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# Status, trends and challenges in the sustainability of small-scale fisheries in the Philippines: Insights from FISHDA (Fishing Industries' Support in Handling Decisions Application) model

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ABSTRACT

Managing small-scale fisheries in a developing country like the Philippines is very challenging because of high pressures from expanding fishing population, poverty and lack of alternative options. Thus, resource-focused fisheries management initiatives such as marine protected area (MPA) establishment will likely result in further marginalization of the poor fishers which could pose more serious problems in coastal communities. In this study, the status of small-scale fisheries in 44 coastal towns in the Philippines was assessed using FISHDA (Fishing Industries' Support in Handling Decisions Application), a simple decision support tool which requires minimal or easily-generated data. Results showed that 68% (30 out of 44) of the studied towns have unsustainable fisheries unless 58% of their fishing grounds are protected from all fishing activities. Alternatively, 53% of the active fishers in towns with unsustainable fisheries must totally stop fishing to avert fishery collapse. Alarming as it may sound, this is still an underestimate as catches incurred by the highly efficient and destructive illegal fishing activities such as blast, poison and large-scale fishing, which are reported to be still rampant in many coastal areas in the Philippines, were not accounted for in this study. This study demonstrated that MPAs alone may not be enough to avert fishery collapse even if MPA size is increased from the current 3% to 15% of the municipal waters, i.e. up to 15 km from the shore, as required by the Philippine law. Various challenges confronting the fishery and important recommendations to address them are further discussed.


## 1. Introduction

The world's coastal fisheries are in a continually declining state [1]. Overfishing from expanding population, unregulated extraction, improved fishing technology among others [2–5], and habitat deterioration from anthropogenic (destructive fishing practices, pollution, and irresponsible coastal developments, to name a few) and natural (climate change, boom of invasive species) disturbances are seriously threatening the fishery with collapse beyond recovery unless urgent actions are taken [6–9]. Fisheries decline has perpetuated poverty in fishing communities which, in turn, aggravated Malthusian overfishing [10] that would undermine both the health of ecosystems and human welfare such as food security and livelihood, especially in the face of burgeoning population [11,12].

Establishment of marine protected areas (MPAs) has been considered by many as among the most effective means to mitigate the impacts of overfishing and arrest further deterioration of coastal ecosystems [13,14]. Recently, there have also been increasing works toward MPA networks that incorporate connectivity, both social (e.g. sharing of experiences and resources) and biophysical (e.g. larval dispersal, adult home range) in MPA establishment, to increase the effectiveness and efficiency of MPA management [15]. However, there have been issues with equity and undesirable socioeconomic implications in MPA establishment as often, too much emphasis has been placed on the state of the resources and less on the socioeconomic considerations resulting in further displacement of the resource users particularly the poor fishers [16]. Some displaced fishers would oppose MPA establishment, especially where alternative livelihood opportunities are lacking, because of its immediate economic implication as affected fishers would have to exploit farther fishing grounds

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[17]. Resource use conflict and displacement of fishers often resulted in less cooperation in coastal resource management (CRM) programs which may jeopardize the purpose of MPA establishment to conserve marine ecosystems [18–20]. In many cases, fishers do not approve closure of their productive grounds, which may also happen to be the most diverse areas or the spawning aggregation areas of highly exploited species such as groupers that need protection for biodiversity conservation. Large MPAs are also not easily acceptable especially in areas that are highly dependent on fishing and opportunities outside the fisheries are lacking or inaccessible [20]. Due to financial and logistical challenges, successful MPA establishment in the Philippines has to be done in consultation with the local community, while upholding transparency and equitable sharing of costs and benefits, in order to encourage local participation and volunteerism in coastal resource management activities [15,21]. Studies have shown that successful coastal resources and fisheries management is often achieved in community-based managed areas where there are strong community support and unity along with leadership with strong political will [22–24].

Alternatively, fishing pressure could also be alleviated by limiting the number of fishers to within the carrying capacity of the fishery [4,25]. Livelihood and other economic-assistance programs would be helpful in facilitating transition of fishers from fishing to non-fishing livelihoods and reduce dependency on the fishery [26,27]. However, in a developing country like the Philippines, there are not much options outside the fishery especially in remote rural coastal areas. Unemployment is a major problem in the Philippines even in urban centers of development. Considering the above challenges, successful fisheries management must carefully take into consideration the welfare of fishery-dependent communities who are directly affected by coastal resources conservation programs [28–31].

Various models have been developed to estimate the maximum sustainable yield (MSY) of the fishery in order to maximize human benefits from the fishery without seriously compromising its sustainability [32]. However, these models are mostly too technical in terms of operation and data needs to be usable in the Philippines [19]. Primary mandate on CRM in the country has been devolved to the local government units (LGUs) who mostly lack the technical skills to effectively carry out such an important mandate. In this regard, various user-friendly and less complicated tools were developed in the Philippines to assist the LGUs and other CRM practitioners [19]. One of these tools is FISHDA which uses basic ecological, fisheries and socioeconomic information to assess the state and sustainability of the fisheries [33]. FISHDA is a user friendly software that requires minimal or easily generated data needs which is very useful in data-deficient areas like in many parts of the Philippines. FISHDA is a simpler and freely distributable version of FISH-BE (Fisheries Information for Sustainable Harvest Bio-Economic model) [34,35].

In this study, FISHDA was used to assess the sustainability of coastal fisheries in 44 towns throughout the Philippines. This is an improved and updated paper that was presented at the International Coral Reef Symposium 2012 in Cairns, Australia in July 2012, and later published in the proceedings of the said symposium [36]. Muallil and colleagues [36] discussed mainly the MPA-size and number of fishers requirement to sustain the fishery of 25 coastal towns. In this study, the number of coastal towns assessed was almost doubled and more details on the fishery characteristics of each study site are presented. Major challenges confronting the fishery and various ways to address them are also discussed. Important findings of this study would be helpful in planning for management interventions such as livelihood and other related programs for fishing pressure alleviation and coastal resources protection like MPA establishment and regulation of fishing pressure.

