Catch composition of fishes by different types of fishing gears in the Andaman sea, Thailand

Composição da captura de peixes por diferentes tipos de artes de pesca no mar de Andaman, Tailândia

Composición de las capturas de peces por distintos tipos de artes de pesca en el mar de Andamán, Tailandia

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ABSTRACT
The Andaman Sea is a rich ecosystem providing significant ecosystem goods and services for people in coastal areas and these areas have fisheries activities using different fishing gears appropriate for different species and habitats. We assessed catch composition and size distribution of economically important finfish captured by a range of fishing gears employed by commercial and artisanal fishers in three provinces adjacent to the central Andaman Sea of Thailand over a 2-year period. Between January 2019 and December 2021, fishers employed 7 main capture gears: surface gillnet, bottom gillnet, fish trap, handline and hook, trawl, purse seines and light-luring anchovy falling net. Trawling captured the highest diversity of target species (35 species) followed by surrounding net (32 species), fish trap (16 species) hook and line (15 species), surface and bottom gillnet (15 species) and the last one of anchovy falling net (2 species). When comparing size at the first maturation of both target species and bycatch, it was found that the percentage of mature fish caught from artisanal fishing gears was higher than of commercial fishing gear because artisanal gears had better selection of catch, especially fish trap and hook and line. Understanding the operation of fishing gears, catch composition and the size
frequencies of target species could be particularly important for stock assessment because gear may influence catch composition.

**Keywords:** catch composition, fishing gears, Andaman coastal sea, bycatch.

**RESUMO**
O Mar de Andaman é um ecossistema rico que fornece bens e serviços ecossistêmicos significativos para as pessoas nas áreas costeiras, e essas áreas têm atividades de pesca que utilizam diferentes artes de pesca apropriadas para diferentes espécies e habitats. Avaliamos a composição da captura e a distribuição do tamanho de peixes ósseos economicamente importantes capturados por uma série de artes de pesca empregadas por pescadores comerciais e artesanais em três províncias adjacentes ao Mar de Andaman central da Tailândia durante um período de dois anos. Entre janeiro de 2019 e dezembro de 2021, os pescadores empregaram 7 artes de captura principais: rede de emalhar de superfície, rede de emalhar de fundo, armadilha para peixes, linha de mão e anzol, rede de arrasto, redes de cerco com retenida e rede de queda de anchova com isca leve. A rede de arrasto capturou a maior diversidade de espécies-alvo (35 espécies), seguida pela rede de cerco (32 espécies), armadilha para peixes (16 espécies), anzol e linha (15 espécies), rede de emalhar de superfície e de fundo (15 espécies) e a última rede de queda de anchova (2 espécies). Ao comparar o tamanho na primeira maturação das espécies-alvo e das capturas acessórias, verificou-se que a porcentagem de peixes maduros capturados por artes de pesca artesanal foi maior do que por artes de pesca comercial porque as artes artesanais tinham melhor seleção de capturas, especialmente armadilha de peixe e anzol e linha. Entender a operação dos equipamentos de pesca, a composição da captura e as frequências de tamanho das espécies-alvo pode ser particularmente importante para a avaliação de estoques, pois os equipamentos podem influenciar a composição da captura.

**Palavras-chave:** composição da captura, artes de pesca, mar costeiro de Andaman, captura acessória.

**RESUMEN**
El mar de Andamán es un rico ecosistema que proporciona importantes bienes y servicios ecosistémicos a la población de las zonas costeras, y en estas zonas se desarrollan actividades pesqueras que utilizan diferentes artes apropiadas para distintas especies y hábitats. Evaluamos la composición de las capturas y la distribución de tamaños de peces de aleta económicamente importantes capturados por una serie de artes de pesca empleadas por pescadores comerciales y artesanales en tres provincias adyacentes al Mar de Andamán central de Tailandia durante un período de dos años. Entre enero de 2019 y diciembre de 2021, los pescadores emplearon 7 artes principales: red de enmalle de superficie, red de enmalle de fondo, trampa para peces, línea de mano y anzuelo, red de arrastre, red de cerco y red de caída de anchoa con cebo ligero. La red de arrastre capturó la mayor diversidad de especies objetivo (35 especies), seguida de la red de cerco (32 especies), la trampa para peces (16 especies), el anzuelo y el sedal (15 especies), las redes de enmalle de superficie y de fondo (15 especies) y, por último, la red de caída de anchoa (2 especies). Al comparar la talla de primera madurez de las especies objetivo y las capturas accesorias, se observó que el porcentaje de peces maduros capturados con artes de pesca artesanales era superior al de los capturados con artes de pesca comerciales, debido a que las artes artesanales presentaban una mejor selección de capturas, especialmente las trampas para peces y el anzuelo y el sedal. Comprender el funcionamiento de las artes de pesca, la composición de las capturas y las frecuencias de
INTRODUCTION

