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THE IMPACT OF ARTISANAL FISHING ON CORAL REEF FISH HEALTH IN HAT THAI MUEANG, PHANG-NGA PROVINCE, SOUTHERN THAILAND

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Abstract

This is a study of the impact of small-scale (artisanal, local, community) fishing on the health of fish species in a coral reef off the mainland of Thailand. Its main aim was to investigate whether there had been a decline in the reef fisheries, and if so, how far that decline was due to small-scale fishing, and what could be done to reverse it. Two methods were used to obtain relevant information: first, fish sampling by underwater fish surveys to determine the current state of the reef fish stocks; second, interviews of key informants and questionnaires administered to artisanal fishers, to find out about their fishing practices (including the gear they used and the catch composition from that gear), and their perceptions of the health of the stocks; the threats to the stocks; and ways of countering those threats. The results of the research were to confirm there had been a decline in piscivores and carnivores, but not of herbivores; that the main perceived threat to the reef fish came from illegal fishing by large-scale (commercial) fishers rather than legal fishing by small-scale (artisanal) fishers; and that the best way to counter such threats was to replace the largely unrestricted fishery with a more regulated regime backed by effective enforcement.

Introduction

Although it is generally acknowledged that the main cause of over-exploitation of fish stocks is commercialised fishing, artisanal fishing is increasingly seen to threaten coastal stocks (IUCN & UNDP 2007).¹ The worst threat comes from explosive and cyanide fishing, but more common types of artisanal fishing, such as coastal push nets and beach seines are known to harm substrates and target juvenile fish (Mangi & Roberts 2006; McClanahan & Mangi 2004), leading to serious stock declines and trophic shifts (Russ 1998a; Mangi & Roberts 2007). The danger of such trophic shifts, or 'fishing down the marine food web', identified by Pauly et al (1998) in temperate fisheries has been demonstrated in tropical fisheries where a reduction in the stocks of piscivores and carnivores at the higher trophic levels serves as the first sign of over-fishing (Russ & Alcala 1998a; Russ & Alcala 1998b; McClanahan, 1994; Jennings & Polunin 1997). However, because coral reef fish ecology is extremely complicated (Sale 2002) and data on fishers catch is scarce, it is not easy to track these trophic shifts, still less their causes and remedies.

Coral reef fish species have a range of traits that make them especially vulnerable if exposed to excessive exploitation (Jennings et al 1999). They tend to be more k-strategy species than do non-reef species, with longer life spans, slower growth, lower reproduction rates, lower natural mortality, more complex life histories, more structured social behaviour, more limited geographic ranges, more specialised habitat needs, and more endemism (Sadovy & Vincent 2002). Accordingly, if there are early signs of decline in stock levels of reef fisheries, it is particularly urgent to address them. Such

¹ The distinction between 'commercial' and 'artisanal' fishing is based less on kind than on scale. It is not a distinction between fishing for a market and fishing for subsistence, since the artisanal fishers in Hat Thai Mueang sell most of their catches to local markets. Nor is it a distinction between mechanised and manual fishing gear, because artisanal fishers increasingly use mechanical aids, including outboard engines and GPS and radar for finding good coral heads and fish schools. The distinction is largely between large-scale and small-scale operations: commercial fishers use large vessels which enable them to fish offshore with otter and seine nets; artisanal fishers use small boats that confine them to inshore waters with spear guns, gill nets, traps, rods, long lines and hand lines.

signs were evident in a newly registered coral reef in the Andaman Sea at Hat Thai Mueang, Phang-Nga Province, Southern Thailand, and this research was designed to investigate them.

Thailand is the fifth largest fishing country in Asia, and the tenth largest in the world (FAO 2005). Until trawlers were introduced in the 1960s, Thailand's waters were fished exclusively by small-scale fishers, and the level of fishing was not considered beyond sustainable limits (though large quantities of tuna were discarded as canning factories had not yet been established). But current catch rates, "measured by catch per unit effort [CPUE] are about 7% of that in the early 1960s" (Poonnachit-Korsieporn & FAO 2000: [add part and section numbers]). The reasons for this decline in CPUE are variously claimed to be too many fishing vessels, damaging gear, habitat destruction, illegal fishing (eg in prohibited areas or seasons), weak enforcement of regulations, inadequate management structures, and policies based on unreliable, incomplete and out-of-date data on catching and landing rates (Poonnachit-Korsieporn & FAO 2000). There is particular concern about Thailand's coral reefs - Thailand is a registered biodiversity 'Hotspot' and yet it is estimated that up to 80% of the coral reefs have been damaged or entirely destroyed (FAO 2005).

In Thailand, fisheries resources are very valuable for both nutritional and employment purposes for artisanal fishers in coastal areas. Yet artisanal fishing is largely ignored in official documents: "despite the plans to improve the standard of living of small-scale fisherfolk, little is known about the latter besides the facts that they constitute the majority of the fishing population, account for less than 10% of the total catch by value and 5–6% by volume" (Poonnachit-Korsieporn & FAO 2000: part 1, section 1.1). For instance, official data on fish catches "under-report or even ignore" small-scale fishers' catches (Lunn & Dearden 2006: 61). The absence of such data makes effective management of small-scale fisheries near impossible, and it is imperative to remedy this lack of information. This research helps to reduce that data deficit.

Several studies have revealed that artisanal reef fishers target many more species, and employ a greater variety of catching techniques, than do commercial fishers (Gobert 2000; Pet-Soede et al 2001; McClanahan & Mangi 2001, 2004; Mangi & Roberts 2006; Campbell & Pardede 2006; Lunn & Dearden 2006). Such an extensive list of targeted species means that discarding is minimal, and that the impact of fishing may be spread over multiple species, thereby taking the pressure off particular species. However, this depends on keeping the overall fishing impact within certain limits (Russ & Alcalá, 1998a), but calculating what are the safe limits is difficult because of the complexity of the chain of impacts to multi-species systems from anthropogenic disturbance. This study sought to explain this complexity in the Hat Thai Mueang reef to estimate whether artisanal fishing was within those safe limits.

In the next section, the methods used to obtain data are explained. In section 4, the results of that data collection are outlined, and in section 5, these results are discussed, along with their implications for future management. Section 6 concludes the paper with a short summary of the study's findings.

3. Methods of obtaining data

The coral reef studied is situated 600m off the coast of Thailand, north of Phuket on the Andaman Sea. The reef area is located in front of a National Park which was designated IUCN category II in 1986, primarily for the protection of nesting sea turtles. Although the reef is not included in the park, it was officially registered as a coral reef resource with the assistance of WWF Thailand in 2006. Post-tsunami research has taken place in this area, including biodiversity and socio-economic surveys conducted by WWF Thailand with a focus on the possibility of a National Park extension, but no detailed research has been dedicated to the small-scale fishing activities within the area. The theoretical/conceptual framework underlying the research is sustainable development (SD) – the notion that management of a natural resource must aim at a balance between the ecological health of the resource, and the socio-economic well-being of the community living off that resource.

