Status of Demersal Fishery Resources in the Gulf of Thailand

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Kongprom A., P. Khaemakorn, M. Eiamsa-ard and M. Supongpan. 2003. Status of demersal fishery resources in the Gulf of Thailand p. 137 - 152. *In* G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R.A. Valmonte-Santos, C. Luna, L. Lachica-Aliño, P. Munro, V. Christensen and D. Pauly (eds.) Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries. WorldFish Center Conference Proceedings 67, 1 120 p.

Abstract

Data from trawl surveys (1961 - 95) and annual production statistics (1971 - 95) were used to examine the status of demersal fishery resources in the Gulf of Thailand. Analyses were focused on biomass trends, population parameters and exploitation rates of dominant species, and assessment of excess capacity from fishing effort and yield estimates. The results indicate by 1995, the trawlable biomass in the Gulf had declined to only about 8.2% of the biomass level in 1961. The substantial decline is true for major components (demersal fish and trash fish) and species groups (*Nemipterus* spp., *Priacanthus* spp., *Saurida* spp. and squids) comprising trawlable biomass. Estimates of exploitation rate (E) for 23 species indicate that most (particularly demersals) are over-fished. By 1995, 21 of the species had E values of 0.79 and higher. Analyses of standardized fishing effort and yield using the Fox model indicate that the 1995 fishing effort was about twice the level needed to harvest the maximum sustainable yield. Overall, the results illustrate that the resources are severely over-exploited. The excess demersal fishing effort is estimated to be about 50% of the number of registered boats in 1995.

Introduction

The demersal resources in the Gulf of Thailand have been subjected to increasing exploitation since the introduction of trawling in 1960. The rapid increase in trawling capacity has resulted in the decline of the resources and operations have become less profitable (Demersal Fish Working Group (DFWG), 1995; Isarankura and Kuhmorgen 1966). Since the introduction of trawling, the Department of Fisheries (DOF), Thailand has conducted systematic trawl surveys to monitor the status of the resources and levels of exploitation. The DOF research vessel *Pramong 2*, later supplemented by *Pramong 9*, were used to conduct the routine surveys. The size and design of these vessels were similar to commercial boats operating in the area. The surveys have provided reliable information on the status of the resources through time and are deemed important for their proper management (Isarankura 1971; Tiews 1965).

The catch-per-unit effort (CPUE) from the trawl surveys has been reported to have declined from 298 $kg \cdot hr^{-1}$ in 1961 to around 20 $kg \cdot hr^{-1}$ in the early 1990s (Department of Fisheries (DOF) 1999). Various studies of the demersal, pelagic and invertebrate resources in the Gulf of Thailand (Boonyubol and Pramokchutima 1982; Chullasorn, 1998; Demersal Fish Working Group (DFWG) 1995; Hongskul 1972; Pelagic Fish Working Group (PFWG) 1995; Supongpan 1988; Supongpan 1993; Supongpan 1996; Vibhasiri, 1987) indicate over-exploitation problems. Catch composition changes toward smaller and less valuable species have been noted. Lately, fishing gear using light lures and nets with smaller mesh sizes have been deployed by fishers in efforts to increase catches. Light luring techniques, however, tend to catch juveniles and so have aggravated over-fishing and conflicts among fishers. While DOF (under the Ministry of Agriculture and Co-operatives) has issued several laws and regulations to improve management of the fisheries, excess fishing capacity and illegal fishing activities still persist.

This study attempts to provide an update on the status of the demersal fishery resources in the Gulf of Thailand. It infers the extent of over-fishing of the resources by looking at (1) the trends in biomass from the trawl surveys, (2) the population parameters and exploitation rates of dominant species, and (3) the available catch and effort time series from the commercial fisheries.

Materials and Methods

Biomass Estimation

Data collected by *Pramong* 2 and *Pramong 9* for the years 1961 to 1995 were used for the estimation of biomass of trawlable resources in the Gulf of Thailand. *Pramong* 2 is a wooden stern trawler with a displacement of 79 gross tons (GRT). It has an overall length (LOA) of 24.5 m and a breadth of 5.2 m. It is fitted with a 320 HP diesel engine with remote control system. *Pramong 9* is also a wooden stern trawler with a displacement of 85 GRT. It has an LOA of 25.2 m, a breadth of 5.95 m and a 412 HP engine.

Both research vessels used the German otter trawl. The net was nylon with a total length of 47.7 m, wing width of 17 m, and a height of 3.5 m. Mesh size ranged from 16 cm at the wing to 4 cm at the cod-end. Surveys since 1981 have used a cod-end cover of 2.5 cm (Eiamsa-ard and Amornchairojkul, 1997). The length of ground and head rope was 48 and 39 m, respectively. The otter boards were made of hard wood with edges covered by steel (Eiamsa-ard et al., 1977).

The Gulf of Thailand (Fig. 1) is situated from 6° to 13°30' North latitude and 99° to 104° East longitude and has a total seabed area of 304 000 km². It is relatively shallow, with a mean depth of about 58 m (the deepest being 85 m) (Supongpan, 1996). For the trawl surveys, the Gulf of Thailand was divided into 9 areas (Area 1 to 9), each area further divided into grids of 30 nm x 30 nm. The sampling scheme involved 80 trawl hauls in each area (one hour per haul), totaling 720 hauls in one year. This sampling scheme was used from 1963 to 1976. As the abundance of commercially important demersal species was very low beyond the 50 m depth contour, the surveys were largely limited to the 10 - 50 m depth range (Isarankura, 1971).

Pramong 9 was commissioned in 1977 to conduct the surveys together with *Pramong 2*. During the first sampling month, *Pramong 2* was deployed in Areas 1 to 4 while *Pramong 9* was simultaneously deployed in Areas 5 to 9. In the next sampling month, vessel deployment was reversed (and so on for the rest of the year). From 1977 onwards, the scheme was changed to grid areas of 15 nm x 15 nm (Fig. 1). As a result, more substantial information on catch, effort, fish biology, and species size distribution was collected. Because of the oil crisis in 1973 and subsequent budgetary shortfalls, the number of hauls in each area was reduced to 60, so that the total number of hauls per year was reduced to 540.

During the surveys, trawling was conducted only during daylight hours. The position, trawling depth, engine speed, vessel velocity and time of operation was recorded for each haul. Trawling speed was maintained at 2.5 knots as much as possible. Places not suitable for trawling (e.g. rough bottom, with obstructions) were marked and their positions noted for future reference.

The catch for each haul was classified into food or trash fish, and then identified to the lowest taxonomic level possible (species or genera). A balance was used to weigh samples. Sea snakes, sea urchins and other poisonous species were separated from the catch and discarded after recording.

Biomass (B) was estimated via the swept area method, using the formula given by (Sparre and Venema, 1992) as follows:

$$B = \frac{\overline{CPUE}}{a * X_1} * A$$

where,
A (total area) = 101 384 km²
a (swept area) = 0.090 29 km²,
X_1 (proportion of fishes in the path of the trawl retained by it) = 0.5 .

