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Decline of demersal coastal fisheries resources in three developing Asian countries

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Abstract

Worldwide, there is serious concern about the state of fisheries; yet for Asia, which accounts for half of the global fisheries production, information on the state of fisheries in order to guide management is sparse. In this paper we review the results of a regional study that examined the state of demersal fisheries resources in the coastal areas of Malaysia, the Philippines and Thailand. In each country time series of scientific trawl survey data (spanning 12–49 years, depending on the area) were used to assess changes in the total biomass of demersal species over time. All countries showed substantial declines in the total biomass. In Malaysia, the declines were greatest in the shallow depths (<50 m) where the biomass declined to 4–20% of the original estimates. In the Gulf of Thailand, by 1995 the total biomass estimates had declined to less than 8% of the 1965 estimates. In the Philippines, changes in the biomass were examined in different bays and fishing areas and the recent estimates of the biomass were 12–64% of the original estimates.

These severe declines in the total biomass are thought to be due to over-fishing, compounded by environmental degradation. While over-fishing has been previously documented for selected species or fisheries in these countries, the fishery-independent data analysed here provide the first multi-country evidence of the widespread degradation of demersal coastal resources. Exploitation ratios (fishing mortality:total mortality), calculated from length frequency data, were on average >0.5, suggesting over-fishing. In Thailand a time series of exploitation ratios for 17 species showed increasing fishing pressure over time. Environmental degradation, in terms of changes in water quality and habitat modification and loss, has been documented in all countries and this is likely to be a contributing factor for the declines.

The serious declines observed in these three countries are illustrative of a regional trend and highlight the urgent need for countries to reduce and manage their fishing capacity. This regional study also identified a requirement for key interventions, such as strengthening licensing systems, limiting entry to fisheries and increasing gear selectivity. It also highlighted the fact that the strategies developed must take into account the context of the developing countries and the broader socioeconomic role of fisheries.

Keywords: Asian fisheries; Exploitation ratios; Demersal fisheries resources; Fisheries biomass declines; Over-fishing

1. Introduction

Worldwide, there is increasing awareness and concern regarding the state of fisheries resources. This concern is due to the levelling off or possible decrease in the total fisheries landings since the 1980s (Watson and Pauly, 2001), the public collapse of major fisheries (e.g. North Atlantic cod; Myers et al., 1996, 1997), the depleted state of many fisheries (FAO, 2002) and the broader ecological changes that have been observed (e.g. changes in the structure of kelp forest and coral reef systems; Jackson et al., 2001). For marine fisheries where assessments are available, FAO estimates that 75% are fully exploited, overexploited, severely depleted or in recovery (FAO, 2002). Most of the examples documented

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in the international scientific literature, regarding the depleted state of fisheries and the urgent need for action, originate from developed countries (e.g. Myers et al., 1996; Cook et al., 1997). This bias is probably driven by numerous factors, particularly the availability and quality of data. Developed countries in general have more robust fishery statistics, longer historical time series and greater research effort focused on evaluating the state of their fisheries. While assessments of fisheries in developing countries have been undertaken, they are often published in "grey literature" and so not widely available.

An exception, however, is the case of the Gulf of Thailand, which is one of the most well-documented examples of fisheries depletion. The Gulf of Thailand has been fished heavily since the introduction of industrial trawling in the 1960s, and the resulting depletion of fish stocks by the 1980s and the "fishing down the food web" phenomenon have been documented (e.g. Ritragsa, 1976; Pauly, 1979; Beddington and May, 1982; Chanprasertporn and Lamsa-ard, 1987; Phasuk, 1987; Christensen, 1998). The state of fisheries resources in select areas in the Philippines has also been documented (e.g. Pauly and Mines, 1982; Silvestre and Pauly, 1987). In general, information on the state of fisheries resources in developing countries is limited and not widely available, even though the need to understand the state of fisheries resources and implement effective governance and management is arguably more critical in developing countries.

Developing countries rely heavily on fish and fisheries, particularly in the poorer sections of their population. Fisheries contribute significantly to developing countries at the national and local levels. Since 1973, the global production from fisheries has increased from 44 to over 82 million tonnes by 2001 (FAO, 2002). Since the 1980s, developing countries have led in capture fisheries production and they now contribute over 65%. Fish are a major agricultural commodity for many developing countries; global fish trade currently earns developing countries an estimated US$ 18 billion annually (Delgado et al., 2003). These export earnings can contribute to lowering international debt and paying for rising food import bills (Kurien, 2004).

Fisheries are an important source of income and means of livelihood in developing countries, particularly in rural areas. It is estimated that capture fisheries employ over 27 million people worldwide, of which 85% live in Asia (FAO, 2002). Small-scale fisheries and related industries are estimated to provide an income to 22 million people living on < US$ 1 per day (FAO, 2002). The open access nature of many fisheries also means that they can act as a "safety net" for the landless poor or when other sources of income fail (Bene, 2003).

Fish also play an important role in food security and nutrition in developing countries. In 1997 people in developing countries consumed 69% of the global fish production, compared to only 45% in 1973 (Delgado et al., 2003). Their consumption is projected to continue to increase with growing population and development (Delgado et al., 2003). Fish are a vital source of animal protein in many developing countries. In countries, such as the Philippines and Malaysia, over 60% of the animal protein comes from fish (Barut et al., 2003; Abu Talib et al., 2003b). However, with rising prices, fish are potentially becoming less available to the poor (Ahmed et al., 1999; Delgado et al., 2003).