The reef is fished by artisanal fishers from 12 fishery-dependent villages along the coast.² Two methods of obtaining data about the reef fishery were employed: 1) underwater fish surveys to

² The fishing communities in Hat Thai Mueang divided into three sectors: marine fishing; mangrove fishing; and fish farming, each utilising different resources. Most fishers moved between sectors depending mainly on the season, but also because of the weather and resource scarcity, which made it

calculate the current fish health on the reef; and 2) interviews and questionnaires to document the fishing gear used, the catch composition from that gear, and stakeholders' perceptions of the state of the stocks, threats to those stocks, and ways of countering the threats.

3.1 Underwater fish surveys

The first method was fish sampling using underwater visual census (UVC) based on the Global Coral Reef Monitoring Network (GCRMN) programme from the Australian Institute of Marine Science (AIMS). Twelve samples were considered achievable with a minimum of 8 for analysis, and a three by four grid was placed over the area containing coral reef to create the 12 sample areas. Stratified haphazard selection was used within each grid for transect placement. Due to a minimal change in reef depth (8 – 12m) and homogeneous reef topography (fringing table reef) the whole reef area was classed together for analysis. Two types of survey were conducted: a rapid visual census to assess species diversity; and belt transects to estimate fish size and biomass of key family groups. Species identification was through phenotype in the form of physical and behavioural characteristics.

3.1.1 Rapid visual census

For the rapid visual census, the researcher swam around the reef area recording all species observed. Each species was recorded once when first seen in 5 x 10 minute intervals. A value was awarded to each species depending on which 10 minute interval the fish was seen in - a value of 5 for the first 10 minutes, a 4 for the second 10 minutes, etc. The survey lasted for 50 minutes and was conducted as specified by the published methodology (Hill & Wilkinson 2004).

3.1.2 Belt transects

For the belt transects, five 3m x 50m transects were laid at each site, and the observer swam ahead of the tape layer, parallel to the coastline, recording both the size and number of species from pre-selected families in the 3m belt. This list excluded the families of Blennidae, Gobiidae and Pomacentridae as it was felt that accuracy would be higher if cryptic and non-target species were removed from this data. A 1m T bar, marked at every 10cm, was carried on all belt transects to assist in estimating the belt width as well as the length of fish. Fish were measured in centimetres, initially in 5cm grouping and then 10cm groups when over 20cm. All fish seen over 50cm were not grouped but recorded individually at their estimated length.

3.1.3 Catch data

One final method of data collection was intended, that of catch data from fishing trips. However, catch data proved difficult to obtain because of the large number of fish landing sites, the unpredictability of fish landing times, and the rapid dispersal of catch to market. The sample size from the small amount that was collected was deemed too small for any reliable analysis, and therefore this data set had to be excluded from the study.

3.1.4 Data analysis

All data was compiled and categorised through 2 treatments: the first treatment was a taxonomic classification by the Linnaeus system to species, if detailed, or family, if general; and the second treatment listed all fish to taxonomic family. The majority of data was classified in the first treatment and analysis was conducted on that data set. The second treatment applied to two questions for statistical analysis. Parameters per species identified were taken from FishBase 2000 (Froese & Pauly 2000). Length-weight relationships, $W = a \times L^b$, where W is weight (kg), L is length (cm) and a, b are the indices for each species were converted for biomass. Length at Maturity from FishBase 2000 was used to establish age in the categories of adult or juvenile. If data deficient, the mean length at maturity from fish within the same genus was used. Trophic level by species was obtained from ecopath data on FishBase 2000, and family levels converted from the species composition found on the reef. Mean trophic level by gear type (k) was calculated using the following formula:

$$TL_k = \frac{\sum_{i=1}^m Y_{ik} TL_i}{\sum_{i=1}^m Y_{ik}}$$

hard to obtain accurate data on the number of fishermen utilising the marine, and more specifically the reef area.

where Y_{ik} is the catch of species i in gear k , TL the trophic level of species i for m fish species (Pauly et al 2001). Mean fish density, frequency and biomass with Coefficients of Variation (CV) were established for each species and then converted into families and the community as a whole. Families were then categorised as either targeted or non-target depending on the results from the fishermen's questionnaires.

3.2 Interviews and questionnaires

Interviews were conducted with seven key informants; questionnaires were administered to 119 artisanal fishers

3.2.1 Key informant interviews

Interviews with key informants from the local community were conducted to provide an overall perspective on fishing in the area. The structured questions were translated into Thai, and asked informally through a Thai translator. Interviewees were selected from the four main stakeholder groups - government departments (GO); non-governmental organizations (NGOs); commercial fishermen (CF); and small-scale fishermen (SSF). The samples consisted of two GOs; one NGO; one CF; and three SSFs, ratios which reflected the profile of the relevant stakeholder population. Names of interviewees were supplied by officials from local government and the national park, cross-checked with local villagers.

3.2.2 Fishers' questionnaires

Of the 119 questionnaires distributed to artisanal fishers, 110 were deemed valid.³ Questions were asked about the fishing gear used; the species targeted; the use of the catch; fishers' income levels; the value of the different species; threats to the stocks; regulations; management structures; and enforcement mechanisms. The questionnaire was delivered in the villages, face to face with the fisher interviewees by a local translator accompanied by the researcher to add gravitas and check the method of data collection, and they were completed onsite. Maps and fish identification materials were provided to assist participants in answering the questions. Groups of villages were chosen by cluster sampling, and interviewees on site were chosen by convenience sampling. All 12 villages were visited, usually before or after respondents went fishing, but if few were present, revisits were arranged.

3.2.3 Data analysis

Each interview was transcribed, and data were presented under the four stakeholder categories - government officer, non-governmental organization member, commercial fisher, small-scale fisher - in a form that provided anonymity to informants. Extra information sourced during the interviews was recorded, as were observations and conversations outside of the interview. All these data were analysed qualitatively, following the interpretive technique developed by Fischer (2003).

The questionnaire returns were analysed quantitatively. Five categories were produced with fish allocated by their dominate food source: Planktivores feeding on plankton; Detritivores on detritus; Herbivores on algae/weed and phytoplankton; Carnivores on zoobenthos; and Piscivores on nekton. One further category was created for species identified to family for Lutjanidae, Carangidae and Serranidae to include the varying feeding habits of species. Chi-square (X^2) and Logistic Regression analysis were conducted: Chi-square was used to establish significances between income and experience with species or gear type; and Logistic Regression was used to ascertain both positive and negative relationships between fish families and trophic groups with gear type.

