries 1995.

Monthly Fishing Costs

Fishing effort by different types of fishing gear varies greatly throughout the year, whether by the number of trips, days or months of operation. Costs of various types of fishing operation also differ per trip, per month or per year. To standardize the costs this study uses the average cost per month (total costs per year divided by number of months in operation). Apart from dividing costs as fixed and variable, it is also possible to divide them into cash and imputed costs (depreciation cost, opportunity cost of capital and opportunity cost of family labor) as discussed below.

Otter Trawls

This type of fishing operation requires 25 - 26 days of operation per month. From Table 22, the average total cost per vessel of large size (18 - 25 m) is maximum at 227 520 Baht (US$5 502 in 1998) per month, followed by 14 - 18 m size at 158 851 Baht (US$3 842), and then at < 14 m, 77 866 Baht (US$ 1 883). The majority of these costs are for fuel and oil, crew, ice, repairs and maintenance, interest on debt and others (marketing expenses, food and fees). Fuel comprises the highest cash expense followed by crew cost. Pair trawls (18 - 25 m) incur higher costs for repair than crew costs owing to high investment in modern equipment, as well as by fishing offshore. The imputed costs for depreciation, opportunity cost of capital and family labor make up an average of 16% of total cost.

Table 22. Cost items (Baht·month^{-1}) per fishing unit by type and size of vessels, 1995.

	Fixed cost (Baht·month^{-1})			Variable cost (Baht·month^{-1})						(Baht·month^{-1})		
	Cash cost			Cash cost								
Type of fishing gear	Interest on debt	Depre-ciation	Opp. cost of capital	Crews	Fuel & Oil	Ice	Repair & main-tenance	Others	Opp. cost of family labor	Cash cost	Impu-ted cost	Total cost
Otter trawls												
< 14 meters	1 449	3 077	3 713	15 752	34 355	4 772	10 862	1 237	2 650	68 426	9 440	77 866
14 - 18 meters	1 789	8 940	14 475	38 756	53 451	10 107	25 075	2 808	3 450	131 986	26 865	158 851
18 - 25 meters	8 657	14 520	21 111	42 173	73 003	15 878	25 647	24 160	2 371	189 518	38 002	227 520
Pair trawls												
< 14 meters	3 208	13 111	20 250	51 000	91 894	12 640	47 413	3 967	–	210 122	33 361	243 483
14 - 18 meters	7 000	16 217	21 000	53 873	108 362	16 037	60 051	4 478	3 520	249 801	40 737	290 538
18 - 25 meters	7 083	29 888	48 000	81 839	168 389	22 562	94 302	8 789	–	382 964	77 888	460 852
Beam trawls												
< 14 meters	375	718	829	6 424	9 018	421	3 083	326	6 167	19 647	7 714	27 361
> 14 meters	2 484	4 832	7 367	32 273	40 617	4 227	10 436	1 685	1 875	91 722	14 074	105 796
Push nets												
< 14 meters	1 391	3 377	5 232	9 464	28 054	747	5 371	2 673	9 724	47 700	18 333	66 033
14 - 18 meters	6 000	5 610	10 083	32 808	47 093	1 988	19 570	1 515	1 543	108 974	17 236	126 210
18 - 25 meters	7 500	13 390	26 350	38 637	120 072	4 900	17 938	3 721	2 850	192 768	42 590	235 358
Purse seines												
< 14 meters												
14 - 18 meters	6 250	3 849	15 722	121 392	38 266	10 147	41 543	1 518	823	219 116	20 394	239 510
18 - 25 meters	7 500	6 239	34 464	133 521	63 635	14 541	36 324	3 568	1 685	259 089	42 388	301 477
	15 000	12 048	41 250	155 754	79 759	21 705	97 731	14 929	2 568	384 878	55 866	440 744
King Mackerel gillnets												
14 - 18 meters	10 000	5 804	22 281	47 850	29 162	4 328	21 776	562	2 089	113 678	30 174	143 852
18 - 25 meters	14 980	7 660	36 477	63 836	42 871	6 486	41 647	36 483	3 524	206 303	47 661	253 964

Source: Fisheries Economic Division, Department of Fisheries 1995.

Pair Trawl

A pair trawl consists of two boats, making its cost of operation higher than other type of fishing operation of similar size. It requires 17 - 27 days of operation per month. Table 22 indicates that the highest monthly operation costs are incurred by the large pair trawlers (18 - 25 m) at 460 852 Baht (US$11 145), followed by the medium size (14 - 18 m) at 290 538 Baht (US$7 026) and the smaller size (< 14 m) at 243 483 Baht (US$5 888). Most costs are cash, averaging about 85% of total costs. Fuel and oil comprise the highest cash costs followed by crew cost, repairs and maintenance, ice and others. The rest are imputed costs (depreciation, opportunitycost of capital and family labor) at 15% of total costs.

Beam Trawls

Beam trawls require 17 - 24 days of operation per month. Table 22 indicates that medium beam trawls (> 14 m) incur the highest monthly operation costs at 105 796 Baht (US$2 558), while the small size (< 14 m) incurs costs of 27 361 Baht (US$662). Most costs are cash, averaging about 84% of total costs. Fuel and oil comprise the highest cash costs, followed by crew cost, repairs and maintenance, ice and others. The rest are imputed costs (depreciation, opportunity cost of capital and family labor), at 16% of total costs.

Push Nets

This type of fishing operation requires between 20 and 25 days of operation per month. The average total cost per vessel of large size (18 - 25 m) is maximum at 235 358 Baht (US$5 692) per month, followed by 14 -18 m size vessels and < 14 m vessels at 126 210 Baht (US$3 052) and 66 033 Baht (US$1 597) respectively (Table 22). The majority of these are costs for fuel and oil, crew, ice, repairs and maintenance, interest on debt and others (marketing expenses, food and fees). Fuel comprises the highest cash expense, followed by crew cost. Imputed costs (depreciation, opportunity cost of capital and family labor) comprise on the average 18% of total cost.

Thai Purse Seines

The three sizes of purse seine operations involve 22 - 23 days per month. Total costs of operation of large boats (18 - 25 m), medium boats (14 -18 m) and small boats (< 14 m) are 440 744 Baht (US$ 10 659), 301 477 Baht (US$7 291) and 239 510 Baht (US$5 792) per month respectively. Most of these costs are cash expenses, averaging 88% of total costs. These costs consist of wages and crew share, fuel and oil, repairs and maintenance, ice, interest charge on debt (fixed cost) and others. Cash expenses differ from those of trawl and push net operations because wages and crew share are the largest expenses while imputed costs (consisting of depreciation, opportunity cost of capital and family labor) constitute 12% of total costs. Family labor cost in large purse seine boats is 3 times higher than that of the small boats due to more family members being employed in large purse seine boats (Table 22).

King Mackerel Gillnets

This type of gear requires the lowest cost of all types of pelagic fishing. Operations of king mackerel gillnets involve 19 - 20 days•month^{-1}, and have an average cost between 143 852 Baht (US$3 479) and 253 964 Baht (US$6 142)•boat^{-1}•month^{-1}. Cash cost comprises 80% of total costs, the majority of which are wages and crew share averaging 47 850 - 63 836 Baht (US$1 157 - 1 544)•boat^{-1}•month^{-1}. The cost of ice to preserve fish is only 4 328 - 6 486 Baht (US$105 - 157)•month^{-1} (Table 22), which is minimal when compared with other gear types of similar size. This is due to the fact that catch by gillnets is good quality and of large size. In some boats, king mackerel are salted soon after harvest, thereby requiring less ice, but requiring salt, (included under the item "others"). Imputed costs consist of about 20% of the total cost, more than half of which are opportunity cost of capital and the rest are depreciation cost and opportunity cost of family labor.

Share System

Among the stated operational costs, the wages of crew are significant. They rank second to fuel cost, especially for pelagic fishing, which incurs the highest crew cost. Benefit sharing between crew and boat owner differ according to the type and size of boats. Benefit sharing can be classified into two systems: (1) wage or salary payment, and (2) sharing value of products sold. Systems of sharing have different effects on risk. In the regular wage system, risk (including expected profit) in both catch and its price for each trip, solely belongs to the boat owners. Crew receive definite wages but lose the opportunity of sharing in the event of a good harvest. In the sharing system, both crew and boat owners jointly share the risk in catch and its price. The fixed wage system induces less enthusiasm from the crew, although the benefit-sharing system is risky due to lack of regular income and job security as in other sectors. This leads to the adoption of a mixed system of part regular wage and part sharing in the value of the catch.