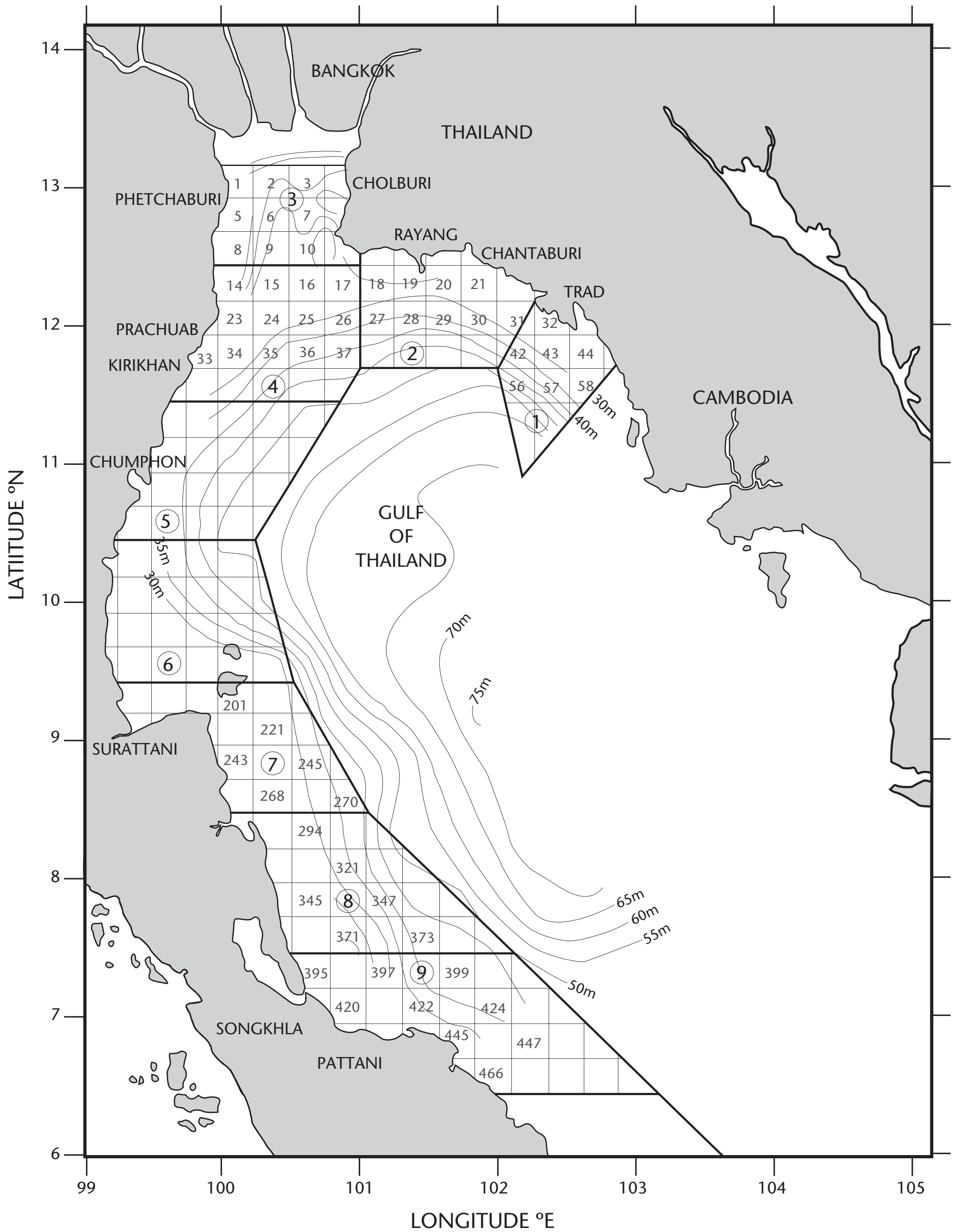

Fig. 1. The Gulf of Thailand showing depth contours, the 9 survey areas and trawl sampling grids.

The swept area was estimated from the equation:

$a = t*v*h*X_2$

where,

t (time spent trawling) = 1 hr,

v (trawling speed) = 2.5 knots

(multiplied by 1.853 2 to convert to $km{\cdot}hr^{-1}$).

h (length of trawl head rope) = 39 m,

X_2 (effective width of the trawl relative to its head rope) = 0.5.

The mean catch-per-unit effort ($\overline{CPUE}$) was calculated as the arithmetic mean of catches from hauls in a given survey year (excluding extremely high values). Although geometric means are better measures of central tendency for trawl survey data, it was not possible to retrieve some of the primary catch (per haul) data, particularly for the earlier surveys. Survey reports giving only arithmetic mean catch rates were used in these instances, therefore arithmetic means were used for consistency of the biomass time series. Interpolation (between years for which estimates were available) was done for a limited number of years when no survey was conducted.

Estimation of Population Parameters and Exploitation Rates

Size frequency data of commercially important species have been collected during the trawl surveys since the early 1980s. Total length was measured using 1 cm length intervals. Punch cards (with scale) were used to record the measurements. The 10 most abundant economically-important species were usually chosen for generation of size distribution data.

Population parameters of nine species (*Rastrelliger kanagurta, Atule mate, Scolopsis taeniopterus, Lutjanus lineolatus, Nemipterus nematophorus, Nemipterus peronii, Epinephelus sexfasciatus, Sepia recurvirostra* and *Sepia aculeata*) were estimated in this study from size frequency data collected during various years. These parameters include:

1. coefficients (a and b) of the length-weight relationship;
2. growth parameters (L_∞ and K) of the von Bertalanffy equation;
3. gear selection parameters ($L_{25\%}$, $L_{50\%}$, $L_{75\%}$); and
4. natural mortality coefficient (M).

The FiSAT (FAO - ICLARM Stock Assessment Tools) software (Gayanilo and Pauly 1997) was used to obtain the parameters. The value of M was estimated using the empirical equation of (Pauly 1980) as incorporated in FiSAT. Apart from the nine species mentioned above, population parameters for 14 other species were obtained from the literature.

For each of the 23 species included in the study, the fishing mortality (F) was estimated by dividing yield (Y) with biomass (B) estimates for the species (i.e. F = Y/B). The Y values were obtained from annual production statistics (Department of Fisheries (DOF), 1971 - 96a) while the B values were estimated from trawl surveys conducted during the 1971 - 1995 period. Total mortality (Z) was calculated by the addition of M and F (i.e. Z = M+F) and exploitation rate (E) estimated by dividing F by Z (i.e. E = F/Z). For each of the 23 species therefore the annual E estimate is given for the 1971 - 95 period.

Fishing Effort and Yield

Annual production or yield (Y) by species or species group during the period 1971 - 95 was taken from statistical records of the Department of Fisheries (Department of Fisheries (DOF) 1971 - 96a). The total number of registered trawlers (sum of otter trawlers, pair trawlers, beam trawlers, and push net units) and other fishing vessels from 1971 - 95 are also given in the annual statistics of the Department of Fisheries (Department of Fisheries (DOF) 1971 - 96b). Generation of a composite annual effort index to match the annual production figures however is difficult given the challenge of standardization across the various types of gear used in the Gulf of Thailand. To estimate annual effort (f), annual production was divided by the annual mean CPUE from the trawl surveys. The resulting f estimate is expressed in standard trawling hours with the survey vessel as standard.