4. Results

4.1 Underwater fish surveys

Results from the underwater fish surveys are summarised under three headings – reef composition; fish size; and trophic composition

4.1.1 Reef composition

³ Nine questionnaires from Tablamu village were discounted because they contained either non-specific or incomplete information.

192 species from 88 Genus in 36 families were recorded during the Rapid Visual Census (RVC). Zanclidae and Holocentridae were the two most abundant families on the reef which comprised only three species. The following 10 families from Chaetodontidae to Acanthuridae comprised higher diversity, 101 species in total, as well as high mean RVC values, ranging from 36 – 19 (Fig 1). Commercially targeted species identified by fishermen, excluding Nempiteridae with the higher value of 29 and Caesionidae at 26, started at a value of 13 for Serranidae followed by Lethrinidae 12 and Lutjanidae 11 with collective species diversity for the three families at 32. Species in the families of Carangidae, Scombridae and Mugilidae were absent during the rapid visual census.

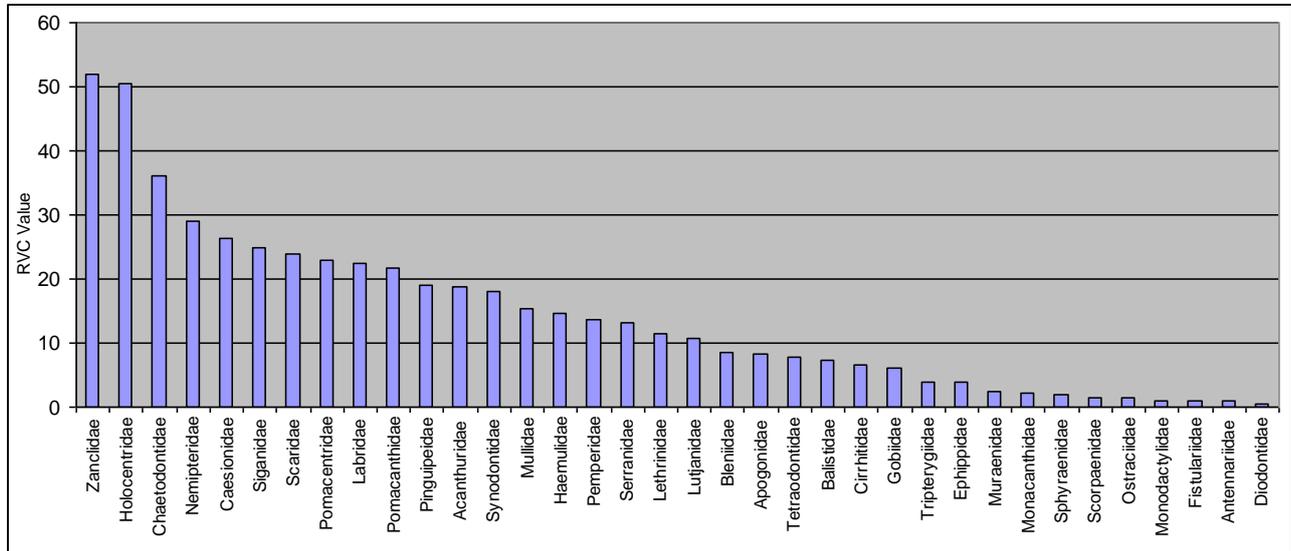


Figure 1: RVC values by Family showing relative abundance. Richness value represents a possible total of 60 from the 12 surveys, a maximum of 5 points per survey

4.1.2 Fish size

Of the six targeted families found on the reef, four had a higher proportion of juveniles to adults (Fig 2). The most marked was Caesionidae with 79.4% under the length at maturity, followed by Serranidae at 62% and Lethrinidae and Haemulidae at 52.5%. The other two, Lutjanidae and Nemipteridae, were recorded as having a higher percentage of fish over the length at maturity, though for Nemipteridae, the species observed on the reef was from the Genus *Scolopsis* as opposed to the Genus *Nemipterus* which was listed in the fisher’s catch surveys, and so was not a targeted family, which explains its higher volume of adults. Of the other non-target species, Holocentridae, Balistidae, and Mullidae had a higher proportion of juveniles to adults (indeed, all of the fish recorded for Holocentridae were below the length at maturity), but all of the remaining non-target species listed by fishers had a higher proportion of adults to juveniles.

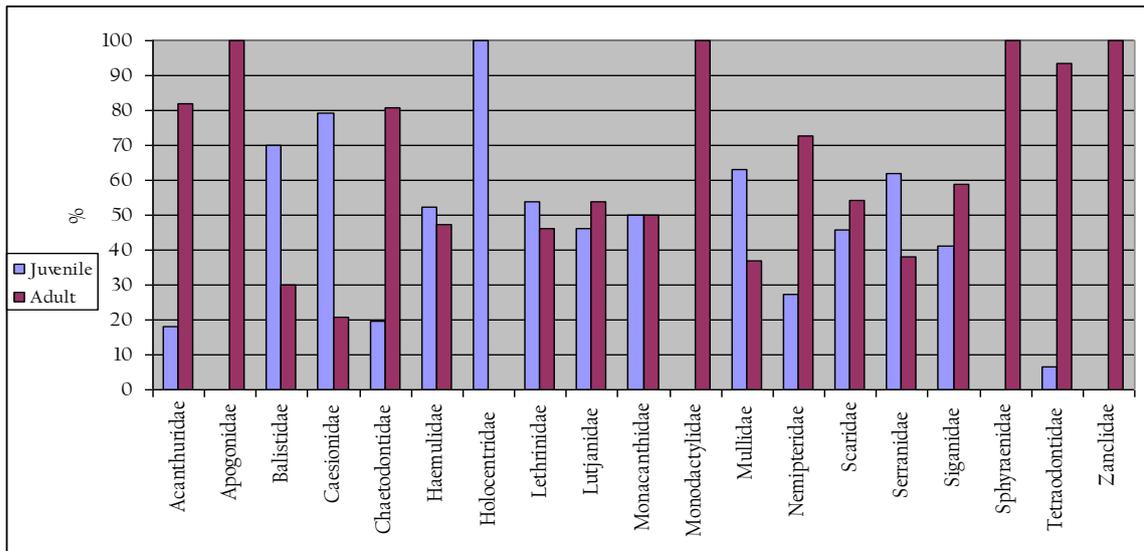


Figure 2 – Comparison of juvenile to adult by key families

4.1.3 Trophic composition

Mean trophic level for the coral reef at Hat Thai Mueang was calculated at 3.4 ± 1 when analysed by family ($n = 36$). Trophic level when analysed by species ($n = 192$) had a mean of 3.3 ± 2 . Trophic variation ranged from 2.0 to 4.4 for family and slightly higher to 4.5 for species (Fig 3).