The Andaman Sea of Thailand contains a high diversity of habitats and species typical for tropical seas, and providing opportunities for a valuable multi-species and multi-gear fishery (Panjarat, 2008). It spans 6 provinces: Ranong, PhangNga, Phuket, Krabi, Trang and Satun. In many areas along the coast, the main livelihood of households depends directly on fisheries. The diverse range of coastal habitats and the shoreline topography along the Andaman Coast influence the types of fish, gear and techniques used by fishers (Boopendranath et al., 2012).

Fisheries are important to Thailand's economy, providing revenue for the country and the primary source of livelihood for coastal fishers in Thailand. Thailand’s multi-species fisheries employ multiple fishing gears of various designs and sizes that vary within both artisanal and commercial fisheries. The marine fisheries sector in Thailand is composed of a highly industrialized commercial sector comprising large vessels, using the most efficient equipment and technologies, and an artisanal sector using small boats and a variety of traditional gears. Both sectors are important for the national economy and for food security of the Thai people, and the commercial sector furthermore depends on international exports of valuable seafood products. Until recently, Thai marine fisheries have been more or less “open access”, which has caused conflicts among fishers as well as overfishing of resources and stock depletion (FAO, 2002). Fisheries statistics from 2015-2018 have shown that low value “trash fish” now comprise more than 70% of the total catch (DOF, 2019).

In 2018, the seafood industry in Thailand was worth over 6.9 billion dollars and in 2019 one of the largest commercial fisheries of the world had over 10,000 vessels whereas artisanal boats were the most numerous in the Thailand fleet with almost 22,000 vessels (making up 67% of the total fleet vessels) (EJF, 2019). By 2018, however, Thai fisheries had dropped to fourteenth place (1.5 million tons) in terms of capture production (FAO, 2021). Over the 10 years period from 2009–19, the fishery resources of the
Andaman Sea experienced reduced catches (DOF, 2009:2019). The proximate cause was fishing vessels equipped with high technology to rapidly deploy more sophisticated fishing equipment, as well as excessive fishing levels, substandard gears and nonselective gears. This resulted in substantial decrease of aquatic resources, overfishing and impacts on important aquatic animal population structures in the ecosystem (Funge–Smith and Kennelly, 2014). Moreover, one of the main concerns of the predominance of high technology fishing and nonselective gears was problems of bycatch leading to the decrease of marine resources and negative impacts on biodiversity (Samanta et al., 2018).

While in Thailand there have been several studies on catch composition, no continuing or long-term studies exist concerning the catch composition of fishes, the catch of fishes on landing, or ratio of target species to non-target species. Artisanal and commercial fishers in Thailand are separated mostly by scale of operation, but also on types of gear and areas of operation. Trawlers, for instance, are prohibited from operating within 3km of shore. Artisanal fishing effort has long been recognized as economically significant for coastal people in Thailand, but historically has been under-reported and remains somewhat of an unknown when trying to understand the long-term sustainability of fishing activities in coastal waters. Here, we report on catch composition of fishes by different types of fishing gears employed by both artisanal and commercial fishers. We used a combination of data collection methods to examine the fishery in terms of the catch weight, species of fish and bycatch, and used these data to estimate the proportion of landed fish that had not yet attained size of first maturation for commercial and artisanal fisheries in Krabi, PhangNga and Phuket provinces along the central Andaman Coast. The results of this study can be used as a guide for basic information to assess fish stocks for resource management as well as to plan and manage resources.