The maximum sustainable yield or MSY (total and for major species groups) and fishing effort corresponding to MSY (f_{MSY}) were estimated using the Fox model. The annual Y and f series for the 1971 - 95 period were utilized following the procedure described by (Sparre and Venema, 1992), viz.:

$$\frac{Y_i}{f_i} = e^{c+df_i}$$

$$MSY = -\frac{1}{d} e^{c-1}$$

$$f_{MSY} = -\frac{1}{d}$$

where *c* and *d* are constants derived via regression, and Y_i and f_i refer to yield and fishing effort respectively for year i.

Results and Discussion

Biomass Trends

Fig. 2 shows the estimates of total trawlable biomass in the Gulf of Thailand (0 - 50 m depth) between 1961 and 1995. Trawlable biomass declined from about 680 000 t in 1961 to about 56 000 t in 1995 (i.e. down to 8.2% of the 1961 level). Separation of trawl survey catches into major species groups began only in 1966. Fig. 2 also shows the substantial decline in biomass of the demersal fish and trash fish components of trawlable biomass. Fig. 3 illustrates the biomass estimates for four major species groups (*Nemipterus* spp., *Priacanthus* spp., *Saurida* spp. and squids) comprising trawl survey catches. All groups show the same downward trend over the period 1966 - 95.

Relative indices of total number of trawlers, catch and biomass (based on available data) during the period 1961 - 95 are illustrated in Figs. 4 - 6. As noted earlier, the trash fish, demersal fish and total

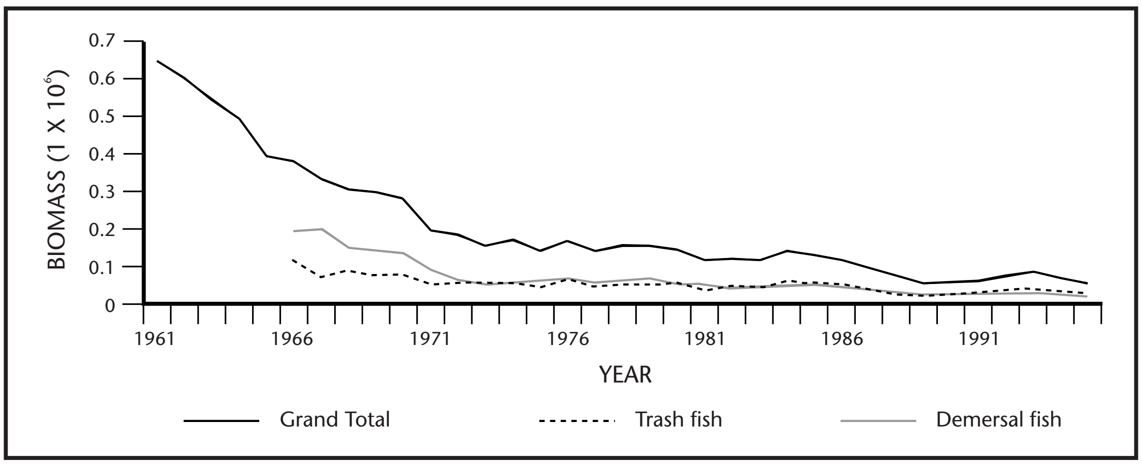

Fig. 2. Total trawlable trash fish and demersal fish biomass in the Gulf of Thailand, 1961 - 95.

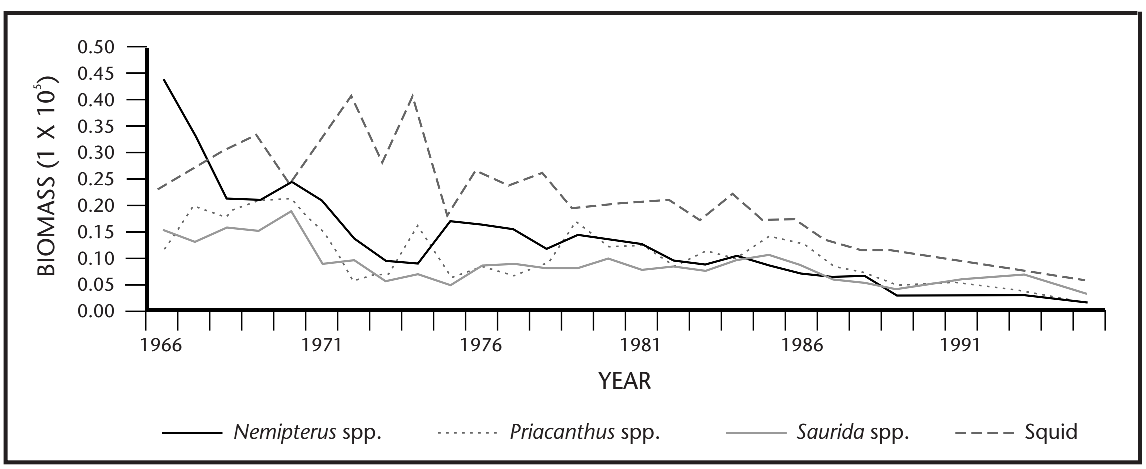

Fig. 3. Biomass of *Nemipterus* spp, *Priacanthus* spp, *Saurida* spp. and squid in the Gulf of Thailand ,1966 - 95.

trawlable biomass estimated from trawl surveys have declined tremendously. The relative number of trawlers and total production generally correspond well (i.e. increases in number of trawlers generally result in increases in total production and vice-versa). During 1985 - 95 however this relationship was reversed, with production increases corresponding to decreases in number of trawlers. Increased production has been attributed to larger trawlers extending their operations to deeper waters while small-sized boats continued fishing in shallow coastal waters (Demersal Fish Working Group (DFWG) 1995). Pair trawlers also expanded their operations into deeper areas and previously untrawlable zones in the middle part of the Gulf by adjusting their riggings (Department of Fisheries (DOF) 1999). Moreover, purse seiners increased their fishing efficiency by reducing their mesh size from 4.7 cm to 3.5 - 3.8 cm, equipping their vessels with fish finders, and by the development of light luring techniques (Department of Fisheries (DOF) 1999; Pelagic Fish Working Group (PFWG) 1995).

Adjustments in the operation of trawlers led to increases in demersal fish catch during 1985 - 95 (Fig. 6), as the trash fish catch declined and then stabilized from its highest level in 1987 (Fig. 5). All these adjustments were undertaken by the trawl fleet as the biomass of demersal fish and trash fish by 1995 had declined to about 7% and 15% respectively, of their 1966 levels. The production

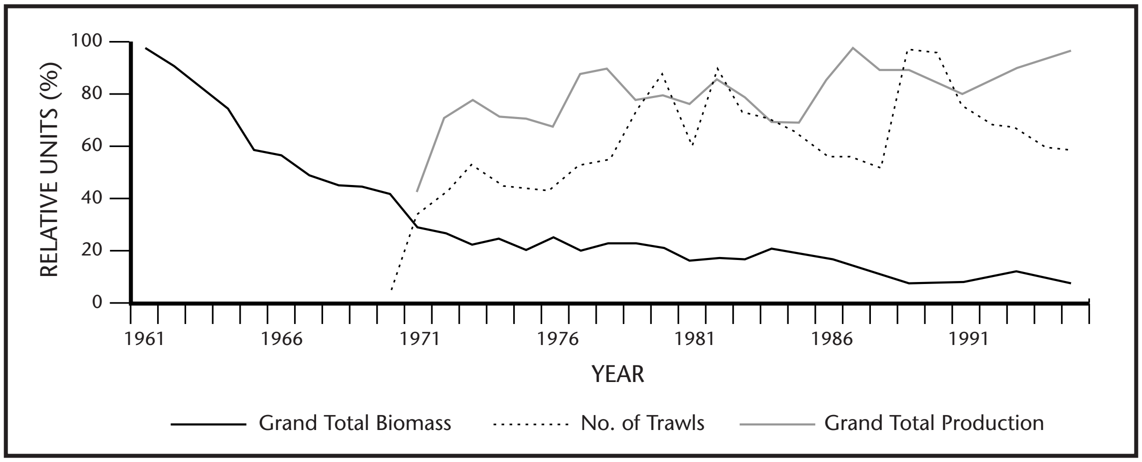

Fig. 4. Relative indices of trawlable biomass, number of trawlers and total production in the Gulf of Thailand, 1961 - 95. Trawl gear are otter board trawl, pair trawl, beam trawl and push net.