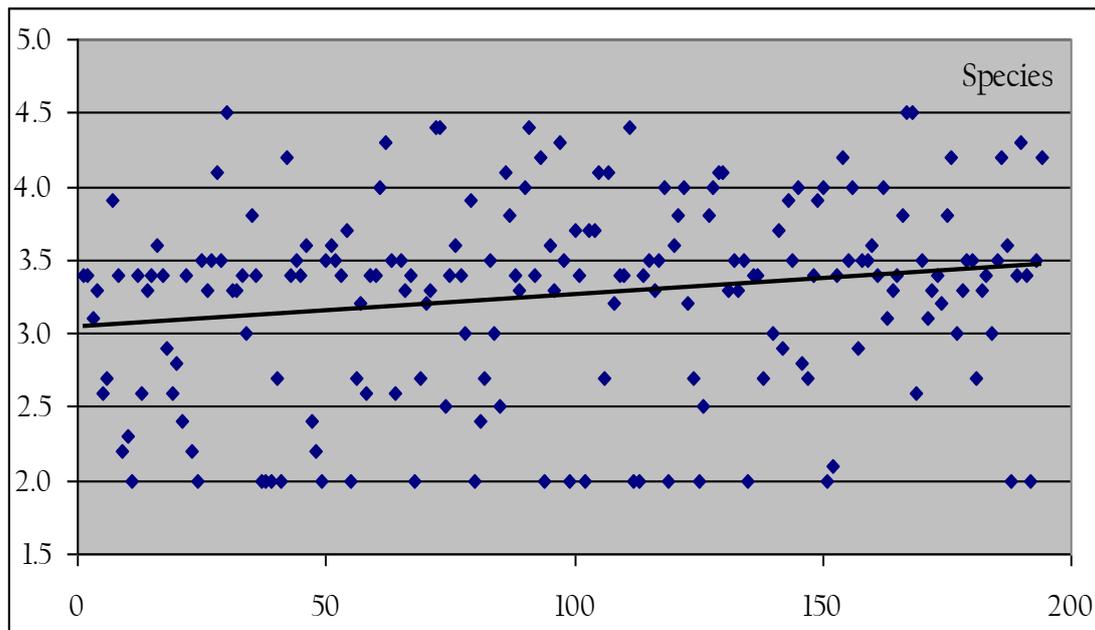


Figure 3 - Mean trophic level presented by species found on the reef with linear trend line

Trophic values were estimated by gear type for both families and species. The mean trophic level from all gear types was 3.9 when analysed by species and 3.7 when analysed by family (Fig 4). Variation within this, ranged between 3.5 and 4.0 for all 7 gear types (mean level only). Trophic levels from species caught in each gear type ranged from 2.4 to 4.5 when analysed by all the species identified from the fishermen's questionnaire.

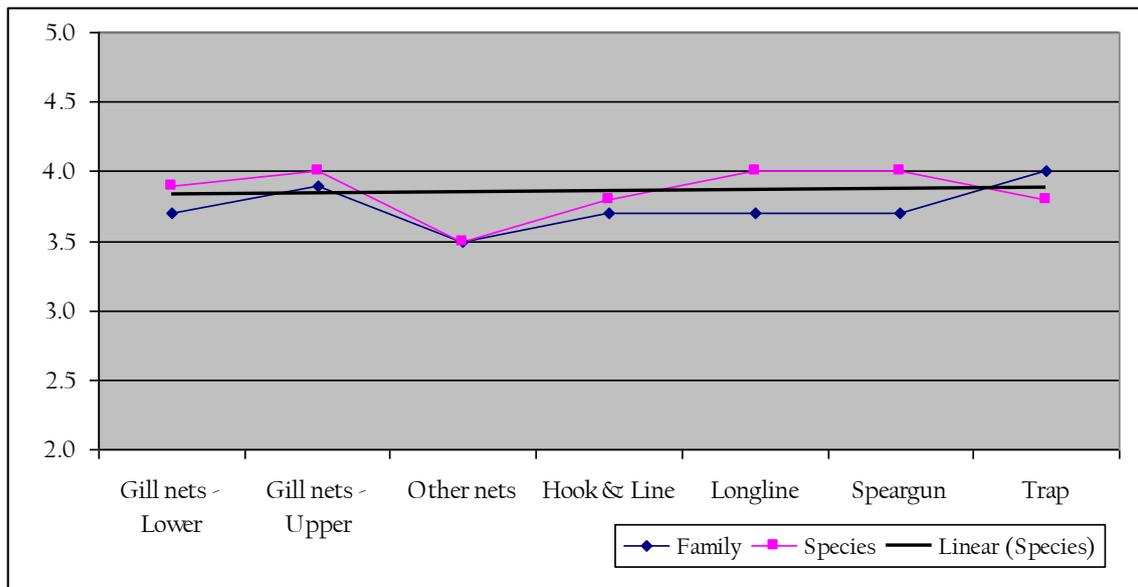


Figure 4 – Mean trophic value per gear type by species and family.

When looking at trophic level by species, long line, spear gun and upper gillnets had a mean trophic level of 4.0 which represented a very high percentage of piscivore and carnivore species. Other nets had the lowest trophic level at 3.5 due to Mugilidae making up a majority of catch.

4.2 Interviews and questionnaires

4.2.1 Interviews

Results from the key informant interviews are divided into three categories: threats to the reef fish stocks; socio-economic problems; and management issues. On threats to reef fish stocks, statements were made during the informants' interviews that commercial boats were the biggest threat. Trawlers, purse seiners and medium-sized boats that fish with lights were blamed for failing stocks by attracting fish away from coastal areas; by heavy extraction of all fish sizes; by taking small-scale fishers gear when trawling in shallow waters; and by causing substrate damage. The GOs were further concerned about the heavy gillnets and nets that surround coral, with the latter considered accidental rather than deliberate, because of the high cost of net replacement. One informant (SSF) supported the GO's concerns about heavy nets, and further mentioned small-scale ray fishing with nets, which, although prohibited, was still practised in some areas. Water parameters were also perceived to have altered since the 2004 tsunami with increased levels of phytoplankton, incidents of red tide, and higher annual seas temperature, which respondents believed to have contributed to increased levels of fish mortality. Reports of poor water quality also extended to the mangroves with small-scale fish farmers losing high number of Serranidae (grouper) fingerling, and one GO informant expressed concern over water exchange practices by some shrimp farms. More general environmental change since the tsunami included reports of changes in water currents and increased flow rates, making deploying nets challenging, as well as unpredictable tide times and wind patterns. Some respondents even reported seeing disorientated fish and lost schools, as well as 'sea ghosts' linked to the increase levels of phytoplankton illuminating the nets and frightening away the fish.