## 2. Materials and methods

### 2.1. Data collection

Primary fisheries and socioeconomic data were generated through snow-ball one-on-one interviews with a total of 6488 small-scale fishers aged 16 to 77 years old in 44 coastal towns or municipalities representing all the six biogeographic regions of the Philippines (Fig. 1). In each town, interviews were carried out in at least four, mostly six, coastal villages or *barangays* that were identified to have high fisher population upon consultation with the local government unit (LGUs) or some local experts. At least four local interviewers, who were college graduates or had previous experiences in doing similar surveys, were contracted to do the surveys. Nonetheless, the interviewers were trained well in delivering the questions prior to the interviews to ensure standardization on data collection. The study was conducted from 2009 to 2013 which constitutes the outputs of various projects where the primary author was actively involved in data collection. Focused group discussions (FGDs) with key informants (mostly fishers, their wives and local leaders) were also conducted to validate results from one-on-one interviews and to discuss issues and threats confronting the fisheries.

Size of municipal waters was estimated using ArcView software. As defined in the Fisheries Code of the Philippines, municipal waters extends from the shore up to 15 km seaward where operation of commercial fishing vessels (e.g. $>3$ gross tons) is prohibited. In cases where municipal waters of two towns overlap, the boundary is delineated right at the middle of the two towns so that they divide the waters equally between them. MPA size and number of municipal fishers were obtained from the database of the Coral Reef and Community Ecology (COMECO) laboratory of the Marine Science Institute of the University of the Philippines or from the records of respective LGUs or various agencies working with the LGUs. In cases where no data is available, the number of fishers was estimated from the FGDs. Size of fishing grounds was also estimated from FGDs. Generally, the area of the fishing grounds were 70% of the municipal waters in towns with open seas (Bolinao, Calauag, Cantilan, Candelaria, Caramoan, Cortes, El Nido, Gubat, Lanuza, Lianga, Looc, Lubang, Marihatag, Masinloc, Roxas, Mati, Sagnay, Siruma, Sta. Ana, Tigaon and Tinambac) and 90% for the rest of towns with close or relatively more sheltered seas (Fig. 1).

### 2.2. Fisheries characteristics and illegal fishing activities

Catch rates were determined as the most frequent catches (in kg) per trip during a normal fishing day. Catches were then divided equally into the number of fishers fishing together (e.g. number of fishers per boat) to obtain the catch rate (kg/day/fisher). The type of boat currently owned by fishers, primary fishing gear and most dominant species caught by fishers were also inquired.

Primary gear type refers to one that is mostly used by fishers throughout the year. Many of the respondents did not provide specific characteristics of their fishing gears so the gears were classified roughly into (i) nets (all fishing gears made of nets such as gill nets, cast nets, push nets, beach seine, lift nets, fine-mesh nets and scissors nets), (ii) hook and lines (e.g. simple handline, multiple hook and line, long line and jig), (iii) pots, (iv) spears, (v) fish corrals and (vi) manual (without use of any fishing gear e.g., gleaning, skin diving).

Dominant species caught were also classified roughly into family level since the fishers provided only the common names of their catches which could not be easily identified to the species level. In some cases, the same common name is used to refer to different species in different places. *Tulingan* for example refers to

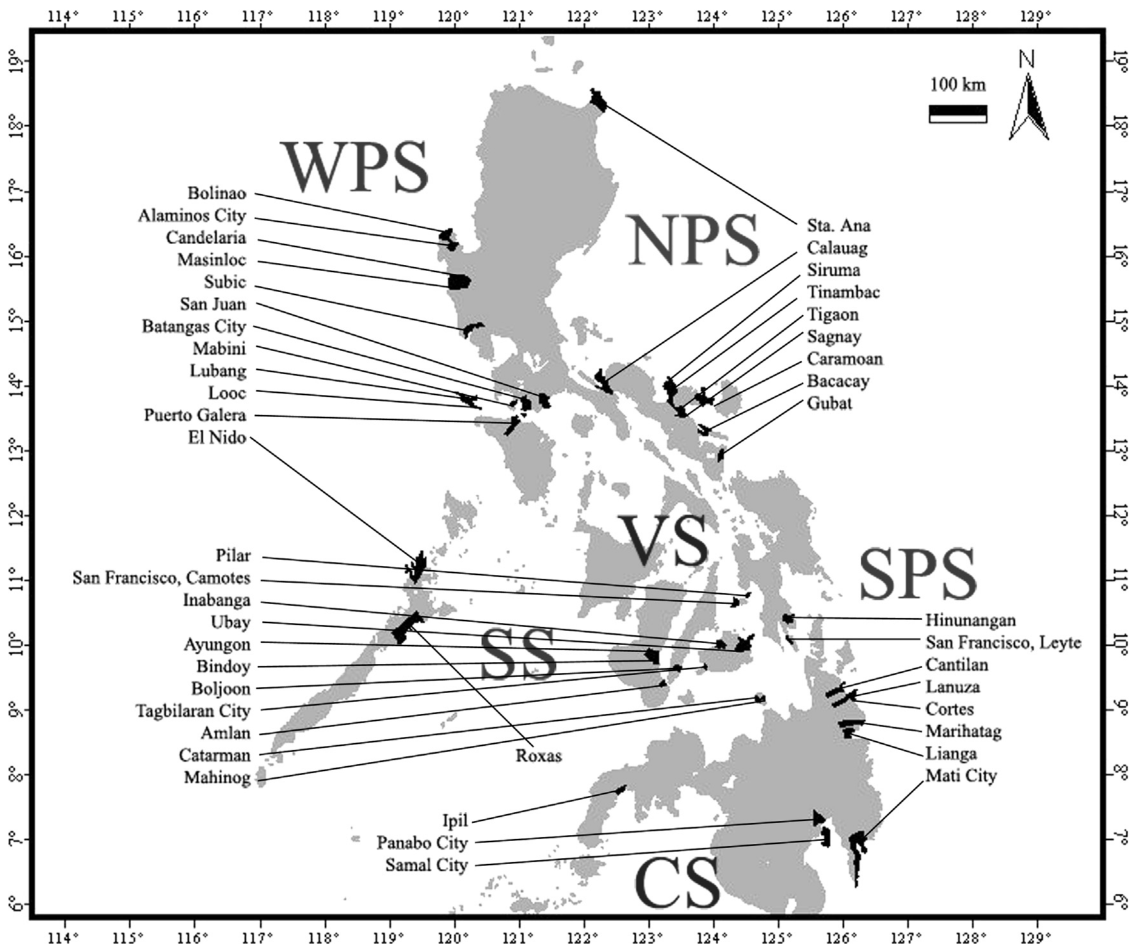


**Fig. 1.** Study sites showing the six biogeographic regions of the Philippines. NPS (North Philippine Sea), SPS (South Philippine Sea), CS (Celebes Sea), VS (Visayan Seas), SS (Sulu Sea) and WPS (West Philippine Sea).

