*Journal of Environmental Science and Management 26-2: 83-97 (December 2023) ISSN 0119-1144*

# Catch of *Otolithes ruber* (Bloch & Schneider, 1801) under Varying Fishing Practices of Municipal Fisherfolks in San Miguel Bay, Philippines


## ABSTRACT

*Tiger-toothed croaker or Otolithes ruber (Bloch & Schneider 1801) is native to San Miguel Bay in Bicol, one of the most productive fishing grounds in the Philippines. Locally known as "abo", it is one of the major fish catch in the bay and its processing is a seasonal livelihood among coastal villages that commands high market price. With the present state of area, this study aimed to provide information on O. ruber catch trend under the different fishing practices among municipal fisherfolks. On-board surveys and observations (fishing trips) were conducted from the selected barangays of the seven municipalities around the Bay, which were attended by fisherfolk who have been into fishing activity for a long time. The morphometric characteristics of the fish in terms of size (lengths and weights), sex type, and sexual maturity were assessed. Fisherfolks prefer to perform fishing activities applying fishing methods such as "timbog" ("tupak"), "patalang" and "hugos", if the water is turbid while others believed in the phases of the moon wherein better catch is experienced when the moon is on its first or last quarters. Fishing trips demonstrated that fisherfolks used bottom-set gillnets and commonly explored the middle to the mouth of the Bay off the municipalities of Mercedes and Siruma. From the 162.69 kg total catch during the 22 fishing trips, 31.49% or 51.22 kg of which were O. ruber caught largely from Mercedes, Calabanga and Cabusao areas. Mercedes employed the "patalang" method while the other two employed "timbog" method. Out of 434 O. ruber samples, 222 females and 212 males, having 1:1 ratio, were identified with TL of 19.14 + 0.11 cm and body weight of 70.76 + 1.46 g. Moreover, macroscopic analyses of gonads revealed that maturity stages of females ranged from mature to ripe or spawning while most males are already mature and gravid with some developing virgin.*


**Keywords**: *Otolithes ruber, catch, municipal fisherfolks, fishing practices, San Miguel Bay*


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## INTRODUCTION

Estuaries are inlets of the sea, where freshwater from rivers and streams mixes with seawater. It is one of the most productive marine environments due to occurrence of large amounts of detritus, as basis of most estuarine food chains, along with the primary production. Also, the nutrients and organic matter brought by freshwater inflows are trapped in estuaries by silt and clay. With this, estuaries provide excellent habitats for the juveniles and young of many species. The high level of nutrients and the lower number of predators allow juveniles and young to grow and develop. It tends to favor benthic organisms, hence, many important commercial fish like croakers and shellfish such as blue crabs and white shrimp (*Penaeus*) spend a part of their life cycle developing in the relatively protected waters of estuaries (*Karleskint et al. 2010*).

As one of the most productive fishing grounds of the Philippines, San Miguel Bay is a major source of finfishes, crabs and shrimps, especially sergestid shrimps. Diverse fish species such as croakers, herrings, mullets, juvenile Spanish mackerels, anchovies, and crevalles are also frequently caught in the Bay (*Mines 1982*) using multi-gears. Croaker *O. ruber* (Sciaenidae) had been one of the long-time target species of the San Miguel Bay municipal fisherfolks. Locally known as "abo", these are abundant in estuaries and are bottom dwellers that prefer occupying muddy and sandy substrates (*Navaluna 1982*).

*O. ruber* is a native species and the most abundant among the eight other species of Sciaenidae found in the Bay (*Lanzuela et al. 2017*) which prefers to occupy muddy and sandy substrata. This species has shown declining catch from 14% contribution to total catch in 1980-1981 (*Navaluna 1892*) to 13% in 1992-1993 (*Silvestre 1996*)

and dropped to around 6% in early 2000s (*Hilomen et al. 2003*). The fish stocks at the Bay are declining, and presumably due to excessive fishing effort as well as habitat or environmental degradation (*Garces and Silvestre 2010*).

Additionally, according to *Bundy and Pauly* (*2001*) as cited by *Lanzuela et al.* (*2020*), San Miguel Bay is an ecosystem under stress due to excess fishing pressure from both large-and small-scale fishery sectors, and the originally abundant stock (e.g. shark rays, slipmouths, etc.) was not fully compensated for by the increase of the smaller biomass of the species that replaced it such as croakers, squids, and shrimps. Moreover, growth in overfishing is also observed in *O. ruber* as a result of using gears with small-meshed nets, as shown in length distribution observed in size composition of mixed gears (*Garces and Silvestre 2010*).

Congruently, in the study by *Bundy and Pauly* (*2001*) highlights that small-scale fishery sector had a more wide-ranging impact on the fishery resources of the Bay than the large-scale fisheries. The gears used by small-scale fishermen are versatile and selective, allowing them to target specific species across various habitats and trophic levels. In contrast, large-scale fisheries employ non-selective gear but harvest a wide range of species. Findings of the classification and ordination techniques applied to catch data revealed a high degree of competition among different fishing gears and this is primarily due to similarity of catch composition and target species (*Garces and Silvestre 2010*).

Relatively, with the present state of San Miguel Bay, there is a need to investigate the status of fishery resources and the factors affecting its production. Thus, this study aimed to provide updated baseline information of *O. ruber* catch and fishing practices among municipal fisherfolks, who are considered to have extensive impact to Bay's fisheries. The study specifically characterized *O. ruber* in terms of size (lengths and weights), sex classification, and sexual maturity, and assessed the fishing practices of municipal fisherfolks in the selected coastal villages around San Miguel Bay.

## MATERIALS AND METHODS

### Study Site

San Miguel Bay is bordered by seven coastal municipalities, namely: Mercedes and Basud (from the province of Camarines Norte), Sipocot, Cabusao, Calabanga, Tinambac, and Siruma (from the province of Camarines Sur) with seventy-nine coastal villages (barangays) (*Lanzuela et al. 2020*). From September 10 to November 19, 2018, on-board surveys and observations (fishing trips) were conducted from the selected barangays from seven San Miguel Bay municipalities with sampling stations (points) across the 12 sampling sites (**Figure 1**). These include Caringo Island and Pambuhan,

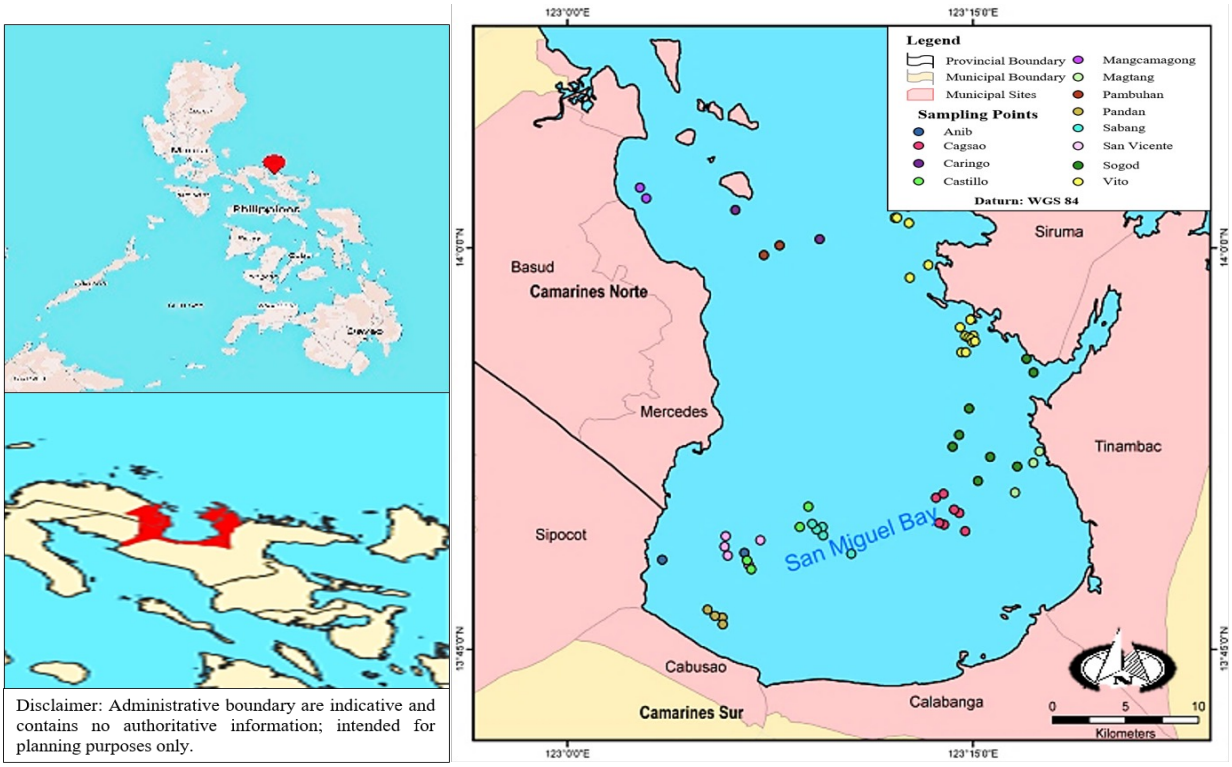


Figure 1. Sampling stations across sampled barangays in San Miguel Bay municipalities, Philippines.