Given the importance of fish resources to developing countries and particularly to poor communities, it is imperative that they are managed for sustainability. A key to this is to have an understanding of the state of fisheries resources. However, this is often difficult due to the nature of the fisheries. In developing countries, fisheries are predominantly of a tropical and multi-species nature. They are exploited by numerous gear types, often in both a small-scale (traditional, artisanal or subsistence) sector and a large-scale or industrialized sector (Silvestre and Pauly, 1987; Charles, 2001). The species caught often overlap between gears and sectors. In some cases the same species may be targetted at multiple life history stages by different sectors, e.g. shrimp in many countries are targetted as juveniles by stake nets and push nets while the adults are targetted offshore by trawlers. Developing country fisheries also tend to have numerous and scattered landing sites, as well as complex and variable market chains. These characteristics limit the collection of robust data from fisheries, particularly on fishing effort, landings and catch composition. While many countries collect and publish fisheries statistics, their accuracy varies considerably (e.g. China; Watson and Pauly, 2001).

Given this situation, Pauly (1996) highlighted the potential of historical scientific trawl survey data to assess the status of coastal demersal fisheries resources. In some developing countries, research surveys, primarily trawling, have been carried out since the early 1900s. These fishery-independent data provide a measure of the resource status and a historical baseline for establishing restoration targets. A key reason why the state of fisheries in the Gulf of Thailand is widely known is that Thailand has conducted annual scientific surveys of the demersal resources since the 1960s (see Garces et al., this issue, pp. 143–157).

This paper reviews a regional project in which, for the first time, Asian countries used similar approaches to collate and analyse their scientific trawl survey data to provide a fishery-independent assessment of the state of coastal demersal resources. We review the results from Malaysia (Abu Talib et al., 2003a), the Philippines (Barut et al., 2003) and Thailand (Krongprom et al., 2003). The analysis provides critical information on the degraded nature of coastal fisheries resources and documents serious over-fishing and declines in biomass. Environmental degradation in the coastal areas may also have contributed to these declines. The results have strong implications for fisheries management and highlight the urgent need for action to reduce fishing effort and restore coastal fish stocks.

2. Methods

The analyses to assess the state of the coastal demersal resources in Malaysia, Philippines and Thailand were based on compiled time series of scientific trawl survey data. The quantity of data available and period of time covered varied between countries (see Garces et al., this issue, pp. 143–157). In the Philippines, where access to some of the original survey data was not possible, the results of the analyses undertaken within this project were compared to the outputs of previous published analyses. We present a summary of the analytical approach and selected results here. Full details can be found in Krongprom et al. (2003), Abu Talib et al. (2003a) and Barut et al. (2003).

2.1. Research survey data

All survey data analysed were first compiled and stored in the Fisheries Resources Information System and Tools (FiRST) software (Garces et al., this issue, pp. 119–129). In general, the research trawl surveys were originally conducted to explore the distribution and potential of fisheries resources. In all cases the areas surveyed by the research vessel cover the commercial fishing areas. The data in each country consist of several surveys conducted in different years. The data are geo-referenced, with latitude and longitude for each station at which a trawl haul was conducted. For each station the key data recorded include: total weight by taxa (usually species, but often by a higher taxonomic grouping in older surveys), water depth, trawl duration (generally 0.5–1 h), trawl speed, and net and vessel characteristics.

2.1.1. Malaysia

Abu Talib et al. (2003a) analysed research survey data from selected years between 1971 and 1998 (Table 1). Malaysian waters are generally separated into four areas, west coast of peninsular Malaysia, east coast of peninsular Malaysia, Sarawak and Sabah (Fig. 1). We discuss the results from peninsular Malaysia and Sarawak, as the sampling of Sabah was very restricted. Each area is then further divided into sub-areas for management and reporting purposes: two sub-areas in west coast peninsular Malaysia, four sub-areas in east coast peninsular Malaysia and three in Sarawak. The sampling covered depths of 18–185 m. Six research vessels were used to conduct the surveys using two sampling designs, stratified random sampling for coastal surveys (18–60 m depth) and systematic random sampling for offshore surveys (18–185 m depth). All surveys, with the exception of the offshore surveys in 1986 and 1987, were conducted with standard German otter-trawl nets with head-rope lengths of 22.4–47.4 m and cod-end mesh size of 38 or 40 mm. The 1986 offshore survey on the east coast of peninsular Malaysia and Sarawak and the 1987 offshore survey on the west coast of peninsular Malaysia used high-lift Engle balloon trawl nets with a head-rope length of 71.9 m and cod-end mesh size of 50 mm. The analyses were stratified by sub-area and depth zone (18–55, 56–91, >91 m). Pelagic species were excluded from the analysis, since they are not properly sampled by the demersal gear.

2.1.2. Thailand

Krongprom et al. (2003) analysed research survey data from 1963 to 1995 (Table 1). The sampling covers the Gulf of Thailand waters from 10 to 50 m depth (Fig. 1). The Gulf

Table 1
The geographic and temporal coverage of the research trawl surveys analysed in each country

Country	Region	Area (km^2)	Depth range (m)	Survey period	References
Malaysia	West coast peninsular Malaysia	27944	18–91	1971, 1981, 1991, 1997	Abu Talib et al. (2003a,b)
	East coast peninsular Malaysia	123366	18–91	1967, 1972, 1981, 1986, 1991, 1998	
	Sarawak	116023	18–185	1972, 1981, 1986, 1993, 1998	
Philippines	San Miguel Bay	1115	2–20	1947, 1980–1981, 1992–1993, 1995–1996	Warfel and Manacop (1950), Vakily (1982), Cinco et al. (1995), Soliman and Dioneda (1997), Barut et al. (2003)
	Carigara Bay	512	5–50	1979–1980, 1995–1996	Aramada and Silvestre (1981), Pura et al. (1996), Barut et al. (2003)
	Manila Bay	1782	10–50	1949–1952, 1992–1993	Warfel and Manacop (1950), MADECOR (1995), Barut et al. (2003)
	Sorsogon Bay	256	4–9	1972, 1994–1995	Ordoñez et al. (1972), Cinco and Perez (1996), Barut et al. (2003)
	Lingayen Gulf	2085	5–50	1949, 1979, 1987–1988	Ochavillo et al. (1989), Silvestre et al. (2003)
Thailand	Gulf of Thailand	101384	10–50	1973–1995	Krongprom et al. (2003)

