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Initial report on retailed reef fishes in Talibon and Pres. Carlos P. Garcia main market, Bohol Province, Philippines

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Abstract

The central Visayas Region has had historical overfishing and persistent illegal, unregulated and destructive fishing practices since the 1970s. Accumulated threats to coral reefs resulted in the reduction of coral cover and coral complexity that led to local loss of species. In the present study, we conducted a fishery survey of reef fishes in the market and fish landing sites of Talibon and Pres. C.P. Garcia. To document the species composition, species diversity (Shannon profiles) and relative abundance, we considered 11 major commercially important coral reef families, namely: Acanthuridae, Scaridae, Lutjanidae, Serranidae, Haemulidae, Mullidae, Lethrinidae, Balistidae, Nemipteridae, Caesionidae and Siganidae. The study recorded a total of 158 reef species in the studied sites; 143 species were recorded in Talibon, while 134 species in Pres. C.P. Garcia. The most numerous species from 11 reef families were recorded to Serranidae, Scaridae, and Lutjanida. Further investigation showed that the relative abundance of reef species differed at each market site ($p<0.05$). In Talibon, Siganidae, Nemipteridae, and Scaridae were the most dominant reef families at 19%, 15%, and 14%, respectively. In Pres. C.P. Garcia, Nemipteridae recorded the highest relative abundance (17%), followed by Siganidae (14%) and Caesionidae (13%). Both surveyed sites have similar records for the least dominant reef families, such as Balistidae and Haemulidae. The initial findings of the market fishery survey could provide insight for stakeholders in the promulgation and implementation of local management and conservation policies.

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Introduction

The province of Bohol, part of the Visayas Region (VR), holds the only barrier reef (Danajon bank) in the Philippines and is recognized as 1 out of 3 barrier reef structures in the Indo-Pacific (Armada *et al.,* 2004). The barrier reef sanctions 9 Bohol coastal municipalities (Tubigon, Clarin, Inabanga, Buenavista, Jetafe, Talibon, Bien Unido, Ubay, and Pres. Carlo P. Garcia) that covers an estimated reef system of 272 km^2, a cluster of large and small coral reef habitats (Armada *et al.,* 2009). The benthic survey conducted by the FISH project in 2004 reported a poor coral cover (≤25%) in 9 out of 12 stations in Danajon reef (Calumpong, 2004). Fishing-related intrusion such as destructive and illegal fishing, unregulated fishing, and exhausted fishing grounds has suggested the main reason for declining benthic conditions (Christie *et al.*, 2006). Despite the intensity of fishing pressure, active management initiatives (ecosystem-based management, MPA networks) tried to mitigate spillage loss on resources by recognizing the importance of the Danajon reef system.

Prevailing reef habitat from Danajon reef inspired fisher's livelihood to adapt for capturing reef and reef-associated fishes. Reef fishing became an essential constituent for Bohol fishery industry and the fishing community. Fisher tools (i.e., hook and line, spear, gill nets) were befitted primarily for targeting reef fishes (Christie *et al.*, 2006). Unfortunately, opportunistic fishing like compressor-poison-aided spears is still rampant in many areas of the Danajon reef (Christie *et al.*, 2009). The demand for ornamental reef and live fish trade associated with high price value leads to unregulated fishing livelihood to thrive, a threat for intrinsic reef species (Gonzales, 2013; Motomura *et al.*, 2017). Coral fishing grounds dispersing distance and the complex structure of reef topography became a deterrent for effective law enforcement.

The Historical findings of the biogeographic region of Visayas have the highest concentration of coral reef fishes compared to elsewhere in the world (Carpenter and Springer, 2005). However, accumulating effects from overfishing, destructive and illegal fishing, habitat degradation, and local records of subsequent loss of reef species suggest a basis for the decline of overall species richness (Lavides *et al.*, 2010; Nañola *et al.* 2011). The continuous exploitation of over-depleted reef fishing ground may result in extinction and/or localized loss of species (Dulvy *et al.*, 2003). The fish transect findings of Nañola *et al.* (2011) in VR, CPUE Municipal fishery data from Green *et al.* (2004) of some coastal towns in the province, and reports on localized species loss in eastern Bohol by Lavides *et al.* (2010) from fisher insight, supported the significant loss of species richness in VR. According to Lavides *et al.* (2010), the province in VR has documented the loss of 21 species over 5 decades. A recent report by Muallil *et al.* (2020) shows that the highest number of recorded reef species using market survey was found in Tawi-Tawi, part of the Sulu sea (SS). This finding was estimated from a comparative analysis of documented reef species of three cohesive sites in Panay Is. (Motomura *et al.*, 2017), Palawan (Gonzales, 2013), and Tawi-Tawi (Muallil *et al.*, 2020). Muallil *et al.* (2020) report was also supported by the fish transect data (Nañola *et al.*, 2011), confirming the SS and West Philippine Sea (WPS) have the highest recorded species-area richness compared to VR with lower recorded species-area richness (including south Philippine sea – SPS). The local extirpation of some coral reef fishes in VR (Nañola *et al.*, 2011) explained the shift of the center of biodiversity to SS, to the heart of the coral triangle, Tawi-Tawi.