2 MATERIALS AND METHODS

The Andaman coast of Thailand runs roughly North-South between 5°–20° N and 97°–106° E. From May to October, the southwest monsoon brings a stream of warm moist air from the Indian Ocean towards the west coast of Thailand causing abundant rain over the coastal lowlands. The coastal area houses high biodiversity, nursery habitats areas and contains nutrients for aquatic animals (Panjarat, 2008). The population of the coastal areas are commonly engaged in fishing enterprises, participating in both artisanal and commercial fisheries. A majority of fisheries product is landed at local piers, maintained
by municipal and private owners, and contributing strongly to local economies. The most commonly employed fishing gears in the area are single boat benthic otter trawls, purse seines, falling net, gill nets, surface gillnet, bottom gillnet and trap.

2.1 STUDY SITE

Periodical sampling was undertaken at 6 commercials and 4 artisanal fish landings in 3 provinces in southern Thailand: Krabi (8°4’ 21” N–98° 54’ 38” E), PhangNga (8° 29’ 37” N–98° 30’ 28” E) and Phuket (7° 58’ 17” N–98° 21’ 4” E) provinces (Figure 1). Data collection comprised primary data (specimens and landing data collected in situ) and secondary data (derived from interviews with fishers and others). The data collection was undertaken every two months between January 2019 and December 2021.

Figure 1. Map showing study sites of fishing pier in the Andaman Sea

A1 Banbangpat Artisanal Pier in Phang Nga province
A2 Klong Pakbang Artisanal Pier in Phuket province
A3 Ko Klang Artisanal Pier in Krabi province
A4 Sangka U Artisanal Pier in Ko Lanta, Krabi province
C1 Fish Marketing Organization Commercial Pier in Kuraburi, Phang Nga province
C2 Nathaphon Commercial Pier in Kuraburi, Phang Nga province
C3 Por. Pichai Commercial Pier in Phuket province
C4 Fish Marketing Organization Commercial Pier in Phuket province
C5 Klong Jilad Commercial Pier in Krabi province
C6 421 Commercial Pier in Ban Bo Muang, Krabi province
Source: Own Authorship
2.2 PRIMARY DATA

2.2.1 Fish sampling

We divided the sampling from artisanal and commercial fisheries according to the predominant capture gears employed in each, i.e., surface gillnet, bottom gillnet, fish trap and hand-line were classified as artisanal fishing gears; trawl, surrounding net and falling net were classified as commercial gears.

Artisanal fisheries data were collected by choosing fisher villages in each province and recording types of fishing gears used, total of their catches, catch per species and catch weight per fishing operation. A creel sample comprising 5% of each species of fish present in a given catch (or all specimens of a species if there were very few) was obtained from the commercial fisheries sampled at fish landing sites in each province, and involved the recording of total estimated catch value, catch per species and catch weight per fishing operation. Catches from the 7 fishing gear types were sampled at the fish landing sites, each group of fish species in catches was collected by random sampling approximately at 5% each species total of catches from fishing gears both target species and bycatch.

After collection, target species samples from both artisanal and commercial fisheries, were stored in ice, while bycatch was fixed in 10% formalin solution before being brought to the laboratory for identification to species.

2.2.2 Identifying species and measuring of fish

Fish samples were identified to species by morphology using Kimura et al., 2009 and FAO, 1974

Total length was measured from the tip of snout to the caudal fin, this measure was the best for fish that have forked caudal fins; fork length was measured from nose to the middle caudal fin rays, because sometime damage of the caudal fin can make it difficult to measure total length. Specimens were weighed on a digital scale. Data were used to derive estimates for catch composition, target species–bycatch ratio and maturation size analysis.
2.3 SECONDARY DATA

Secondary data were obtained by inspection of records and interviews with the fishermen; supplementary information was obtained by inspecting data collected by Department of Fisheries, MoT Marine Department and Port–In Port–Out (PIPO) Control Centers operated by DoF. The secondary data was tabulated according to types of fishing gears, catch rate, catch species, and date of landing obtained from commercial and artisanal fishing operations.