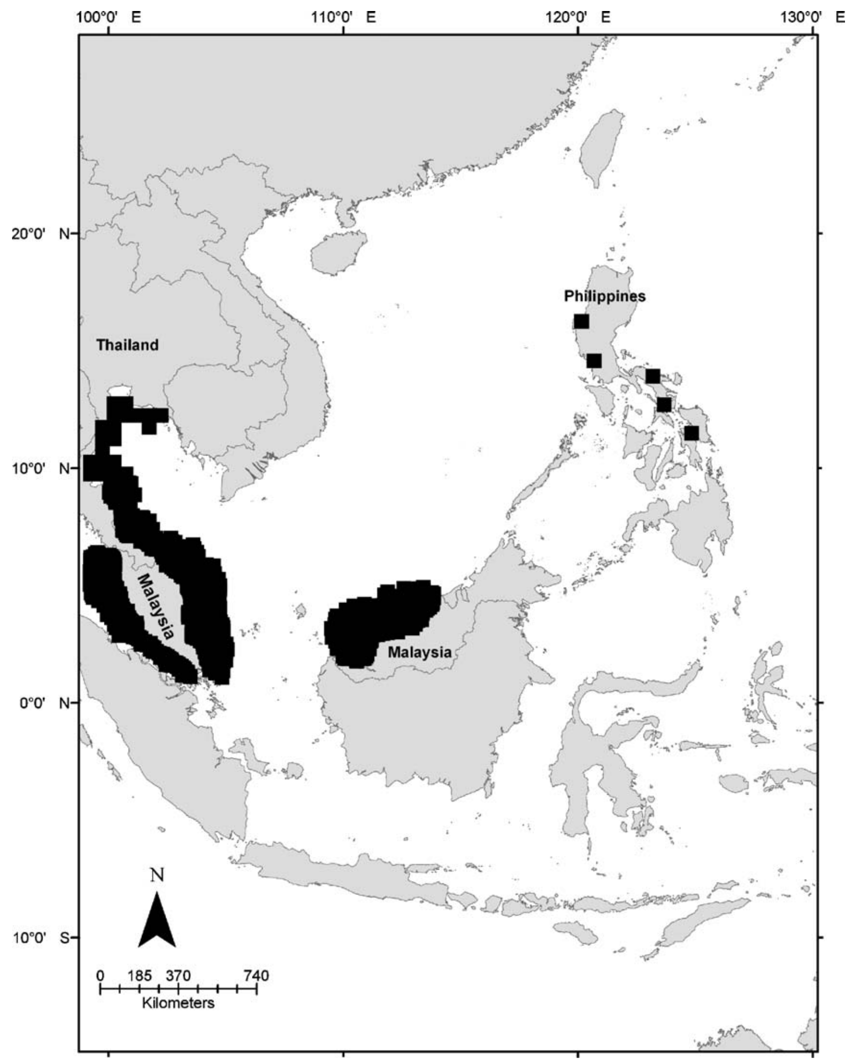

Fig. 1. The areas covered by the research surveys and biomass analyses in Malaysia, the Philippines and Thailand.

of Thailand is divided into nine areas for reporting and management purposes. Between 60 and 80 trawl surveys were conducted in each area every year. The surveys were conducted with two vessels Pramong 2, 24.5 m (LOA) and 79 GRT and Pramong 9, 25.2 m (LOA) and 85 GRT. The nets used were German otter-trawl nets with head-rope length of 39 m and mesh size of 40 mm. Surveys since 1981 have used a cod-end cover of 25 mm, to correspond to the commercial trawlers. The estimate of the total catch prior to 1981 was adjusted to match the 25 mm cod-end cover. A regression was fitted between the catch in the cod-end and the catch in the cod-end cover for the recent years when the cover was in use. The regression was then used to estimate the total catch prior to 1981.

Aside from the total biomass, Krongprom et al. (2003) also examined the trends in biomass of major groupings (demersal fish and trash fish) and for four major species groups (*Nemipterus* spp., *Priacanthus* spp., *Saurida* spp. and squids).

2.1.3. The Philippines

Barut et al. (2003) compiled information from over 40 scientific trawl surveys that were conducted in different fishing grounds of the country. A comprehensive trawl survey was conducted from 1947 to 1949 for the entire country (Warfel and Manacop, 1950) to determine the "trawlable" areas. Surveys since then have been area-specific and confined to bays, gulfs and particular fishing grounds. Barut et al. (2003) extended the analysis done by Silvestre et al. (1986), which covered data from 1947 to 1980 using data from 1981 to 1995 in selected fishing grounds (Table 1, Fig. 1).

2.2. Data analyses

The aim was to provide comparable analyses between the countries; however, there was some variation in the data available and the analyses.

2.2.1. Biomass estimates

The total biomass of all demersal species combined was based on the swept area method (Sparre and Venema, 1992), which takes into account differences in the trawl speed and net size (head-rope length) as follows:

$$B = \frac{\overline{\text{CPUE}}}{aX_1} \times A \quad (1)$$

where $\overline{\text{CPUE}}$ is the average catch per unit effort (kg h^{-1}). This was based on arithmetic means for the Philippines and Thailand while Malaysia (Abu Talib et al., 2003a) used geometric means. A = total area covered by the survey (km^2); X_1 = proportion of fish in the path of the trawl retained by it, this was assumed to be 0.5 based on the suggestion of Pauly (1980a); a = swept area of the trawl (km^2) = $tvhX_2$, where t = time spent trawling (h), v = trawling speed (km h^{-1}), h = head-rope length (km), and X_2 = effective head-rope length – assumed to be 0.5 – based on Pauly (1980b).