Perception on imperative status of Danajon reef (as well for VR) for reef refuges still has limited information on recorded species for captured-fisheries, specifically on Bohol archipelago. In many coastal communities in the region, fishing on reefs remains an important subsistence livelihood for food security which exposes coral reefs to increasing operation, mistreatment, and bulging population. The present study aims to determine the species composition, species diversity and relative abundance of the 11 major retailed and commercial reef families and to compare findings between the two main markets of Talibon and Pres. Carlos P. Garcia.

Materials and methods

Surveyed sites

Fishery surveys were accomplished by visiting the public fish market and fish landing site in Talibon and Pres. C.P. Garcia, Bohol from July 2019 and August 2019 (Fig. 1). The studied municipalities were selected based on the topmost number of registered fishers from the Bohol fishery profile of 2016 (BFAR Region 7) and on involvement in Fisheries Improved for Sustainable Harvest (FISH) project of 2005-2010 in the Danajon area (FISH, 2010).

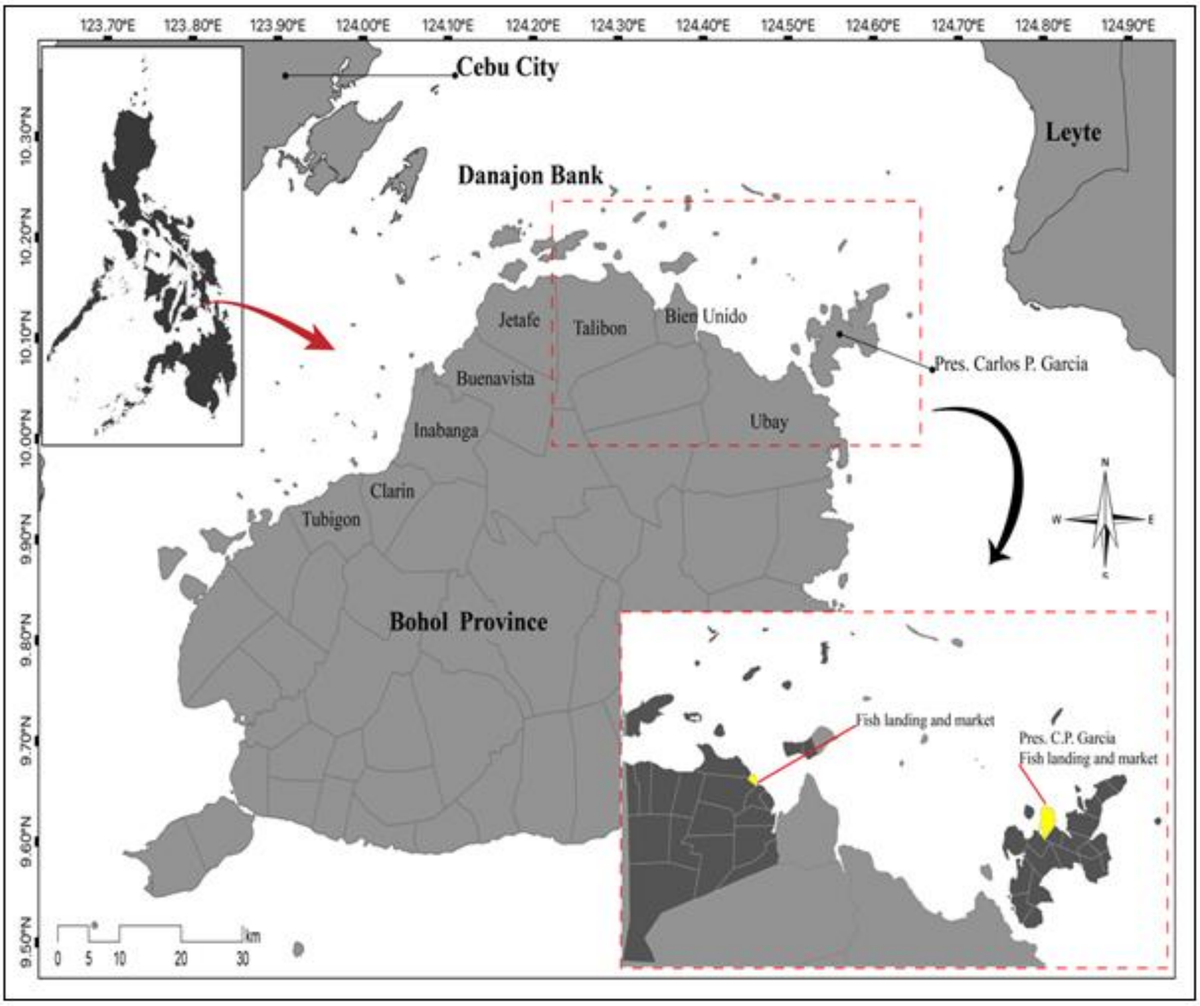

Fig. 1. Map of Bohol showing the location of sampling sites.