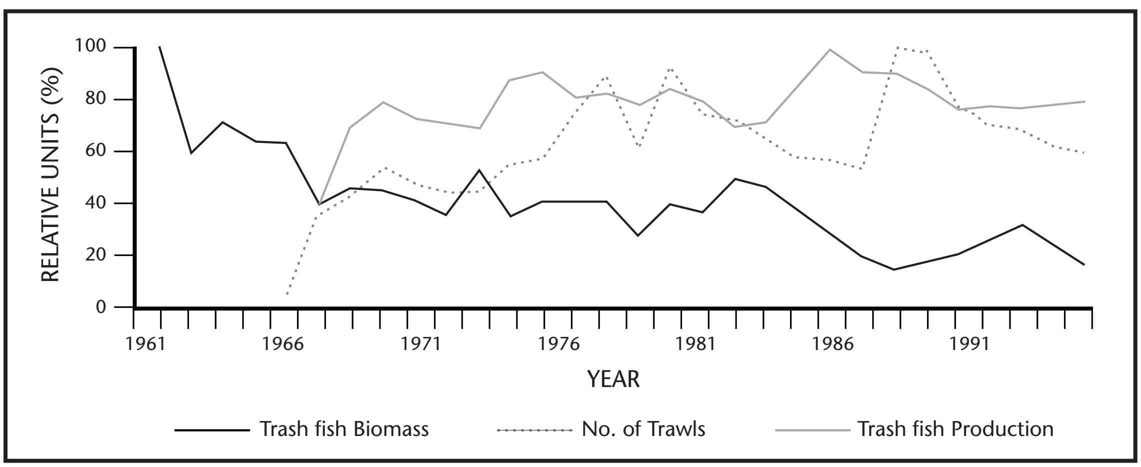

Fig. 5. Relative indices of trash fish biomass, number of trawlers and trash fish production in the Gulf of Thailand, 1966 - 95.

of *Nemipterus* spp., *Priacanthus* spp. and *Saurida* spp. (which are main components of the demersal fish catch) increased substantially after 1985. These groups are mostly used to make *surimi* (artificial crabmeat) because of their good flesh, taste and colour. In recent years, fishers have sorted out more rigorously small-sized individuals of *Nemipterus* spp., *Priacanthus* spp. and *Saurida* spp. from trash fish for making *surimi*. This is partly the reason why demersal fish production increased while trash fish production declined between 1985 and 1995. (Fig. 5 and 6).

Fig. 7 gives the relative indices of squid production, biomass and total number of trawlers for the 1966 - 95 period. At the beginning of the squid fishery, fishers used trawls as the major gear for catching squids. Since 1982, fishing gear using light luring techniques have been gradually expanded. More squid catches come from light luring fishing techniques than trawling (Supongpan 1996). Squid production has fluctuated considerably, but exhibits a general trend of decline since reaching a maximum in 1977. Estimates of squid biomass from trawl surveys had declined by 1995, to only about 14% of the maximum level reported in 1974. Table 1 presents the species composition changes from trawl survey catches in the Gulf of Thailand. There is a noticeable increase in the contribution of squids (*Loligo duvauceli*) from 1966 to 1986 and a decreasing trend in the contribution of threadfin breams (*Nemipterus hexodon*) in

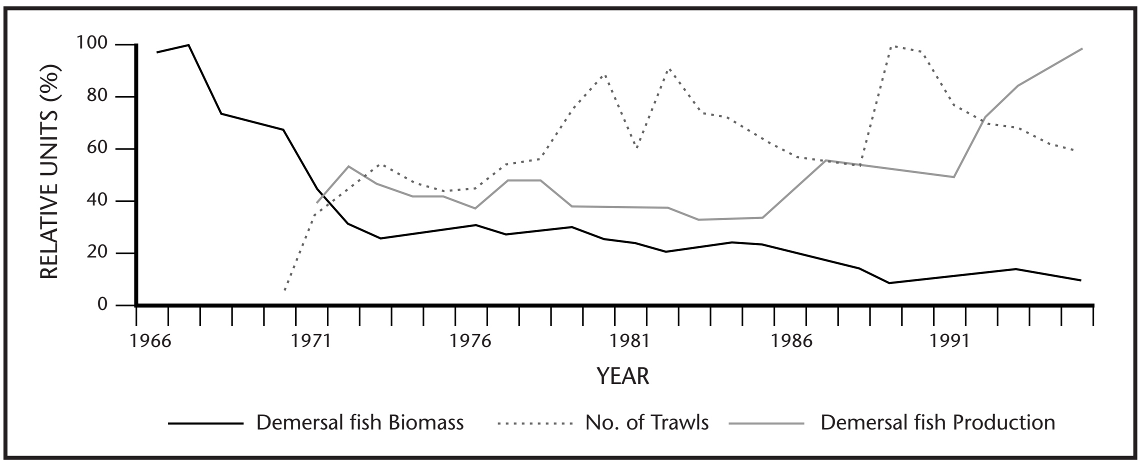

Fig. 6. Relative indices of demersal fish biomass, demersal fish production and number of trawlers in the Gulf of Thailand, 1966 - 95.

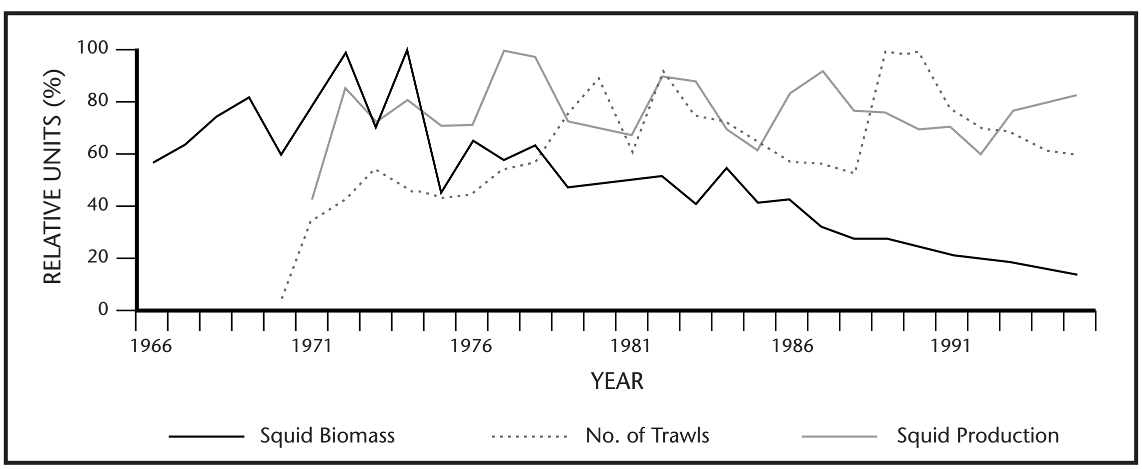

Fig. 7. Relative indices of squid biomass, squid production and number of trawlers in the Gulf of Thailand, 1966 - 95.