On socio-economic problems, respondents reported that the number of artisanal fishers was in decline, as the younger generation sought opportunities in tourism or migrated to urban areas in search of other forms of employment. The profile of years served in fishing showed a steady decrease in the proportion of fishers entering the profession. Most interviewees also stated that many small-scale fishermen had to travel further from land and outside the 3km national protection zone to catch fish of a suitable size.

On management issues, there was some uncertainty over fishing cooperatives. One GO held that cooperative existed whilst the other GOs stated that no cooperatives existed, but that groups were formed for funding opportunities after the 2004 tsunami. Other informants reported that informal groups had been established in villages to agree on regulations such as mesh sizes, and one SSF head

said that these groups were registered with the fisheries department as local cooperatives. Of the informants who said that fishing cooperatives did exist, one GO claimed they were self-organized and received advice on good practice from the fisheries department, adding that “it’s up to them as long as it’s within the law”, while an SSF claimed that the cooperatives had no communication with the fisheries department but dealt with the local NGOs on fishery and tourism related issues. Another SSF mentioned a funding scheme available via the fisheries department but believed that few groups utilised the scheme.

However, all informants were agreed that there were no restrictions on fishing in the area beyond the national government’s regulations which permitted no commercial fishing within 3km of the coast line, and prescribed minimum mesh sizes (MMS) for nets, and that there was no specific fishing plan for the region. Some informants declared that villages and small groups had made agreements with each other on issues such as minimum size of catch and mesh, with no interference from the fisheries department as long as they were within the law. Other informants discussed local attempts to reduce destructive fishing practices and the success of social stigma against individuals who breached these agreements.

4.2.2 Questionnaires

Results from the questionnaires are divided into four categories: gear ownership; gear use; species caught by gear; and the state of the reef fish stocks. On gear ownership, the questionnaire returns indicated that 12 types of fishing gear were owned for fish capture: 6 types of nets, 3 hook and line methods, 2 types of traps, and spear fishing (Fig 5).⁴ Gillnets made up the majority of the gear owned, totalling 31% overall, deployed at three different depths in the water. Of the three, heavy nets, which sink down to the substrate, made up the highest percentage (13%), followed by sink nets (12.3%), which hang in the middle to lower water column, and, lastly, float nets (5.7%) which are positioned at the surface. Rods were the next most important gear type (20%) followed by traps (16.9%) and long lines (14.2%). Bream nets and mullet nets were listed separately by fishermen from the supplied list on the questionnaire and later classified as cast nets, totalling 9.2% and 1.6% respectively. Of the traps, two types were identified, fish and squid traps, but they were classed as one due to many fishermen using the general term on the questionnaire. Hand lines were listed separately but used in a similar manner to rods with hooks and bait or in some cases with artificial jigs. Shrimp nets were also listed for fish capture and later identified as trammel nets totalling 3.4%.

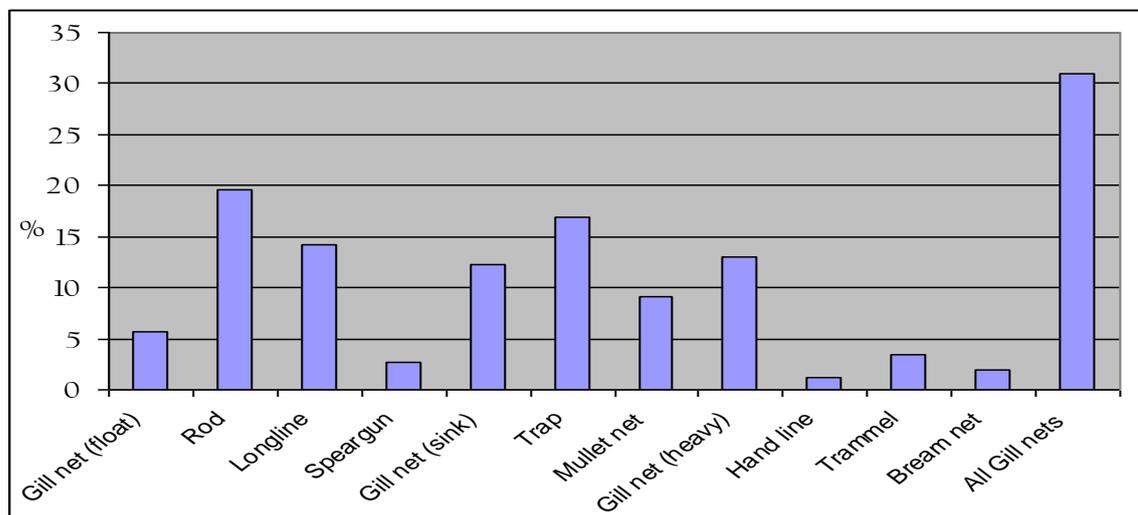


Figure 5 - Distribution by fishing gear owned

On gear use, the questionnaires indicated that gillnets, rods and traps made up 20.9%, 20.9% and 19.1% respectively of primary gear use (Fig 6). Traps were 67.7% more likely to be used as a primary than secondary gear, followed by gillnets at 56%. Of gillnets, sink nets had the highest use, followed by heavy gillnets, and, finally, floating gillnets. Long lines made up the highest percentage of second gear, chosen at 17.1%, and were 66% more likely to be used as a secondary than primary gear. Spear

⁴ Compare this figure with WWF (2007)’s assessment which recorded 22 types of fishing gear used by Hat Thai Mueang community members, which included non-reef gear and gear targeting benthic invertebrates.

guns had an 83.3% chance of being used as the primary gear source, but made up only 4.5% of total primary gear.