2.4 DATA ANALYSIS

2.4.1 Assessment of length at the first maturity size (Lm)

We calculated the length at first maturity (L_m) for each species from the pooled samples. L_m is a parameter that can be used to estimate the proportion of juvenile fishes in a sample (and hence degree of juvenile overfishing). Froese and Binohlan (2000) developed a method for estimating L_m from point samples using parameters that could be either obtained directly from Fishbase (https://www.fishbase.in/), or back-calculated from the length-frequency data obtained from the sample. L_∞ (the mean length that the fish would reach if they were to grow indefinitely) can be calculated from L_max (the largest specimen obtained) to derive L_m, thus:

\[ \log_{10} L_m = 0.8979 * \log_{10} L_\infty - 0.0782 \pm 0.127 \] (Froese and Binohlan, 2000)

3 RESULTS AND DISCUSSION

3.1 CATCHES ATTRIBUTED TO ARTISANAL FISHING GEARS

3.1.1 Surface gill net

Collation of data obtained during this study with figures from DoF records indicate that artisanal fishers targeted 12 species with surface gill nets. By far the largest proportion of the catch were Indian mackerel (Rastrelliger kanagurta) 81.47%. Hardtail scad (Megalaspis cordyla) 4.35% and Short mackerel (Rastrelliger brachysoma) 3.75%
were the other significant targets, although they contributed relatively little to the catch. Bycatch (non-target, but including commercially valuable species) in most catches including spotted scat (*Scatophagus argus*) 16.68%, Brownstripe red snapper (*Lutjanus vitta*) 14.87% and Hamilton's thryssa (*Thryssa hamiltonii*) 13.81% (Figure 2a).

### 3.1.2 Bottom gillnet

Fishers employing demersal gillnets targeted 12 species, and proportions of the most caught species included Monogrammed monocle bream (*Scolopsis monogramma*) 22.22%, blackfin mullet (*Ellochelon vaigiensis*) 20.61% and Longarm mullet (*Valamugil cunnesius*) 17.28%. Non–target species and bycatch comprised 14 species, largely Malabar trevally (*Carangoides malabaricus*) 18.43%, Blue trevally (*Carangoides ferdau*) 18.04% and Indian scad (*Decapterus russelli*) 11.76%. A recent study by Samphan (2016) found that the majority of fishes captured by gillnet in Satun province (further to the south than this study) comprised mostly whiting (*Sillago sihama*), but varied widely according to season. Since the majority of demersal gillnets used by the artisanal fishers are set in shallow coastal waters, it is reasonable to assume that wide variations in salinity and water temperatures between seasons will strongly influence catch composition between localities and times of year (Figure 2b).

### 3.1.3 Demersal fish trap

Artisanal fishers preferred to deploy demersal fish traps on or adjacent to coral reefs, and in this study we found 16 species of target fishes of which the highest proportion were Malabar grouper (*Epinephelus malabaricus*) 15.52%, Mangrove red snapper (*Lutjanus argentimaculatus*) 12.78%, and Longfin grouper (*Epinephelus quoyanus*) and Pink ear emperor (*Lethrinus lentjan*) 9.72%. Non-target species harvested from the fish traps were commonly of 7 species, and the most of bycatch included Dark–banded fusilier (*Pterocaesio tile*) 29.82%, Blue–barred parrotfish (*Scarus ghobban*) 18.35%, and Freckled goatfish (*Upeneus tragula*) 13.76% (Figure 2c). From interviews with the fishermen about their application of fish trap, the fish trap mainly attracted large predatory fish that feed on prey in the trap, and most of the prey were small fish and non–target species. The gear was set to first attract the prey and prey then attracted the large predatory fish to come in and be trapped inside the fish trap. One process reducing the
amount of bycatch was to change funnel traps with rectangular traps for bycatch and narrow–bodied species to escape; this change would not reduce the amount of high value fish. Therefore, changing the funnel could make this gear more sustainable without reducing revenues of the fishermen (Johnson, 2010).

3.1.4 Hand–held hook and line

The total number of captured species using hand-held lines was 15 target species, with a preference for Orange–spotted grouper (*Epinephelus coioides*) 23.41%, Yellowfin snapper (*Lutjanus xanthonpinnis*) 22.80% and Narrow–barred Spanish mackerel (*Scomberomorus commerson*) 7.30%. Hand-lines did not result in bycatch because fishermen would rig for particular species and tended to discard non-target species when caught (Figure 2d).