small species of tuna (bullet tuna) in Visayas and Luzon areas but refers to the bigger species of tuna (yellowfin tuna ) in many areas in Mindanao. Dominant catches were further grouped into (i) pelagic species such as *Carangidae* (jacks and scads), *Scombridae* (tunas and mackerels), *Engraulidae* (anchovies and silversides), *Clupeidae* (sardines and herrings), *Exocoetidae* (flyingfishes), *Mugillidae* (mullets), *Trichiuridae* (hairtails), *Caesionidae* (fusiliers), *Belonidae* (needlefishes), *Hemiramphidae* (halfbeaks) and other pelagics (marlins, barraccudas and the rest of pelagic species), and (ii) demersal species such as *Siganidae* (rabbitfishes, spinefoots), *Nemipteridae* (breams), *Labridae* (wrasses and parrotfishes), *Haemulidae/Lutjanidae/Lethrinidae* (sweetlips, emperors and snappers), *Serranidae* (groupers), *Mullidae* (goatfishes), *Leiognathidae* (slipmouths or ponyfishes), *Acanthuridae* (surgeonfishes) and other demersals (triggerfishes, eels, squirrelfishes, damselfishes, angelfishes, cardinalfishes and the rest of demersal species). Invertebrate catches include shrimps, crabs, cephalopods (squids, cuttlefishes and octopuses) and other invertebrates (sea cucumbers, lobsters and shellfishes) which were classified as demersals in FISHDA analysis (see below).

Illegal fishing activities or those that are prohibited by the law to operate in municipal waters were gathered through series of FGDs with key informants. Three major illegal fishing activities that were identified were blast fishing, poison fishing and commercial fishing using boats larger than $>3$ gross tons. Catches from illegal fishing activities were excluded from FISHDA analysis since these were not properly quantified during the survey. Nonetheless, the prevalence of these illegal fishing activities for each town based on discussions with key informants during FGDs was discussed. The prevalence of occurrence of illegal activities was categorized into (i) low (minimal to no occurrence of violations, e.g. less than once a week), (ii) moderate (e.g. about once to 6 times in a week) and (iii) high (at least once a day).

### 2.3. Analysis

FISHDA was used to model the sustainability of the fisheries in each coastal town. Specifically, the following information were determined: (i) the fishery's sustainability in 20 years, (ii) the number of fishers that can be sustained by the fishery, and (iii) the minimum size of MPA needed to sustain municipal fish stocks. For the first two objectives, three MPA scenarios ( (i) actual MPA size, (ii) no MPA, and (iii) MPA size of 15% of the municipal waters which is the recommendation of the Philippine government) were used to determine the effectiveness of MPAs to sustain the fishery.

Table 1 lists the parameters that were inputted to the FISHDA model. For the rest of parameters, the default values in the software were used due to unavailability or difficulty in obtaining these data for most sites. Nonetheless, the default values were based on the results of many studies conducted in tropical areas in the Southeast Asia and neighboring regions [33]. Most of the default parameters were on the biological processes such as (i) fish turnover rate (1.5 per year for demersal stocks, 2 per year for pelagic stocks), (ii) initial stock (1.3 mt/km$^2$ for demersal stocks, 2 mt/km$^2$ for pelagic stocks), (iii) fishing carrying capacity (10 mt/km$^2$ for demersal stocks, 3 mt/km$^2$ for pelagic stocks), and (iv) MPA spill over rate (10% both for demersal and pelagic stocks).

## 3. Results

### 3.1. Fisheries and demographic characteristics

Results revealed high variability in terms of the various fisheries and demographic characteristics both among and within studied towns (Table 1, Fig. 2,). Average (±SD) catch rates ranged from 2.0 (±2.6) kg/day/fisher in Hinunangan to 17 (±62) kg/day/fisher in Ipil with about 5.3 (±3.6) kg/day/ fisher on average across all towns (Table 1). About half of the fishers (47±14%) across all towns have motorized boats who also may or may not have non-motorized boats. 31 (±15) % have non-motorized boats only while the rest (22±11) % of the fishers did not possess any boat. The majority of the fishers in all study sites used nets and hook and lines (44±15% and 40±18%, respectively) as their major fishing gears. The remaining 16% of the fishers used spears, fish corrals and pots with gleaners comprising less than 1 percent of the fishers.