Mercedes; Mangcamagong, Basud; San Vicente and Anib, Sipocot; Pandan and Castillo, Cabusao; Sabang and Cagsao, Calabanga; Magtang and Sogod, Tinambac; and Vito, Siruma. The fishing trips were conducted at random dates depending on the availability of the fisherfolks, weather condition and water situations.

### *Otolithes ruber* in San Miguel Bay

*O. ruber* or tiger-toothed croaker belongs to Family Sciaenidae, which one of the seven croaker species found in San Miguel Bay (**Figure 2**). It is one of the top species caught from the Bay, as evidenced by the 2015-2017 landed catch data of the Bureau of Fisheries and Resources-National Stock Assessment Program 5. Its abundance may be attributed to the presence of many *Acetes* spp. or locally known as "balaw", which is common on the diets of postlarvae and juvenile *O. ruber*.

This species occurs whole year round and observed to have large supply from January to May. Calabanga recorded the largest catch of *O. ruber* followed by Tinambac and Cabusao from 2015-2017. On the other hand, the low catch recorded in Mercedes and Siruma was due to small number of fisherfolks who target *O. ruber*. The large number of fisherfolks as well as the continuous trawl operations may explain the high catch in Calabanga, Cabusao and Tinambac municipalities. Proximity of fish ports to fishing areas, market availability and high market prices were other reasons for high catches of the two municipalities. Both Cabusao and Calabanga are known producers and suppliers of *O. ruber* dried fish and biti, a swim bladder from the fish known as Abo or tigertooth croaker, endemic in the San Miguel Bay in the Philippines.

### Analysis *O. ruber* fish catch

From the total catch of the fisherfolks during the on-board surveys (fishing trips), at least 5 kg of *O. ruber* 434 composite samples were collected and stored in a freezer. Each sample was weighed (in grams) and the total length (in centimeters) using a measuring board from the tip of the snout to the end of the causal fin. Fish samples were dissected, and the gonads were removed and photo documented. After which, gonads were placed in clean vials and properly labelled following the code MUN-Boat No.-Fish No., (e.g. CAL-B1-01), then stored in a freezer to ensure the tissues stay intact.

Figure 2. *Otolithes ruber*, locally known as "abo" or tiger-toothed croaker, in San Miguel Bay, Philippines (Source: www.fishbase.org).

Out of the 434 samples, 90 sub-samples (46 female and 44 male) were taken using Microsoft Excel Analytical tool, and size class of each sex was determined based on the mean values of the total gonads' length and weight of the fish, having 20% of the total number of samples for each size class. Gonads were preserved using 10% formalin seawater solution.

To verify the sex, identify the stage of development, and document the presence of intersex, macroscopic analyses of gonads were conducted to determine the sex of the fish as well as its maturity stage. Sex identification was determined based on the gross appearance of the gonads such as color and size while stages of sexual maturity were determined using the 7-stage of maturity adapted by *Hoda and Ajazuddin* (*1992*).

To calculate the sex ratio of *O. ruber*, manual calculation was done due to minimal differences between sexes. Using histograms, length frequency was analyzed, while linear regression analysis was employed to determine correlations between fish lengths and weights in both female and male *O. ruber*.

### Assessment of fishing practices

Earlier to the on-board survey, a series of Knowledge-Sharing Workshop via Focus Group Discussion (FGD) were conducted in the seven municipalities which were attended by municipal fisherfolks whose target species is *O. ruber* and/or have been into fishing activity for a long time.

Perception maps indicating the locations of fishing areas and routine in fishing activities and information on fishing practices such as frequency and duration of fishing, fishing paraphernalia, catch size and composition, and seasonality of *O. ruber* and catch per season were produced from the activity. Information on beliefs, market situation and channels and socioeconomic benefits were also gathered.

Brief orientations among the fisherfolks-cooperator about the purpose and flow of the survey were facilitated

prior to on-board survey (fishing trips). To avoid potential adjustments in usual fishing practices and eventually minimize bias in the results, methods and techniques were not disclosed to them.

Using underwater slates, details of the entire fishing trips were recorded such as the time of departure and arrival, duration of fishing activity (deployment-catch-end), crew size, type of fishing boats (length, width, engine capacity), gears used (quantity, length, mesh size), other technology used, and catch species composition. At the course of the trip, unstructured interviews to fisherfolks were also conducted to elicit and validate prior information generated from FGD about their fishing practices and efforts.

The coordinates of the locations from the point of origin to point of destination including areas where fisherfolks deployed gears were captured using GPS. For each fishing activity (deployment to end of fishing) at least 2 to 3 waypoints or location coordinates were taken. Track logs were also set and saved and these were used in generating maps of the actual fishing areas and routines.

Distances from mainland or points of origin and landing centers, number of surrounding boats, stationary fishing gears (e.g., liftnet), and presence of solid wastes and sea condition were also noted.

## RESULTS AND DISCUSSION

Out of 162.69 kg total catch, 31.49% or 51.22 kg of which were *O. ruber* caught largely from Mercedes, Calabanga and Cabusao areas (**Table 1**). In Mercedes, the "patalang" method was employed, while the "timbog" method was employed in the other two areas. Most of the municipal fisherfolks, except those from Mercedes practiced this kind of fishing method. Although prohibited, most fisherfolks consider it as an effective method and ensure high catches. The "hugos" method which was adopted in Vito (Siruma) and Magtang (Tinambac) recorded low catches of *O. ruber*.

A total of 434 combined individuals were sampled from the seven municipalities around San Miguel Bay. Out of which, 222 females and 212 males were identified (**Figure 3**), having a 1:1 ratio. Calabanga recorded to have the highest number of fish catch both for female (106) and male (62). This was followed by Cabusao, and Sipocot with 34 and 27 catch of female fish, while Sipocot and Mercedes recorded to have 55 to 44 second highest catch of male fish. Dominance of either sex can be influenced by different factors such as schooling behavior, maturation and even spawning (*Hoda and Ajazuddin 1992*).

The smallest *O. ruber* recorded was 11 cm weighing 30 g while the largest was 30.2 cm with 315 g body weight. Female lengths ranged from 11 to 30.2 cm with 0.0103 to 15.60 g body weights while for male the total length ranged from 12. 5 to 27 cm and body weights ranged from 0.007 to 12.5 g (**Figure 4**).