In cases where the cod-end mesh size varied for different surveys, e.g. Malaysia, the catch by species was standardized to a single size mesh size. The catch was scaled based on the ratio of the mesh sizes.

2.2.2. Exploitation ratios

For selected species, usually the most common in the catch, for which length frequency data were available, length frequency analysis was used to estimate growth parameters, mortalities and exploitation rates. The FiSAT software (FAO-ICLARM Stock Assessment Tools) (Gayanilo et al., 1996) was used to estimate the parameters of the von Bertalanffy growth curve, the asymptotic length (L_∞) and the growth coefficient (k) (Gayanilo and Pauly, 1997). The growth parameters were then used to estimate the total mortality (Z) using length-converted catch curves (Gayanilo and Pauly, 1997). To calculate the estimate of Z, percent samples from all or part of the length frequency data were pooled. The aim here was to simulate a steady-state population. The selection of points that were included in the estimation of Z was based on taking the points to the right of the highest point in the catch curve.

The estimate of Z was split into its fishing mortality (F) and natural mortality (M) components. The estimate for M for each species was calculated, using Pauly's (1980c) equation:

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.463 \log_{10} T$$

Subtracting the estimate of M from Z gives an estimate of fishing mortality F. The exploitation ratio (E) for each species was estimated by dividing F by Z.

Abu Talib et al. (2003a) calculated exploitation ratios for 15 species from the west coast of peninsular Malaysia, 26 species from the east coast of peninsular Malaysia and 26 species from Sarawak, using length frequency data from the 1997 and 1998 surveys. Krongprom et al. (2003) calculated annual exploitation ratios for 17 species from 1971 to 1995. The results are presented at 5-year intervals.

Estimates of exploitation ratios were also compiled from published stock assessments. Barut et al. (2003) summarized exploitation ratios from length-based stock assessments of 107 species, 273 stocks in Philippine waters, published between 1984 and 1996. A regional summary was compiled by Silvestre et al. (2003) from length-based stock assessments that had been published by Bangladesh, India, Indonesia, Malaysia, the Philippines and Sri Lanka between 1980 and 1999. Estimates of exploitation ratios for stocks were extracted from these. In cases where a species was assessed in several areas within a country, the mean value for the exploitation ratio of the stocks of that species was taken using up to four estimates within a country. In total, values for 132 species (185 stocks) were collated.

3. Results

3.1. Biomass estimates

All countries showed substantial decreases in the total catch rates and estimated total biomass over the time periods examined (12–48 years).

In Malaysia (Abu Talib et al., 2003a), the recent estimates of the total biomass show a reduction down to 4–56% of the earliest available estimates in the different areas and depth strata (Table 2). The largest reductions were seen in the shallowest depth stratum, 18–50 m. Off the west coast of peninsular Malaysia, by 1981 the total biomass in 18–55 m had declined to 46% of the 1971 estimate, and continued to decline to 11% by 1997. However, this estimate is less robust as it was based on a small number of trawls. In the 56–91 m depth the initial biomass estimate was only available from 1981, but the biomass had declined to 30% of the 1981 estimate by 1997.

Off the east coast of peninsular Malaysia, by 1991 the estimated total biomass in the 18–55 m depth stratum had declined to 32% of the 1967 estimate. The 1998 estimate suggests that the total biomass had declined even more, down to 4%, but again this was based on a small number of trawls. In the 56–91 m depth stratum, the estimated biomass in 1998 was only 9% of the 1986 estimate. In Sarawak, by the 1990s the total biomass in the 18–55 m stratum had declined to about 20% of the 1972 estimate, while the 56–91 m stratum showed a decline to 56% during the same time period. In the deepest stratum, >92 m, only found in Sarawak, the earliest data were available only from 1986 and the estimated biomass increased between 1986 and 1998.

In the Philippines (Barut et al., 2003) declines in the catch rate and estimated biomass were seen in all bays but to different extents, with recent total biomass estimates at 10–64% of the earlier total biomass estimates (Table 3). The bays, for which estimates were available from 1947 to 1948,

Table 2
The mean catch rate of demersal fish by depth and year, within each area from the scientific trawl surveys in Malaysian waters, along with the estimated densities and biomass

Areas	Depth stratum	Area (km^2)	Year	Stations (*n*)	Catch rate ($kg\,h^{-1}$)		Density ($t\,km^{-2}$)		Biomass (t)	%
					Mean	S.E.	Mean	S.E.		
WCPM	1	11244	1971	97	70.84	0.28	2.44	0.005	27379	100
			1981	38	58.09	0.04	1.12	0.004	12631	46
			1991	43	21.82	0.28	0.45	0.005	5060	18
			1997	8	23.85	0.66	0.27	0.007	3036	11
	2	16700	1981	28	150.75	0.51	1.30	0.005	21627	100
			1991	15	38.24	0.50	0.79	0.009	13193	61
			1997	22	33.46	0.35	0.39	0.003	6430	30
ECPM	1	49889	1967	73	238.14	0.28	5.21	0.005	259922	100
			1972	72	147.89	0.31	5.09	0.010	254060	98
			1981	40	99.17	0.40	3.42	0.012	170371	66
			1986[a]	26	204.22	0.27	1.75	0.001	52752	20
			1991	11	81.49	0.58	1.69	0.013	84063	32
			1998	7	19.91	0.69	0.23	0.009	11474	4
	2	73467	1986	13	227.63	0.43	1.96	0.003	143628	100
			1998	14	14.75	0.78	0.17	0.015	12489	9
Sarawak	1	54738	1972	101	150.54	0.02	4.52	0.003	247598	100
			1981	69	122.56	0.02	5.80	0.003	317298	128
			1986	21	169.89	0.06	1.46	0.001	79735	32
			1989/1993[b]	44	106.67	1.29	2.10	0.004	47068	19
			1998	22	88.70	0.12	1.02	0.003	55833	23
	2	38347	1972[b]	20	86.29	0.45	2.97	0.014	65132	100
			1986	36	124.39	0.06	1.07	0.002	40903	63
			1989/1993[b]	44	127.55	0.30	1.67	0.012	47062	72
			1998	31	82.93	0.04	0.95	0.001	36430	56
	3	53654	1986	44	115.63	0.08	0.99	0.002	39093	100
			1998	49	119.06	0.09	1.36	0.003	53654	137