**Table 1**
Fisheries parameters used as inputs to FISHDA model.

| BioGeoRegion | Town | Respondents | Municipal waters ($km^2$) | MPA ($km^2$) | MPA (% of municipal waters) | Number of fishers | % of demersal species in catch composition | Catch rate (kg/day/fisher) (mean ± SD) | No. of fishing days per year | *Fish price (US $ per kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| CS | Ipil | 195 | 159 | 0.8 | 0.5 | 1600 | 53.0 | 17.0 | 275 | 2.0 |
| | Panabo City | 59 | 36 | 0.5 | 1.4 | 191 | 86.0 | 3.5 | 267 | 1.9 |
| | Samal City | 94 | 1037 | 53.8 | 5.2 | 4015 | 65.2 | 4.6 | 270 | 1.9 |
| NPS | Bacacay | 159 | 223 | 4.5 | 2.0 | 1850 | 72.0 | 4.2 | 207 | 1.8 |
| | Calauag | 243 | 581 | 0.1 | 0.0 | 2924 | 72.0 | 3.3 | 264 | 2.7 |
| | Caramoan | 139 | 882 | 1.0 | 0.1 | 5000 | 75.0 | 3.8 | 244 | 1.7 |
| | Gubat | 195 | 451 | 2.4 | 0.5 | 1200 | 85.5 | 2.9 | 260 | 2.3 |
| | Sagnay | 225 | 170 | 1.4 | 0.8 | 220 | 17.0 | 4.4 | 278 | 2.0 |
| | Siruma | 182 | 1014 | 19.9 | 2.0 | 1330 | 66.0 | 5.5 | 270 | 1.4 |
| | Sta. Ana | 202 | 1494 | 1.0 | 0.1 | 2745 | 32.0 | 15.0 | 204 | 1.9 |
| | Tigaon | 70 | 32 | 0.6 | 1.9 | 72 | 29.0 | 3.3 | 254 | 1.9 |
| | Tinambac | 89 | 199 | 1.0 | 0.5 | 2252 | 45.4 | 5.7 | 167 | 1.8 |
| SPS | Cantilan | 132 | 252 | 0.6 | 0.2 | 6348 | 63.8 | 6.1 | 208 | 1.8 |
| | Cortes | 80 | 287 | 1.1 | 0.4 | 687 | 83.3 | 3.0 | 248 | 2.0 |
| | Hinunangan | 151 | 181 | 1.2 | 0.7 | 582 | 69.3 | 2.0 | 152 | 2.1 |
| | Lanuza | 141 | 148 | 0.6 | 0.4 | 720 | 43.3 | 2.5 | 165 | 2.2 |
| | Lianga | 129 | 238 | 0.9 | 0.4 | 680 | 54.0 | 13.0 | 206 | 2.1 |
| | Marihatag | 118 | 147 | 1.5 | 1.0 | 462 | 70.0 | 3.2 | 188 | 2.0 |
| | Mati City | 219 | 1222 | 5.8 | 0.5 | 2000 | 57.4 | 10.2 | 251 | 2.2 |
| SS | Roxas | 203 | 1260 | 85.7 | 6.8 | 2000 | 71.0 | 8.3 | 255 | 4.8 |
| VS | Amlan | 175 | 43 | 0.1 | 0.2 | 536 | 13.9 | 3.7 | 247 | 2.2 |
| | Ayungon | 198 | 114 | 1.0 | 0.9 | 1650 | 45.0 | 7.0 | 256 | 2.2 |
| | Bindoy | 144 | 81 | 1.1 | 1.4 | 931 | 28.0 | 3.3 | 261 | 2.0 |
| | Boljoon | 176 | 109 | 0.2 | 0.2 | 750 | 31.8 | 3.3 | 226 | 2.0 |
| | Catarman | 87 | 276 | 0.9 | 0.3 | 1200 | 19.0 | 8.2 | 186 | 1.9 |
| | Inabanga | 179 | 163 | 0.1 | 0.1 | 5000 | 67.1 | 2.2 | 274 | 2.2 |
| | Mahinog | 47 | 154 | 0.3 | 0.2 | 1000 | 60.0 | 3.6 | 171 | 2.6 |
| | Pilar | 175 | 301 | 2.5 | 0.8 | 1242 | 48.0 | 2.7 | 239 | 2.0 |
| | San Fran, Camotes | 180 | 899 | 0.4 | 0.0 | 3205 | 37.9 | 4.9 | 237 | 1.6 |
| | San Fran, S. Leyte | 137 | 116 | 0.1 | 0.1 | 425 | 46.7 | 2.0 | 143 | 1.8 |
| | Tagbilaran City | 167 | 51 | 0.1 | 0.2 | 6000 | 43.1 | 4.6 | 247 | 2.5 |
| | Ubay | 167 | 232 | 1.5 | 0.6 | 1495 | 80.0 | 3.1 | 236 | 2.0 |
| WPS | Alaminos City | 91 | 199 | 16.6 | 8.3 | 1979 | 90.8 | 2.4 | 240 | 1.4 |
| | Batangas City | 100 | 354 | 0.1 | 0.0 | 1121 | 44.7 | 2.5 | 199 | 1.7 |
| | Bolinao | 105 | 863 | 1.1 | 0.1 | 4202 | 91.3 | 3.7 | 227 | 1.3 |
| | Candelaria | 116 | 212 | 2.5 | 0.0 | 1000 | 44.0 | 3.7 | 192 | 2.1 |
| | El Nido | 115 | 1612 | 543.0 | 33.7 | 3000 | 66.7 | 6.4 | 245 | 1.1 |
| | Looc | 133 | 1487 | 70.0 | 4.7 | 888 | 82.5 | 5.1 | 241 | 1.8 |
| | Lubang | 103 | 1143 | 70.0 | 6.1 | 834 | 30.7 | 6.8 | 240 | 1.2 |
| | Mabini | 107 | 196 | 3.4 | 1.7 | 772 | 30.0 | 5.1 | 221 | 1.9 |
| | Masinloc | 77 | 209 | 77.7 | 37.2 | 1320 | 27.1 | 16.5 | 166 | 1.5 |
| | P. Galera | 104 | 118 | 10.0 | 8.5 | 333 | 35.6 | 4.8 | 168 | 2.2 |
| | San Juan | 498 | 409 | 3.0 | 0.7 | 2000 | 41.0 | 3.2 | 213 | 2.1 |
| | Subic | 82 | 76 | 1.0 | 1.3 | 1286 | 63.0 | 3.7 | 220 | 1.9 |
| | **AVERAGE** | 147 | 442 | 23.0 | 3.0 | 1850 | 54.0 | 5.3 | 226 | 2.0 |

* Conversion rate used was US $1=PhP 45.