The aggregated mean length of all samples was 19.14 cm (19.97 cm - female and 18.27 cm – male). Average lengths of samples per municipality ranged from 14.91 to 20.98 cm. Samples from Mercedes recorded the highest combined (female and male) mean length of 20.98 followed by Basud (20.2 cm), Calabanga (19.91 cm) and Cabusao (19.72 cm). On the other hand, samples from Sipocot (17.04 cm) and Tinambac (14.91 cm) have the least mean total lengths (**Figure 5**). This explains that catch in these areas were mixed of well-grown juveniles,

Table 1. *O. ruber* catch and fishing effort based from on-board surveys during the 22 fishing trips conducted with fisherfolks in selected coastal barangays along San Miguel Bay, Philippines (September 10 to November 19, 2018).

| Municipality | Fishing method | Total catch | *O. ruber* catch | % Contribution | Time spent (hr) | Manpower | Gear type | Fishing power (hp) | Boat size (cm) |
|---|---|---|---|---|---|---|---|---|---|
| Mercedes | Patalang | 35.65 | 18.5 | 51.89% | 1-4 | 2-3 | Crab pot, gill net | 12 | 7-12 |
| Basud | Patalang | 5.95 | 1.08 | 18.15% | 2.5-3 | 1-2 | BSN | 10-16 | 7 |
| | Timbog | | | | | | BSN | 12 | 7.5-9 |
| Sipocot | Timbog | 19.1 | 4.3 | 22.51% | 1.5-4.5 | 2 | BSN | 12 | 6-9.5 |
| Cabusao | Timbog | 25.247 | 6.747 | 26.72% | 2-5 | 2-3 | BSN | 12 | 9 |
| Calabanga | Timbog | 29.75 | 17.7 | 59.50% | 4-7.5 | 2 | BSN, | 12 | 7-9 |
| Tinambac | hugos, timbog | 24.3 | 1.3 | 5.35% | 4-7 | 2 | gillnet for crab | | |
| Siruma | timbog, hugos | 22.7 | 1.6 | 7.05% | 4-6 | 2-3 | BSN, double net | 12 | 7-9 |
| Total | | 162.69 | 51.227 | 31.49% | | | | | |

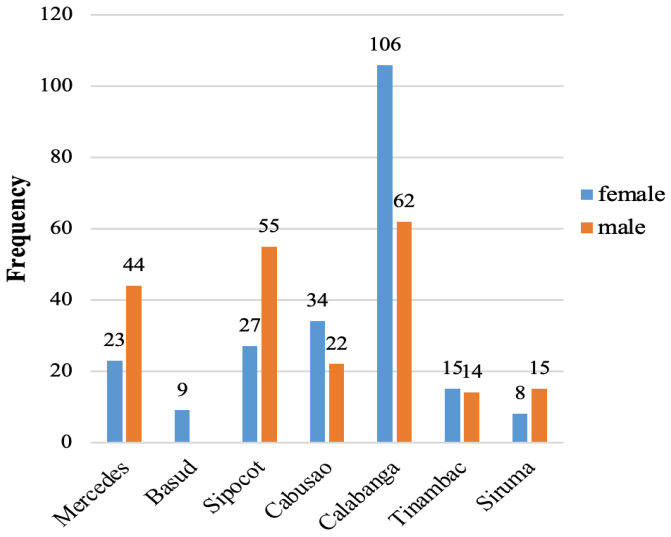


Figure 3. Number of female and male *O. ruber* across municipalities along San Miguel Bay, Philippines.

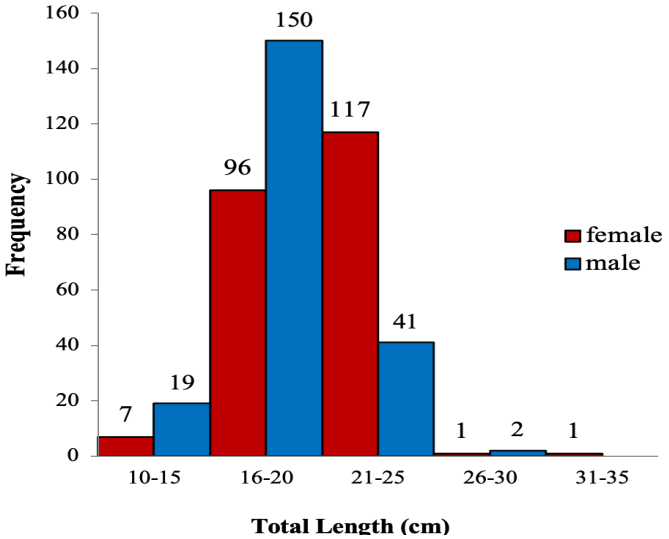


Figure 4. Length and abundance distribution of female and male *O. ruber* samples from San Miguel Bay, Philippines.

which just came from sea after few months of feeding and growing. Fishing activities were conducted near Cotmo-Anib River in Sipocot and Looc River in Tinambac.

Compared to other countries, the recorded maximum length of *O. ruber* was 90 cm, as observed in South Africa and Kuwait waters which are all found along Indian Ocean (**Table 2**). In the study, municipality of Sipocot recorded to have the smallest length of 11 cm, followed by the sample from Tinambac with 12.5 cm. The only *O. ruber* fish sample with the largest total length was found in Cabusao having 30. 2 cm, and most of the samples have the maximum lengths varying from 20 to 24 cm. Moreover, results revealed that most of the *O. ruber* found in San Miguel Bay already reached the length at first maturity, and this further suggests that majority of them have already developed ripe gonads for the first time.

Croakers were characterized as small to large fish that ranged from 10 to 200 cm in total length (*Chao 2003*). This means that *O. ruber* in San Miguel may reach up to 100 cm or above just like other Asian countries. However, those *O. ruber* recorded with large total lengths were found along Indian Ocean while San Miguel Bay lies along Pacific Ocean.

## Fish Length-Weight Relationship

The length-weight relationship (LWRs) is a vital factor for assessing the fish growth of a population, studying biology of fishes, as well as in finding out relative well-being of the fishes. The LWR and relative condition factor are of great importance in fishery assessment studies since it provides information about the growth of the fish, its general well-being, and fitness in a marine habitat (*Jisr et al. 2018*). This is important in fisheries science, notably to raise length-frequency samples to total catch, or to

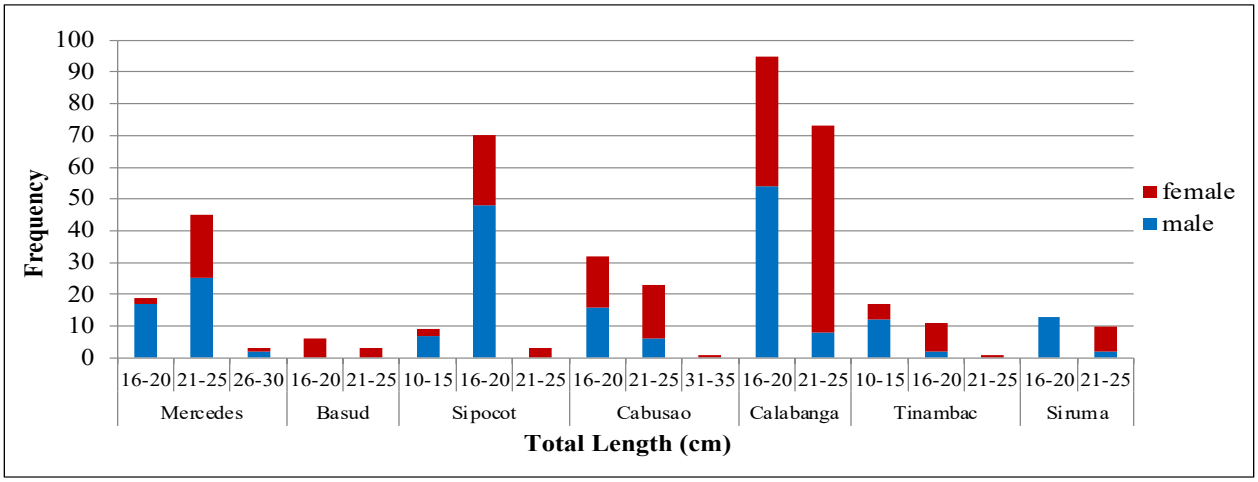


Figure 5. Frequency and lengths of female and male *O. ruber* samples across sampling sites.