The Fish Public Market and fish landing site in Talibon and Pres. C.P. Garcia "Pitogo" were the main fresh fish trade market route both located in *barangay Poblacion* of the municipal proper. According to local buyers, fishes sold in the market mainly come from Danajon reef supplied by their fishermen and other neighboring municipalities (Christie *et al*., 2009). Some fishes from farther Provinces such as Cebu, Leyte, and Camotes Island are also reportedly brought in fish landing through the commercial fishing vessel, or those using boats of more than 3 gross tons. These caught fishes were mostly assorted with pelagic catches like tunas (*Thunnus sp*), skipjack (*Katsuwonus pelamis*), and sardines (*Sardinella sp*). Nevertheless, those unbought fish are sold after 4-7 days in the warehouse by the manufacturer that processes for fish feeds. There are reports (Christie *et al*., 2009) indicating abundance yield on mariculture in the area such as milkfish "*bangus" (Chanos chanos)* and pond culture such as "tilapia" (*Oreochromis sp*), shrimp (*Peneaus sp*), and carp (*Hypopthalmichthys sp*).

Data collection

All surveys were conducted during the daytime at the fish landing sites from 5:00 to 8:00 am to have easy access to transported retailed fish. Afterward, we proceeded to the market to continue the surveys during the peak hours from 8:00 to 10:00 am. With the permission of the vendors and traders, a group of fish was photographed from the top just high enough to capture a lot of reef fishes. This method was modified into a simpler approach due to time constraints to avoid disrupting the market flow and for accurate fish identification and verification. This also allows repetitive monitoring for the next succeeding days while avoiding nuisance with the fish vendor. The market and fish landing surveys were conducted on alternate days for a minimum of three (3) days per week of random visits in the area.

Limitation

Fish landing data were used as supplementary information for each surveyed site on species composition. Fishes in the fish landing site were not accessible to researchers as they were kept inside storage boxes. High-valued reef fishes (i.e., *Plectropomus sp*; grouper), juveniles, and unbought fishes (by-catch) were mostly bargained or kept by local buyers. Fish landing surveys were only applicable to fishes that were still outside the cargo boxes, usually when traders sorted their fish products in preparation for transport or during the time when fishermen delivered their caught fish.

Data analysis

The study followed the guidelines set by Muallil *et al.* (2020) for the 11 major commercially important coral reef fishes, such as surgeonfish (Acanthuridae), parrotfish (Scaridae), snapper (Lutjanidae), grouper (Serranidae), sweetlips (Haemulidae), goatfish (Mullidae), emperor (Lethrinidae), triggerfish (Balistidae), monocle and whiptail bream (Nemipteridae except for genus Nemipterus), fusilier (Caesionidae) and rabbitfish (Siganidae).

Species composition

Species were identified and validated using the following references by Allen *et al.* (2003), Kuiter and Tonozuka (2004), and Allen and Erdmann (2012). Reef fish conservation status was determined from the IUCN Redlist of Threatened Species website (https://www.iucnredlist.org/).

Relative abundance

Relative abundance is defined as the proportion of individuals per family to the total number of families at the duration of the sampling period. The relative abundance of fish species was calculated as:

$$Relative\ abundance = \left(\frac{No.\ of\ individual\ of particular\ species}{Total\ No.\ of\ individual\ of\ all\ species}\right) \times 100$$

Market data was used to determine relative abundance for each surveyed site. In each sampling visit, all the stalls that have reef fishes sold by the vendor were surveyed by taking pictures at the top with the group of fishes. Images captured were consolidated for processing by counting the number of individuals per species. To avoid resampling of the same reef fish, the photograph was taken only once per stall. The findings of this study will report on the cumulative reef fish products within the market fishes displayed at the given period.

Species diversity

Ecological indices such as Shannon–Weiner diversity index (H'), Simpson dominance index (1-D), Pielou evenness index (J), and species richness were calculated. The data on count *per* species were tabulated in MS excel and analyzed using Paleontological statistical software or PAST (Hammer *et al.,* 2001).

The species diversity indices are based on the following formula (s):

$$H' = \sum i \frac{ni}{N}\ ln \frac{ni}{N}$$ (Shannon and Wiener, 1949)

$$1 - D = \sum i \left(\frac{ni}{N}\right)^2$$ (Simpson, 1949)

Where ni = the number of individuals per taxon or species *I*, and N = the total number of individuals in the community or sampling.

$J = \frac{H'}{\ln S}$ (Pielou, 1966)

Where S = the total number of species per site.

Statistical analysis

The statistical analysis aims to compare relative abundance between surveyed sites. One-way ANOVA was used to test the main effects of studied sites and reef families (fixed factor and dependent variable) on relative abundance as the independent variable.

Tests for data normality and homoscedasticity were performed using Kolmogorov's and Levine's tests, respectively. Data were transformed using Box-Cox transformation to normalize and homogenize the data for the independent variable. All Statistical analyses were processed using SPSS version 25 (IBM, Arnock, NY, USA).

Results and discussion

Species composition

A total of 158 species was recorded in the study sites for the 11 commercially important reef and reef-associated fishes (Table 1). Of the 158 reef species, 143 were recorded from Talibon, while 134 species were recorded in Pres. C.P. Garcia. Among the 11 reef families, Serranidae has the most numerous species recorded in both sites and the disparity in the number of reef species was observed on subsequent reef families (Fig. 2).