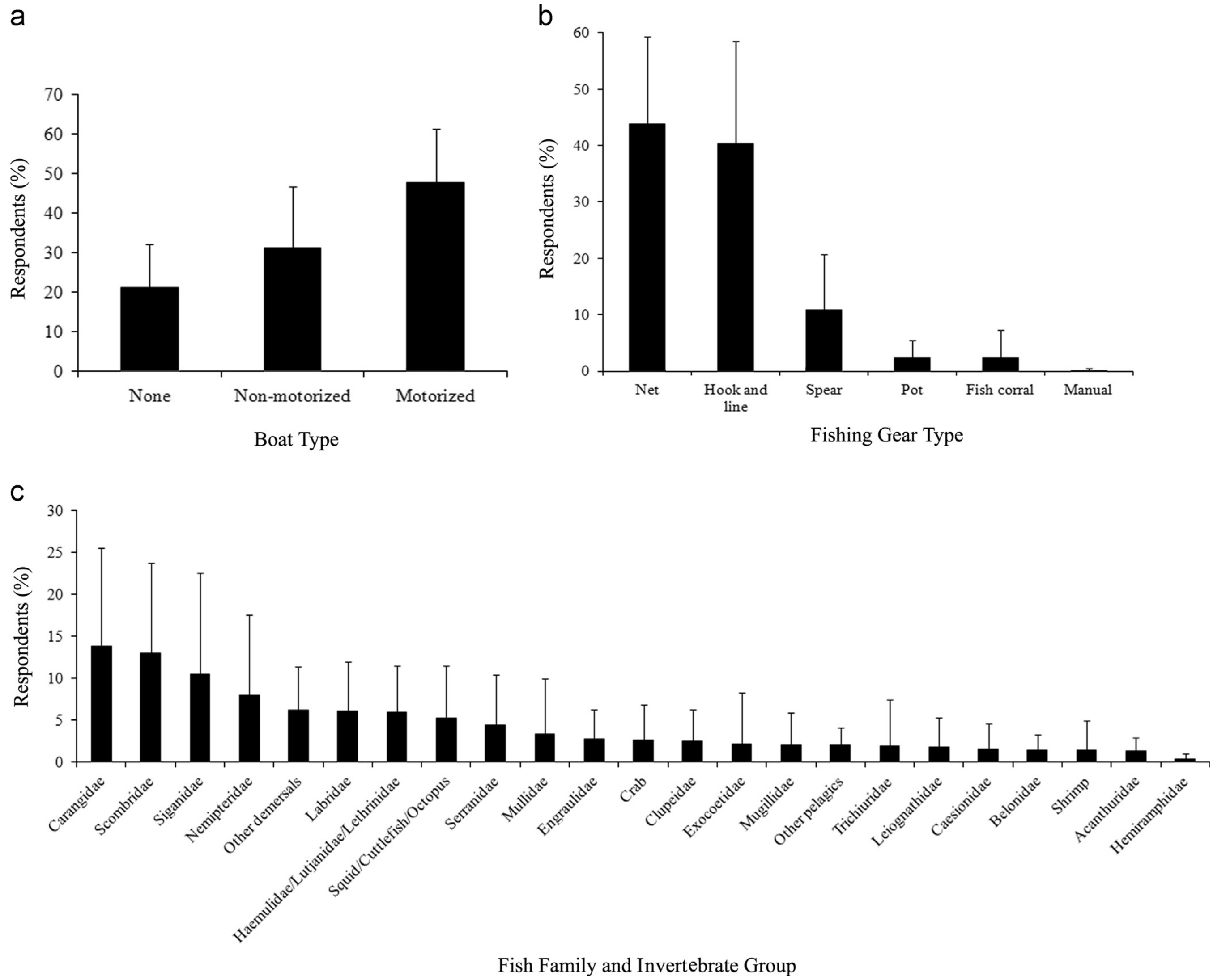


**Fig. 2.** (a) Boat ownership, (b) major fishing gear and (c) dominant catch composition of fishers across all towns. Bars and whiskers represent average and standard deviation, respectively, of percentages of respondents in all towns.

A little more than half (53 ± 21%) of the fishers were catching demersal species (Table 1). Demersal catches were more variable in composition than pelagic ones which were dominated by families Carangidae (jacks and scads) and Scombridae (tunas and mackerels), the two most dominant catches overall (Fig. 2). The next most dominant catches were demersal fishes like Siganidae (rabbitfishes, spinefoots), Nemipteridae (breams but mostly threadfin breams), Labridae (wrasses but mostly parrotfishes) and Serranidae, respectively.

### 3.2. *Illegal fishing activities*

Intrusion of commercial fishers inside the municipal waters was the most rampant form of illegal fishing activities incurred inside the municipal waters (Table 2). Key informants during FGDs in all studied towns reported observation of commercial fishing activities (at least at moderate level) inside the municipal waters, 75% of the towns actually reported daily occurrence (high level). Poison fishing was the next most rampant illegal activity which was reported to be in high and moderate levels in 57% and 29% of the studied towns, respectively. There were no report of poison fishing in the rest of the towns. Blast fishing was relatively the least rampant which was reported, at least at low (to none) level, moderate and high levels in 36%, 21% and 43%, respectively, of the studied towns.

### 3.3. *FISHDA model*

Results of FISHDA showed that the fisheries in 30 of the 44 towns (68%) are bound to collapse (Fig. 3). To sustain the fishery, given the actual number of fishers, an average of 42% of the municipal waters across all towns must be protected and become off limits to all fishing activities (Fig. 4). For the 30 towns with unsustainable fisheries, 58% of the municipal waters must be protected to avert collapse of the fishery. At present, only 3% of the municipal waters is protected. Alternatively, reduction of 36% of the active fishers is needed to make the fishery sustainable in all towns, given the actual MPA size. For towns with unsustainable fisheries, the number of active fishers must be reduced by 53%. More than 90% of the active fishers must completely stop fishing in order to sustain the fishery in Tagbilaran City, Cantilan and Ipil.

The percentage of fishers that must completely stop fishing increased to 38% at no MPA scenario, and decreased to 32% at 15% (of the municipal waters) MPA size scenario. Except for El Nido, all the towns that are unsustainable at no MPA scenario are also unsustainable at the actual state of MPAs. At 15% MPA size scenario,

**Table 2**

| Biogeographic Region | Town | Blast fishing | Poison fishing | Commercial fishing[a] |
|---|---|---|---|---|
| NPS | Bacacay | | | |
| | Calauag | | | |
| | Caramoan | | | |
| | Gubat | | | |
| | Hinunangan | | | |
| | Sagnay | | | |
| | San Fran, S. Leyte | | | |
| | Siruma | | | |
| | Sta. Ana | | | |
| | Tigaon | | | |
| | Tinambac | | | |
| SPS | Cantilan | | | |
| | Cortes | | | |
| | Lanuza | | | |
| | Lianga | | | |
| | Marihatag | | | |
| | Mati City | | | |
| CS | Ipil | | | |
| | Panabo | | | |
| | Samal City | | | |
| VS | Amlan | | | |
| | Ayungon | | | |
| | Bindoy | | | |
| | Boljoon | | | |
| | Catarman | | | |
| | Inabanga | | | |
| | Mahinog | | | |
| | Pilar | | | |
| | San Fran, Camotes | | | |
| | Tagbilaran City | | | |
| | Ubay | | | |
| SS | Roxas | | | |
| WPS | Alaminos | | | |
| | Batangas City | | | |
| | Bolinao | | | |
| | Candelaria | | | |
| | El Nido | | | |
| | Looc | | | |
| | Lubang | | | |
| | Mabini | | | |
| | Masinloc | | | |
| | P. Galera | | | |
| | San Juan | | | |
| | Subic | | | |

[a]During fishing season.