Figure 2. The target and bycatch by artisanal fishing gears in Andaman Coastal Sea.
3.2 CATCHES ATTRIBUTED TO COMMERCIAL FISHERIES

3.2.1 Trawl fishery

This resulted in capture of a large and diverse range of species, but the main target species were demersal. The demersal/midwater trawling fishery targeted 35 species, including Threadfin bream (*Nemipterus peronii*) 9.35%, Brushtooth lizardfish (*Saurida undosquamis*) 9.04% and Mangrove red snapper (*Lutjanus argentimaculatus*) 8.57%. Bycatch from trawling included 38 species of fishes, of which *Selaroides leptolepis* 7.23%, *Megalaspis cordyla* 6.01% and *Lutjanus Lutjanus* 5.85% were most abundant. Widodo *et al.* (2017) reported that the nearby Sumatran trawl fishery captured at least 40 species of fishes, with the largest fractions being ponyfish (*Leiognathus spp.*) 10.81%, threadfin bream (*Nemipterus japonicus*) 9.82%, tall fin goatfish (*Upeneus indicus*) 8.32%, spotted catfish (*Arius maculatus*) 6.81% and yellow striped goatfish (*Upeneus vitattus*) 6.76% (Figure 3a). Trawl fishing is the most bycatch-intensive fishery in Thailand, with up to 80% of total landings being bycatch; this is especially apparent in
beam trawl fishing, the small mesh size of this fishing gear and its nearshore operation compared to other trawl fisheries (Kaewnern and Wangvorala, 2005). The high species diversity of trawl gear catches can be attributed to the non-selective nature of the gears and its flexibility in operation: the same vessels can undertake bottom trawl, midwater otter trawls and midwater pair trawls (SEAFDEC, 2019).

3.2.2 Purse seines

In this study purse seine fishers obtained the majority of their catch from 36 species, the largest proportion of targeted species included Longtail tuna (*Thunnus tonggol*) 16.70%, Spotted Sickle fish (*Drepane punctata*) 10.55%, and Blackbanded trevally (*Seriolina nigrofasciata*) 10.12%. Surrounding net fishers focused on pelagic fish, but also caught 23 species of bycatch, comprising 15-32% of total catch (Table 1). Bycatch included Spotted sardinella (*Amblygaster sirm*) 10.50%, Goldband fusilier (*Pterocaesio chrysozona*) 9.49% and Purple–spotted bigeye (*Priacanthus tayenus*) 8.38% (Figure 3b). This might be compared with catch composition of purse seines off the west coast of India (Kamble *et al.* 2017) that found fish catches of the purse seines were Indian mackerel (14.77%), Sardines (14.41%), Horse mackerel (9.50%) and Tuna (4.36%) of total fish landings.

3.2.3 Light-luring anchovy falling net

Light-luring anchovy falling nets fishers in this study had only 2 target species: Buccaneer anchovy (*Encrasicholina punctifer*) and Shorthead anchovy (*Encrasicholina heteroloba*). This practice commonly caught 9 species of bycatch. Common ponyfish (*Leiognathus equulus*) 15.36% was the most common bycatch, followed by Indian mackerel (*Rastrelliger kanagurta*) 13.73% and Toothpony (*Gazza minuta*) 13.39% (Figure 3c). Loychuen *et al.* (2010) reported that anchovy fisheries along the Andaman coast of Thailand normally operated anchovy falling net and anchovy purse seine gears. These authors found that the main species captured were *Encrasicholina punctifer*, *Encrasicholina heteroloba* and *Encrasicholina devisi*, also capturing *Rastrelliger spp.*, *Sardinella* spp. and *Selaroides leptolepis*. Perngmark (2005) reported that anchovy fisheries in Satun province captured 5 species of anchovy. This researcher found that the anchovy falling net had most impact on non–target species, since the practice of luring
schools of fish with powerful lights disproportionately captured juveniles of such economically important fishes as *Rastrelliger brachysoma*, *Rastrelliger kanagurta*, *Sardinella spp.* and *Selaroides leptolepis*.