Table 1. Species composition and frequency occurrence of identified reef species in Talibon and Pres. C.P. Garcia markets and fish landing.

Species Name	Common Name	Talibon	C.P. Garcia	IUCN Status
Acanthuridae				
Acanthurus lineatus	Lined Surgeonfish	+	+	LC
Acanthurus mata	Elongated Surgeonfish	+	+	LC
Acanthurus nigricauda	Blackstreak Surgeonfish	+	+	LC
Acanthurus olivaceus	Orange band Surgeonfish	+	+	LC
Acanthurus pyroferus	Mimin Surgeonfish	+	+	LC
Acanthurus xanthopterus	Yellowfin Surgeonfish	+	+	LC
Ctenochaetus striatus	Striped Bristletooth	+	+	LC
Naso annulatus	Whitemargin Unicornfish	+		LC
Naso caeruleacuda	Bluetail Unicornfish		+	LC
Naso hexacanthus	Sleek Unicornish	+		LC
Naso lituratus	Orange Spine Surgeonfish	+	+	LC
Naso minor	Blackspine Unicornfish	+		LC
Naso thynnoides	Singlespine Unicornfish	+		LC
Naso unicornis	Bluespine Unicornfish	+	+	LC
Naso vlamingii	Bignose Unicornfish	+	+	LC
Zebrasoma scopas	Brushtail Tang	+		LC
Zebrasoma veliferum	Sailfin Tang	+		LC
Balistidae				
Balistapus undulatus	Oranged-lined triggerfish	+	+	NE
Balistoides conspicillum	Clown triggerfish	+	+	NE
Balistoides viridescens	Titan triggerfish	+	+	NE
Canthidermis maculatus	Rough Triggerfish	+	+	LC
Melichthys niger	Black Triggerfish	+	+	LC

Melichthys vidua	Pinktail Triggerfish		+	NE
Odonus niger	Redtooth Triggerfish	+	+	NE
Pseudobalistes flavimarginatus	Yellowmargin Triggerfish	+	+	NE
Sufflamen bursa	Scythe Triggerfish	+	+	NE
Caesionidae				
Caesio caerulaurea	Scissortail Fusilier	+	+	LC
Caesio cuning	Redbelly yellowtail Fusilier	+	+	LC
Caesio teres	Yellow and Blueback Fusilier	+	+	LC
Pterocaesio chrysozona	Glodband Fusilier	+	+	LC
Pterocaesio digramma	Double-lined Fusilier	+	+	LC
Pterocaesio marri	Marr's Fusilier	+	+	LC
Pterocaesio pisang	Banana Fusilier	+	+	LC
Pterocaesio randalli	Randall's Fusilier		+	NE
Pterocaesio tessellate	One-stripe Fusilier	+	+	LC
Pterocaesio tile	Dark-banded Fusilier	+	+	LC
Haemulidae				
Diagramma pictum	Painted Sweetlips	+	+	NE
Plectorhinchus chaetodonoides	Harlequin Sweetlips	+	+	NE
Plectorhinchus chrysotaenia	Goldlined Sweetlips	+	+	NE
Plectorhinchus lessonii	Striped Sweetlips	+	+	NE
Plectorhinchus lineatus	Lined Sweetlips	+		NE
Plectorhinchus polytaenia	Riobboned Sweetlips	+	+	LC
Plectorhinchus vittatus	Indian Ocean Oriental	+	+	LC
Lethrinidae				
Gnathodentex aureolineatus	Striped Large-eye Bream	+	+	LC
Lethrinus erythracanthus	Orange-spotted Emperor	+	+	LC
Lethrinus erythropterus	Longfin Emperor	+	+	LC
Lethrinus harak	Thumbprint emperor	+	+	LC
Lethrinus lentjan	Pinkear Emperor	+	+	LC
Lethrinus microdon	Smalltooth Emperor	+	+	LC
Lethrinus nebulosus	Spangled Emperor	+		LC
Lethrinus obsoletus	Orange-striped Emperor	+		LC
Lethrinus olivaceus	Longface Emperor		+	LC
Lethrinus ornatus	Ornate Emperor	+	+	LC
Lethrinus semicinctus	Black-spot Emperor		+	LC
Monotaxis grandoculis	Humpnose Big-eye Emperor	+	+	LC
Lutjanidae				
Lutjanus argentimaculatus	Mangrove red Snapper	+	+	LC
Lutjanus biguttatus	Two-spotted red Snapper	+	+	LC
Lutjanus bohar	Red Snapper	+	+	LC
Lutjanus carponotatus	Spamish Flag Snapper	+	+	LC