The sharing system differs according to type and size of fishing gear. In small otter trawls < 14 m in length, about 80% of cases studied employed fixed wages. Medium and large sized otter trawls (14 - 18 m and 18 - 25 m) employ a mixed system. Between 50 - 75% of pair trawls employ fixed wages. Most of the beam trawls and push nets use benefit sharing based on net value of catch after deduction of operating expenses. This net value is divided in a ratio of 7 : 3 between boat owner and crew. The crew share is divided according to rank and responsibility with the master fisher receiving the biggest share. If the catch is higher than the target, the crew receives a bonus, in addition to regular wages and shares. Taking into account all benefits, crew members of medium size push netters (14 -18 m) receive an average of 8 588 Baht (US$208)•month^{-1} (Table 23). As for pair trawlers, each crew member of a small boat (14 - 18 m) receives 4 197 Baht (US$102)•month^{-1}.

Pay for purse seiners and gillnetters is based on a

Table 23. The sharing system by type and size of vessels, 1995

Type of fishing gear	No. of crews	Percentage of fishing units by type of sharing system			Average crew cost (Baht·month^{-1})	
		Fixed wages	Share	Fixed wages & share	per fishing unit	per crew
Otter trawls						
< 14 meters	4	80	–	20	18 402	4 601
14 - 18 meters	7	25	39	36	42 206	6 029
18 - 25 meters	8	11	23	66	44 548	5 569
Pair trawls						
< 14 meters	10	50	–	50	51 000	5 100
14 - 18 meters	11	25	–	75	57 393	5 218
18 - 25 meters	14	25	25	50	81 839	5 846
Beam trawls						
< 14 meters	3	–	100	–	12 591	4 197
> 14 meters	5	–	100	–	34 148	6 830
Push nets						
< 14 meters	3	10	90	–	19 188	6 396
14 - 18 meters	4	–	100	–	34 351	8 588
18 - 25 meters	5	–	100	–	41 487	8 297
Purse Seines						
< 14 meters	9	5	13	82	121 392	7 141
14 - 18 meters	7	–	11	89	133 351	6 350
18 - 25 meters	19	–	9	91	155 754	6 230
King Mackerel gillnets						
14 - 18 meters	8	8	16	76	47 850	5 317
18 - 25 meters	11	5	20	75	63 836	6 384

Source: Fisheries Economic Division, Department of Fisheries 1995.

mixed system of fixed monthly wage and sharing catch value. About 82 - 91% of purse seiners and 75 - 76% of gillnetters use this system. Net value after the deduction of expenses is divided between boat owners and crew in a ratio of 6 : 4 in the case of king mackerel drift gillnet vessels. Among all types of purse seine and gillnet boats, crew of small boats receive at most 7 141 Baht (US$173)•month^{-1}.

Revenue and Profit

Gross Revenue

Gross revenues are the total value of the catch. Gross revenue of large pair trawlers (18 - 25 m) is highest at 521 289 Baht (US$12 607)•month^{-1} and lowest for small beam trawlers (<14 m) at 34 129 Baht (US$825)•month^{-1} (Table 24). Gross revenue of trawling varies significantly among boat sizes (Table 24). Three sizes of otter trawler namely, small, medium and large yield revenues of 79 249 Baht (US$1 917), 196 227 Baht (US$4 746), and 290 158 Baht (US$7 017)•month^{-1} respectively. Small boats have gross revenue 2.5 times less than medium-size boats, but medium-size boats have gross revenue close to that of large boats. Three sizes of push netters namely, small, medium and large yield revenues of 67 802 Baht (US$1 640), 128 690 Baht (US$3 112), and 242 650 Baht (US$5 868) •month^{-1} respectively. Gross revenue of large purse seiners (18 - 25 m) is highest at 528 602 Baht (US$ 12 784)•month^{-1} and lowest for medium-size king mackerel gillnetters (14 - 18 m) at 153 946 Baht (US$3 723)•month^{-1}.

Cash Flow

Cash flow indicates the highest revenue received and is derived from gross revenue less total cash costs. Cash flow of trawlers and push netters and

Table 24. Profitability per fishing unit by type and size of vessels, 1995.

Type of fishing gear	(Baht·month^{-1})				
	Gross revenue	Cash flow	Net income	Operating profit	Net profit
Otter trawls					
< 14 meters	79 249	10 823	7 746	9 622	1 383
14 - 18 meters	196 227	64 241	55 301	62 580	37 376
18 - 25 meters	290 158	100 640	86 120	106 926	62 638
Pair trawls					
< 14 meters	245 610	35 488	22 377	38 696	2 127
14 - 18 meters	322 483	72 682	56 465	76 162	31 945
18 - 25 meters	521 289	138 325	108 437	145 408	60 437
Beam trawls					
< 14 meters	34 129	14 482	13 764	8 690	6 768
> 14 meters	122 180	30 458	25 626	31 067	16 384
Push nets					
< 14 meters	67 802	20 102	16 725	11 769	1 769
14 - 18 meters	128 690	19 716	14 106	24 173	2 480
18 - 25 meters	242 650	49 882	36 492	54 532	7 292
Purse Seines					
< 14 meters	252 137	33 021	29 172	38 448	12 627
14 - 18 meters	349 020	89 931	83 692	95 746	47 543
18 - 25 meters	528 602	143 724	131 676	156 156	87 858
King Mackerel gillnets					
14 - 18 meters	153 946	40 268	34 464	48 179	10 094
18 - 25 meters	265 594	59 291	51 631	70 747	11 630

Source: Fisheries Economic Division, Department of Fisheries 1995.
Note: 1. Cash flow (Gross revenue) - (Cash cost)
2. Net income (Cash flow) - (Depreciation cost)
3. Operating profit (Gross revenue) - (Variable cost): or
(Cash flow) - (Opp. cost of family labor) + (Interest on debt)
4. Net profit (Gross revenue) - (Total cost)

large pair trawlers (18 - 25 m) have the highest at 138 325 Baht (US$3 345)•month^{-1}, while small beam trawlers (< 14 m) have the lowest cash flow at 14 482 Baht (US$350)•month^{-1}. Large purse seine boats (18 - 25 m) have the highest cash flow of 102 490 Baht (US$2 479)•month^{-1} and medium-size gillnetters (14 - 18 m) have the lowest cash flow at 40 268 Baht (US$974)•month^{-1}.

Net Income

Net income is cash income less depreciation. This value indicates the fisher's ability to sustain a long-term fishing operation. Net income is the return on inputs such as capital, family labor, management and rent (resource rents and rents of ability). In demersal fisheries, the highest net income is received by large pair trawlers (18 - 25 m), totaling 108 437 Baht (US$2 622)•month^{-1} and the lowest net income is for small beam trawlers (< 14 m) at 13 764 Baht (US$333)•month^{-1} (Table 24). Large purse seiners (18 - 25 m) yield the highest net income at 131 676 Baht (US$3 184)•month^{-1} and medium-size gillnetters yield the lowest net income at 34 646 Baht (US$838)•month^{-1}.

Operating Profit

Operating profit is the difference between gross revenue and variable costs. Operating profit indicates whether a fishing operator can continue to operate during the working life of running assets.

The results in Table 24 indicate that operators of all types and sizes of fishing vessels can continue working. Large pair trawlers (18 - 25 m) yield the highest operating profit at 145 108 Baht (US$ 3 509)•month^{-1} while small beam trawlers (< 14 m) receive the lowest operating profit, at 8 690 Baht (US$210)•month^{-1}. This is due to the fact that large trawlers can fish in distant fishing grounds that sometimes include the waters of neighbouring countries, while the small trawlers can only fish along the coast. Large purse seine boats (18 - 25 m) yield the highest operating profit of 156 156 Baht (US$3 776)•month^{-1} while smaller boats of this type (< 14 m) yield 38 448 Baht (US$ 930) operating profit•month^{-1}.

Net Profit

Net profit is the difference between gross revenue and total costs. Fishers should not continue operations if net profit is not higher than depreciation cost plus interest on debt and opportunity cost of capital. This study showed that almost all types and sizes of operation could maintain their work (Table 24). However, many types of fishing gear continue to operate owing to the fact that any adverse effect is lower than opportunity cost of capital plus interest on debt. These are small otter trawlers, small pair trawlers, small purse seiners and all sizes of push net and gillnet boats, on which this return is higher than taking other work. Large otter trawlers (18 - 25 m) return the highest net profit in demersal fishing at 62 638 Baht (US$1 515) •month^{-1} while for pelagic fisheries, large purse seiners (18 - 25 m) yield the highest net profit at 87 858 Baht (US$2 125)•month^{-1}, with the mackerel gillnetters yielding the lowest at 10 094 Baht (US$244)•month^{-1}. On average, all types and sizes of purse seine and gillnet boats yield higher net profits than any other type of fishing gear.