Table 1. The change over time of 10 leading species composition caught by RV in the Gulf of Thailand (Source: Supongpan 2001)

Species	1966 %	Species	1976 %	Species	1986 %	Species	1995 %
Dasyatidae (Rays)	8.15	*Loligo duvauceli*	10.60	*Loligo duvauceli*	10.06	*Leiognathus splendens*	13.06
Nemipterus hexodon	7.39	*Nemipterus hexodon*	5.84	*Priacanthus tayenus*	8.61	*Loligo duvauceli*	9.04
Mullidae	4.97	*Loligo chinensis*	3.83	*Saurida undosquamis*	4.14	*Sphyraena obtusata*	6.96
Nemipterus mesoprion	4.67	*Priacanthus tayenus*	3.80	*Loligo chinensis*	3.59	*Secutor spp.*	5.30
Loligo duvauceli	4.39	*Nemipterus mesoprion*	3.69	*Nemipterus hexodon*	3.48	*Scolopsis taeniopterus*	5.19
Tachysuridae	2.84	*Trichiuridae Lepturus*	3.31	*Priacanthus macracanthus*	2.99	*Saurida undosquamis*	3.96
Priacanthus tayenus	2.54	*Saurida undosquamis*	2.82	*Nemipterus mesoprion*	2.19	Mullidae	3.80
Saurida undosquamis	2.44	Mullidae	2.74	*Scolopsis taeniopterus*	2.05	Siganidae	3.05
Lutjanus lineolatus	1.84	*Loligo sumstrensis*	2.00	Mullidae	1.95	*Loligo chinensis*	3.00
Atule mate	1.73	Gerreidae	1.98	*Loligo sumstrensis*	1.88	*Leiognathus bindus*	2.68

the same period. Dasyatidae (rays) were most abundant 1966 trawl survey catches but has disappeared from the top ten in the more recent years, and in 1995, the most abundant species were the pony fishes. These trends are consistent with documented species composition changes due to effects of overfishing in other fishing areas in Southeast Asia (Silvestre 1990; Silvestre et al. 1995)

Population Parameters and Exploitation Rates

Table 2 gives a summary of the population parameters for the 23 species included in the study. Parameters for nine of the species were estimated using the FiSAT software and length distribution data from trawl surveys between 1980 and 1989. Parameters for the 14 other species were obtained from previous studies conducted in the Gulf of Thailand. The 23 species together accounted for about 30% of the total trawlable biomass and about 50% of 'good fish' biomass (pelagic fish, demersal fish and invertebrates combined minus trash fish) during the 1995 trawl survey. The species exhibit relatively high rates of growth (K = 0.46 - 3.72) and natural mortality (M = 1.09 - 4.67).

Table 3 gives the annual exploitation rate (E) calculated for the 23 species from 1971 to 1995. E values for some species were only available for a few years (e.g. *Megalaspis cordyla, Loligo chinensis* and *Epinephelus sexfasciatus* during the years 1988 - 95). Pelagic fishes like *Scolopsis taeniopterus* and *Megalaspis cordyla*, which are not fully vulne-rable to trawl gear, had relatively low E values for most of the period considered. The E values for the rest of the species were initially low, but had increased to very high E values (0.79 - 0.98) by 1995. Some demersal species, particularly *Priacanthus tayenus, Saurida elongata, Saurida undosqamis, Nemipterus hexodon* and *Nemipterus peronii*, had E values close to the 0.9 level. The exploitation rates and biomass declines noted above indicate that the fishery resources, particularly the demersals, were over-exploited.

Fishing Effort and Yield

Estimates of total production in the Gulf of Thailand from 1971 to 1996 are given in Table 4. From 1971 to 1984, the production statistics did not include the contribution of smallscale fishing gear (fish gillnets, mackerel gillnets, squid light luring fishing gear, shrimp gillnet, squid trap, crab gillnets and fish trap). Only statistics on the production of 11 important types of gear were available. To estimate total production for 1971 - 84, the production of the 11 important gear was adjusted by 15%, the average difference representing small scale production for the period 1985 - 93.

The time series of production (yield) and fishing effort (expressed in trawling hours) from 1971 to 1995 were used to estimate MSY and f_{MSY}. The

Table 2. Population parameters of 23 marine species in the Gulf of Thailand. Where the source is this study, the years in brackets refer to the data from those years. Parameters are defined in the methods section.

Species	a	b	L_∞ (cm)	W_∞ (g)	K (yr^{-1})	$L_{25\%}$ (cm)	$L_{50\%}$ (cm)	$L_{75\%}$ (cm)	M (yr^{-1})	References
Rastrelliger brachysoma	0.006	3.21	22.0	113	3.72				4.67	Demersal Fish Working Group (DFWG) 1995
Rastrelliger kanagurta			28.0		1.30				2.19	This study (1988, 1989)
Scomberomorus commerson	0.013	2.88	110.0	10046	1.19				1.41	Cheunpan (1988)
Selar crumenopthalmus	0.171	2.90	28.4	281	2.40				3.26	Isara (1993)
Atule mate			31.0		1.40	10.6	12.4	14.2	2.24	This study (1980)
*Megalaspis cordyla**	0.014	2.98	28.8	320	2.40				3.25	Noopeth and Podapol (1983)
Selaroides leptolepis	0.004	3.31	19.2	76	1.54				2.72	Noopeth (1984)
Scolopsis taeniopterus	0.027	2.76	31.0		1.04	8.1	9.6	11.0	1.84	This study (1989)
Saurida undosqamis	0.004	3.18	40.6		1.80				2.45	Boonvanich (1991)
Saurida elongata	0.007	3.05	46.1		1.94				2.48	Boonvanich (1991)
Trichiurus lepturus			95.5		1.18				1.46	Dhamniyom (1993)
Lutjanus lineolatus			23.0		1.50	4.1	4.7	5.3	2.55	This study (1988) Demersal Fish Working Group (DFWG) 1995
Priacanthus tayenus	0.018	2.95	31.0		1.90				2.73	Isara (1991) Demersal Fish Working Group (DFWG) 1995
Nemipterus hexodon	0.018	2.91	31.8		1.74				2.56	Isara (1991)
	0.002(T)	2.93(T)	19.5							
Nemipterus mesoprion	0.078(E)	3.10(E)	15.5		0.97				2.00	Isara (1991)
Nemipterus nematophorus			27.0		0.57	5.1	5.4	5.7	1.29	This study (1988)
	0.012(T)	2.99(T)								
Nemipterus peronii	0.020(E)	3.00(E)	31.0		1.60	7.1	8.5	9.9	2.44	This study (1989)
Epinephelus sexfasciatus			33.0		0.48	6.0	7.2	8.4	1.09	This study (1988)
Loligo duvauceli	0.374	2.00	26.6	266	0.86				1.70	Supongpan (1988)
Loligo chinensis	0.421	2.00	40.9	704	0.46				1.00	Supongpan (1988)
Sepia recurvirostra			15.0		1.2	5.9	6.9	7.8	2.48	This study (1988)
Sepia aculenta			21.0		1.3	5.2	5.9	6.7	2.38	This study (1988)
Portunus pelagicus	< 0.001	3.48	23.0		2.84				3.87	Bannasopit et al. (1980)

Note: * *Megalaspis cordyla;* L_∞ is in fork length.