Table 2. Length at first maturity and maximum length of *O. ruber* found in other countries.

| Lm (cm) | Maximum length (cm) | Geographical areas | References |
|---|---|---|---|
| 19.8 | | Kuwait waters | *Devadoss (1969)* |
| | 45.55 | Kuwait | *Hussain and Abdullah (1977)* |
| 22.1 | | Arabian Gulf, Kuwait | *www.fishbase.org* |
| 17.5 | 44 | Indian water | *Chakraborty et al. (2000)* |
| | 42.5 | Yemen | *Al Sakaff and Esseen (1999)* |
| 23.7 | | KwaZulu-Natal, South Africa | *Fennessy (2000)* |
| | 90 | South Africa | *Fennessy (2000)* |
| | 44 | Indian waters | *Fennessy (2000)* |
| | 90 | Kuwait waters | *Dadzie and Abou-Seedo (2004); Dadzie (2007)* |
| | 30 (1950s) | | |
| Nd | 20 (1970s) | Hongkong waters | *Darta (2010)* |
| | 20 (2000s) | | |
| | 30.2 | San Miguel Bay, Philippines | *Bergonio (2023)* |

Note: Lm-length at first maturity; nd – no data

estimate biomass from underwater length observations (*Binohlan and Pauly n.d.*). It is used to estimate the average weight of the animal in a given length group by establishing a mathematical relationship between the length and weight variables (*Santhoshkumar 2014*).

The total length (cm) and body weight (g) of the 434 *O. ruber* samples have a high degree correlation as indicated in $R^2$ value of 88% (**Figure 6**). This means that as the body length of *O. ruber* increases, its weight also increases. This implies that *O. ruber* in San Miguel Bay were still in normal condition despite changes in coastal habitat conditions, adverse change in water quality (e.g., high TSS and counts of fecal coliform) and prevalence of siltation problem that resulted to decrease in water depth.

The high correlation was due to similarities of lengths and weights among samples particularly those from Mercedes, Basud, Cabusao, Calabanga and Siruma. The samples were collected from areas where the water depth was approximately from 7 to 16 m which were probably on the same habitat or environmental conditions like currents, type of bottom, type of sediment, etc. The parameters for length-weight relationship may vary by season, habitat and even on a daily basis (*Bagenal and Tesch 1978; Olim and Borges 2006*). There were several factors that could affect the LWR of a fish and these include habitat, season, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and differences in the observed length ranges of the specimen caught (*Tesch 1971; Wootton 1998*).

Overall, the aggregated mean length of *O. ruber* was 19.14 cm with mean body weight of 70.76 g. It was observed that female catch are larger than male as to total length and body weight.

Fish samples from Mercedes have a total length ranging from 17.8 to 27 cm with a mean of 20.98 cm and the body weight of 50 to 200 g with 93.74 cm mean value. The total length of fish samples from Basud ranged from 18.3 to 22.8 cm with mean value of 20.2 cm and weight of 80 to 130 g with 106.44 cm mean value. For Sipocot, fish samples have 11 to 20.5 cm lengths and has 17.04 mean value while body weights ranged from 20 to 90 g with mean value of 50.54 g. Fish lengths of samples from Cabusao recorded 16.3 to 30.2 cm length sizes, mean value of 19.72 cm and its body weights ranged from 40to 315 g with 82.92 g mean value.

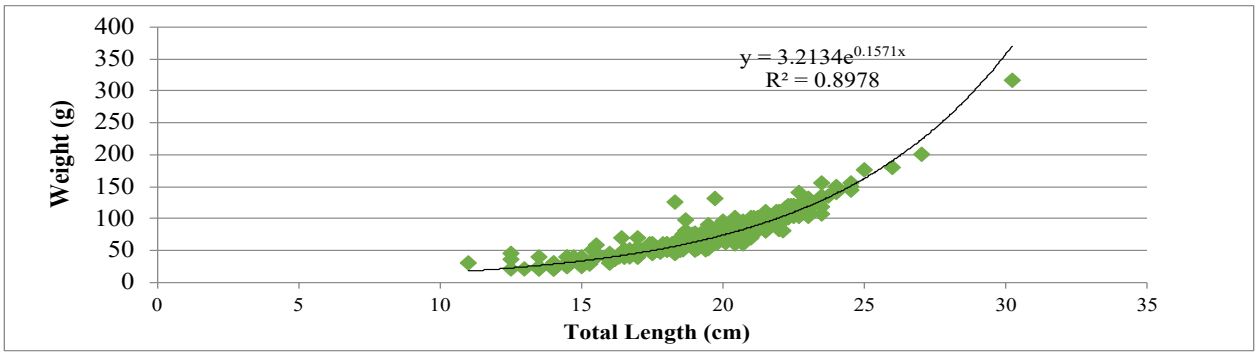


Figure 6. Length-Weight Relationship of *O. ruber* samples from San Miguel Bay, Philippines.

The total lengths of collected *O. ruber* form Calabanga area have total lengths of between 15.4 and 24.5 cm with 30 to 143 g body weights with mean values of 19.91 cm and 72.37 g, respectively while samples from Tinambac measured 12.5 to 22 cm long with mean values of 14.91 cm and 20 to 100 g body weights with 32.24 g mean values. The total lengths of *O. ruber* samples in Siruma ranged from 16 to 24.5 cm (19.12 cm mean value) and have 30 to 155 g body weights (69.13 g mean value).

Female lengths ranged from 11 to 30.2 cm with 0.0103 to 15.60 g body weights. In the case of male *O. ruber*, total length ranged from 12. 5 to 27 cm while body weights ranged from 0.007 to 12.5 g (**Figure 7**).

The municipalities of Mercedes (21.62 cm, 103.91 g), Siruma (21.55 cm, 101.25 g) and Calabanga (20.56 cm, 80.28 g) are the areas that recorded with highest mean total length and body weight of female *O. ruber*. On the other hand, areas of Mercedes (20.65 cm, 88.43 g), Calabanga (18.80 cm, 58.85 g), and Cabusao (18.65 cm, 65.40) noted the three highest average total lengths and weights for males. *O. ruber* samples from Tinambac have the lowest mean values for both female (15.53 cm, 37.06 g) and male (14.25 cm, 27.07 g). Variation in the relative growth of the species reported from different places suggests an inter-regional difference in the LWR of the fish (*Sangeetha and Nair 2023*).

**Sexual maturity**

Through macroscopic examination and guided by the 7-stage of maturity of *Hoda and Ajazuddin* (*1992*), results revealed that there were 3% immature, 14% developing virgin, 7% maturing, 24% mature, 30% gravid, and 22% ripe, running or spawning and 0% spent.

For samples collected by fisherfolks from Mercedes (with highest mean total lengths), maturity of females and males ranged from gravid (7, 23) to ripe or spawning (14, 18) stages. There were more spawning (43) and gravid (30) female O. ruber in Calabanga while males were mostly mature to gravid. Majority of female *O. ruber* from Cabusao were classified as under the gravid stage while males were developing and mature (**Table 3**).

*O. ruber* samples from Siruma have gravid to spawning stages for females while males were under mature to ripe stages. Tinambac recorded the least mean length size of *O. ruber* and most of which were under developing virgins with some immature for male samples. Both female and male samples from Sipocot were mostly mature.

In general, the maturity stages of female *O. ruber* ranged from mature to ripe or spawning while most male *O. ruber* were already mature and gravid with some developing virgin, found mostly in Mercedes, Calabanga and Cabusao. *O. ruber* is amphidromous that regularly migrate between freshwater and the sea (in both directions), but not for the purpose of breeding (www.fishbase.org). Since the surveys were conducted in the months where wind pattern was southwest monsoon probably most of the mature species were migrating from southern portion of the Bay (Siruma and Tinambac areas) going to the innermost part of it (Calabanga and Cabusao areas) heading towards west (Sipocot) to north (Mercedes) and back and forth. Migrations of this species are cyclical and predictable and cover more than 100 km.

In addition, there were more developing virgin to maturing male as compared to females. The results indicate that the length of fish can be an indicator or somehow determine the stages of its maturity; and it size at first maturity may vary in aspects such as the environment, population size, food availability, and estimated length frequency (*Hossain et al. 2017*). In this case, *O. ruber* that were longer sizes could be at the stage of gravid to ripe or spawning while those that were smaller were either immature or still developing. This may also denote that *O. ruber* were still in good condition as the size and color of the gonads, as examined, correspond to length and body size of the fish.