Factor Return

Return on Capital

Return on capital indicates feasibility of fishery investment. Since fishing is one of the highest natural risk operations, its return is high for certain types of fishing gear. This study examines return on initial investment. Return is defined as percentage of net profit and opportunity cost of capital on initial investment. Return on capital for trawlers and push netters is higher than for purse seiners and gillnetters. Return on capital for small beam trawlers is the highest at 104% owing to the lower investment requirements than for other types of gear of similar size (Table 25). Purse seiners that yield highest returns on capital are medium purse seiners (14 - 18 m) and large purse seiners (18 - 25 m) at 30%. Large gillnetters (18 - 25 m) yield the highest return on capital at 18%.

Returns to Labor

Return to labor is the compensation per working day of operation. When comparing the return against the national minimum wage (145 Baht (US$5.82 at 1 US$ = 24.92 in 1995, source: oanda.com) per day in 1995), the return in the fisheries sector is higher on the whole (Table 25). This value includes food which hired crew receive in addition to wages and share.

Table 25. Return to labor and capital by type and size of vessels, 1995.

Type of fishing gear	Return to capital (%)[1/]	Return to labor (B/person-day)
Otter trawls		
< 14 meters	13	180
14 - 18 meters	39	257
18 - 25 meters	38	212
Pair trawls		
< 14 meters	15	420
14 - 18 meters	23	260
18 - 25 meters	28	321
Beam trawls		
< 14 meters	104	296
> 14 meters	68	285
Push nets		
< 14 meters	49	417
14 - 18 meters	29	434
18 - 25 meters	32	664
Purse Seines		
< 14 meters	9	327
14 - 18 meters	30	280
18 - 25 meters	30	275
King Mackerel gillnets		
14 - 18 meters	16	292
18 - 25 meters	18	337

Source: Fisheries Economic Division, Department of Fisheries 1995.
Note: [1/] Return to initial investment = (net profit per year + opportunity cost of capital per year) * 100/ (initial investment)

Discarding and by-catch

The percentage of marine fish utilization during the past 30 years indicates that the availability of fish for human consumption has declined significantly. The main reason is the substantial increase in the amount of trash fish that is mostly channeled into the fishmeal industry. This is not justifiable when the per capita fish consumption is declining due to increase in population and in export requirements, while malnutrition is a serious problem in the rural areas. The main cause of malnutrition is poverty and inequality of food distribution. The marine fisheries sector that provides protein food should help in alleviating this problem.

In response to the misuse of the fish resources, the Department of Fisheries has created a program for converting trash fish and small pelagic fish, now used for fishmeal, into food for direct human consumption. This can be done through employing appropriate techniques in handling at sea and during transport, These fish can be processed into edible products. This will improve income for those who harvest by-catch fish and increase value-added in the fisheries sector.

Improved utilization may not satisfy the fishmeal industrialist who will be a competitor in buying trash fish at higher prices. The higher cost may become a barrier to exporting fishmeal. Fishmeal might not be distributed to the domestic animal feed industry; this industry would then import fishmeal or substitute fishmeal with other feeds. If the cost of fishmeal is partially passed to the animal feed industry, the burden will fall heavily on consumers. However, this may not be serious as long as consumers have other choices of protein food.

Analysis of Market Structure and Price of Fish

Marine Fish Marketing in Thailand

Setting Up the Fish Market

The government institution that deals with fish marketing in Thailand is the Fish Marketing Organization (FMO). The functions of the FMO are: (1) to provide fishers with a place for distribution of their produce, (2) to manage and control the agents who sell the fish, (3) to collect fees and service charges from people who use the facilities of the market, and (4) to assist, promote development and provide welfare for fishers and their villages, as well as their cooperatives or organizations.

Operation of the FMO

At present, the FMO operates three wholesale markets in Bangkok, Samut Sakorn south of Bangkok and Samut Prakran east of Bangkok. The FMO also operates eleven fishing ports along the coast (two in the east, nine in the south, of which six are along the Gulf coast and two along the Andaman coast).

The FMO acts as the owner of the market and people involved in the market must obey their rules and regulations. For example, fish agents cannot charge fishers more than 6% of the total value of sales, and 1% must go to the FMO. Other service charges that the FMO receives include renting space, parking lots, containers etc. The role of the FMO is not only providing a market place but also stimulating production.

Market Structure and Marketing Channels

Traders in the marine catch are fishers themselves, fish agent collectors, wholesalers and retailers. Fishers may contemporaneously conduct fishing, selling and processing. Some large scale fishers are also marine product traders and fish agents. Fish agents may be registered with the FMO, or non-registered and conduct their business in private or at municipal landing ports. Fish agents may receive fish from fishers and trade by means of auction as well as negotiation. In remote areas, there are fish collectors who buy from fishers and/or fish agents and sell to wholesalers who run large wholesale markets in big cities and sell to the retailers. The trading method employed at the FMO fish market and landing ports is mainly auction. At landings the non-registered fish agents bargain for fish.

Generally, fishers who land catch at private fishing ports have contracts with the agents who usually own the port. Thus, the agents influence the price, rather than the fishers. Small scale fishers, however, also usually perform as fish agents and have other market outlets. In addition, there are many places where fishers can land their catch, and even fishers with contracts can land their catches somewhere else. The degree of monopoly is thus not too strong at this stage.

Fish marketing facilities are inadequate, which makes possible the non-competitive trade. The central wholesale markets are limited to areas close to Bangkok (e.g. Samut Sakorn for fish and cuttlefish, Samut Prakran for shellfish, and Rayong for squid). The Bangkok wholesale fish market seems to have reached its maximum capacity. Landing points are numerous and scattered. More marketing facilities are required such as markets with auctions, ice plants, cold storage facilities and refrigerated truck transportation. Improvement in quality control to minimize loss in trading should be implemented.

Fish Price Determination

Price Determination in Fisheries Products

In theory "price determination" deals with the price theory and the manner in which economic forces influence price under the various market structures and the length of run, while "price discovery" is used to express the process of struggling between buyers and sellers to arrive at a price. There are five pricing system methods: (a) individual negotiation, (b) trading on organized exchange or auctions, (c) formula pricing, (d) group bargaining, and (e) administrative decisions, including those made in both the private and public sectors.

The criteria for choosing a method are that it should not create excess supply, it should have some social welfare aspects, i.e. that price is an incentive to the fishers for further fishing, provide quick and reliable information and provide a mechanism at low cost for price setting.

Methods of Setting Price of Fish

The bidding among buyers for fisheries products is the most appropriate one. Since fish are difficult to standardize and have a wide range of quality (size and freshness), physical inspection for each lot must be observed by buyers. If there are many buyers and the manipulation of price is difficult or impossible, the bidding price is a competitive price.

There should be more than one method of pricing fish among the fish agents and fish buyers in a fish market. A study of the system for fresh cephalopods in Thailand (Tokrisna et al. 1985) showed that cephalopod traders had four buying methods namely, consignment, auction, bargaining and price setting. However, trading at the levels of fish agents and collectors, the setting of sale prices was classified into three types, by buyers, by sellers and bidding among buyers. At the wholesaler and retailer levels, sellers set the prices. Setting fish prices at each level of trade should be more or less similar to that for squid.

Factors Affecting Fish Price Setting

Tokrisna et al. (1985) described the factors affecting the sales price of fresh cephalopods as follows: (a) buying price, which means the cost of products, (b) quality of the products (size and freshness) so that prices can be set by sellers, (c) market situation, which means the demand for and supply of products in the market at that time and (d) prices of processed products, especially the export price which the exporters use as the basis of estimating the purchasing price of raw material.

Tokrisna et al. (1985) found that the fishers knew not only the amount and species of fishes in their boats before approaching the port but also had price information at all the major ports. Therefore, searching for a marketing place had already been done. Selecting the species of fish is also dominant in each fish market or fishing port.