Table 3. Estimate of exploitation ratio for 23 species in the Gulf of Thailand during the period 1971 - 95.

Species	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1991	1993	1994	1995
Atul mate	0.14	0.29	0.42	0.18	0.39	0.47	0.32	0.34	0.34	0.35	0.53	0.48	0.44	0.48	0.54	0.52	0.55	0.72	0.73	0.74		0.93	0.83
Epinephelus sexfasciatus												0.23	0.21	0.26	0.42	0.47	0.70	0.65	0.81	0.76	0.91	0.98	0.96
Loligo chinensis	0.37	0.48	0.53	0.47	0.63	0.54	0.65	0.63	0.62	0.61	0.59	0.65	0.70	0.58	0.61	0.68	0.76	0.75	0.75	0.78	0.81	0.94	0.87
Loligo duvauceli	0.26	0.35	0.40	0.34	0.50	0.41	0.52	0.50	0.49	0.48	0.46	0.53	0.57	0.45	0.48	0.56	0.65	0.64	0.64	0.67	0.73	0.92	0.79
Lutanus lineolatus	0.30	0.53	0.40	0.47	0.48	0.32	0.44	0.53	0.38	0.51	0.49	0.32	0.33	0.17	0.35	0.44	0.49	0.46	0.68	0.81	0.91	0.92	0.86
Megalaspis cordyla					0.07	0.09	0.04	0.10	0.09	0.13	0.19	0.21	0.17	0.03	0.08	0.19	0.23	0.32	0.39	0.31	0.64	0.98	0.39
Nemipterus nematophorus	0.31	0.52	0.56	0.58	0.43	0.39	0.46	0.56	0.48	0.44	0.50	0.54	0.53	0.47	0.57	0.72	0.80	0.75	0.89	0.90	0.94		0.98
Nemipterus hexodon	0.18	0.34	0.40	0.40	0.28	0.25	0.30	0.39	0.31	0.29	0.33	0.37	0.36	0.31	0.40	0.56	0.65	0.61	0.82	0.84	0.88	0.77	0.97
Nemipterus mesoprion	0.22	0.40	0.46	0.46	0.33	0.30	0.35	0.45	0.37	0.35	0.38	0.43	0.42	0.37	0.46	0.62	0.71	0.67	0.86	0.87	0.93	0.81	0.96
Nemipterus peronii	0.19	0.35	0.41	0.41	0.29	0.26	0.31	0.41	0.32	0.30	0.34	0.38	0.37	0.32	0.40	0.57	0.65	0.63	0.83	0.84	0.95	0.75	0.92
Portunus pelagicus	0.57	0.49	0.71	0.68	0.71	0.76	0.80	0.77	0.58	0.63	0.71	0.82	0.79	0.79	0.78	0.76	0.87	0.81	0.80	0.83	0.78	0.69	0.85
Priacanthus tayenus	0.19	0.47	0.35	0.20	0.43	0.30	0.46	0.33	0.15	0.23	0.20	0.26	0.24	0.24	0.21	0.31	0.50	0.52	0.61	0.63	0.82	0.81	0.95
Rastrelliger brachysoma	0.63	0.84	0.81	0.90	0.89	0.85	0.85	0.78	0.58	0.80	0.80	0.71	0.77	0.84	0.79	0.80	0.86	0.74	0.96	0.95	0.72	0.77	0.95
Rastrelliger kanagurta		0.54	0.66	0.75	0.61	0.49	0.52	0.58	0.53	0.58	0.60	0.52	0.61	0.49	0.50	0.57	0.62	0.81	0.90	0.92	0.75	0.95	0.94
Saurida elongata	0.31	0.38	0.45	0.37	0.45	0.31	0.34	0.37	0.32	0.28	0.28	0.27	0.31	0.26	0.24	0.38	0.53	0.55	0.63	0.58	0.73	0.70	0.87
Saurida undosquamis	0.31	0.38	0.46	0.37	0.46	0.31	0.34	0.37	0.33	0.28	0.28	0.27	0.32	0.27	0.24	0.38	0.53	0.56	0.64	0.59	0.72	0.79	0.89
Scolopsis taeniopterus	0.26	0.30	0.39	0.42	0.40	0.38	0.43	0.02	0.14	0.06	0.06	0.12	0.02	0.08	0.03	0.05	0.19	0.20	0.17	0.09	0.02		0.02
Scomberomorus commerson					0.62	0.71	0.78	0.75	0.67	0.68	0.82	0.69	0.79	0.81	0.74	0.84	0.83	0.87	0.85	0.75	0.77	0.95	0.87
Selar crumenopthalmus												0.09	0.17	0.02		0.06	0.39	0.72	0.77	0.72	0.37	0.97	0.89
Selaroides leptolepis	0.12	0.25	0.38	0.16	0.35	0.42	0.28	0.30	0.30	0.31	0.49	0.44	0.40	0.45	0.50	0.47	0.50	0.69	0.68	0.72		0.31	0.80
Sepia aculenta	0.41	0.50	0.59	0.46	0.58	0.56	0.64	0.64	0.61	0.64	0.66	0.83	0.86	0.87	0.84	0.89	0.88	0.87	0.94	0.96	0.91	0.88	0.94
Sepia recurvirostra	0.40	0.49	0.58	0.45	0.57	0.55	0.63	0.63	0.61	0.64	0.65	0.82	0.85	0.87	0.83	0.89	0.88	0.87	0.94	0.96	0.93	0.96	0.91
Trichiurus lepturus	0.44	0.43	0.49	0.56	0.3	0.41	0.58	0.62	0.35	0.74	0.82	0.59	0.51	0.56	0.57	0.59	0.38	0.83	0.79	0.73	0.65	0.96	0.95

Table 4. Estimate of total production (t) of fisheries resources in the Gulf of Thailand during the period 1971 - 96. The 11 important gear types are: otter board trawl, pair trawl, beam trawl, push net, three purse seines (Light luring, Thai, Green), anchovy purse seine, mackerel encircling gillnet, king mackerel gillnet, bamboo stake trap.