The percentage change in biomass is also shown and the standard errors (S.E.) for the means. The depth strata are: 1 = 5 nm to 50 m, 2 = 56–91 m, and 3 = >92 m. WCPM = west coast of peninsular Malaysia; ECPM = east coast of peninsular Malaysia.
[a] Only two out of the three sub-areas were sampled.
[b] Only two out of the four sub-areas were sampled.

Table 3
The mean density of demersal fish by year, within each area from the research surveys in Philippine waters, along with the estimated biomass

Area	Year	Stations (*n*)	Mean catch rate ($kg\,h^{-1}$)	Mean density ($t\,km^2$)	Relative density (%)	Biomass (t)	Reference
All areas around the Philippines	1947–1949	157	95	7.88	100		Barut et al. (2003)
	1993–1995			1.39	17.6		
San Miguel Bay	1947	6		10.60	100	8900	Warfel and Manacop (1950)
	1980–1981			2.13	20.1	1790	Vakily (1982)
	1992–1993	56	32.3	1.96	18.5	1646	Cinco et al. (1995)
	1995–1996			1.31	12.4	1107	Soliman and Dioneda (1997)
Lingayen Gulf	1949	48		92.1	100		Ochavillo et al. (1989)
	1979			63.7	69.2		
	1987–1988	102	31.8	31.8	34.5		
Manila Bay	1949–1952	27		4.61	100	8240	Warfel and Manacop (1950)
	1992–1993		13.8	0.47	10.2	840	MADECOR (1995)
Carigara Bay	1979–1980	2		2.00	100	1624	Aramada and Silvestre (1981)
	1995–1996	40	12	1.04	52.0	533	Pura et al. (1996)
Sorsogon Bay	1972			1.87	100	477	Ordoñez et al. (1972)
	1994–1995	84	6.64	1.20	64	306	Cinco and Perez (1996)

Changes in the relative density are shown.

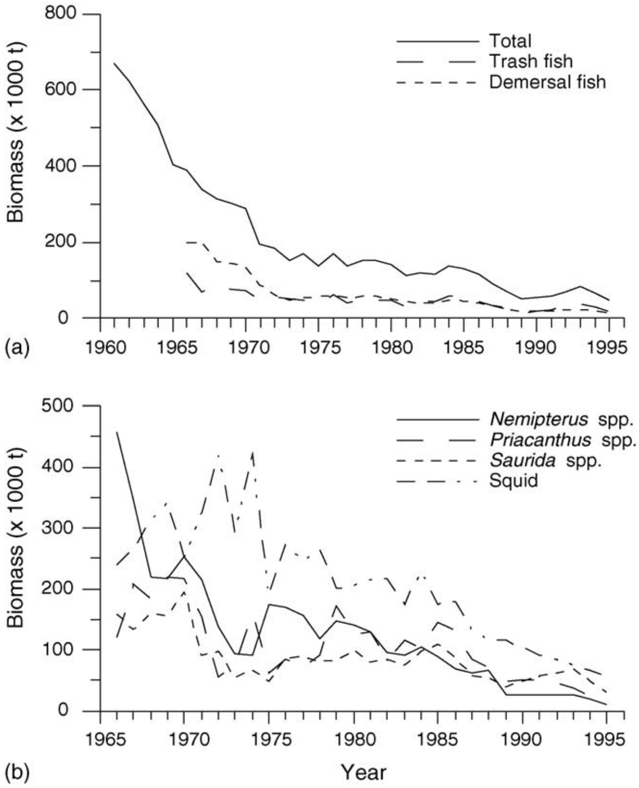

Fig. 2. The trends in estimated biomass from the scientific trawl surveys in the Gulf of Thailand: (a) total biomass, biomass of demersal commercial fish and trash fish (i.e. not of commercial value); (b) biomass of *Neimpterus* spp., *Priacanthus* spp., *Saurida* spp. and squids.

showed the greatest declines; the largest decline was seen in Manila Bay, which by 1993 was reduced to 10% of the 1947/1948 estimate. Cangara and Sorsogon Bays showed smaller declines in the catch rate and total biomass over time (down to 52% and 64% of the earlier estimates), but for these bays the earliest survey data were only available for 1979 and 1972, respectively.

Thailand (Krongprom et al., 2003) has the most comprehensive data set in terms of years of regular surveys and the estimated total biomass showed a substantial decline through time (Fig. 2a). The total biomass for the Thai waters in the Gulf of Thailand had been estimated at around 680,000 t in 1961 and was reduced to 56,000 t in 1995, or 8.2% of the 1961 estimate. Separation into major groupings, demersal fish and trash fish, shows similar rates of decline in the biomass of these groups (Fig. 2a). Four major species groups, namely *Nemipterus* spp., *Priacanthus* spp., *Saurida* spp. and squids, also show similar declines (Fig. 2b). The estimated biomass of *Nemipterus* spp. declined to <3% by 1995.