Summary and Implications for Fisheries Management

Summary

Small Scale Fisheries

The exceptionally high return on some groups of fishing gear is because of the monopolistic power of these fishing technologies in the coastal areas. The high returns are a reflection of the fishing skills and entrepreneurial ability of their operators as well as of the abundance of fisheries resources in coastal areas. Thus, this return consists partly of rents of ability and quasi-rents and partly of resource rents. This is also reflected in the higher wages. From the economic point of view, it appears that there is reason for maintaining those gear groups and their contribution to employment and fish production.

Thus, the most important determinant of profits appears to be interaction between type of gear and fishing ground. Having the right type of gear at the right fishing ground with appropriate skill and entrepreneurial spirit appears to be the recipe for high profits. The small scale fishers living in the coastal areas are in the worst possible situation because of the paucity of funds, of fish resources and of non-fishing alternatives.

Commercial Fisheries

The analysis of investment, cost, revenue and returns on demersal and pelagic fishing operations can be summarized as follows: (1) the returns differ markedly by size of fishing boat and type of fishing gear; (2) the ability to generate profit is greater in large fishing boats than small boats due to their greater ability to adjust to both economic (investment) and biological (fishing ground) changes; and (3) among all trawlers, medium and large size boats can best adjust and maintain continuous profits while for push nets, all sizes of boats have declining net profits. As for pelagic fishing operations, purse seiners have been developed to make high profit and still yield a higher return than trawlers and gillnet fishing operations. Finally, the return to labor, or daily wage, on average is higher than the national minimum wage rate.

Due to the open-access fisheries resources, it can be forecast that: (1) without restrictions on involvement in the fisheries sector, profits will encourage new fishers into the system; and (2) new entrants under static marine resources and price conditions will result in a declining trend in profit over the long-run. This decline will restrict employment and investment since revenue will not exceed opportunity loss. Will the rapid growth of the fishing industry reduce profit? Will this profit slowly decline with expansion of fishing effort? These questions could not be clearly answered due to insufficient data to indicate fisheries status; and results obtained from studies during previous years are applicable to the situation only under constant economic and biological conditions. Changes in these conditions may conceal a decline of profit, so that profit is ostensibly increasing (real profit may even decline), leading to the entry of new fishers.

Implications for Fisheries Management

The present level of exploitation of demersal fisheries resources in inshore waters of the Gulf of Thailand up to 50 m depth is higher than the estimated maximum sustainable yield (MSY) for this area. It is clear that this over-fishing is brought about by intensive trawl operations in the area and that it is the root cause of the current difficult fisheries situation. The current situation is clearly reflected in the index of abundance or catch per unit effort, which has measurably decreased in recent times. At the same time, the amount of trash fish in the demersal catches has increased significantly. Immediate action is therefore needed to tackle these problems, and to conserve the resources through such measures as reduced fishing effort, and by further promoting cooperation between fishers and the Department of Fisheries. Fisheries management practices to conserve marine resources in Thai waters also need further improvement and existing fisheries regulations need to be more strictly enforced.

The measures of fisheries management undertaken by the Government of Thailand so far are: (i) to control and limit entry into fisheries; (ii) the “Command program” (see The Command Program for fisheries management) for fisheries management; and (iii) adopt a community-based fisheries management regime.

Control and Limited Entry Into Fisheries

The marine capture fisheries of Thailand presently face many problems arising from the enforcement of EEZs, resulting in a realignment of fishing grounds and a decrease in available marine resources. In addition, the excessive fishing effort and the types of fishing gear used by trawlers often cause conflicts with the local fishers because of encroachment into their traditional fishing grounds, and the destruction and interference caused to the small scale and fixed fishing gear.

In 1978, the Thai Cabinet adopted a resolution to control and reduce the number of trawlers and push nets. The Cabinet Resolution and the subsequently adopted Fisheries Act of Thailand have had considerable influence in bringing about improvements in the fisheries management practices and rationalization of fishing effort in Thailand. Several specific rules and regulations to limit entry into both demersal and pelagic fisheries have since been declared with different objectives and results, both positive and negative.

Operation of fishing gear in Thai waters requires a license from the Department of Fisheries and a navigation certificate from the Harbour Department. The license was originally issued automatically on a routine basis on payment of nominal fee, and only some small scale fishing gear and certain types of small fishing boat were exempted. Issuance of fishing licenses has since been made subject to closer scrutiny on a case-to-case basis.

The basic objective of a ministry regulation issued in March 1990 was to gradually reduce the number of trawlers and push netters and thereby bring down demersal catches to the optimum sustainable level. This entailed cutting down the total number of trawlers operating from 6 576 units to 3 200 units in the Gulf of Thailand and 300 units along the Andaman Sea coastline. Push nets were to be gradually phased out as they invariably operate in shallow waters and catch very small fish.

The license regulations of the Ministry were based on the following strategies:

1. The number of trawlers and push netters to be regulated by controlling the entry of new boats into these fisheries as follows:

   - new fishing licenses not to be issued for any type of trawler or push netter;
   - a fishing license for other types of fisheries should not be transferred or utilized to operate trawlers and push netters;
   - only the licenses and navigation certificates of the holders of the license/certificate for the preceding year to be renewed; transfer of these licenses to another person not to be allowed or negotiated under any circumstances, except as instances of family inheritance.

2. The number of currently operating trawlers and push netters to be reduced by various measures as follows:

   - transfer of licenses issued for trawling and push net fisheries to other types of fishing to be encouraged;
   - diversification and alternative utilization of vessels used in fisheries for tourism, cargo transport, passenger transport, etc. to be promoted;
   - licenses of vessels which become involved in trespassing and encroachment into the jurisdictional waters of other countries to be forfeited and not reissued.

In 1982, the above regulations were implemented. Their effectiveness became evident during the 1981 - 1988 period, as the number of registered trawlers and push netters gradually decreased. However, the total number of registered trawlers and push netters then again increased to accommodate demands for expansion of fisheries into the EEZs of other countries through bilateral agreements.

The Command Program for Fisheries Management

Under the 1947 Fisheries Act, a series of ministerial rules and regulations concerning the conservation of marine resources was issued in six groups:

1. Prohibition of the use of certain types of fishing gear during the spawning and breeding seasons of some commercially important species.

2. Prohibition of certain types of fishing gear in some areas.

3. Protected areas are those adjacent to temples and monasteries or any other area designated as such by the governors of provinces. All such areas are considered as fish sanctuaries where fishing of any sort is not permitted.

4. Prohibition of catching endangered and threatened species.

5. Ban on the use of poisons and stupefying chemicals, explosives and electric stunning.

6. Prohibition/restrictions on certain types and sizes of fishing gear.

The enforcement of the above regulations has not been very effective to date, since they apply to a very extensive area spread over the entire coastline of Thailand. The number of officials in the field to inspect and enforce the regulations is too few. The laws of the country require that the fishers need to be caught in the actual act of illegal fishing or violating the regulations for the law to be upheld in court.

It can thus be concluded that more effective management of marine resources on a long-term basis requires implementation and enforcement of all current regulations in the field. In particular, there is a need for more officials in the field, better infrastructure facilities to accomplish effective enforcement, and delegation of sufficient enforcement authority rather than only to the provincial fisheries officers.

Community-based Fisheries Management Regime

The existing control measures have limited success for the following reasons: (a) the number of enforcement staff and patrol boats is limited compared with the coastal length of 2 614 km and the huge number of fishing boats operating the various types of fishing gear, (b) lack of cooperation from fishers, (c) high enforcement costs and (d) lack of coordination among relevant agencies.

Community-based fisheries management, as initiated by the government, has been implemented in coastal areas, particularly in the Phang-Nga Bay (Andaman Sea) and Bang Sapan Bay (Gulf of Thailand). These projects aimed to change the perceptions and attitudes of fisherfolk from that of a user to a manager. Activities on grouping, training, social development programs, and fish landing-site management which unite fisherfolk, and awareness-building and participation in resource conservation, have been implemented in the target villages. Regular meetings among working committees of each village have been organized to monitor the progress and problems of implementation in each village. Visits to the target villages have been regularly carried out. When the fisherfolk learn how to manage and conserve the fisheries resources for sustainable utilization, the provision of fishing grounds in their village or group of villages as part of village property and as a source of their livelihood will be extended to them.