Year	Total production (t) *	Production of 11 Important gear types (t)**
1971	(654 292)	568 950
1972	(1 056 089)	918 339
1973	(1 218 594)	1 059 647
1974	(1 177 448)	1 023 868
1975	(1 194 858)	1 039 007
1976	(1 296 552)	1 127 437
1977	(1 782 937)	1 550 380
1978	(1 698 755)	1 477 179
1979	(1 488 949)	1 294 739
1980	(1 448 611)	1 259 662
1981	(1 498 983)	1 303 464
1982	(1 574 134)	1 368 813
1983	(1 632 510)	1 419 574
1984	(1 567 496)	1 363 040
1985	1 744 683	1 426 789
1986	1 951 404	1 638 495
1987	2 174 942	1 800 560
1988	2 001 645	1 690 483
1989	1 963 657	1 696 719
1990	1 923 433	1 671 565
1991	1 820 687	1 559 808
1992	2 082 528	1 759 824
1993	1 929 672	1 724 251
1994	1 996 542	
1995	2 318 053	
1996	1 903 555	

Note: * Data for 1971 - 84 were estimated by adding 15% (average from 1985 - 93) to the production of the 11 important gear types.

estimates were made for all types of fish (total production including pelagics), trash fish, pelagic fish and various demersal groupings. Table 5 gives a summary of the estimates derived in this study together with the results obtained by other studies for comparison purposes. Figs. 8 to 10 illustrate the trend of yield and effort for total (all fishes and invertebrates), trash fish, and demersal plus trash fish group in the Gulf of Thailand. The results indicate that the 1995 level of fishing effort is about twice the effort necessary to harvest MSY, and indicate that the demersal and other fishery resources are severely over-fished.

It is noted that the MSY and f_{MSY} estimates from other works are different from those given in this study. This is due to a number of reasons, namely: (1) the use of production data only for the 11 important types of fishing gear, thus excluding the smallscale fisheries production; (2) differences in the definition of demersal groups; (3) the use of a longer time series in this study compared to previous works; and (4) the use of research vessel as fishing effort standard in this study compared to commercial boat categories as standard. However, the trends noted by this and other studies, as well as conclusions that the resources are over-fished, are consistent.

Conclusion

Numerous studies have been conducted and regulations have been issued to help resolve the problem of resource over-exploitation and conflicts among fishers in the Gulf of Thailand. The 3rd National Seminar organized by the Department of Fisheries, Fisheries Society of Thailand and Fish Marketing Organization was held in April 1999 specifically to find out the needs of the fishers and how to improve management of the marine resources (Department of Fisheries (DOF) 1999). Trawl fishing was one of the main topics and recommendations were made to enforce a ban on push nets and enlarge the cod-end mesh size of shrimp and fish trawls (to 2.5 cm and 3.0 cm, respectively). The present study clearly shows that the demersal and other fishery resources in the Gulf are severely over-fished. Reduction of excess fishing capacity, particularly in the trawl fisheries, requires urgent management attention.

Table 5. Summary of MSY and f_{MSY} estimates for the Gulf of Thailand.

Group	MSY (t)	f_{MSY}* (x 10^6 hr)	Years	References
Total (All species groups and all gear; including smallscale fisheries)	2 159 049	64.25	1971 - 95	Fox Model (This study)
Trash fish (including small scale fisheries)	818 722	61.76	1971 - 95	Fox Model (This study)
Pelagic fish (including smallscale fisheries)	624 318	295.55	1971 - 95	Fox Model (This study)
Demersal fish (All gear, including small scale fisheries)	196 953	19.99	1971 - 95	Fox Model (This study)
Demersal fish (11 major gear**, excluding small scale fisheries)	136 300	10.1	1971 - 91	Demersal Fish Working Group (DFWG) 1995
Demersal group (Demersal fish and trashfish combined; including small scale fisheries)	970 905	35.65	1971 - 95	Fox Model (This study)
	944 632	23.3***	1973 - 97	Fox Model (Boonchuwong and Dechboon this vol.)
	1 036 428	23.9***	1973 - 97	Schaefer model FAO (2001)
Demersal group (Demersal fish, trash fish and invertebrates combined; excluding small scale fisheries)	884 202	28.6	1972 - 89	Fox Model Boonvanich (1993)

Note: * refers to standard research vessel units unless specified otherwise.
**** refers to otter board trawl, pair trawl, beam trawl, push net, three purse seines (Light luring, Thai, Green), anchovy purse seine, mackerel encircling gillnet, king mackerel gillnet, bamboo stake trap.**
***** refers to standard commercial boat units.**

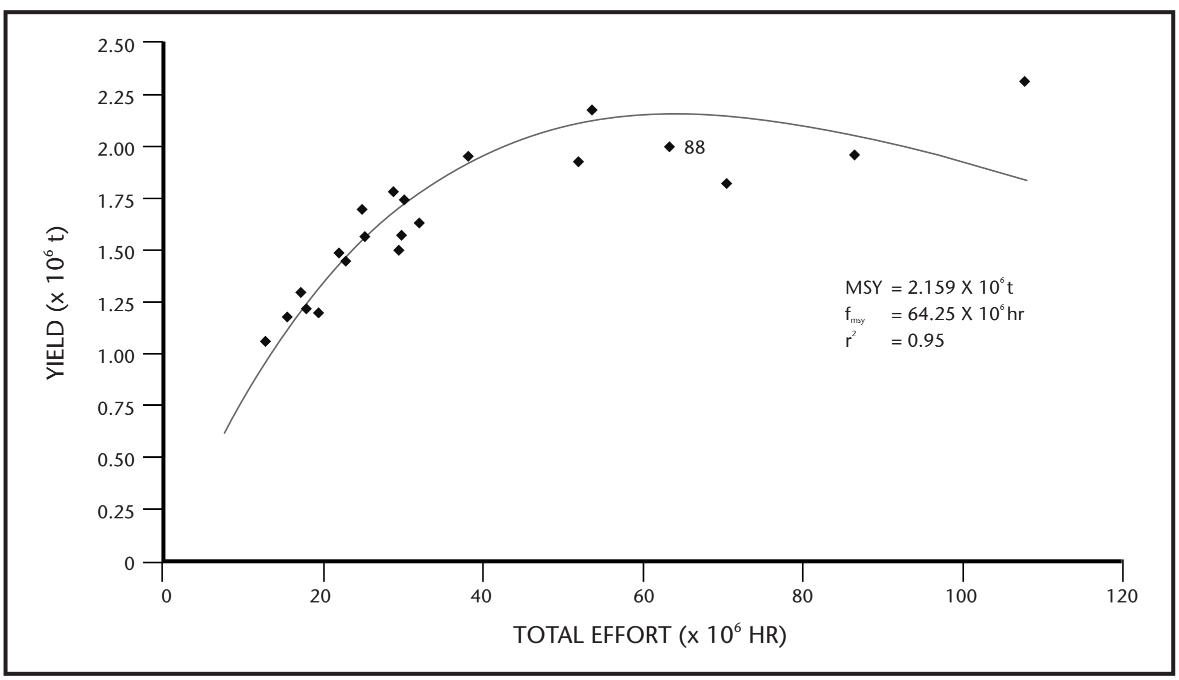

Fig. 8. Total yield and fishing effort in the Gulf of Thailand fisheries.