Lutjanus decussatus	Checkered Snapper	+	+	LC
Lutjanus ehrenbergii	Blackspot Snapper	+	+	LC
Lutjanus fulviflammus	Dory Snapper	+	+	LC
Lutjanus fulvus	Blacktail Snapper	+	+	LC
Lutjanus gibbus	Humpback red Snapper	+	+	LC
Lutjanus kasmira	Common Bluestripe Snapper	+	+	LC
Lutjanus lemniscatus	Yellowstreaked Snapper	+	+	LC
Lutjanus lutjanus	Bigeys Snapper	+	+	LC
Lutjanus monostigma	One-spot Snapper	+	+	LC
Lutjanus quinquelineatus	Five-lined Snapper	+	+	LC
Lutjanus rivulatus	Yellow-lined Snapper	+		LC
Lutjanus russellii	Russell's Snapper	+	+	LC
Lutjanus timorensis	Timor Snapper	+	+	LC
Lutjanus vitta	Brownstripe Red Snapper	+	+	LC
Macolor macularis	Midnight Snapper	+		LC
Macolor niger	Black and White Snapper	+	+	NE
Mullidae				
Mulloidichthys flavolineatus	Yellowstripe Goatfish	+		LC
Mulloidichthys vanicolensis	Orange Goatfish	+	+	LC
Parupeneus barberinus	Dash-and-Dot Goatfish	+	+	LC
Parupeneus crassilabris	Thicklipped Goatfish	+	+	LC
Parupeneus cyclostomus	Gold-saddle Goatfish	+	+	LC
Parupeneus heptacanthus	Cinnabar Goatfish	+	+	LC
Parupeneus indicus	Indian Goatfish		+	LC
Parupeneus multifasciatus	Banded Goatfish	+	+	LC
Parupeneus pleurostigma	Sidespot Goatfish	+	+	LC
Upeneus moluccensis	Goldband Goatfish		+	LC
Upeneus tragula	Freckled Goatfish	+	+	LC
Upeneus vittatus	Yellowstriped Goatfish	+	+	LC
Nemipteridae				
Pentapodus bifasciatus	White-shouldered Whiptail	+	+	NE
Pentapodus caninus	Small-toothed Whiptail	+	+	LC
Pentapodus trivittatus	Treestriped Whiptail	+	+	LC
Scolopsis affinis	Peter's Monocle Bream	+	+	LC
Scolopsis bilineata	Two-lined Monocle Bream	+	+	LC
Scolopsis ciliata	Saw-jawed Monocle Bream	+	+	LC
Scolopsis lineatus	Striped Monocle Bream	+	+	LC
Scolopsis margaritifer	Pearly Monocle Bream	+	+	LC
Scolopsis monogramma	Monogram Monocle Bream	+		LC
Scolopsis taeniopterus	Lattice Monocle bream	+	+	LC
Scolopsis xenochrous	Oblique-barred Monocle Bream	+	LC	
Scaridae				

Calotomus spinidens	Spinytooth Parrotfish	+		LC
Cetoscarus ocellatus	Bicolor Parrotfish		+	LC
Chlorurus bleekeri	Bleeker's Parrotfish	+	+	LC
Chlorurus capistratoides	Pink-margined Parrotfish	+		LC
Chlorurus microrhinos	Steephead Parrotfish	+		LC
Leptoscarus vaigiensis	Marbled Parrotfish	+	+	LC
Scarus chameleon	Chameleon Parrotfish	+	+	LC
Scarus dimidiatus	Yellowbarred Parrotfish	+	+	LC
Scarus flavipectoralis	Yellowfin Parrotfish	+	+	LC
Scarus forsteni	Forsten's Parrotfish	+	+	LC
Scarus ghobban	Blue-barred Parrotfish	+	+	LC
Scarus hypselopterus	Yellow-tail Parrotfish	+	+	LC
Scarus niger	Dusky Parrotfish	+	+	LC
Scarus oviceps	Darkcaped Parrotfish	+	+	LC
Scarus prasiognathos	Singapore Parrotfish	+		LC
Scarus psittacus	Common Parrotfish	+	+	LC
Scarus quoyi	Qouy's Parrotfish	+	+	LC
Scarus rivulatus	Rivulated Parrotfish	+	+	LC
Scarus rubroviolaceus	Ember Parrotfish	+	+	LC
Scarus schlegeli	Yellowband Parrotfish	+	+	LC
Scarus spinus	Grensnout Parrotfish	+		LC
Scarus tricolor	tricolor Parrotfish	+	+	LC
Serranidae				
Anyperodon leucogrammicus	Slender grouper	+	+	LC
Cephalopholis argus	Peacock Grouper	+	+	LC
Cephalopholis boenak	Chocolate Grouper	+	+	LC
Cephalopholis cyanostigma	Blue Spotted hind	+	+	LC
Cephalopholis miniata	Coral Hind	+	+	LC
Cephalopholis sexmaculata	Six-blotch Hind		+	LC
Cephalopholis urodeta	Darkfin Hind	+	+	LC
Cromileptes altivelis	umpback Grouper	+	+	DD
Epinephelus coioides	Oranged-spotted Grouper	+	+	LC
Epinephelus fasciatus	Blacktip Grouper	+	+	LC
Epinephelus fuscoguttatus	Brown-marbled Grouper	+		VU
Epinephelus hexagonatus	Star-spotted Grouper	+		LC
Epinephelus maculatus	Highfin Grouper	+		LC
Epinephelus merra	Honeycomb Grouper	+	+	LC
Epinephelus ongus	Speckefin Grouper		+	LC
Epinephelus polyphekadion	Camouflage Grouper	+		VU
Epinephelus quoyanus	Longfin Grouper	+	+	LC
Epinephelus sexfasciatus	Sixbar Grouper	+	+	LC
Plectropomus areolatus	Squaretail grouper		+	VU