Bioeconomic Modeling

Rationale

Thai marine fisheries have experienced rapid growth during the last 30 years. Endowed with a large Exclusive Economic Zone (EEZ) and productive marine resources, Thailand has been one of the top ten fishing nations of the world since 1972. However, fisheries development has created huge pressure on the resources, especially for the demersal species in the Gulf of Thailand. The demersal fisheries are declining due to over-fishing by trawling at a depth of more than 50 m. Catch per unit effort (CPUE) by trawlers has steadily declined while the number of trawlers of all sizes and types has continued to increase. Fishers began to use a small cod-end mesh size so that more trash fish could be caught to compensate for declining production. In addition, many trawlers which used to fish in foreign fishing grounds returned to the Gulf of Thailand after the declaration of EEZs in the neighbouring countries. Increases of fuel prices from time to time, a part of total costs, forced the fishers to reduce unit cost by increasing fishing effort while the catch of trash fish increased to 60 - 70% of total catch. All of these factors contributed to the depletion of valuable marine species and decline of fishery resources. The CPUE steadily decreased from 231.6 kg per standard fishing hour (kg•sfh^{-1}) in 1963 to 47.3 kg•sfh^{-1} in 1977 (Jetanavanich, 1981) and to 15.85 kg•sfh^{-1} in 1995. New investment is still taking place to increase fishing effort in order to maintain or increase the production volume. Overall, current fishing effort in the Gulf of Thailand has expanded far beyond the biological and economic maximum yields.

Despite the number of studies on demersal fisheries, few have been done on the economics of fisheries in the Gulf of Thailand. Of these, the most notable was the study by (Panayotou and Jetanavanich, 1987), which made the first attempt to determine the levels of catch and fishing effort that give rise to the static MEY. They found that the optimum catch and effort (given a mesh size 2.5 cm) for demersal fisheries were 958 000 t and 15.7 million standard fishing hour respectively. More importantly, the results implied that the demersal catch had surpassed the level of static MEY.

The past and current conservation measures are based purely on biological data, but the integration of economics and biological factors in determining the optimal utilization of demersal resources is necessary to manage these fish stocks. For this purpose, a multi-disciplinary approach is needed. A detailed analysis of demersal fishing in the Gulf of Thailand that includes both fisheries population dynamics and economic considerations would be highly valued.

This study focuses on the bioeconomic modeling of demersal fisheries in the Gulf of Thailand with the objective of providing the basis for more effective management of the demersal resources in the area. The study employs a dynamic approach to arrive at the optimal level of demersal stock, yield and fishing effort. Also, recommendations for demersal fisheries management are provided.

Review of Fisheries Legal Environment

The Fisheries Act of 1947 empowers the responsible Minister with the authority to introduce a licensing system and fishing regulations such as closed areas and seasons, mesh size limitations, gear restrictions and catch quotas, and with the authority to enforce these measures. In practice, however, the Minister has not used these powers to introduce an effective licensing system and other fisheries regulations because of both administration constraints and political considerations. As in many other countries, the budget, manpower and the authority of the Department of Fisheries (DOF) are clearly inadequate for operating and enforcing a licensing system and other fisheries regulations. Moreover, political considerations militate against a substantial reduction of effort and against restrictions on its expansion.

Even the licensing scheme, which freezes the number of trawlers and prohibits their transfer and the construction of new vessels, may be inadequate. First, as the fishing vessels are to be registered with the Harbour Department while the gear is licensed by the DOF, a loophole exists which enables registered fishing vessels to operate without a license for gear. Second, with the current budget and manpower it is not easy for the DOF to enforce the licensing system over an extensive and technologically advanced fleet which can operate from foreign ports. Third, even if the system could be enforced, it can block new entrants and may reduce fishing effort by normal attrition, but it will take a very long time to cut effort to about half its current level, as required. Last, even if effort could be reduced to its optimum level, without an effective mechanism of creaming off resource rents, the newly established rents (as a result of the reduction in effort) would create such a potent incentive to increase effort that rents would again be dissipated through either excess effort or higher enforcement costs.

Similarly, other regulations such as the prohibition of push netting and trawling within 3 km from the shore and the recommendation for a 4 cm mesh size are generally ignored, as evidenced by the large numbers of push netters and trawlers in the prohibited zone, and the use of 2.5 cm mesh size. A two-month seasonal closure of the central western Gulf was not well accepted.

Input policies, such as subsidized credit and tax exemptions for fishing machinery and equipment, are intended to relieve short-term hardships. However, these policies are certain to deepen capital intensity at the expense of labor employment, to encourage new entry to the resources and to widen the dualism between small- and large scale fishers. Moreover, new entries will nullify any temporary gains to the fishers, necessitating new subsidies in the future which, having created a precedent, will be difficult to resist.

Output policies such as price supports, while intended to raise fishers' incomes and to ensure increased fish supplies for human consumption at low prices, are self-defeating in the long run under open-access. To the extent that they are effective in raising fishing incomes, new entrants are attracted into the fishery, and, as a result, the resource base deteriorates, incomes fall, and new supports are required.

Intervention in international trade, such as promotion of exports and tariffs on fish imports may temporarily succeed in raising fishing incomes, in improving the balance of payments and in protecting the local industry, but no lasting benefit can be expected under the present open-access status and the depleted state of the resource. At present, increased fishery exports can be had only through destructive or 'piratical' fishing.

Effort is also being made to conserve fishery resources by encouraging distant-water fishing, especially through joint fishing ventures and other fishery agreements with neighbouring countries (e.g. with Bangladesh, Malaysia, Myanmar and Indonesia). Although some additional fish supplies have been forthcoming as a result of these ventures, there is no evidence that over-fishing in Thai waters and encroachment on foreign resources have diminished. To the extent that joint ventures are successful, they tend to encourage the construction of new, larger vessels rather than the utilization of existing ones.

Framework and Estimation

Model Specification

Size of fishing effort is a major determining factor in the production from and sustainability of a developed fishery. Hence, for optimal resource use (Panayotou and Jetanavanich, 1987), it is often recommended that fishing effort be controlled to prevent over-fishing or dissipation of economic rents. From the economic point of view, the optimal level of effort is the level at which economic rents are maximized. This level of effort generates the MEY which is the return on the scarcest factor of production, the fish stock. Of course, a managing authority may define as optimum yield that which maximizes other benefits such as "employment, equity or stability", but here we will assume that the objective is to maximize the economic return from the fishery (MEY).

MEY is determined by maximizing the spread between total fishing revenues and costs, which is accomplished by equating the marginal revenue (MR) of effort to the marginal cost (MC) of effort. This requires estimation of revenue and cost functions. Assuming constant cost per unit of effort (c), the cost function (TC) presents no difficulty. The total marginal and average costs may be written respectively as:

$$TC = cf \quad (1)$$

$$MC = AC = c \quad (2)$$

where f denotes fishing effort and AC denotes average costs.

However, estimation of the revenue function involves estimation of the underlying sustainable yield function, which is a relationship between sustainable catch (Y) and effort (f). In the case of single species fisheries or when species are aggregated, a sustainable function can be estimated by fitting a logistic growth curve to catch and effort data; the Schaefer (Schaefer 1954) and Fox (Fox 1970) Models can be used.

The Schaefer Model, a linear model is specified as:

$$Y/f = a + bf \quad (3)$$

where a and b are estimated parameters

The Schaefer model, a parabola, has its MSY at an effort level of:

$$f_{MSY} = -0.5\ a/b \quad (4)$$

with the corresponding sustainable yield:

$$MSY = -0.25\ a^2/b \quad (5)$$

The Fox Model gives a straight line when the logarithms of Y/f are plotted on effort:

$$Ln\ (Y/f) = c + df \quad (6)$$

The Fox Model can be rewritten as:

$$Y/f = e^{c + df} \quad (7)$$

where c and d are constant parameters.

The level of effort generating the MSY can be obtained from (7) through differentiation as:

$$f_{MSY} = -1/d \quad (8)$$

MSY itself is obtained by combining equations (7) and (8) to give:

$$MSY = (-1/d)e^{c-1} \quad (9)$$

Then the total (TR), marginal (MR) and average (AR) revenue functions for the Schaefer Model may be written respectively as:

$$TR = p\ (af + bf^2) \quad (10)$$

$$MR = p\ (a + 2bf) \quad (11)$$

and

$$AR = p\ (a + bf). \quad (12)$$

The total, marginal and average revenue functions for Fox Model may be written respectively as:

$$TR = p\ (fi\ e^{(c + df)}) \quad (13)$$

$$MR = pG\ (f(d)e^{(df)} + e^{(df)}) \quad (14)$$

$$AR = p\ (e^{(c + df)}) \quad (15)$$

where, TR = total revenue
p = fish price.

G = estimated constant; parameter of the sustainable yield function

The optimum or MEY level of effort is obtained by equating the MR and MC of effort, i.e.