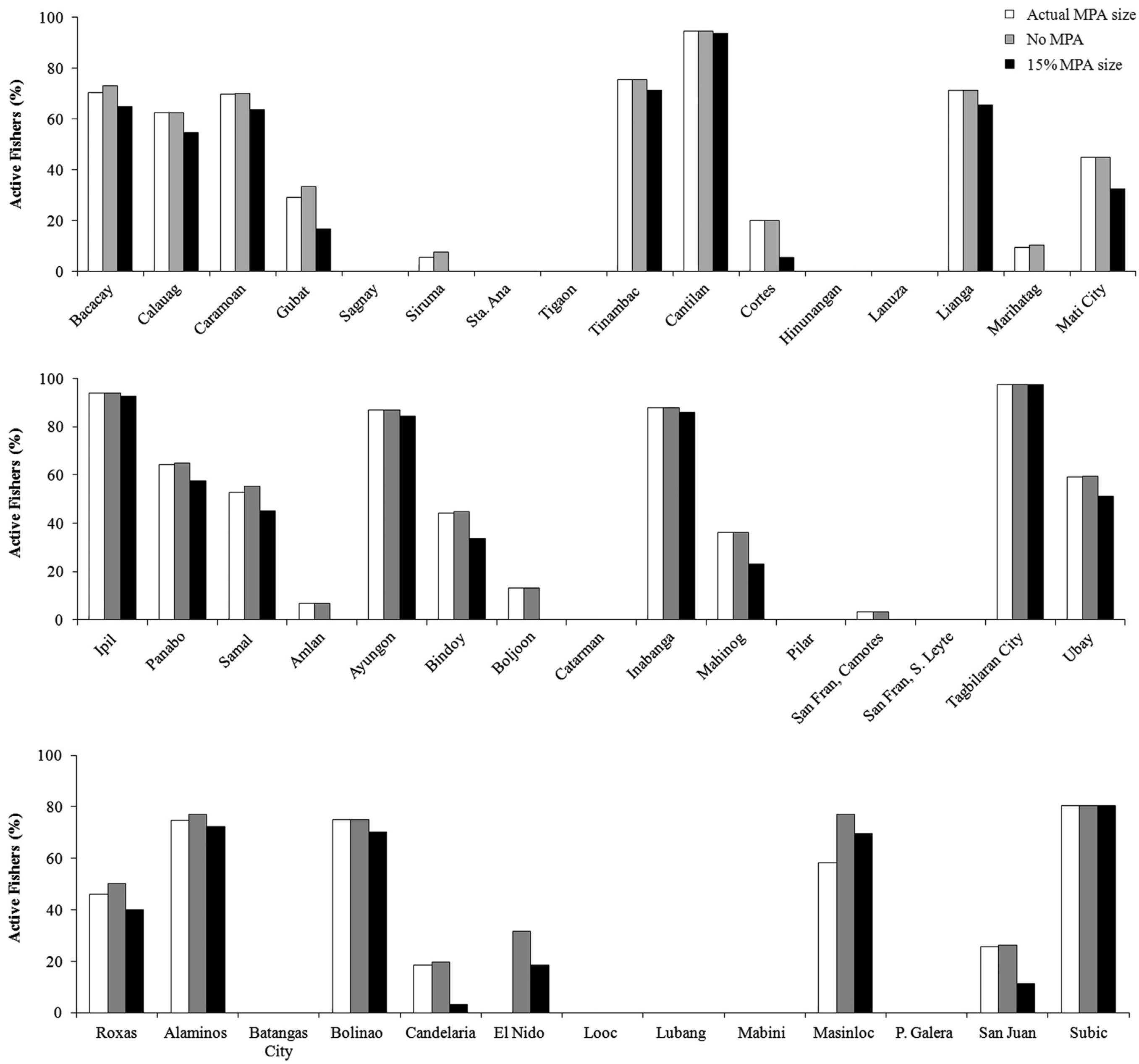


**Fig. 3.** Sustainability of fisheries in each town at 3 MPA-size scenarios (actual, white bar; no mpa, gray bar; 15% of municipal waters, black bar). Bar indicates unsustainable fisheries as well as the proportion of fishers that must exit the fishery to avert fishery collapse.

5 towns (Boljoon, Marihatag, Amlan, Siruma and San Francisco Camotes) or about 17% of the towns with unsustainable fisheries at no MPA scenario became sustainable. The status of fishery in El Nido, although, already with sustainable fishery with approximately MPA size of 34% of its municipal waters, became unsustainable when its MPA size was reduced to 15% of the municipal waters.

## 4. Discussion

Results of the study reveal that most coastal fisheries in the Philippines will eventually collapse due to overfishing alone, even if illegal fishing activities such as blast, poison and commercial fishing in coastal areas were effectively controlled or even when the recommendation of the Philippine government to designate 15% of the coastal waters as MPAs were implemented. 68% of the Philippine coastal fisheries are found unsustainable which is almost comparable to the findings of Worm and colleagues [6] that about 63% of the world's fisheries require rebuilding. Average yield across all towns is approximately 12 ($\pm$24) mt/km$^2$/yr, which is more than two times higher than the estimated 5 mt/km$^2$/yr MSY for island coral reefs [3]. Although, the results revealed that 24 towns or about 54% of the studied towns, are still within this MSY limit and besides the fact that some fishers may be fishing outside the municipal waters, actual fishing pressure could be underestimates since catches from highly efficient but destructive illegal fishing operations were excluded in the study.