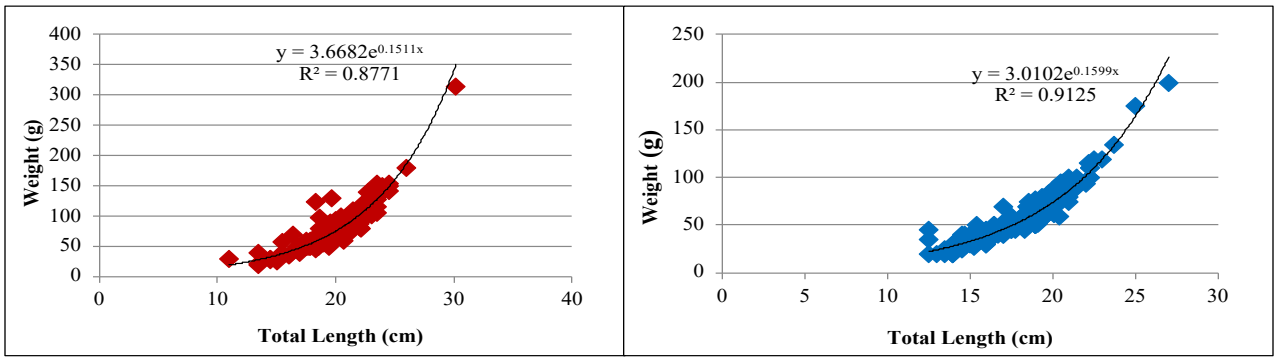


Figure 7. Length-Weight Relationship of female and male *O. ruber* from San Miguel Bay, Philippines

Table 3. Maturity stages of female and male *O. ruber* per municipality.

| Municipality | Mean total length (cm) | Mean body weight (g) | Maturity stages (male, female) |
|---|---|---|---|
| Mercedes | 20.98 (17.8-27) | 93.74 (50-200) | mature: 2, 3; gravid: 7, 23; ripe or spawning: 13,18 |
| Basud | 20.2 (18.3-22.8) | 106.44 (80-130) | mature: 1 (f); gravid: 5 (f); ripe or spawning: 3 (f) immature: 4 (m); developing virgin: 3, 12 |
| Sipocot | 17.04 (11-20.5) | 50.54 (20-90) | maturing: 7, 5; mature: 12, 22; gravid: 5, 10; ripe or spawning: 2 (m); developing virgin: 1, 9; maturing:2,2 |
| Cabusao | 19.72 (16.3-30.2) | 82.92 (40-315) | mature 5, 11; gravid: 18 (f); ripe or spawning: 7 (f); spent: 1 (f); developing virgin: 4, 10; |
| Calabanga | 19.91 (15.4-24.5) | 72.37 (30-143) | maturing: 10, 4; mature: 19, 23; gravid: 30, 2; ripe or spawning: 43, 1; immature: 2, 6 |
| Tinambac | 14.91 (12.5-22) | 32.24 (20-100) | developing virgin: 11, 7; mature: 1,1; ripe or spawning: 1(f) |
| Siruma | 19.12 (16-24.5) | 69.13 (30-155) | immature: 1 (m); developing virgin: 1 (m); mature: 5 (m); gravid: 4, 4; ripe or spawning: 3, 4 |

**Fishing practices of municipal fisherfolks**

The map indicates the fishing locations, usually those frequently visited to catch *O. ruber*, as perceived by the small-scale fisherfolks across seven municipalities (**Figure 8**). Fisherfolks share and compete for common fishing spaces in the areas of Mercedes, Siruma and Calabanga to catch *O. ruber*. While most of the municipal fisherfolks travel to middle to outer part of the Bay, Tinambac fisherfolks prefer to perform fishing activities in adjacent places or near the shoreline of their point of origin. They seldom fish in distant areas, contented with what they have nearby. Siruma fisherfolks also desire to do fishing within the vicinity of their municipal waters but also go to other municipalities to catch *O. ruber*. From January to March, fisherfolks are concentrated to areas along Mercedes and Siruma, as they considered these periods with large supply of *O. ruber*.

As to frequency of fishing activity, fisherfolks usually went on daily fishing trip regardless of seasonal variation or shift in wind direction, as long as there is no typhoon and the water current and waves are not so strong that would endanger their lives. The same views were noted during the informal interviews with 47 fisherfolks while on board that fishing is their primary source of income. Some of them only knew fishing as a form of livelihood, thus, they do this activity as frequently as possible.

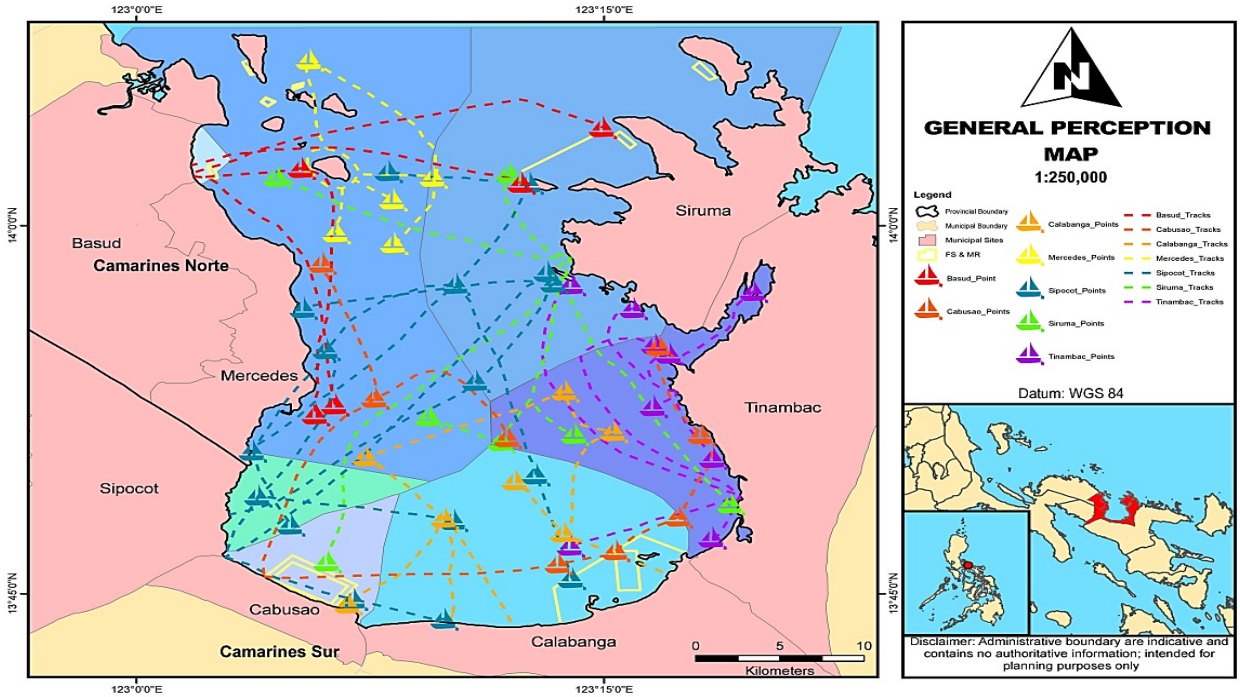


Figure 8. Indicative map of the fishing locations where to catch *O. ruber* in San Miguel Bay, Philippines.

Most of the fisherfolks devote their time 4 to 6 hrs at sea. While Basud (2-4 hrs) and Cabusao (3 hrs) fisherfolks do short fishing trips, Sipocot prefer longer periods in their fishing activities that ranged from 8 to 9 hrs (**Table 4**). Fishing activity among fisherfolks is normally conducted early morning until before noon time, however, other suggests that the best time to engage in fishing activity is in the late afternoon to evening and/or both in the morning and afternoon.

Both motorized and non-motorized boats that ranged from 6 to 10 m long were frequently used. Fishing activities were conducted by 1 to 2 fisherfolks involved using gillnets with varying mesh sizes of 7 to 9 cm. Other fishing gears that were observed to have *O. ruber* catch include gillnet for crab, shrimp, herring. As their adaptation strategy to fish seasonality, fisherfolks owned multiple gears intended for particular species. They believed that having a variety of gears would make them ready for whatever species are available in the bay and ensure catch all throughout the year. Besides the use of pulse stick ("tupak"), no other technology or equipment was used in the fishing activity. Estimated cost of the fishing trips ranged from Php 100.00 to 500.00 per trip to cover foods and gasoline.