Figure 3. The target and bycatch by artisanal fishing gears in Andaman Coastal Sea. (a.) Trawl (b.) Purse seines (c.) Light–luring anchovy falling net

The amount of fish landings decreased in 2021 compared with 2019, and based on information gathered from interviews with the fishermen this was caused by impact of Covid–19, some areas experiencing great difficulties due to the closure of markets causing the fishermen to limit the number and duration of fishing trips, especially for
artisanal fisheries (http://hdl.handle.net/20.500.12067/1470). When comparing the ratio between target species and bycatch, it was found that the trawl fishing gear had the highest capture of bycatch, which was more than target species, whereas there was no bycatch had not in hand-line fishing gear. Demersal fish were target species of trawl fishing gear, but trawl is a non–selective gear and can be used for fishery in both the benthic and pelagic zones (SEAFDEC, 2019). This causes the amount of bycatch to be higher than any other gears. Environmental problems from trawl gears were severe efficient because it is a non–selective method. Trawl fishing gears in Asia’s tropics contributes to overfishing and declines of stocks (FAO, 2015). While the research of Balisco et al., (2019) about fishing gears and their common catch, they explain that the hand-line and spear gun were the most commonly used by fishermen because they are not a complicated method and highly selective of target species and sustainable because they do not cause overfishing of local resources.

Table 1. The annual total catches of fish landing in the Andaman Coastal Sea.

| Sites of fisheries | Fishing gears                     | Fish landed (tons per year) |         |         |         |         |
|--------------------|----------------------------------|----------------------------|---------|---------|---------|---------|---------|
|                    |                                  |                           | 2019    | 2020    | Total   |         |         |
|                    |                                  | Target | Bycatch | Target | Bycatch |         |         |
| Krabi              | Surface gillnet                  | 1,052  | 112     | 371    | 97      | 1,632  |         |
|                    | Bottom gillnet                   | 236    | 166     | 123    | 50      | 575    |         |
|                    | Fish trap                        | 244    | 104     | 203    | 54      | 605    |         |
|                    | Hand – held hook and line        | 360    | 0       | 242    | 0       | 602    |         |
|                    | Trawl                            | 6,210  | 15,618  | 2,984  | 5,836   | 30,648 |         |
|                    | Purse seines                     | 17,822 | 3,557   | 12,006 | 3,310   | 36695  |         |
|                    | Light–luring anchovy falling net | 2,323  | 1,005   | 2,386  | 779     | 6,493  |         |
| Phang Nga          | Surface gillnet                  | 1,265  | 168     | 484    | 33      | 1950   |         |
|                    | Bottom gillnet                   | 222    | 161     | 100    | 20      | 503    |         |
|                    | Fish trap                        | 238    | 113     | 160    | 31      | 542    |         |
|                    | Hand – held hook and line        | 350    | 0       | 106    | 0       | 456    |         |
|                    | Trawl                            | 7,012  | 24,330  | 3,250  | 6,300   | 40,892 |         |
|                    | Purse seines                     | 14,822 | 2,230   | 8,416  | 2,676   | 28,144 |         |
|                    | Light–luring anchovy falling net | 1,985  | 988     | 1,432  | 198     | 4603   |         |
| Phuket             | Surface gillnet                  | 1,027  | 159     | 304    | 65      | 1,555  |         |
|                    | Bottom gillnet                   | 250    | 196     | 122    | 33      | 601    |         |
|                    | Fish trap                        | 233    | 100     | 198    | 48      | 579    |         |
|                    | Hand – held hook and line        | 302    | 0       | 250    | 0       | 552    |         |
|                    | Trawl                            | 7,251  | 25,661  | 5,977  | 7,628   | 46,517 |         |
|                    | Purse seines                     | 15,163 | 3,144   | 10,622 | 3,214   | 32,143 |         |
|                    | Light–luring anchovy falling net | 2,015  | 1,002   | 2,344  | 321     | 5,682  |         |

Source: Own analyzed from Port in - Port out Control Centers operated by DoF, Thailand.
3.3 SIZE AT FIRST MATURATION