The recommendation that as high as 58% of the municipal waters must be closed from all fishing activities to achieve fisheries sustainability may be impossible to implement for the majority of coastal areas in the Philippines where large portion of the population is highly dependent on the fishery and alternative opportunities outside the fishery are lacking. Many fishers would be displaced and without alternative options, closing large area of the fishing grounds

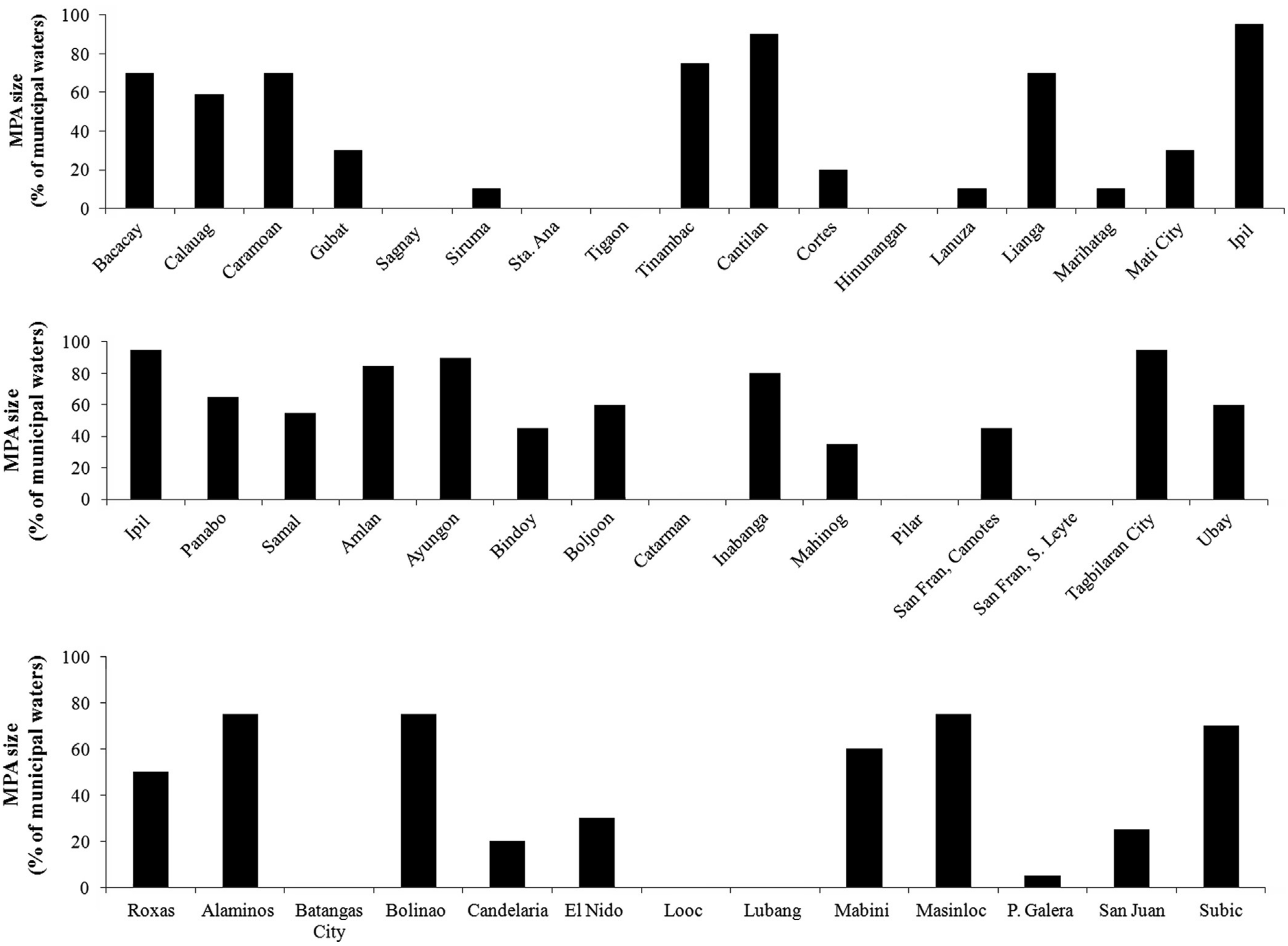


**Fig. 4.** The minimum size of MPA needed to avert fishery collapse given the actual number of fishers in the respective towns.

would result in immediate loss of short-term benefits for fishers which in turn could worsen poverty incidence in the fishing communities that may aggravate problems on food security, health, illiteracy and even crimes. Further, small-scale fishers, due to poverty, may not have the capacity to improve fishing technology to exploit farther "open" fishing grounds which may also be seriously overfished themselves [37]. Previous studies using FISH-BE in major bays in the Philippines also suggested variable but generally very large MPA sizes requirement for sustainable fisheries, e.g. 20% of the fishing grounds in Calauag Bay, 55% in Tayabas Bay [38], 11% in Honda Bay, 54% in San Miguel Bay, 77% in Lingayen Gulf, 38% in Sogod Bay, 23% in Ormoc Bay, 80% in Sapian Bay, 41% in Davao Gulf, 0% in Butuan Bay and 0% in Gingoog Bay [39].

Alternatively, fishing pressure could also be alleviated by promoting transition of fishers into alternative livelihood [26]. This study suggests that for towns with unsustainable fishery, about 53% of the active fishers must completely exit the fishery to achieve fisheries sustainability. Even when 15% of the municipal waters have been allocated as MPAs, active fishers must still be reduced by 46%. With too many fishers in the Philippines, 46% is equivalent to about 813 small scale fishers in each town and could be as high as more than 1000 small-scale fishers in 10 towns or 22% of the studied towns. With very limited resources, developing countries like the Philippines could not afford to provide enough livelihood and other economic assistance that would sufficiently reduce the number of fishers to within the sustainable limit of the fishery as suggested by the results of this study.

There are, however, existing government livelihood and economic-assistance programs in the Philippines down to the community level. The Department of Science and Technology in partnership with various State Colleges and Universities are developing products using various product development protocols to increase use and value of raw materials available in the local level while the Department of Trade and Industry provides training on product development, product packaging, promotions and marketing. The Department of Agriculture is providing stocks for backyard farms both planting materials (quality seeds and seedlings) and livestock of various kinds. Skills trainings that can hone the employment capacities of local community members are also provided by the Technical, Education and Skills Development Authority (TESDA). Scholarship and Educational Assistance programs are available from the Local Development Funds, Discretionary Funds of Local Officials including the Congressmen. Both livelihood skills trainings such as food processing, novelty items production, among others and microfinancing to provide capitalization for small businesses are available in some Local Government Units under their regular programs and services. It is, however, being advocated that the primary target beneficiaries or partners of these supplemental or alternative livelihood or enterprise development programs will be the fishers and members of the fishing households in order to reduce their dependency on the fishery. Apart from its potential to reduce fishing pressure, any form of economic assistance is necessary to alleviate poverty in the fishing households as average daily catches from fishing of $5.3 \pm 3.7$ kg/fisher, or a gross income of about US $ 10 a day, are barely enough to provide the basic needs of fishers' households and the fishing expenses. Moreover, there are days, especially during lean season, when catches are less than a kilogram. Sometimes fishing is not even possible during typhoons or very bad weather condition brought about by strong Asian monsoonal winds.