There were 22 on-board surveys conducted across the 12 sampling sites in the 7 municipalities. A total of 47 municipal fisherfolks participated in the on-board survey. Most of them were also the participants during the FGD while others were recommended bythose participant-fisherfolks who were not able to join in the survey. They were chosen based on their length of engagement in fishing. On the other hand, fishing vessels, type of gears and other fishing paraphernalia used were the option of the fisherfolks. The duration of the fishing trips was, likewise, at their discretion.

The average fishing activities ranged from 4 to 7 hours (**Table 1**) using motorized boats with 2-3 fisherfolks involved. Fishing activity was done on a daily basis, usually early morning and few does it in late afternoon until evening. The longest trip recorded was in Cagsao (Calabanga) which lasted for more than 7 hours. Municipal fisherfolks share common fishing grounds where to catch *O. ruber*, which was nearly at the middle part and outer portions of the Bay, particularly in the areas of Mercedes and Siruma, with estimated water depth of the fishing areas ranged from ~3 to 21 m (**Figure 9**).

It was observed that most fisherfolks went too far fishing areas to fish unlike before when their fishing activities were usually conducted near the shore. Moreover, fisherfolks were free to visit and do fishing activities, without any restriction, to other municipal waters as evidenced by the fishing trips of fisherfolks from Sipocot (San Vicente), Cabusao (Castillo), Calabanga (Sabang), and Tinambac (Sogod). Due to lack of restriction, some fisherfolks were not familiar with the location of the established Fish Sanctuary and Marine Reserve (FSMR) as they traversed and perform fishing activities in those places, especially the trips in Basud and Cabusao (Pandan). Additionally, Tinambac (Sogod) fisherfolks visited areas close to Looc River, which is between Tinambac and Siruma and recorded to have catches mainly consisting of juvenile *O. ruber*.

Accordingly, catches are usually brought to Calabanga, Mercedes and Cabusao fish ports for local auction (whisper bidding) while others sold fresh catch directly to frequent middlemen or fish vendor (rigaton). Based from *Bailey* (*1982*), these are places ideal for fishing activities during southwest monsoon, which was the prevailing weather condition at the time on-board surveys were conducted last September 10 to November 2018.

Table 4. Perceptual fishing practices and effort of San Miguel Bay fisherfolks.

| Municipality | Fishing areas | Frequency and duration | Vessel type | Crew size | Gear type | Trip cost |
|---|---|---|---|---|---|---|
| Mercedes | Mercedes Siruma | daily (2) 4-5 hrs | Motorized | 2-3 | gillnet 6-7 cm | P200-450.00 |
| Basud | Basud, Siruma, Mercedes | daily (2) 2-4 hrs | motorized & non-motorized (6-10 m) | 1-2 | Gillnet 7-9 cm | P150.00-500.00 |
| Cabusao | Cabusao, Calabanga, Tinambac, Sipocot, Mercedes | Daily 3 hrs | motorized (6-8 m) | 2-4 | gillnet 8-9 cm | P150.00-200.00 |
| Sipocot | Sipocot, Cabusao, Calabanga, Siruma | Daily 8-9 hrs | motorized & non-motorized (7-10) | 1-2 | gillnet 7-9 cm | P100.00-400.00 |
| Calabanga | Calabanga, Mercedes, Siruma | Daily 4-5 hrs | motorized & non-motorized (5-7 m) | 1-2 | gillnet 10-11 cm | P150.00-400.00 |
| Tinambac | Tinambac, Calabanga, Siruma | Daily 6 hrs | motorized (6-10 m) | 2 | gillnet 8-9 cm | P200.00-300.00 |
| Siruma | Siruma, Cabusao, Mercedes | Daily 5 hrs | motorized & non-motorized (6 m) | 1-3 | gillnet 10 cm | P500.00 |

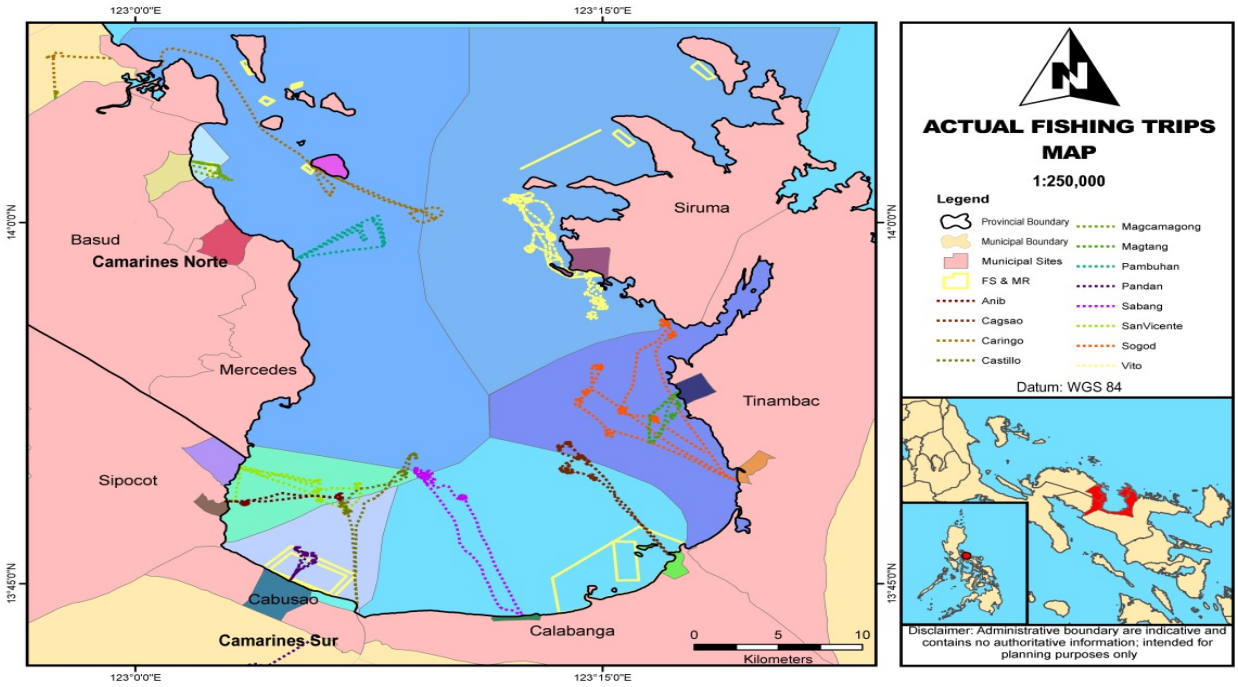


Figure 9. Map of fishing ground locations of small-scale fishers based on actual fishing trips, San Miguel Bay, Philippines.

From all the 22 fishing trips, 3 fishing methods were observed to have *O. ruber* catch, namely, "patalang", "timbog", and "hugos"All of these used gillnets with varied lengths and mesh sizes. Lengths of gillnet used, particularly bottom set gillnets, ranged from 15 to 40 knots (50 to 200 m knot$^{-1}$) with 7 to 10 cm mesh sizes. Gillnets have rubber floats attached and sinkerline had lead sinkers. Plastic bottles or styrofoam with attached colored flaglets served as buoy while stones were used as anchor.

The "Patalang" method is a passive fishing method which was done by just setting gillnets across the path of the fish with no other activities to pursuit *O. ruber* (**Figure 10**). On the other hand, both "timbog" and "hugos" methods were categorized as active fishing method as it scares and pushed the gears in the pursuit of *O. ruber*. In particular, "timbog" used pulse stick (locally known as "tupak") as banger to create sound and drive the fish towards the gear (**Figure 11**). This fishing practice was commonly observed in all municipalities, except in Mercedes as this method is prohibited by the local government. Only few fisherfolks from Basud practiced this kind of method. Using this method, the fishing activities (for 4-5 deployment and harvesting) lasted for five hours. Recorded *O. ruber* catches were 9.7 kg (Sabang) and 6.5 kg (Castillo), which were accounted as the next two largest catch among all the trips. The "hugos" method was done by dropping a large stone along with the gear, then, the boat started to maneuver around it for about 20to 30 minutes in order to trap the fish (**Figure 12**).