3.2. Exploitation ratios

The countries showed similar patterns in terms of the exploitation ratios for species, with most species having ratios over 0.5 (Fig. 3). In Malaysia, over 70% from the 1996–1997 surveys had ratios greater than 0.5. In the Philippines, the compiled results from studies undertaken in the 1980s and 1990s indicated that 55% of stocks had exploitation ratios greater than 0.5. In Thailand, all the species, except *Scolopsis taeniopterus*, showed increasing exploitation ratios through time (Table 4) and by 1995 over 80% of the species had exploitation ratios greater than 0.8. The regional compilation reflected a similar pattern with over 65% of the stocks that have been examined showing exploitation ratios greater than 0.5.

Table 4
Variation in estimated exploitation ratios (fishing mortality:total mortality) of abundant demersal species in Thailand from 1971 to 1995

Species	Exploitation ratio					
	1971	1975	1980	1985	1989	1995
Atule mate	0.14	0.39	0.35	0.54	0.73	0.83
Epinephelus sexfasciatus			0.23	0.42	0.81	0.96
Lutjanus lutjanus	0.3	0.48	0.51	0.35	0.68	0.86
Megalaspis cordyla		0.07	0.13	0.08	0.39	0.39
Nemipterus nematophorus	0.31	0.43	0.44	0.57	0.89	0.98
Nemipterus hexodon	0.18	0.28	0.29	0.4	0.82	0.97
Nemipterus mesoprion	0.22	0.33	0.35	0.46	0.86	0.96
Nemipterus peronii	0.19	0.29	0.3	0.4	0.83	0.92
Priacanthus tayenus	0.19	0.43	0.23	0.21	0.61	0.95
Rastrelliger brachysoma	0.63	0.89	0.8	0.79	0.96	0.95
Rastrelliger kanagurta	0.54	0.61	0.58	0.5	0.9	0.94
Saurida elongata	0.31	0.45	0.28	0.24	0.63	0.87
Saurida undosquamis	0.31	0.46	0.28	0.24	0.64	0.89
Scolopsis taeniopterus	0.26	0.4	0.06	0.03	0.17	0.02
Selar crumenopthalmus			0.09	0.06	0.72	0.89
Selaroides leptolepis	0.12	0.35	0.31	0.5	0.68	0.8
Trichiurus lepturus	0.44	0.3	0.74	0.57	0.79	0.95

Derived from Krongprom et al. (2003).

4. Discussion

The results from these three Asian countries illustrate a disturbing regional trend of substantial depletion of demersal fisheries resources, down to <10% of the initial biomass estimates in some areas. It is also clear that in Thailand, where the decline had been documented up to the 1980s (see Ritragsa, 1976; Pauly, 1979; Beddington and May, 1982; Chanprasertporn and Lamsa-ard, 1987; Phasuk, 1987), it has continued unabated (Fig. 2). The other countries involved in the regional project (Bangladesh, India, Indonesia, Sri Lanka and Viet Nam) were not able to collate time series data as comprehensive as those discussed here. However, they all documented evidence of resource decline, such as decreasing catches and catch per unit effort (Khan et al., 2003; Manh Soon and Thuoc, 2003; Purwanto, 2003; Samarayanke, 2003; Vivekanandan et al., 2003). These results should raise serious concern for the ability of coastal resources to sustain current fishing pressure, provide the necessary protein and livelihoods for these developing countries, and maintain ecosystem integrity.

The analyses of changes in the total biomass and estimates of exploitation ratios are relatively crude measures of

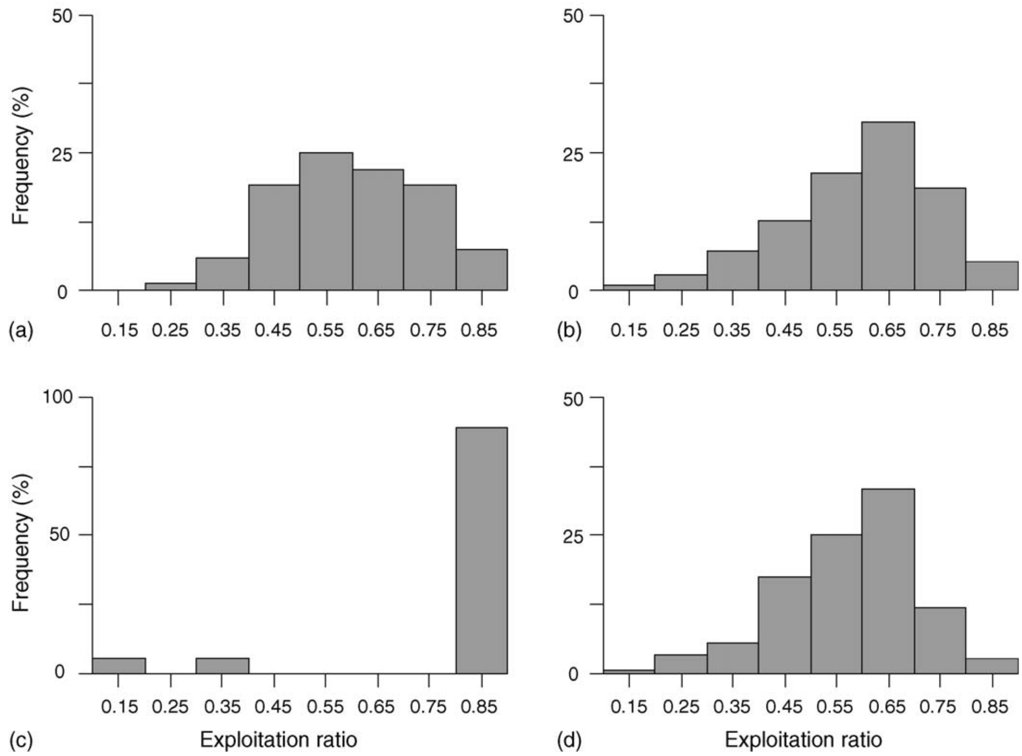

Fig. 3. The frequency of exploitation ratios (fishing mortality:total mortality) for demersal fish stocks based on length frequency analyses in: (a) Malaysia; (b) the Philippines; (c) Thailand; and (d) regionally.