Reproductive maturation is an important indicator of the resiliency of a stock. Under fishing pressure, age–length and age–maturation were not necessarily well–linked, although Froese and Binohlan (2000) developed a workable estimate for data-limited fisheries. In Figure 4, we show the percentage of mature versus immature fishes estimated by examining landings by gear type. The target species group from trawl gear with the highest percentage of immature fishes, comprised 10 species (29.41%) of estimated immature size followed by purse seines with 8 species (25.80%), bottom gillnet 2 species (16.67%) and hand-line 1 species (6.67%). For the surface gillnet, fish trap and light–luring anchovy falling net, all the target fish caught were of calculated mature size. But in the analysis of bycatch, it was found that the light–luring anchovy falling net had the highest percentage of immature fish, namely 8 species (88.89%) from the total of bycatch. This was a higher percentage than for trawl gear, although anchovy falling net had a lower number of species than trawl fishing gear. The percentage of immature bycatch by trawl gear, which had the highest number of bycatch species, but 24 species (63.16%) were of immature size from the total number caught of bycatch. Surrounding net had 13 species (54.17%) of immature size, and light-luring anchovy falling net had 1 species (16.67%). Amongst the artisanal gears, surface gillnets, and traps appeared to preferentially capture mature specimens of target species, whereas bottom nets and hook and line fishermen captured and kept specimens of all sizes. Bottom gillnets are often set close inshore. Considering the long soak times typically used by Thai local fishermen, accidental mortality of juvenile fishes entangled in gillnets is likely to be high. That the hand-line fishermen choose to discard non-target species yet keep juveniles of target species may indicate a need for a public education initiative amongst artisanal fishermen to increase the sustainability of their industry.
Trawling is clearly the least sustainable type of fishery examined here in terms of overall bycatch. Trawl gears often lead to direct threat to communities of fish (Stiles et al., 2010). Here, we found that trawling – the largest contributor to total catch – can result in an annual average of >78% bycatch, of which >63% consists of juvenile fishes. Anchovy falling nets, likewise, appear to disproportionately kill juveniles of non-target species, which includes commercially valuable fishes. Clearly, this is likely to have impacts on the sustainability of fishing in this region.

According to Loychuen et al. (2010) falling net fisheries along the Andaman Sea Coast of Thailand yield up to 93.09% juveniles amongst target species. In addition to the anchovy, landings of non-target but economically important species by this method (such as mackerel, Sardine and Yellow–stripe scad), largely were of immature individuals. Avenido et al. (2017) reported that Philippine fishers using falling net fishing gears and
similar light-luring techniques likewise caught a disproportionate number of juveniles, especially in the mackerel fish group. These researchers suggested that this gear was probably not suitable for vulnerable fisheries and tighter controls and limits on the gear were required to enhance sustainability. Gear type and use can therefore, affect the efficiency of fish capture, the selectivity and composition of fish resources (McClanahan and Mangi, 2004). Many fishing methods and inefficient fishing gears employed by both artisanal and commercial operators in this study were not sustainable and damage fish populations; to improve the sustainable use of fish resources, therefore, fishers should be encouraged to increase the selectivity of fishing also actively fish for medium sized fish and large fish (post maturation size).

4 CONCLUSION

Artisanal and commercial fishers employ a range of gears to exploit the diverse fishery of the Andaman Coast of Thailand. We used a combination of data collection methods to examine the fishery, such as examination of catches, species composition of target species catches and bycatch. These data were used to estimate the proportion of landed fish that had not yet attained size of first maturation for commercial and artisanal fisheries and to gain insight into the sustainability and impact of the use of various gears. In this study, we found that artisanal fishers account for a significant proportion of landed fish on the central Andaman Coast, and that – in general – the gears employed by artisanal fishers are more selective and more sustainable than those of commercial operators. Trawling, especially, appears to have an enormous impact on the potential sustainability of all the fisheries in the area, since it results in the largest volume of landings overall, of which up to 78% is bycatch composed of non-targeted species, of which more than 60% are juveniles. Surrounding net fisheries are the next most wasteful, but result in only a fraction of the juvenile bycatch associated with trawling. Light-luring fishing of anchovies is a relatively small contributor to the total catch, but disproportionately captures juveniles of non-target species, and may have a significant impact on the long-term sustainability of other commercially important fish species. Moves towards increased sustainability and long-term economic security for coastal people should, perhaps, incorporate these insights, and investigate ways to expand access to the industry for the more sustainable artisanal fishery while restricting the scale and scope of the larger and more destructive commercial enterprises.
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