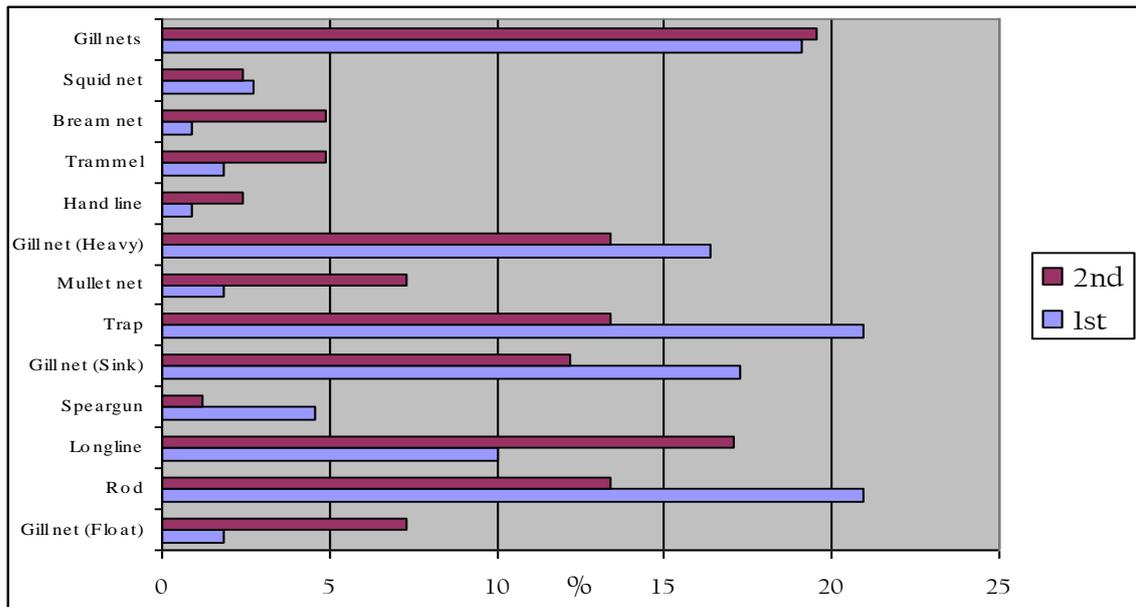


Figure 6 – Primary and secondary gear use

Results from the time period of use showed the majority of fishing took place at night: 49 of the 110 fishermen questioned said they fished at night, compared with 21 during the day and 40 during both time periods. Gill nets were mainly deployed at night (Fig 7) while traps were operational at all times of the day due to the method of fishing and month long soak times. Spear fishing was the only method that took place predominantly during the day.

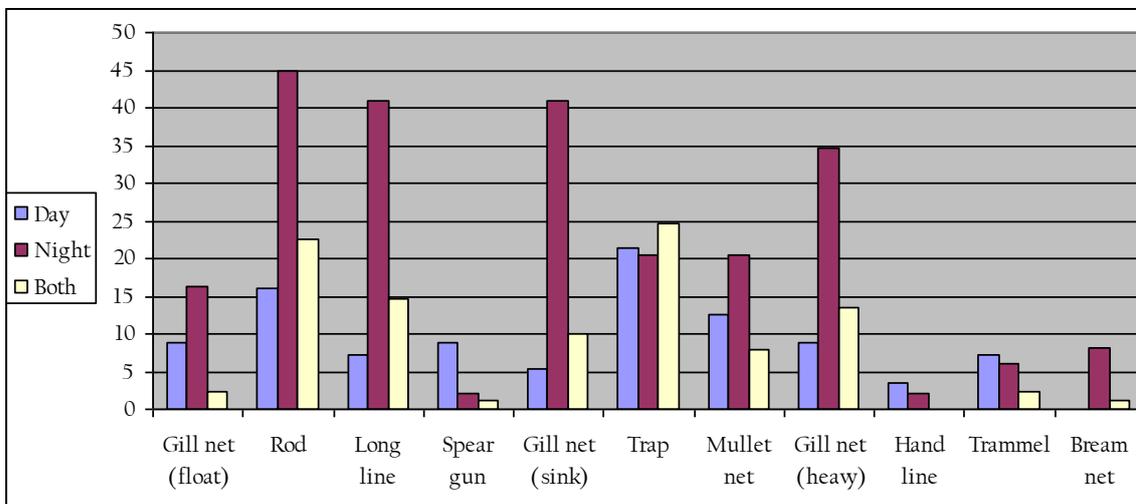


Figure 7 – Time period of use for each gear type

On species by gear, data from the fishermen’s questionnaires was used to analyse species composition by gear type (Fig 8). 20 families and 28 species were identified as the majority of fishermen’s catch from all gear types. Dominant families extracted by all gear were Lutjanidae and Carangidae, with the highest percentage at 23.1% and 22.9% respectively, Serranidae at 19.7% and Lethrinidae, 17.2%. Scombridae, Mugilidae, Nempteridae and other families each totalled <5%. For gear type distribution, Carangidae, Lutjanidae and Serranidae were caught in all seven gear types, Lethrinidae and Mugilidae in six, and Scombridae in four.

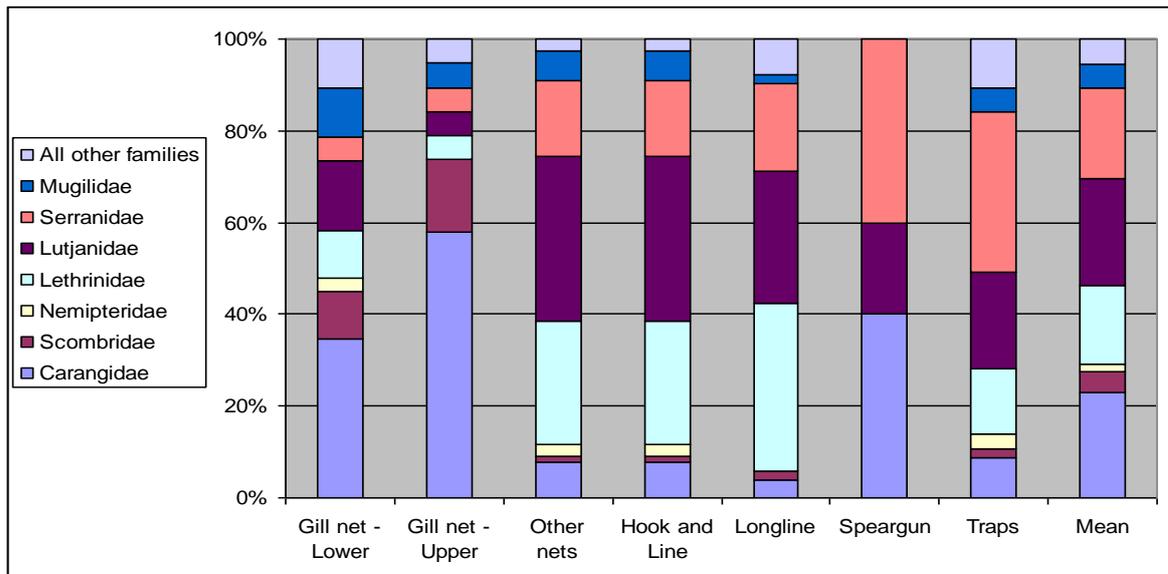


Figure 8 - Percentage distribution of families by gear type

Logistic [Estelle, I don't understand your Comment no. 015] regression analysis was conducted to establish any significant relationships between fish families and gear type (Table 1). For statistical analysis, trammel and float nets were classed as upper gillnets, while sink and heavy nets were classed as lower gillnets. Results included both positive and negative relations for all gear type, excluding spear gun due to data deficiency. The family of Carangidae had the strongest odds of presence ratio, with upper gillnets at 19.250 times odds of using other gear types. This was followed by Lethrinidae with an odds of presence using long line at 15.481 times odds of using other gears excluding hook and line with an odds 3.757 times that of the remaining gears. For Carangidae, Lower gillnets also had a strong relationship with an odds of presence 7.394 time that of other gears. Long line, Hook and Line and Traps had a negatively significant relationship with Carangidae. Scombridae had an odds of presence with lower gillnets 5.571 times that of using other gear type. Nemipteridae and Mullidae had positive odds of presence using others nets at 10.857 and 4.982 times odds with other gear types, respectively. Lutjanidae had a negative relationship with both gillnets but a strong odds of presence with bait methods such as hook and line at 8.952 and long line at 3.214 times odds of other gear type. Finally, Serranidae was the only family to have a positive relationship to traps with an odds of presence of 5.766 times odds using other gear type. This family had no other positive relationships.