the changes occurring in the fisheries resources and coastal ecosystems. These analyses are also constrained by their underlying assumptions, such as the use of a single catchability coefficient, and the assumptions of length-based assessments for the exploitation ratios (Hilborn and Walters, 1992). The trends in total biomass also do not indicate the changes in species composition that are likely to have occurred as well. In Thailand, reductions in the relative abundance of larger species and increases of the smaller, less valuable species have been documented (Pauly, 1979; Christensen, 1998; Supongpan, 2001). However, while smaller species have increased in proportion, the total biomass has continued to decline, as the actual biomass of these smaller species has also decreased (Fig. 2b). In the Philippines, similar changes in species composition have been seen in association with a decline in biomass in specific locations (e.g. Silvestre et al., 1986; Ochavillo et al., 1989). Further analysis, facilitated by the collation of these data, should examine the details of these species composition changes. However, the current analyses clearly demonstrate that these resources are severely depleted and management actions are required.

Over-fishing appears to be the primary cause of the reductions in biomass, although environmental degradation is likely to also have contributed. This can been seen by the rapid depletion after the introduction and spread of industrialized fishing during the 1960s and 1970s. In Malaysian waters where the analyses were stratified by depth, greater reductions in biomass were seen in the shallower depths, closer to shore (Table 2). Historically fishing has concentrated in these areas and has only moved further offshore as the shallower depths have become less productive, fishing technology has increased and Exclusive Economic Zones were introduced. The high exploitation ratios also suggest over-fishing. The sustainable range of exploitation ratios for fished stocks is suggested to be between 0.35 and 0.55 (Gulland, 1988; Pauly, 1984), most species examined here were above this range (Fig. 3). In Thailand, the time series of exploitation ratios show that while the biomass of *Nemipterus* spp. and *Saurida* spp. has decreased (Fig. 2), the exploitation ratios (Table 4) and, therefore, the fishing pressure, have increased over time. This situation is unlikely to be sustainable for these species. The large declines and excessive exploitation ratios show that coastal fisheries resources cannot sustain such a high level of fishing pressure.

The documented biomass declines confirm the available fishery-dependent assessments. In the Philippines, Silvestre and Pauly (1987) demonstrated that the demersal fishery was already over-fished during the 1970s. In Thailand, Supongpan (1996) showed that the five dominant demersal species caught by trawlers were over-fished. In Malaysia, Kimoto and Ibrahim (1996) estimated that Nemipteridae, a dominant group in trawl fisheries, was overexploited by as much as 30%. The coastal fisheries resources of these countries are not just over-fished in biological terms but also in economic terms. Silvestre and Pauly (1987) estimated that the Philippines was loosing US$ 125 million per year via rent dissipation due to excessive fishing effort. Ahmed et al. (2006) demonstrate the extent of economic over-fishing of demersal fisheries across the region.

Both small- and large-scale fisheries using a range of gear contribute to the over-fishing of the demersal resources documented by the scientific trawl surveys. Small-scale fishers usually work closer to shore and each country has a nearshore area designated for small-scale fishers, from which commercial boats are excluded (see Garces et al., this issue, pp. 143–157). The small-scale fishers (with both motorized and non-motorized vessels) use gear such as gillnets, demersal long-lines, "baby-trawls", trammel nets and small push-nets to target demersal species (Cruz-Trinidad, 2003; Abu Talib et al., 2003b; Boonchuwongse and Dechboon, 2003). The larger, commercial fisheries also exploit demersal resources using otter-board trawls (both shrimp and fish trawls), pair trawls and push-nets (Cruz-Trinidad, 2003; Abu Talib et al., 2003b; Boonchuwongse and Dechboon, 2003). In both sectors excessive fishing capacity and inappropriate fishing practices are key issues. The latter includes the harvest of juveniles and fry by gear with small mesh sizes, such as some push-net and trawls (Barut et al., 2003; Janekitkosol et al., 2003). Managing the over-fishing of these coastal resources requires an understanding of the relative impact of the different sectors and gears, as well as the flow of benefits to different sectors of the communities. The cost and implications of over-fishing may differ between the sectors; for instance, the small-scale fishers may be less able to cope with the declines in resources or restrictions on their fishing effort.

While over-fishing is likely to have been the major cause of the serious declines, these have probably been exacerbated by environmental degradation. Water quality and habitat quality and quantity have been reduced in most coastal areas, decreasing in turn the productivity of the coastal environment for many fish species. Coastal development, increasing coastal populations and other land-based activities (i.e. agriculture, mining, and industrial processing) have all contributed to pollution and siltation of the coastal waters. In Malaysia and the Philippines, over 98% of the population live within 100 km of the coast, and in Thailand, over 38% (http://www.earthtrends.wri.org), most with ineffective sewerage treatment. In the Bangkok metropolitan area, 60–70% of the sewerage is discharged untreated (Cheevaporn and Menasveta, 2003). Processing industries and agricultural production, with increasing intensification, are also major contributors to water pollution (Burke et al., 2001; Barut et al., 2003). Organophosphate levels in the Gulf of Thailand have increased over time and are thought to be contributing to eutrophication and increasing occurrences of plankton blooms (Cheevaporn and Menasveta, 2003). In the Philippines, water quality parameters (including dissolved oxygen, turbidity, heavy metal content and coliform counts) exceed national standards in many areas (Valmonte-Santos et al., 1996; Talaue-McManus, 1999). In Malaysia, siltation due to land development is a serious issue in the coastal zone and excessive *ortho*-phosphates and heavy metal pollution have also been documented (reviewed by Abu Talib et al., 2003b).