Schaefer Model may be written, as:

$$p\ (a + 2bf) = c$$

$$f_{MEY} = (c-pa) / 2bp \quad (16)$$

Fox Model may be written, as:

$$pG\ [dfe^{df} + e^{df}] = c, \text{ or}$$

$$dfe^{df} + e^{df} = c/pG \quad (17)$$

Under open-access, fishers attempt to maximize their profits but because of lack of exclusive property rights over the resource, they have no incentive to take into account the effect of their fishing effort on other fishers' catch. The guiding variable for expansion of effort is the expected average revenue of effort rather than the marginal revenue. That is, under open-access the profit-maximizing rule for the individual fishers (but not society as a whole) is to expand effort as long as the average revenue (AR) of effort exceeds the average cost (AC) of effort, no matter what this might do to other fishers' revenues and to future revenues. Thus, under open-access the effort for the fisheries as a whole expands to point where AR = AC, or

For the Schaefer Model

$$f_{OA} = (c\text{-pa}) / bp \quad (18)$$

for the Fox Model

$$pe^{(c + df)} = c, \text{ or} \quad (19)$$

$$e^{(c + df)} = c / p \quad (20)$$

By taking the natural logarithm ln to both sides we obtain (12) as:

$$ln\ e^{(c + df)} = ln\ c/p, \text{ or}$$

$$c + df = ln\ (c/p), \text{ or}$$

$$f_{OA} = [ln\ (c/p) - c]/d \quad (21)$$

Thus at the f_{OA} level of effort profits are totally dissipated:

$$TR_{OA} - TC_{OA} = 0 \quad (22)$$

At the f_{OA} level of effort, neither do the fishers earn profit nor does the society earn economic rents for its scare fishery resource. All potential surplus of revenues over costs has been totally dissipated in excessive effort under open-access. Reduction of effort from f_{OA} down to f_{MEY} would generate substantial profits to remaining fishers (or rents to the society), and at the same time increase the size of the fish stock, even if at f_{OA} the stock is severely depleted.

Data: Catch, effort, fishing costs and fish price

Catch

The data for dermersal fish and trash fish catches in the Gulf of Thailand for the 1971 - 95 period were collected from the Fisheries Statistics Base on the Sample Survey (various issues), officially reported by the Fisheries Economics Division of DOF. For this study, demersal harvests were divided into demersal fish (17 species) and trash fish. Species of demersal fish included barracuda, croaker, threadfin bream, monocle bream, lizardfish, hairtail, snapper, sweetlip, bigeye, sand whiting, barbell eel, marine catfish, rays, sharks, flatfishes, Indian halibut and conger eel. Inconsistencies in the way in which the data were reported were evident, and they were therefore adjusted to attain greater accuracy.

For the period 1971 - 84, the data reported the catch of the demersal fish and trash fish from Thai waters, but were broken down by gear type and vessel size. The proportion of demersal fish and trash fish from the Gulf of Thailand was estimated from the 1985 - 95 Marine Fisheries Statistics Base on the Sample Survey.

The 1985 - 95 report showed the catch of demersal fish and trash fish from the Gulf of Thailand and Andaman Sea broken down by gear type and vessel size.

Fishing effort

To match demersal catches with their corresponding levels of fishing effort, data were collected in the Gulf of Thailand for vessel-fishing-hours. During 1971 - 95, fishing effort was obtained from the Marine Fisheries Statistics Base on the Sample Survey. Since demersal resources are caught by various types of gear and size of vessels, it was necessary to translate fishing effort into equivalent, or standardized units. For commercial fishing, gear is shown in Appendix Table 1, namely: otter board trawl, pair trawl, beam trawl, push net, purse seine, anchovy purse seine, mackerel encircling gillnet, king mackerel gillnet, and nominal fishing hours. Since engine horsepower (HP) is different for different sizes of vessels and types of gear, nominal fishing hours were standardized by using the 14 - 18 m otter board trawl as the standard, and an index of vessel HP is shown in Appendix Table 2. Standard effort was calculated by multiplying the HP index of each gear by nominal fishing hours for that gear, and is shown in Appendix Table 3. For small scale fisheries and bamboo stake traps, data on fishing hours were unavailable. Standard effort was calculated by dividing catch by the catch per hour of a 14 - 18 m otter board trawl vessel. The total standard effort is the sum of the standard effort of all the gear-types, and is shown in Appendix Table 3. Since effort is affected over time through gear improvement, a technological adjustment factor is calculated by dividing catch per hour of the standard vessel by catch per hour of a research vessel (Ahmed 1991). The catching power of the research vessel remained unchanged over time, allowing it to serve as a technological standard. CPUE of the research vessel is shown in Appendix Table 4. In 1990, 1992 and 1994, no experimental survey was conducted. For these years the mean CPUE of the preceding and the following year was used as an estimate of CPUE. The adjusted effort was calculated by multiplying standard effort by a technological adjustment factor.

Fishing Cost

The unit cost is represented by cost per standard unit of fishing effort. The total cost of fishing for demersal fish and trash fish was calculated from the Cost and Earnings Survey of Major Fishing Gear in 1995 (Department of Fisheries (DOF) 1972 - 97). The major fishing gear was otter board trawl, pair trawl and push net. By using the annual cost of major fishing gear per vessel, the major cost of each fleet was calculated by multiplying the annual major fishing gear cost per vessel by the total number of vessels in the Gulf of Thailand in 1995 employed in that fleet. The total fleet cost is the sum of the costs of all the gear-types, and it represents the total cost of total catches in the Gulf of Thailand. The proportion of demersal fish and trash fish catch value was estimated from Fisheries Statistics of Thailand in 1995 (Department of Fisheries (DOF) 1972 - 97). The demersal fish and trash fish cost was calculated by multiplying percentage of demersal fish and trash fish value by the total cost. The demersal fish and trash fish cost of major fishing gear divided by the total standard fishing effort of those gears gave CPUE .

Fish Price

Figures on demersal fish and trash fish prices from the Gulf of Thailand are available in Fisheries Statistics of Thailand in 1995. (Department of Fisheries (DOF) 1972 - 97).

Model Estimation and Results

Having described the economics and the state of Thai marine fisheries resources, the optimal level of resources use can now be determined. The optimal resource use was postulated to be the level of catch and effort that maximize the sustainable economic yield (MEY) or rent from the fisheries, that is, the excess of sustainable revenues over costs. Of course, it is always possible to increase current economic rents (profits) beyond this level but, in the same way that catch above MSY cannot be sustained for long, profits above MEY cannot be sustained. Thus, ignoring adjustment and enforcement costs which could be substantial, fisheries management should aim at the attainment of the MEY level of effort, as it can be shown to be superior to all other levels of effort, including that of MSY in terms of return on a limited resource. The purpose of this study is to determine MEY for the Gulf of Thailand and the corresponding levels of effort, catch, revenues, costs and profits and compare them to those prevailing under open-access and MSY management. Following our theoretical framework, this estimation is based on an assumption of fixed prices.

The State of the Resources - MSY

Both the Schaefer model and the Fox model were used to obtain estimates of MSY for a mesh size of 2.5 cm (commercial fleet), using 1971 - 95 data (see Model specification).

$$Y/f = a + bf,$$

$$\mathrm{Ln}\,(Y/f) = c + df,$$

where Y is catch, and f is standardized fishing effort, and a and b are parameters to be estimated. Estimation was derived by dividing equation by effort to obtain the CPUE as a function of effort. We then regressed CPUE on standardized effort to obtain estimates of the parameters a and b. The empirical results indicate that the Schaefer model and the Fox model fitted the catch and effort data. The results are as follows:

Schaefer Model

$$Y = 57.134\,589\,1 - 0.000\,000\,821f$$

$$R^2 = 0.90,\ F = 222.824\,7,\ df = 24$$

Fox Model

$$Y = fe^{(4.19 - 0.000\,000\,026f)}$$

$$R^2 = 0.96,\ F = 618.8,\ df = 24$$

where R^2 is the coefficient of determination adjusted for degrees of freedom, *F* is the F-ratio, and df denotes degrees of freedom.