Table 1– Logistic Regression – odds ratios for presence: family

Family	Gillnet - Lower odds ratio	Gillnet - Upper odds ratio	Other nets odds ratio	Hook and Line odds ratio	Long line odds ratio	Speargun odds ratio	Traps odds ratio
Carangidae	7.394	19.250	NS	0.257	0.125	NS	0.233
Scombridae	5.571	NS	NS	NS	NS	NS	NS
Nemipteridae	NS	NS	10.857	NS	NS	NS	NS
Lethrinidae	0.390	NS	NS	3.757	15.481	NS	NS
Lutjanidae	0.482	0.106	NS	8.952	3.214	NS	NS
Serranidae	0.189	NS	0.114	NS	NS	NS	5.766
Mugilidae	NS	NS	4.982	NS	NS	NS	NS
All other Families	NS	NS	NS	NS	NS	NS	NS
<i>n</i>	113	19	29	78	52	10	57

On the state of the reef fish stocks, nearly every village reported a longstanding decline in fish stocks, with some fishers claiming to have experienced a particularly serious fall in catches (up to 50%) during 2008. They blamed commercial vessels for excessive fishing effort, as well as for destroying their nets while illegally fishing within the 3km coastal zone, which is closed to commercial fishing. Other areas of concern included water parameters, which were believed to have altered since the 2004 tsunami,

with increased levels of phytoplankton, incidents of harmful Algae Blooms (red tide) and higher annual sea temperatures, to which fishermen attributed increased levels of fish mortality, with small-scale fish farmers losing high number of Serranidae (group) fingerling in the mangroves.

5. Discussion

Four themes emerged from the above results. First, the reef fishery is showing signs of over-exploitation. One such sign is the absence of certain family groups, such as Carangidae, Scombridae and Mugilidae during the rapid visual census. Another sign is a reduction in fish density, because under fishing pressure, the density of target fish reduces (Jenning & Polunin 1997). A reduction in density was detected in all target families found on the reef, with the possible exception of Caesionidae, a family of low-to-moderate vulnerability to fishing pressure due to high fecundity (Carpenter 1988). The current rate of extraction of species at the top of the trophic pyramid is another sign of over-exploitation, in that the heavy targeting of piscivores and, to a lesser extent, carnivores, by both small-scale and large-scale operations on the reef has led to a decline in catch rates. It is true that this has not resulted in herbivores becoming target species for small-scale fishers, as has been found in other research (GCRMN & Wilkinson 2004; Campbell & Pardele 2006). It is also true that the fact that high trophic species are still being extracted challenges allegations of severe over-fishing compared with locations where catches contain a high number of lower trophic species (Teh & Sumaila 2007). Nevertheless, disproportionate catches of higher trophic species suggests the early stages of over-fishing, and continued extraction at this trophic level will inevitably result in trophic shift which may already be in process, as reported by local fishers as well as by commercial fishers, and the danger of herbivores becoming target species cannot be ruled out. An additional sign of over-exploitation is the increasing ratio of juveniles to mature fish in reef fisheries, which further lowers the trophic levels. For example, while the diversity of Serranidae at 16 species is a good richness the small size of all species demonstrates fishing pressure.

Second, it would appear the main culprit responsible for the over-exploitation of reef fish stocks is not small-scale artisanal fishers, but over-fishing by large-scale commercial fishers. A head fisher said that “trawlers have the highest impact because they can take anything – eg small fish, equipment, coral heads etc. They come into shallow water...along the whole coast line at dusk during the monsoon season”. An artisanal fisher explained that “Pair trawlers pull the nets in a manner that reduces their mesh size and so then they can take smaller fish”. Another head fisher claimed that “The commercial boats take too many small fish and do not let them grow...[So there are] No large fish in this area”. Another artisanal fisher complained that commercial fishers placed over 1,000 very large traps (up to 7-9m in length) with small meshes around the deep water rocky and reef areas, within and outside the 3km zone, thereby attracting fish away from the gear of local fishers. Further indications come from the underwater fish survey, which recorded that Serranidae, a family more accessible to small-scale fishers than commercial fleets, though undersized, was present on the reef, yet species targeted by both small-scale and large-scale ventures were low in number or absent. Also, although it cannot be confirmed by catch data, the composition of herbivore families on the reef suggests low fishing pressure by small-scale fishers. This conclusion contrasts with the findings of Campbell & Pardele (2006), which reported high artisanal fishing pressure on herbivore in Indonesian coral reefs. Furthermore, commercial fishers were accused by a head fisher of a high proportion of turtle mortalities: “We see many dead turtles on the water from commercial fishing boats”.

Moreover, by contrast to commercial fleets, which were maintaining their legal catch through fishing with increasingly efficient fishing gear in the productive coastline waters, thereby inevitably depleting stocks in the reefs, artisanal fishers generally appeared to be avoided the more damaging methods of fishing in these areas. For example, controversial gear types used in other locations such as beach seines (Glaesel 2000; Mangi & Roberts 2006) and push nets (Poonmachit-Korsiepor & FAO 2000) did not seem to be widely used in this area, while destructive practices (such as the use of explosives or cyanide), the severest form of over-fishing (Pauly 1993) were not recorded. It is true that a village head fisherman stated that local fishers used heavy nets which dragged on the coral - an admission confirmed by Jones who found that sink gillnets were deployed on the reef, and that heavy nets stored by landing sites had a high percentage of dead coral, indicting their use in the reef area. It is also true that another head fisher accepted that some local fishers “cover the rocky area and coral area with the nets and damage the substrate”, and that the first head fisher revealed that although ray fishing was banned, small-scale fishers still did it, because rays fetched a lot of money at the retail outlet on Tablamu pier. There were even rumours of cyanide fishing. Nevertheless, on the whole, the negative

impact of small-scale fishing on the reef were considered much less than that of commercial fishing. As a head fisher remarked about the substrate damage, “The numbers are low...and most of the time it is an accident as the nets are expensive and the local fishermen can’t afford to replace them”.