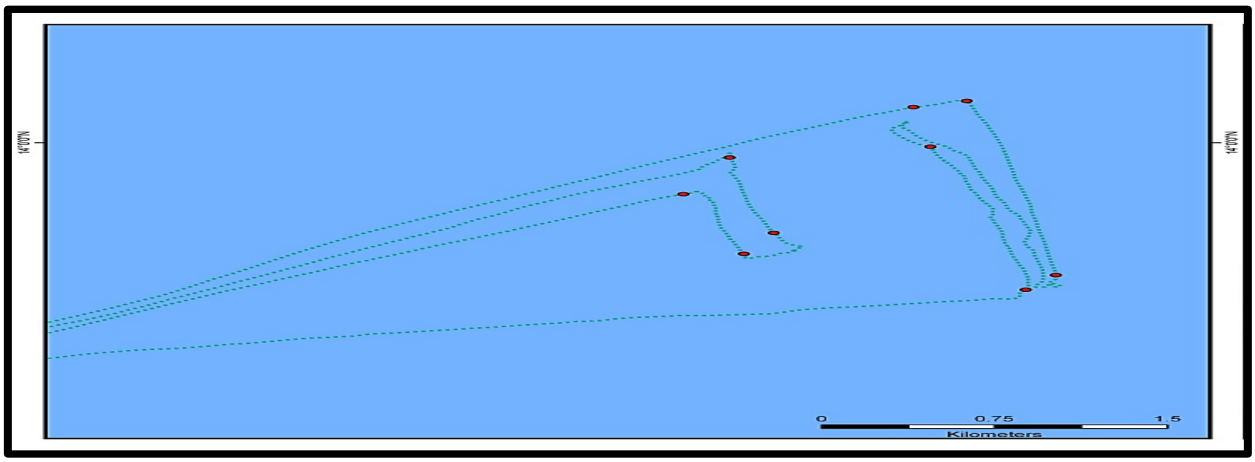


Figure 10. Actual track and routine of the fishing trips in Pambuhan (Mercedes) using "patalang" technique in San Miguel Bay, Philippines.

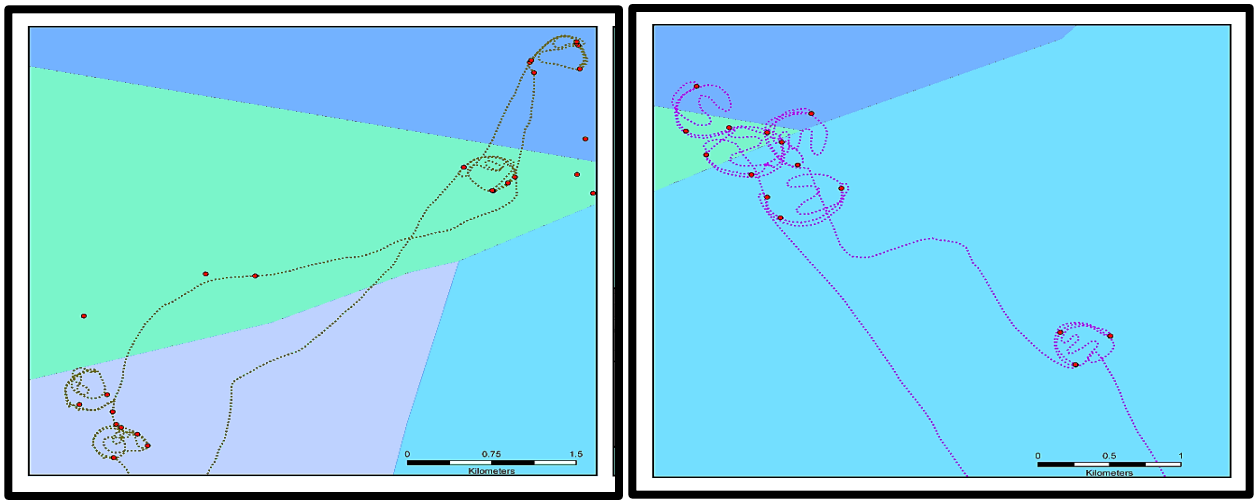


Figure 11. Actual tracks and routine of the fishing trips in Castillo (Cabusao) and (Sabang) Calabanga using "timbog" technique in San Miguel Bay, Philippines.

A total of 162.69 kg of catch were recorded during the fishing trips across sampling sites. Thirty-one percent or 51.22 kg of which were *O. ruber* caught largely from Mercedes, Calabanga and Cabusao areas. In Mercedes the "patalang" method while the "timbog" method was employed in the two other areas. Most of the municipal fisherfolks, except those from Mercedes, practiced the "timbog" fishing method. This type of fishing method is effective and ensures high catches, but prohibited. The "hugos" method recorded low catches of *O. ruber*. This could be attributed to the types of fishing gears which were intended for shrimp and crab and the large mesh size of gillnet used by fisherfolks in Tinambac.

Fisherfolks prefer to perform fishing activities if the water is turbid while others believed in the phases of the moon wherein better catch is experienced when the moon is on its first or last quarters. They undergo 1 or 2 fishing trips per day but most of them preferred early morning trips, especially those areas nearby ports (in Mercedes, Cabusao and Calabanga) where local auction or "bulungan" is conducted daily and twice a day (early morning and noon time).

Fisherfolks have regular areas to fish. They are usually guided by territorial boundaries and sometimes by natural boundaries or landmarks like hills, mountains and rivers. They knew the locations to be visited for a particular species to catch. Moreover, most of them rely on their co-fisherfolks in looking for better fishing areas. If many fisherfolks are amassed in a certain area, sometimes fisherfolks tend to join them with the belief that they can have great catch. Other fisherfolks randomly select areas where to deploy their gears based on their estimates.

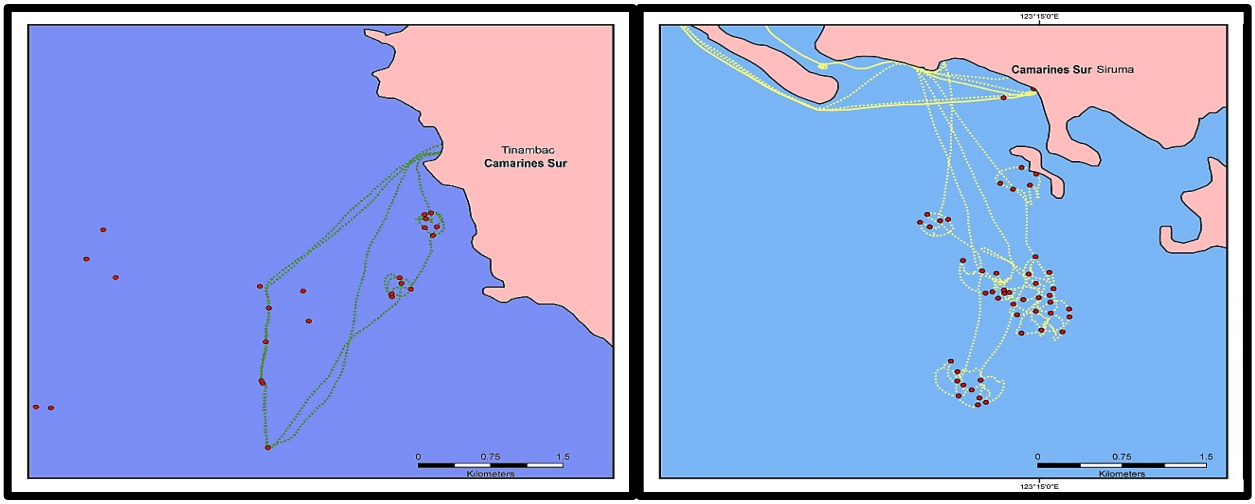


Figure 12. Actual tracks and routine of the fishing trips in Magtang (Tinambac) and Vito (Siruma) using "hugos" method in San Miguel Bay, Philippines.