Based on these estimates, we calculated MSY and corresponding level of effort using equations (5), (4), (9) and (10) of our theoretical framework. The results are as follows:

Schaefer Model

f_{MSY} = 34.76 x 10^6 standard fishing hours (sfh)

MSY = 993 x 10^3t

Fox Model

f_{MSY} = 37.69 x 10^6 sfh

MSY = 915 x 10^3 t

Optimal Resource Use (Fixed Price Model) - MEY

Recall that the level of effort yielding the MEY, f_{MEY} of the Schaefer model and the Fox model were given in equations (16) and (17) respectively as:

$f_{MEY} = (c\text{-}pa) / 2bp$,

$dfe^{df} + e^{df} = c / pG$,

where *p* is the price of fish per kg, *c* is the cost per unit of standard fishing effort and a, *b* and *G* are the parameters of the sustainable yield function. The 1995 value for fish price and cost per unit effort were estimated as: price (p) = 6.68 Baht·kg^{-1} and cost (c) = 69.67 Baht·sfh^{-1} (for a mesh size of 2.5 cm). Substituting these values into the equation above we obtain the result for Schaefer model as follows:

f_{MEY} = 28.42 x 10^6 sfh

MEY = 960 x 10^3 t

Solving the equation for effort (f_{MEY}) of the Fox model, f_{MEY} = 25.86 x 10^6 sfh with a mesh size of 2.5 cm. The corresponding catch is obtained by substituting the value of f_{MEY} in equation (7) to obtain:

$Y_{MEY} = f_{MEY} .e^{a + bf_{MEY}}$

where *a* and *b* are the parameters of the function. Substituting these values into the equation above we obtain: Y_{MEY} = 960 x 10^3 t with a mesh size of 2.5 cm.

The results reported are in Tables 26 - 27 and Fig.2 with the corresponding actual 1995 figures, and the estimated MSY and open-access figures. From Table 26, the MEY level of effort is about 50% of the actual 1995 level and 82% of the MSY level. However, the actual catch is 93% of MEY and 90% of MSY catch. Profits are as expected, i.e. highest at MEY, amounting to 4 433 million Baht (US$178 million at 1 US$ = 24.92 Baht in 1995) or 5% higher than at MSY. From Table 27, the MEY level of effort is about 46% of the actual 1995 level and 69% of the MSY level. However, the actual catch is 98% of MSY catch. Profits are highest at MEY amounting to 3 943 million Baht (US$158 million) or 5% higher than at MSY. According to these findings, MEY management would earn the industry and the country an additional 1 904 - 2 394 million Baht (US$48 - 96 million) in profits, gross of management costs. If the fishery is left unmanaged, it is expected to reach an open-access (zero profits) level at 56.62 - 69.56 x 10^6 sfh, with a sustainable catch of 593 000 - 725 000 t, and society would lose 3 943 - 4 433 million Baht (US$158 - 178 million) in resources rents.

Table 26. Comparison of catch, revenues, costs and profits at different levels of effort based on the Schaefer Model and 1971 - 95 data, the Gulf of Thailand.

Items	Effort (sfh x 10^6)	Catch (t x 10^3)	Revenues (Baht x 10^6)	Costs (Baht x 10^6)	Profits (Baht x 10^6)
MSY	34.76	993	6 634	2 422	4 212
MEY	28.42	960	6 413	1 980	4 433
Open-access	56.84	593	3 960	3 960	0
Actual (1995)	56.62	896	5 983	3 945	2 039

1 Baht = US$0.04 in 1995 (source: oanda.com)

Table 27. Comparison of catch, revenues, costs and profits at different levels of effort based on the Fox Model and 1971 - 95 data, the Gulf of Thailand.

Items	Effort (sfh x 10^6)	Catch (t x 10^3)	Revenues (Baht x 10^6)	Costs (Baht x 10^6)	Profits (Baht x 10^6)
MSY	37.69	916	6 116	2 626	3 491
MEY	25.86	860	5 745	1 802	3 943
Open-access	69.56	725	4 846	4 846	0
Actual (1995)	56.62	896	5 983	3 945	2 039

1 Baht = US$0.04 in 1995 (source: oanda.com)

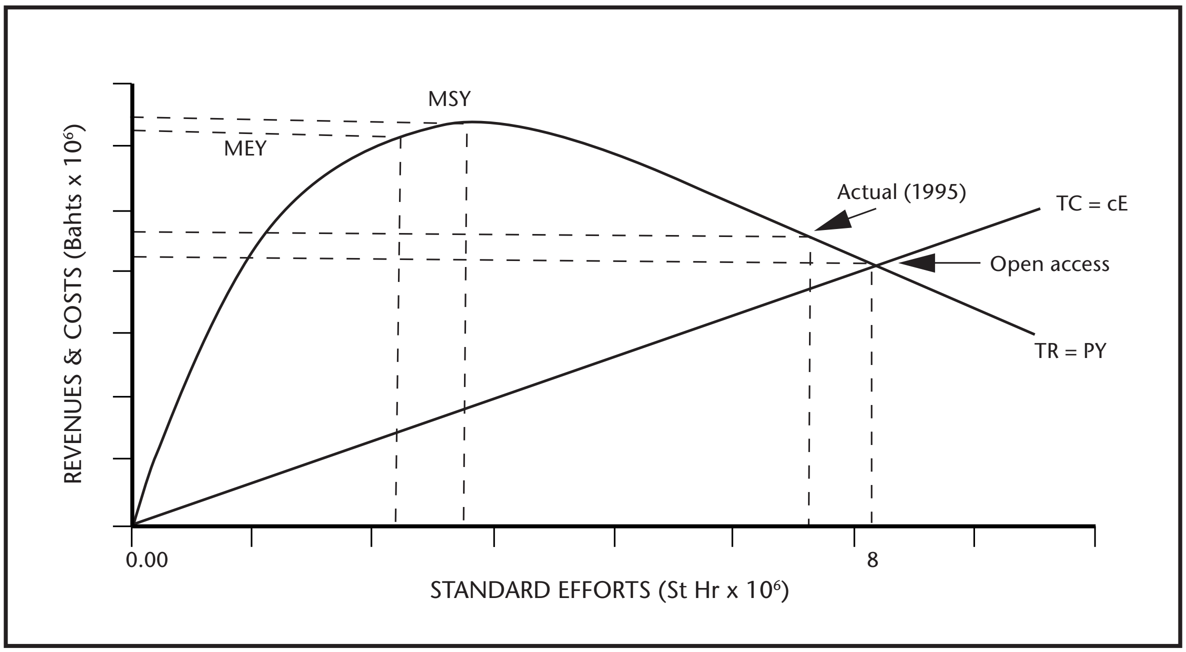

Fig. 2. Fixed price model applied to demersal fisheries (demersal fish and trash fish) in the Gulf of Thailand.

Discussion

In the light of our findings, the feasibility of stated government objectives and the effectiveness of current policies in achieving these objectives are evaluated. Modifications of fishery policy targets in the context of the country's broader development objectives as well as alternatives are proposed.

Policy Issues

From the preceding analysis of the Thai fisheries three fundamental policy issues emerge: (a) how to reduce over-fishing and induce a recovery of Thailand's demersal resources without reducing fishery production and employment; (b) how best to utilize Thailand's sizeable distant-water fleet and technological advantage; (c) to reduce the encroachment into neighbouring countries' EEZs and improve Thailand's international image. Taken together these three issues amount to a quest for a national fisheries policy which would maximize the overall benefits from the fishery to the society with due concern for their distribution and short-run adjustment problems.

This is admittedly a difficult task for any country, but especially for a developing country such as Thailand, which has little tradition and experience in sustainable resource management and limited enforcement capability. With the notable exception of joint fishing ventures, it is difficult to think of management interventions that will not involve curtailment of fisheries production and employment and increased conflict, at least in the short run. As our models have shown, whether the maximization of physical or economic yield is selected as the objective of management makes little difference by comparison to a situation of no management or open-access.

As evidenced by the National Fisheries Policy and other official statements, the government does perceive these issues, and attempts are being made to tackle them. The question is whether the existing legal and policy frameworks are appropriate and sufficient to deal with these issues, especially in the light of budgetary and administrative constraints and the high enforcement costs. To investigate this, it is necessary to review the existing legislation and policy framework.

In addition to the fisheries legislation and related management policies which aim at regulating fishing effort, the policy framework for Thai fisheries includes input, output and trade policies which aim to raise fishers' incomes, thereby subsidizing fishing effort. Such policies include financial support at subsidized interest rates, fuel price and fish price subsidy, tax exemptions for fishing machinery and equipment, provision of storage and processing facilities, price support, export promotion and import discouragement. These policies are usually introduced as second-best solutions or stop-gap measures at a time of a sudden shock or crisis, but usually outlive their original purpose.