Plectropomus laevis	Blacksaddled Coral Grouper	+	+	LC
Plectropomus leopardus	Lepard Coral Grouper	+	+	LC
Plectropomus maculatus	Bar-cheeked grouper	+		LC
Plectropomus oligacanthus	Highfin Coral Grouper	+	+	LC
Variola albimarginata	White-edge Lyre Tail	+	+	LC
Variola louti	Yellow-edge Lyretail	+		LC
Siganidae				
Siganus argenteus	Forktail Rabbitfish	+	+	LC
Siganus canaliculatus	White-spotted Rabitfish	+	+	LC
Siganus corallinus	Blue-spotted Spinefoot	+	+	LC
Siganus fuscescens	Mottled Spinefoot	+	+	LC
Siganus guttatus	Golden Rabbitfish	+	+	LC
Siganus puellus	Masked Rabbitfish		+	LC
Siganus punctatissimus	Fined-spotted Rabbitfish	+	+	LC
Siganus punctatus	Gold-spotted Rabbitfish	+	+	LC
Siganus spinus	Scribbled Rabbitfish	+	+	LC
Siganus vermiculatus	Vermiculated Rabbitfish	+	+	LC
Siganus virgatus	Doblebar Rabbitfish	+	+	LC
Siganus vulpinus	Foxface Rabbitfish	+	+	LC

Legend:
DD – Data deficient
LC – Least concern
NE – Not evaluated
EN – Endangered
CR – Critically endangered.

Based on the status of threat from the International Union for Conservation of Nature (IUCN, 2018), 3 recorded species were listed as vulnerable (VU). These species were *Epinephelus fuscoguttatus* and *Epinephelus polyphekadion,* recorded in Talibon and *Plectropomus areolatus* recorded in Pres. C.P. Garcia (Table 1). They belong to the family of Serranidae or commonly known as groupers which are considered to be high-valued fish with market price from 250-600 (dead) to 800-3,500 PHP (alive) depending on size, based on the interview of the key informant. Out of 158 species, 139 were evaluated as Least Concern (LC), while one species of grouper *Cromileptes altivelis* was listed as Data Deficient (DD).

Table 2. Diversity index of the surveyed sites.

Sites	Shannon Diversity	Pielou Evenness	Species Richness	Total Species	Simpson Dominance	H max
Talibon	5.77	1.16	118	143	0.141	4.96
Pres.C.P. Garcia	4.33	0.88	98	134	0.129	4.90

The remaining 15 species were classified as Not Evaluated (NE). There were no identified species that are under Endangered (EN) or Critically Endangered (CR) species during the survey. The proximity of the study sites explains the comparable findings on identified reef fishes. This variation in species composition was marginally shown with <15% of the unique listed species (198 similar species) between the studied sites (Table 1). Reef topography and physical state (i.e., Salinity, Temperature, water movement) of the fishing ground may be attributed to the similarity of identified reef species. As such, these reef fishes are harvested from the richness of the Danajon Bank Marine Ecosystem. The unique structure of Danajon Bank became a suitable ecosystem for coral reefs to flourish, which provides a vital refuge system for reef fishes (Bacalso and Wolff, 2014). Reef fishes have a typical behavior of constantly staying on coral reefs, which have a constraint on depth depending on species and do not travel 20 meters distance separated by a patchy reef and sand rubbles (Chapman and Kramer, 2000). This is an advantage for a barrier reef structure that could potentially harbor a productive ecosystem.