Capacity building and livelihood programs must be pursued to increase chances of fishers to shift from fishing to alternative occupations. These, however, must not be pursued blindly as fishers have been shown to have varying behavior in terms of their willingness to exit the fishery [27,40]. Muallil and colleagues [27] suggested that fishers who are newer in the fishery could be potential candidates for livelihood programs. Further, younger fishers especially those with growing kids must be targeted for livelihood assistance as they are the ones associated with higher fishing effort [25]. Fishers' children must also be provided education and training support to increase their chances of venturing into non-fishing occupations in the future. Older fishers and those who have been fishing longer must be encouraged to become fish wardens in order to increase their participation in marine stewardship and awareness programs. They can help in reducing instances of illegal and destructive fishing activities such as encroachment of commercial fishers to the municipal waters and poison and blast fishing which are still reported in most of the study sites. The fishers during FGDs, cited these unsustainable fishing practices as the major causes of the drastic decline of fish catches starting the 1980s (See also [41–43]). Strong information, education and communication (IEC) campaigns on the importance of coastal resources must be enhanced and sustained by making it part of every CRM program and incorporating it in basic education curriculum. Effective IEC campaigns can increase awareness and appreciation especially among the youth, resource users and local leaders who are key in successful coastal resources management [23].

Aside from MPA establishment and reducing the number of fishers through economic assistance and other livelihood programs, strengthening law enforcement against destructive and unsustainable fishing practices seemed to be more urgent. It emerged during FGDs that illegal and destructive fishing activities like blast fishing, poison fishing and commercial fishing are still very rampant, especially the latter, in most of the study sites. Weak law enforcement and poor governance are attributed as the major reason for the prevalence of these illegal fishing activities despite the strict prohibition against them as explicitly indicated in the Philippine Fisheries Code of 1998. According to fishers during series of FGDs, intrusion of commercial fishers inside the municipal waters is the major threat to the fishery that is most challenging to address. Commercial vessels are normally owned by wealthy and influential people that could not be easily apprehended by local law enforcers, usually composed of fish wardens from local residents who are often underequipped and less competent to confront the aggressive behavior of commercial fishing operators. In cases where apprehensions occurred, the penalty is sometimes very light, such as monetary fines of less than US $ 222 (PhP 10,000), for commercial fishing operators. In some cases, the violators go unpunished after some “under the table” negotiations took place between the wealthy owners and the local government unit. Conversely, blast and poison fishing are often operated by small-scale fishers which are relatively easier for the local law enforcers to regulate. Thus, most of the remaining illegal fishing activities occur in remote part of the town where law enforcement is weak.

Commercial fishing gears that are illegally used within the municipal waters include purse seines (*pangulong*), bagnet (*basnig*), modified Danish seines (*kubkob, hulbot-hulbot, liba-liba*) and trawl (*galadgad, norway*). Most of the commercial fishers use more advanced fish tracking device such as sonar, instead of the usual but still commonly used super light, which make them less visible to law enforcers. The use of sonar also makes fishing efficient even during the day. Key informants estimated that the nets commonly used by commercial vessels measure at least 1 ha in area with estimated catches per fishing vessel per day of at least 1 t of fish. During peak fishing season, one commercial fishing vessel can catch up to more than 10 t a day, which is already more than the total catches of all small-scale fishers in some coastal towns. Most fishers during FGDs attributed the drastic decline of fish stocks to the prevalence of commercial fishing vessels because aside from the large size, the nets used by commercial fishers have very small mesh size, usually smaller than 3 cm inch stretched mesh size, that can catch even immature individuals of tunas, scads and mackerels.

Regulation of other destructive or unsustainable fishing gears such as those that are destructive to coral reefs and other marine habitats and those that can catch reproductively immature individuals must also be strongly enforced. In most areas, trammel nets (*2ply/3ply, double net/triple net*), which can catch even small immature fishes, are becoming commonly used. Beach seines (*baling*) in some areas like Puerto Galera, Ayungon, Tigaon, Candelaria, among others, which have fine meshed catching chambers, are literally scraping off the fauna and flora of the substratum as the nets, approximately 200 m in length, are dragged toward the beach. Unregulated harvest of fries and small pelagics in most studied towns is also seriously threatening the sustainability of the fisheries [44]. Anchovies, silversides, sardines, herrings, shrimps and fries of groupers, milkfishes, siganids, and fusiliers are the main target of this fishery but immature individuals of other species like tunas, mackerels are among the bycatches. Closed season during some period of the fishing season, instead of total ban, is highly recommended for fry and small pelagic the fishery so as not to completely displace the fishers that are highly dependent on this fishery.

This study provides the most comprehensive assessment of the sustainability of Philippine small-scale fisheries by far. Apparently, the projected 68% of the towns to be unsustainable is still an underestimate as catches incurred by the highly efficient and destructive illegal fishers such as blast, poison and large-scale fishers, which are reported to be still rampant in many coastal areas in the Philippines, were not accounted for in the study. The MPA size needed and the number of fishers that should completely exit the fishery to prevent fishery collapse are actually much higher than proposed in this study. While this study has various limitations such as by using the same standing fish stocks and fish turnover rates in all sites, and treating the entire fishing grounds as homogenous, it could provide valuable and science-based insights especially to the national government in identifying areas that are critically overfished and where law enforcement against illegal fishing activities must be strengthened. Thus, the government including all other aid agencies both local and foreign can extract useful insights from this study to carefully plan for appropriate intervention measures to address overfishing, destructive fishing and other threats to coastal resources of the Philippines which have provided innumerable benefits not only to the local communities but also to the rest of the world that have, in one way or another, exploited these resources for food, medicines and other natural products.

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