Third, the reason why over-exploitation by commercial fishers occurs is because of weak management (Poonnachit-Korsieporn & FAO, 2000). It is true that a government fisheries officer claimed that illegal fishers were arrested by the department and suffered legal punishment, while another stated that the Thai Navy had good relations with the fisheries with regard to illegal fishing, adding that the (maximum) punishment for fishing in the 3km zone was 10,000THB (\$312) and 12 month’s imprisonment. It is also true that a commercial fisher reported that in December 2007, four trawlers were arrested. However, other respondents said there was inadequate action being taken against illegal fishing carried out by commercial boats, because of difficult sailing conditions for enforcement vessels. These respondents pointed out that unpunished illegal fishing undermined attempts at management of coastal resources, because artisanal fishers did not see the sense of protecting the remaining stocks for commercial fishers to fish out. Tackling this problem is critical to achieving any other management objectives, and is in essence a public duty for resource protection (Mulekon et al [Mulekom in References] 2006). [Estelle, is the spelling Mulekon or Mulekom?]

Fourth, it seems generally agreed by respondents that the present free-for-all is not sustainable, and that more regulations beyond the national 3k limit and MMS need to be introduced and enforced. It is true that there is some socio-economic advantage in a free-for-all system, in that it serves as a subsistence safety net. Fishing is often quoted as a “livelihood of last resort” (Béné 2003; Stocbutzki [Stobutzi in References] [Estelle, is the spelling Stocbutzki or Stobutzi?] et al 2006; Alison & Ellis 2001) – an activity that allows the poorest to subsist when all else fails: an “insurance or safety mechanism against shock for people who have lost permanently or temporarily their means of survival” (FAO 2000: point 24.). This service to society relies directly on the open access system. However, by conventional wisdom, open access is considered the root cause of resource depletion (Béné 2003), because it poses problems for the collection of reliable data on resource dependency and extraction, and it makes the enforcement of regulations very difficult.

The resilience of multi-species environments such as reef fisheries may mask the extent of damage to fish assemblages, but as a precautionary measure, management should take action to halt a further cascade effect in trophic extraction. The most obvious management solution to the reduction of fish density observed on the Hai Thai Meaung reef would be an extension of the national park to include this marine resource. Findings by Russ (2002) support marine park status as a precautionary measure for a wide range of reasons that cannot be ignored even with continuing debate over their short-term success. However, whilst national park extension would theoretically be beneficial for this reef, without adequate enforcement to reduce poaching through illegal fishing, little would be accomplished to increase fish density and size of target species (Russ 2002). Significantly, WWF Thailand, who first identified the coral reef, do not want it protected as part of the National Park, because they have little faith in the governing system. Recommendations that have been made to sustain other reef fisheries in similar situations include a proposal by McClanahan & Mangi (2004) to reduce the overlapping of gear type (gear which targets the same species). A simpler proposal would be to ban or strictly regulate gear types known for their heavy impacts, such as spear fishing, and, more importantly, weighted gillnets in reef areas. Diversifying the gears used to select from all trophic groups has also been proposed by McClanahan & Mangi (2004: 58): “Managing for sustainability and trophic level maintenance can be improved by determining the trophic levels being captured by various gears and adjusting the mix of gears to maintain the full trophic composition of the fishery”. However, whether this would be palatable to small-scale fishermen would depend on the marketability of lower trophic species, but steps could be taken to manage local markets. This research has highlighted the role that market demand can have on reef fishery gear and fish composition, in that even with abundant fish availability (herbivores), a lack of marketability resulted in non-capture.⁵ This creates an opportunity for management to control/reduce capture of certain heavily targeted species by influencing the demand in local markets. Short-term inflation in fish values during periods of low catch rates is also of concern, as there is little incentive for fishers to reduce their pressure on dwindling stocks, so control is needed over the fluctuating prices of fish by long-term pricing strategies that build in the variations in catch volume.

⁵ So far as we know, no other study has shown how the market rather than opportunism is the main driver of fish capture in artisan reef fishing.

The viability of all such recommendations critically rests on their reception by artisanal fishers, who currently feel that they need to fish at every opportunity, restricted only by the weather. Management initiatives that influence the market are likely to please fishers, but restrictions on access such as fishing seasons may be greeted with hostility unless increased security and benefits can be offered to small-scale fishing outside these seasons. When questioned about management, small-scale fishermen stated that they were not opposed to reduced access if it meant improving coastal stocks for themselves, but not when the benefits would be shared with external fishers. Lowering the costs of fishing operations, such as replacing lost equipment (and preventing the loss of gear in the first place), improving inshore stocks; and reducing the volume of gasoline needed as fuel, would significantly increase the security of, and benefits for, small-scale fishermen.

However, what is also required is stakeholder participation in the decision-making process responsible for such policies, and this entails a change in the structure and style of the management system. The remedy for weak management is not to impose a strong, national, top down, coercive mode of fisheries governance on the reef fishery, but to empower artisanal fishers with the authority to establish regulations for its protection together with the resources to monitor fishers' behaviour and enforce the regulations on violators. If the objection were raised that artisanal fishers could not be trusted with such authority, a government officer (GO)'s statement provided assurance: he said that many of the artisanal fishers had a good grasp of coastal ecology and understood the need to look after the coral reef resource. Another GO said that small-scale fishing was not a concern because artisanal fishers had a "good ecological understanding". The first GO added that many artisanal fishers also had a personal incentive to be good environmental stewards of the reef, because they did not have land or any alternative way to make money, so they knew they had to look after what they had. According to another GO, there was already provision for public participation in the National Park system, "but if it is not supported then the province can create a Provincial Declaration that can protect the reef and limit fishing activities". He added that informally, the "village headmen can manage by themselves and police the activities". [Estelle, this quotation came from Ekkasak Punyasnudes]. Moreover, a head fisher claimed that local fishers "report any use [of dynamite and cyanide fishing] that they know about to the police", and that the "Locals follow [the] rules of local fisheries...not to damage the reef, use damaging gear or take small fish", adding that there is "social stigma if people break the rules". Another head fisher remarked that "local fishermen try to set up groups themselves to monitor the commercial fishing in the area", and that "local fishermen want the 3km zone to be extended to 5km to protect the shallow waters and allow the bigger fish to come closer to shore...[and] to function as a buffer zone".

6. Conclusion

The findings of this paper are that while the Hat Thai Mueang coral reef fishery is not in crisis, there are worrying signs of decline in reef fish stocks due to over-exploitation that need to be addressed. However, the main cause of the decline in fish stocks is commercial, rather than artisanal fishing, and the main remedy suggested is to replace the largely open access or 'free-for-all' regime of fisheries management with a mode of governance that empowers the local stakeholders to impose stricter regulatory control over fishing activity. Only by such a system of bottom-up environmental stewardship will the sustainability of the reef fishery be secured.

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