Towards a National Fisheries Policy

Problems such as those facing the Thai fishing industry require a comprehensive fisheries policy in line with broader development objectives. One possibility worth considering is to empower the Department of Fisheries with the formulation and implementation of a national fisheries policy with upgraded authority and budget, thus strengthening its enforcement capability.

The first step in such a policy would be an immediate and effective freeze in the number of trawlers and push netters, in particular through prohibition of the construction of new vessels and the compulsory registration of existing vessels with the Department of Fisheries. The next step would be the issuance of fishing licenses to existing vessels based on their current level of catching power, unless it is determined that the current mesh size is smaller than the optimum, in which case a larger mesh size should be specified. Licenses would need to be made non-transferable without exemptions and be retracted upon the retirement of either the owner or the vessel, whichever comes first, until the fleet is reduced to its optimum size. The license fees which are now negligible (e.g. 5 Baht (US\$0.12 in 1998)$\cdot m^{-1}$ foot-rope for trawlers, 2 Baht (US\$0.05 in 1998)$\cdot m^{-1}$ foot-rope for gillnetters and purse seiners and 150 Baht (US\$3.63 in 1998) per gear for push netters) would need to be raised to the estimated market value of the license. As effort is reduced (or fish prices rise), the license fees should be revised upward to extract the newly created rents and to reduce the incentive for expansion of effort. Annual adjustments of the allowable effort and license fees may be necessary to take account of natural fluctuations in the resources and changes in fishing costs.

The government could speed up the attrition process by offering to buy back and cancel the licenses of fishers who choose to leave the fishery. This could be made more attractive by offering to retrain and/or relocate those who leave the fishery as well as by developing alternative employment opportunities. It is possible to use the licensing mechanism to discourage certain gear, such as trawl, and encourage others such as purse seine, if they are judged to have a differential impact on the state of the resources.

Finally, every effort needs to be made to minimize enforcement costs through technical means and self-policing. This is particularly applicable to the government's efforts to improve the Socioeconomic position of small scale fishers and to reduce their conflicts with large scale fishers. One of the regulations most difficult to enforce has been the prohibition of trawling and push netting within the 3 km from shore strip reserved for small scale fishers. These boats not only compete with coastal fishers for a limited resource but they destroy the inshore nursery grounds and habitat, by catching large quantities of juvenile fish and causing damage to stationary and other gear employed by small scale fishers. Small scale fishers, unable to compete, often resort to equally destructive fishing methods such as dynamite, poison and fine mesh nets.

The ultimate success of a national fisheries policy lies in the correct and timely mix of fisheries management and non-fisheries development. Under the prevailing conditions of rising landlessness and swelling unemployment in the rest of the economy, only broad-based rural development will put an end to the continual drift into 'common-property' resources and major urban centers. In its absence, fisheries regulation cannot be effective. Unemployed fishers have little choice but to encroach on reserved forests, mineral concessions and public land, or move into urban centers creating a host of social and environmental problems.

Conclusions and Recommendations

The management of the demersal fisheries in the Gulf of Thailand that began in the 1980s by controlling the number of trawlers has been based purely on biological data. A detailed analysis of the fishery that includes both bioeconomic and Socio-economic factors would be highly valuable in determining the optimal utilization of the demersal resource (including trash fish). Unfortunately, data on socio-cultural and human factors are limited and subjective. This study has focused on bio-economic modeling of demersal fish and trash fish with the objective of providing an effective foundation for the utilization and management of the demersal fisheries in the Gulf of Thailand.

The bioeconomic model based on (Fox 1970) of demersal fish treats the stock as a single entity or biomass, and growth is assumed to be density-dependent. The result indicates that demersal fish are economically over-fished. The fishery could earn additional rents by curtailing both excessive fishing effort and catch. For a start at controlling the demersal fisheries, a license limitation and mesh size enlargement scheme are recommended.

Optimal resource utilization based solely on achieving economic efficiency may fail to reflect broader social issues. Any controls or constraints on fishers' behaviour that will be acceptable must incorporate social, political, and legal concerns. Nevertheless, departure from economic efficiency as the objective should only be allowed within limits.

In Thailand, the fishing industry is very complex, with multi-species, multi-gear fisheries, and different scales of fishing operations. Actions directly targeted on one species can be expected to affect all other species. This suggests that optimal fishing for one species considered alone may mean sub-optimal fishing in other fisheries. This makes fisheries management in Thailand a difficult task.

However, the Thai fishing industry needs proper regulation and fishing effort should be reduced through prohibition of construction of new trawlers and a ban on push nets, change from destructive fishing gear to other methodologies or aquaculture, and purchasing of excess fishing vessels from fishers.

Other important fishery policy issues not covered by this study include prohibition of fishing by all type of fishing gear at all times in protected areas. Coral reefs, seagrass beds and mangroves are important habitats and spawning grounds of several marine resources. Additional measures include minimization of by-catch, by improving fishing techniques, controlling mesh size and limiting the amount of time spent fishing.

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Appendix Table 1. Demersal catch, efforts, catch per effort (CPUE), 1966 - 95.

Year	Commercial Catch: Demersal Fish and Trash Fish (tons)	Average catch by research vessel at mesh size 2.5cm ($kg \cdot hr^{-1}$)	Estimated total efforts ($St \cdot hr^{-1} \times 10^6$)
1966	348 683	140.72	2.48
1967	388 333	120.72	3.22
1968	531 762	104.13	5.11
1969	577 621	97.86	5.90
1970	607 225	94.17	6.45
1971	624 067	60.35	10.34
1972	737 939	51.16	14.42
1973	738 136	45.64	16.17
1974	848 424	45.46	18.66
1975	814 828	44.49	18.31
1976	588 622	54.62	10.78
1977	791 839	42.24	18.75
1978	792 230	46.81	16.92
1979	727 212	47.85	15.20
1980	725 864	44.42	16.34
1981	740 180	35.00	21.15
1982	744 191	37.83	19.67
1983	729 040	38.26	19.05
1984	690 458	47.18	14.63
1985	711 691	44.98	15.82
1986	889 600	38.08	23.36
1987	1 029 209	29.69	34.67
1988	920 631	21.76	42.31
1989	903 741	15.59	57.97
1991	774 132	20.40	37.95
1993	869 601	27.45	31.68
1995	899 899	15.82	56.88

Source: Marine Fisheries Economic Division, Department of Fisheries 1946 - 95.

Appendix Table 2. Annual costs of trawl and push net fisheries by size of fishing vessel in Gulf of Thailand, 1995.

Type of fishing gear	Size of vessel (Meters)	No. of fishing (Unit)1/	Average annual cost (Baht·unit^{-1})2/	Amount cost (Bahts x 10^6)
Otter trawl	< 14	1 784	825 380	1 472.48
	14 - 18	1 948	1 556 740	3 032.53
	18 - 25	1 496	2 275 200	3 403.70
			Sub-total	7 908.71
Pair trawl	< 14	16	1 947 864	31.17
	14 - 18	186	2 702 003	502.57
	18 - 25	491	4 608 520	2 262 78
			Sub-total	2 796.52
Push Net	< 14	402	614 107	246.87
	14 - 18	85	1 173 753	99.77
	18 - 25	35	2 306 508	80.73
			Sub-total	427.37
Grand Total				11 132 60

Source: Fisheries Economic Division, Department of Fisheries.

Appendix Table 3. Computation for catch cost of demersal fisheries per standard efforts.

Amount Cost (Baht x 10^6)	11 132.60
Percentage of catch value (%) (demersal fish and trash fish)	34.33
Catch cost for demersal fish and trash fish (Baht x 10^6)	3 821.82
Standard effort (Hr x 10^6)	54.82
Cost per unit effort (Baht•St Hr^{-1})	69.72

Appendix Table 4. Summary of Fox's Model Output

Regression Statistics			
Multiple R			0.8529548
R Square			0.72753188
Adjusted R Square			0.71663316
Standard Error			0.42318985
Observations			27
ANOVA			
	Regression	**Residual**	**Total**
df	1	25	26
SS	11.95492447	4.477241209	16.4321657
MS	11.95492447	0.179089648	
F	66.7538553		
Significance F	1.597E-08		
		Intercept	Variable (X)
Coefficients		2.130987563	-4.864E-06
Standard Error		0.115928278	5.9531E-07
t Stat		18.38194785	-8.1703033
P-value		4.89686E-16	1.597E-08
Lower 95%		1.892228973	-6.09E-06
Upper 95%		2.369746154	-3.638E-06
Lower 95.0%		1.892228973	-6.09E-06
Upper 95.0%		2.369746154	-3.638E-06