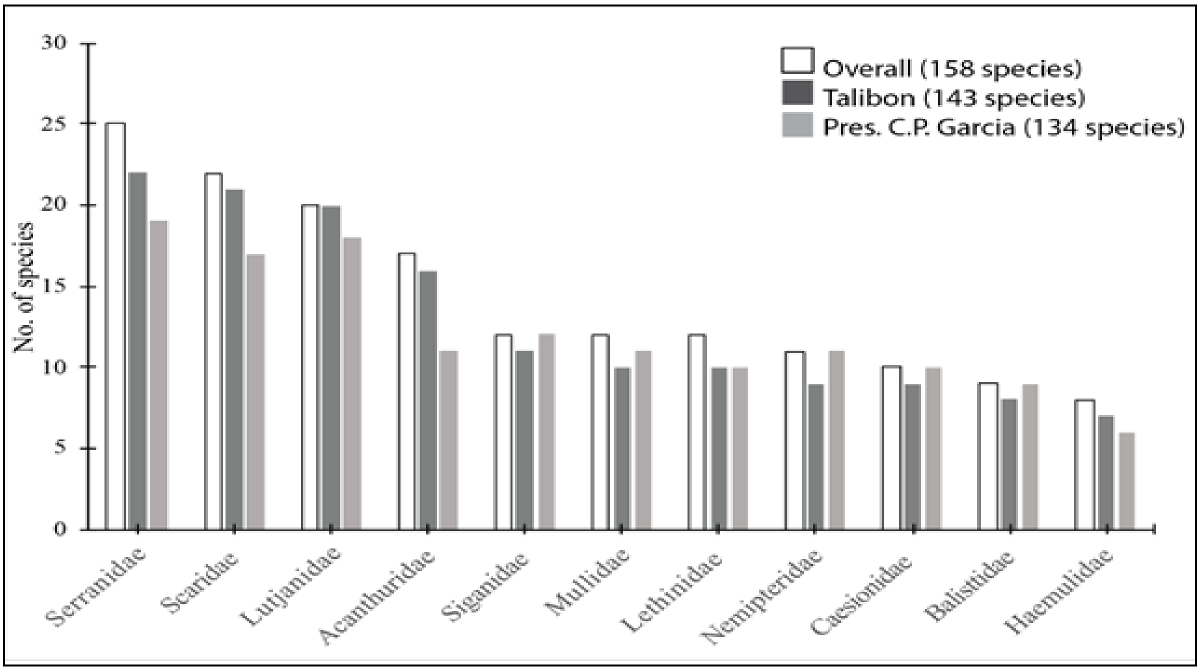

Fig. 2. The number of reef species belonging to 11 reef families.

Fishing is one of the major sources of income in the community. Most fishing practices are accustomed to targeting reef fishes using several fishing gears and norms (Christie *et al.*, 2006). Thus, the extent of fisher catch for reef fishes would categorically derive within municipal or provincial water (constrained within Provincial water jurisdiction).

The fisheries of the Bohol region are more reef-dependent because of the reef structure of Danajon Bank (Armada *et al.*, 2009). Unfortunately, illegal and destructive fishing such as blast fishing, poison fishing and compressor-aided spearfishing (*hookah* spearfishing) are still rampant in some reef areas of the Danajon Bank (Nañola *et al.*, 2011; Bacalso and Wolff, 2014). Despite reports on illegal and destructive fishing, the study recorded high reef species composition in Talibon and Pres. C.P. Garcia at 2 months of extensive market survey. The author recommends that the survey will be conducted for a longer duration than 2 months on a seasonal basis to validate the temporal distribution of reef fishes in the region.

Relative abundance

A total of 8,710 fish individuals were counted for the 11 reef families considered based on the photographs taken during the market survey. In Talibon, it consisted of 5,146 fish counts compared to 3,564 fish counted in Pres. C.P. Garcia. The sum of recorded fish provides initial estimates of reef fish that were being displayed or sold in the market at an average of 515 ± 130 (Talibon) and 356 ± 98 (Pres. C.P. Garcia) reef fish individuals, respectively. One-way ANOVA revealed a significant difference in relative abundance between sites ($p< 0.05$), as shown in Fig. 3A. In

Talibon, the families Siganidae, Nemipteridae, and Scaridae were the most dominant groups with 19%, 15%, and 14% relative abundance, respectively. In contrast, in Pres. C.P. Garcia, Nemipteridae was the most dominant family with an abundance of 17%, followed by Siganidae (14%) and Caesionidae (13%). Both sites have similar records on the least dominant reef families, namely: Balistidae and Haemulidae listed in descending order.

The dominance of Siganidae in captured fisheries in Talibon is associated with the habitat preference of siganids which inhabit between habitats transition of seagrass and coral reef (Allen *et al.,* 2003; Kuiter and Tonozuka, 2004). The geography of Talibon consisted of many islands near the coastal mainland where coasts are abundant of seagrass beds and shallow reefs (Calumpong *et al.*, 2004), thereby affecting fisher's catch. In Pres. C.P. Garcia, captured fisheries consisted mainly of the family Nemipteridae which was possibly influenced by the geographic structure of Pres. C.P. Garcia. Nemipteridae is a reef-associated fish that interact between mid-pelagic and demersal habitats, and most nemipterids reside on habitat preference of sand, lagoons, coral rubbles, and deeper waters (Allen *et al.*, 2003; Kuiter and Tonozuka, 2004). Pres. C.P. Garcia is an island municipality, and its resource comes from surrounding marine waters with few off-shore islands compared to Talibon.

The geography and structure of reef habitats in both sites may explain the difference in abundance of species and retailed reef families in the main market. Fishing gears used by the fisher could also affect the composition of the fisher's catch because gear types have some degree of selectivity that capture certain fish species depending on the modification of fishing gears.