In Indonesia, there were two main fishing gear types recorded for fishing (*Humphries et al. 2019*), the spearguns for herbivores species and handlines for piscivores species. The catch per unit effort (CPUE) was greater in handlines than spearguns, 10.8 and 9.97 kg trip$^{-1}$, however, spearguns captured more species overall and the number of species increased as the CPUE increased.

Using Google Earth, distances of the fishing areas to the point of origin and nearby fish ports/ landing centers were measured (**Table 6**).

Most *O. ruber*, either female or male, are abundant in parts of Mercedes, Calabanga, Cabusao and Sipocot even during the season of southwest monsoon (habagat) compared to other parts of the Bay such as Tinambac and Siruma where habagat has unfavorable effect to their fishing activity. On-board surveys in these two areas were conducted in October and mid-November 2018 where shift in monsoon season was occurring, thus, low fish catch was documented.

According to the study of *Qasim* (*2022*), in Iraqi marine water northwest of the Persian Gulf, the breeding period of O. ruber was determined from March to April, reproduces once a year. Contrariwise, according to *Farkhondeh et al.* (*2018*), although the reproductive period of *O. ruber* species has been recorded within the Persian Gulf and the Gulf of Oman, still the breeding period of this species has been observed throughout the year in San Miguel Bay of the Philippines and Indian waters (*Lanzuela et al. 2020*), hence, occurrence of this species is abundance.

However, variation in findings may be attributed to the change in the spawning time of O. ruber in habitat zones, which may be due to asymmetry in population, temperature, and currents (*Jawad et al. 2021*). Moreover, according to *Mamauag et al.* (*2011*), different fishing gears have different effects on the catch of O. ruber. For instance, their results revealed that small-mesh gears can capture a higher proportion of juvenile O. ruber than large-mesh gears, contributing to overfishing and stock depletion. Similarly, destructive fishing practices such as bottom trawling, purse seining, and gillnetting have contributed to overfishing (*Carneiro and Martins 2022*), leading to a decline in fish populations, which can have negative impacts on the ecosystem and the livelihoods of people who depend on fishing (*Sumaila and Tai 2020*).

## CONCLUSION AND RECOMMENDATIONS

In terms of fishing efforts, municipal fisherfolks along San Miguel Bay usually conduct daily fishing for a longer period which was a consequence of having too many fisherfolks and continued encroachment and operations of commercial fishers. Fishing trips were done with 2-3 fisherfolks. In terms of gear type, fisherfolks opted to use gillnets with smaller mesh sizes to capture *O. ruber* since catch were also getting smaller probably due to significant changes in coastal habitats. The shift in gear sizes would also be the result of unstoppable operations of commercial fisher using trawl with very fine mesh size.

From the 162.69 kg total catch, 31.49% or 51.22 kg of which were *O. ruber* caught largely from Mercedes, Calabanga and Cabusao areas. Fisherfolks from Mercedes employed the "patalang" method while fisherfolks from the other two areas employed "timbog" method. Most of the municipal fisherfolks, except those from Mercedes practiced this kind of fishing method. Although prohibited, but most fisherfolks consider it as effective method and ensure high catches. The "hugos" method which was adopted in Vito (Siruma) and Magtang (Tinambac) recorded low catches of *O. ruber*.

Table 6. Estimated distances of fishing areas to point of origin and fish ports.

| Municipality | Distance point to origin | Distance to fish port/s |
|---|---|---|
| Mercedes | 4.43 to 5.97 km (Pambuhan)<br>2.26 to 8.57 km (Caringo) | 13.59 km to 19.42 km |
| Basud | 1.75 to 2.53 km | 19.9 km (to Mercedes) |
| Sipocot | 4.99 to 7.25 km (San Vicente)<br>1.42 to 6.77 km (Anib) | 2 to 10 (Barcelonita)<br>3 to 12 km (Castillo) |
| Cabusao | 2.43 to 2.91 km (Pandan);<br>7.5 to 12.18 km (Castillo) | 3 to 12 km (Castillo) |
| Calabanga | 10.18 to 13.36 km (Sabang)<br>7.90 to 10.91 km (Cagsao) | 9 to 12 km |
| Tinambac<br>Siruma | 1.28 to 4.51 km (Magtang)<br>7.07 to 13.37 km (Sogod)<br>2.24 to 8.10 km (Vito) | 15.62 km (Calabanga) |

Out of 434 composite samples, 222 females and 212 males were identified, having a 1:1 ratio. The smallest *O. ruber* recorded was 11 cm weighing 30 g while the largest was 30.2 cm with 315 g body weight. The aggregated mean length of all samples was 19.14 cm (19.97 cm - female and 18.27 cm – male). Average lengths per municipality ranged from 14.91 to 20.98 cm. Mercedes recorded the highest combined (female and male) mean length of 20.98 followed by Basud (20.2 cm), Calabanga (19.91 cm) and Cabusao (19.72 cm). On the other hand, samples from Tinambac (14.91 cm) have the least mean total length.

Maturity stages of female *O. ruber* ranged from mature to ripe or spawning while most male *O. ruber* were already mature and gravid with some developing virgin, found mostly in Mercedes, Calabanga and Cabusao. In addition, there were more developing virgin to maturing male as compared to females.

Basically, there is a direct relationship among number of fisherfolks, fishing effort and practices and security of income. The greater the number of fisherfolks means an expanded fishing effort and higher potential catch and/ or production, which can ultimately transform into a higher income for the local fishing families. The extent and type of fishing efforts may likewise dependent to the ecological conditions of the Bay as well as the common practices observed by other fisherfolks. However, the catch or production may also be influenced by some environmental factors, such as the prevailing local weather, calamities, siltation and seasonality of species.

Unsustainable fishing practices will eventually contribute to further environmental problems that will significantly result in negative outcomes like decline of *O. ruber* catch, low dried fish production and eventually affect fisherfolk's income in the long run. If not abated, the declining trend of *O. ruber* catch (2015-2017) will be sustained year-on-year and eventually the potential and considerable income, employment and livelihood opportunities generated from *O. ruber* processing would diminish and vanish anytime.

With those circumstances, in order for *O. ruber* fisheries to become sustainable, the primary indicator or consideration would be the degree of fishing effort as it was the main driver towards overfishing, depletion of stocks ,and declining fish catch in San Miguel Bay. However, with appropriate regulations and adaptive management options in place that could help maintain the healthy ecological conditions of San Miguel Bay and sustained its fisheries productivity, food security and financial income of marginalized municipal fisherfolks may be ensured.

However, appropriate institutional arrangements are very essential in order that attitudes, behavior and decisions of the commons would be redirected for sustainable fisheries. Moreover, looking into other functional units or compartments of San Miguel Bay fisheries is crucial so as to address other wicked problems challenging the municipal fisherfolks and resource managers of San Miguel Bay. It is also essential that, in harmony, the seven San Miguel Bay municipalities together with the fisherfolks through its Municipal Fisheries and Aquatic Resources Management Councils, must take care of the marine ecosystem and resources by maintaining sanctuary and imposing control mechanisms, rehabilitation of important habitats like mangroves, and serious enforcement of laws.

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## ACKNOWLEDGMENT

We wish to thank all the persons who supported and participated in the study: DOST-SEI, 7 San Miguel Bay municipalities, BFAR NSAP 5, Ms. Rosvilinda B. Intia, Ms. Catalina Rowelia S. Delos Reyes, Mr. Jogie Sagales, Engr. Joey T. Moral, Mr. Hector P. Magana, Ms. Lorna V. Avellana, Mr. Arnulfo B. Hermoso, the 6 MFARMC Chairmen and fisherfolks of San Miguel Bay coastal barangays, Mr. Gil B. Ramos, Ms. Consuelo A. Sempuego, Dr. Noemi SB. Lanzuela, Ms. Alexandra A. Tenajeros, Ms. Oshin Lorico, Mr. Victor P. Sayangco, Ms. Tinay San Andres, Mr. Jeremy Jansalin. Special thanks to Central Bicol State University of Agriculture and Department of Science and Technology – Science Education Institute for the support and assistance extended to complete the research.