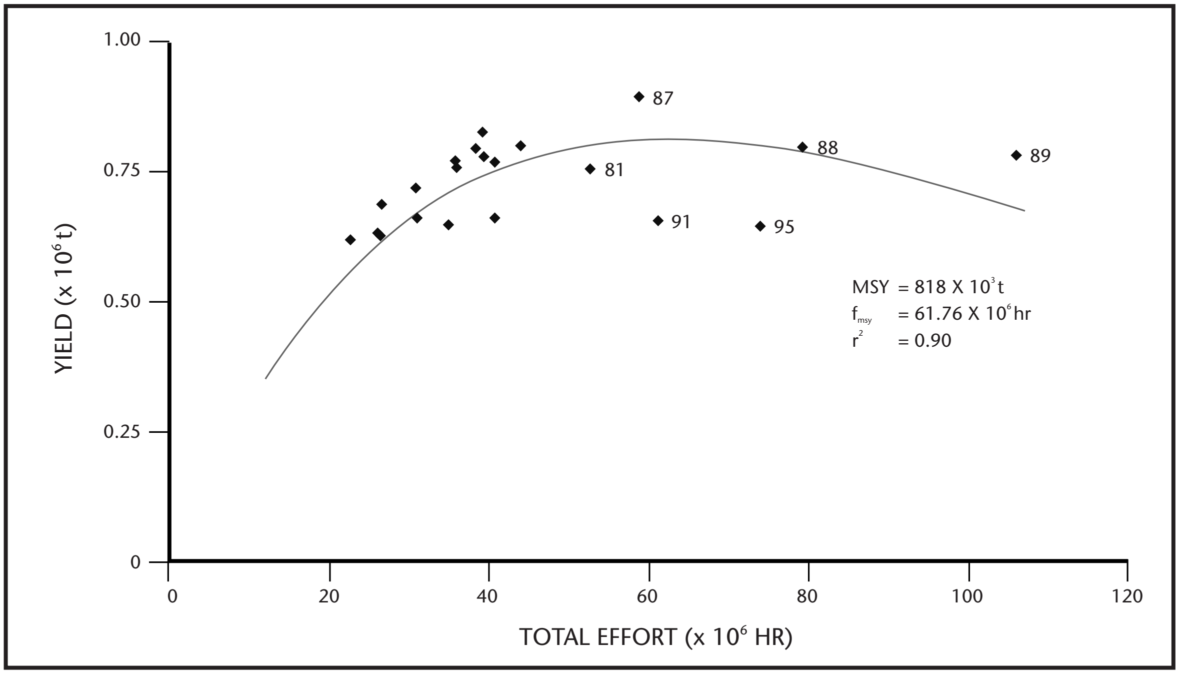

Fig. 9. Trash fish yield and effort in the Gulf of Thailand.

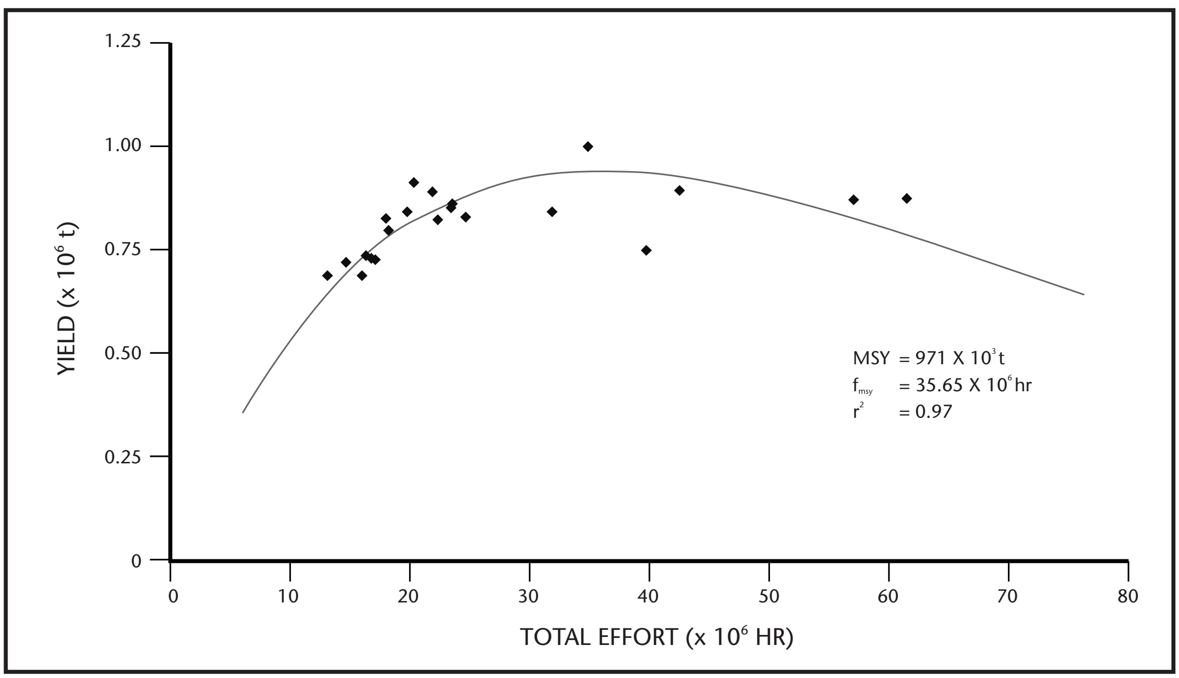

Fig. 10. Demersal fish plus trash fish yield and fishing effort in tbe Gulf of Thailand.

It is known that trash fish production figures taken from the statistical records emanate from both demersal and pelagic fishing gear. Their actual proportions, however, have not been established. This requires research attention in the effort to reduce capacity and improve management of the resources.

The excess demersal fishing effort is estimated to be about 50% of the number of registered boats in 1995. The excess number of fishing boats totals 2 506 units, which can be broken down into 1 024 medium otter board trawlers, 1 309 large otter board trawlers, 1 081 pair trawlers, and 167 push nets. The excess fishing effort should be eliminated from the fishery and new entrants effectively banned.

A ban on push nets would lower excess fishing effort by about 3%. A ban on both push nets and pair trawlers would result in the lowering of excess fishing effort by about 22%. The reduction of pair trawls and push nets should receive first priority as they operate near-shore and catch valuable small sized fish that only goes into fish meal factories. They also sometimes operate within 3 km from the coast which is illegal.

Other suggestions to improve management of the demersal resources include:

1. Studies to examine the appropriate cod-end mesh size for both fish and shrimp trawls, including examination of the economic loss (or gain) for affected fishers.

2. The areas within 3 km from the coast in the Gulf of Thailand and Andaman Sea are protected areas, to protect nursery grounds for fish eggs, larvae and juvenile fishes. The existing protected area should be enlarged to 3 nm and the enforcement of fishery laws must be strengthened.

3. Studies should be conducted into alternative fishery-related activities for those who will be affected by (proposed) management measures and regulations.

4. Financial assistance must be provided for fishers who want to change to non-destructive fishing gear/practices like fish gillnet, as well as for those who are willing to go into other forms of livelihood.

5. In places where communities are already organized, community-based fisheries co-management programs must be established so that the local fishers can take care of their own resources.

6. Awareness and education programs should be established and sustained over the long term.

7. Government service officers should exert every effort to make fishers appreciate the importance of responsible fishing.

Acknowledgements

The authors thank ADB and ICLARM/WorldFish for funding support (through the ADB-RETA 5766 project) during the course of this study. Thanks are also due Geronimo Silvestre and Francisco Torres Jr. for their useful suggestions during the preparation of this paper.

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