The quantity and quality of physical habitats has also been altered by coastal development and fishing activities. Mangrove clearing is one of the most obvious causes of habitat destruction in the region; for example, in the Gulf of Thailand 50% of the mangroves have been cleared (Janekitkosol et al., 2003). This will reduce the productivity of fishery species that depend on mangroves as a nursery area (Beck et al., 2001; Nagelkerken and Van der Velde, 2002; Mumby et al., 2004). Fishing itself is likely to also have damaged habitats on which demersal species rely. Gear, such as trawls and large push-nets, damage sea-grass beds and the attached benthic species, such as sponges and corals, which create important structural habitats utilised by some demersal species (reviewed by Hall, 1999). On Australia's northwest shelf, there was a clear link between loss of benthic habitat-creating species due to damage by trawling and changes in the fish community (Sainsbury, 1988). Trawlers are the dominant commercial vessel type in Malaysia and Thailand, which have over 3700 (Abu Talib et al., 2003b) and 7900 (Boonchuwongse and Dechboon, 2003) registered trawlers, respectively. In the Philippines, trawlers are also the dominant commercial vessel type but their number has declined since the 1980s as they are replaced by purse-seiners (Cruz-Trinidad, 2003). The cumulative impact of these trawlers and other damaging fishing methods (e.g. push-nets) on the seafloor and habitat has not been quantified, but it is likely that they have reduced the attached benthic species and habitat structure.

The severe declines in fisheries resources and also the vast number of people dependent on these resources should raise serious concern and spur action. Without at least halting this decline, fisheries and coastal ecosystems face a bleak future. Asia currently contributes over half of the global fisheries production and has over 85% of the world's fishers (FAO, 2002). This production and these livelihoods are threatened by this decline. The countries in the region have previously made attempts to manage fishing capacity. Since 1987, the Malaysian policy has been to reduce fishing effort in coastal areas and encourage offshore fishing, through a moratorium on new fishing vessels and gear licenses in coastal fisheries. The number of vessels licensed in Malaysia in 1997 was 35% lower than in 1980, and the number of fishers was declining (Abu Talib et al., 2003c). While there are reports of an increasing catch rate for the remaining vessels, the research surveys show that the decline in the resource biomass has not been halted (Table 2). Both Thailand and the Philippines have also tried to reduce effort through moratoriums, encouraging offshore fishing and declaring closed areas and seasons (Barut et al., 2003; Janekitkosol et al., 2003). Moratoriums on licenses and attempts to reduce the number of fishing vessels will only be effective if enforcement and compliance are high. However, the high levels of "illegal" fishing in the region (Silvestre et al., 2003) suggests that enforcement and compliance are low.

The extent of resource decline documented here was a crucial input to national workshops held within each country which identified key recommendations for action (Stobutzki et al., this issue, pp. 109–118). In terms of halting and reversing the resource decline, over-fishing was regarded as the key issue and all countries identified the urgent need to reduce fishing capacity to appropriate levels. The interventions suggested include: strengthening licensing systems, limited entry to fisheries, increased protected areas, increased gear selectivity and the elimination of destructive gears or fishing patterns. In all cases, it was recognized that reductions in fishing effort would require increased opportunities for alternative livelihoods, particularly for poorer communities. In terms of environmental degradation, the countries identified the need for coastal rehabilitation, catchment management, wastewater management and the establishment/implementation of integrated coastal zone management and sanctuaries. All countries also identified the need to increase awareness among stakeholders of the causes of the decline in resources and to engage more broadly with stakeholders in the development of solutions. The strengthening of fisheries governance and institutions, as well as research and management capacity, was also perceived as necessary to address the problems.

Spurred on by the declines demonstrated here, Malaysia has initiated its first steps towards effectively addressing its excess fishing capacity. In 2003, it held the "National Conference on Management of Coastal Fisheries in Malaysia", which examined the outputs from Abu Talib et al. (2003a). The national conference recognized the urgent need for action and established a national steering committee to implement activities to address the degraded coastal fisheries (Anonymous, 2003). The conference recommended that a pilot area in northwest peninsular Malaysia be used to develop effective approaches to fisheries management. This area is now the focus of projects examining co-management approaches, fisheries indicators and the development of an exit programme to reduce fishing capacity. The results of this approach will not be known for several years but, if effective, it should be extended to other areas.

5. Conclusion

This regional study has clearly demonstrated the severely degraded state of coastal fish stocks in Asian countries caused by over-fishing, and compounded by environmental degradation. What needs to be done is also clear: reduce fishing effort and restore and rehabilitate coastal habitats. Developing countries in Asia must urgently tackle the central issue of formulating approaches to effectively reduce fishing capacity within a developing country context. This will require approaches that explicitly address the role of fisheries in food security and livelihoods of poor communities, while restoring the productivity of the natural resource base. Without the formulation and implementation of approaches to reduce fishing effort, Asia is unlikely to be able to continue contributing over half of the global fisheries production.

The analyses described in this paper are crucial for developing countries where fishery-dependent information is scarce and potentially unreliable. They provide clear independent evidence of degraded fisheries resources in several Asian countries. This study provides significant fishery-independent evidence of the degraded state of fisheries resources while the multi-country nature of the study points to even greater urgency since this issue is not only for a single country but is a regional one. The regional nature of the project makes the problem even more critical since it spans a huge geographic area and involves multiple governments and management systems. Studies such as these are critical in helping developing countries to identify the extent of the problem and in demonstrating urgency for action to reform fisheries management. The results of the present work have already helped to focus attention on the issue in at least one country and have promoted government consideration of new policy and management initiatives. If this work can be further expanded and communicated to other countries, the prospects for fisheries in the region could improve significantly.

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