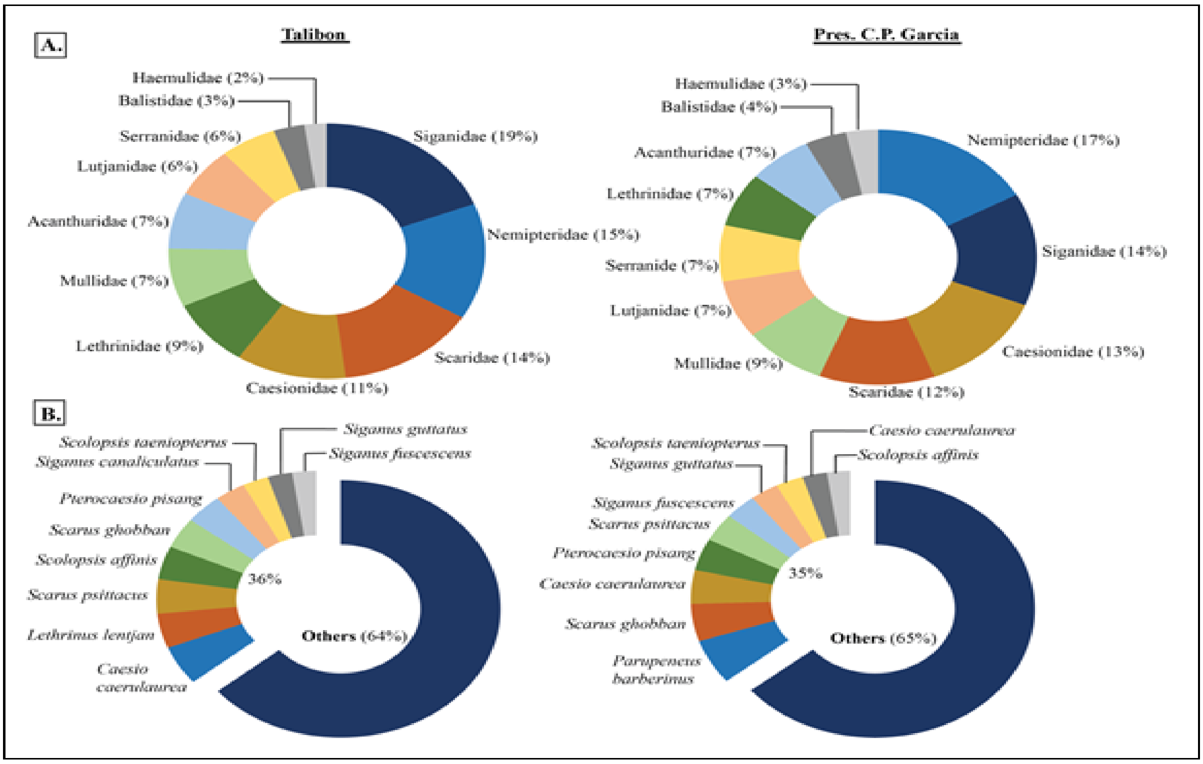

Fig. 3. Relative abundance per family (A) and top 10 abundant reef species (B) of the surveyed sites.

Species-wise, the *Siganus fuscescens*, Siganidae (4.9%), *Siganus gutatus*, Siganidae (4.4%), *Scolopsis taeniopterus*, Nemipteridae (4.3%), *Siganus canaliculatus*, Siganidae (4.2%) *and Pterocaesio pisang*, Caesionidae (3.9%) were the top five most abundant species in Talibon (Fig. 3B). In Pres. C.P Garcia fish market, *Scolopsis affinis*, Nemipteridae (5.6%), *Caesio caerulaurea*, Caesionidae (4.7%), *Scolopsis taeniopterus*, Nemipteridae (4.3%), *Siganus guttatus*, Siganidae (4.0%) *and Siganus* *fuscescens*, Siganidae (3.6%), were the most abundant species.

Fig. 4 shows the most abundant reef species per family. In Talibon, the most abundant species were *Siganus fuscescens* (26%) for Siganidae, *Scolopsis taeniopterus* (29%) for Nemipteridae, *Scarus ghobban* (26%) for Scaridae, *Ptereocaesio pisang* (35%) for caesionidae, *Lethrinus lentjan* (29%) for Lethrinidae, *Acanthurus mata* (25%) for Acanthuridae, *Upeneus vittatus* (30%) for Mullidae, *Lutjanus vitta* (20%) for Lutjanidae, *Epinephelus fasciatus* (18%) for Serranidae, *Odonus niger* (44%) for Balistidae and *Plectorhinchus polytaenia* (32%) for Haemulidae. For Pres. C.P. Garcia, the most abundant species were *Siganus guttatus* (28%) for Siganidae, *Scolopsis affinis* (33%) for Nemipteridae, *Scarus psittacus* (27%) for Scaridae, *Caesio caerulaurea* (36%) for Caesionidae, *Lethrinus lentjan* (28%) for Lethrinidae, *Acanthurus mata* (38%) for Acanthuridae, *Parupeneus barberinus* (28%) for Mullidae, *Lutjanus fulviflammus* (19%) for Lutjanidae, *Epinephelus fasciatus* (21%) for Serranidae, *Odonus niger* (29%) for Balistidae and *Plectorhinchus polytaenia* (29%) for Haemulidae.

Species Diversity

Species diversity indices differed between Talibon and Pres. C.P. Garcia. The highest Shannon – Weiner diversity index (H'), species richness, Pielou evenness index (J) and Simpson dominance index (1-D) were observed in Talibon (Table 2). According to Namin and Spurny (2004), the H' values could evaluate the condition of species diversity based on 4 categories; where ≥ 3.00 is considered high, ≥ 2.00 to < 3.00 moderate, ≥ 1.00 to < 2.00 poor and < 1.00 very poor species diversity. In this study, high species diversity was observed in both sites.

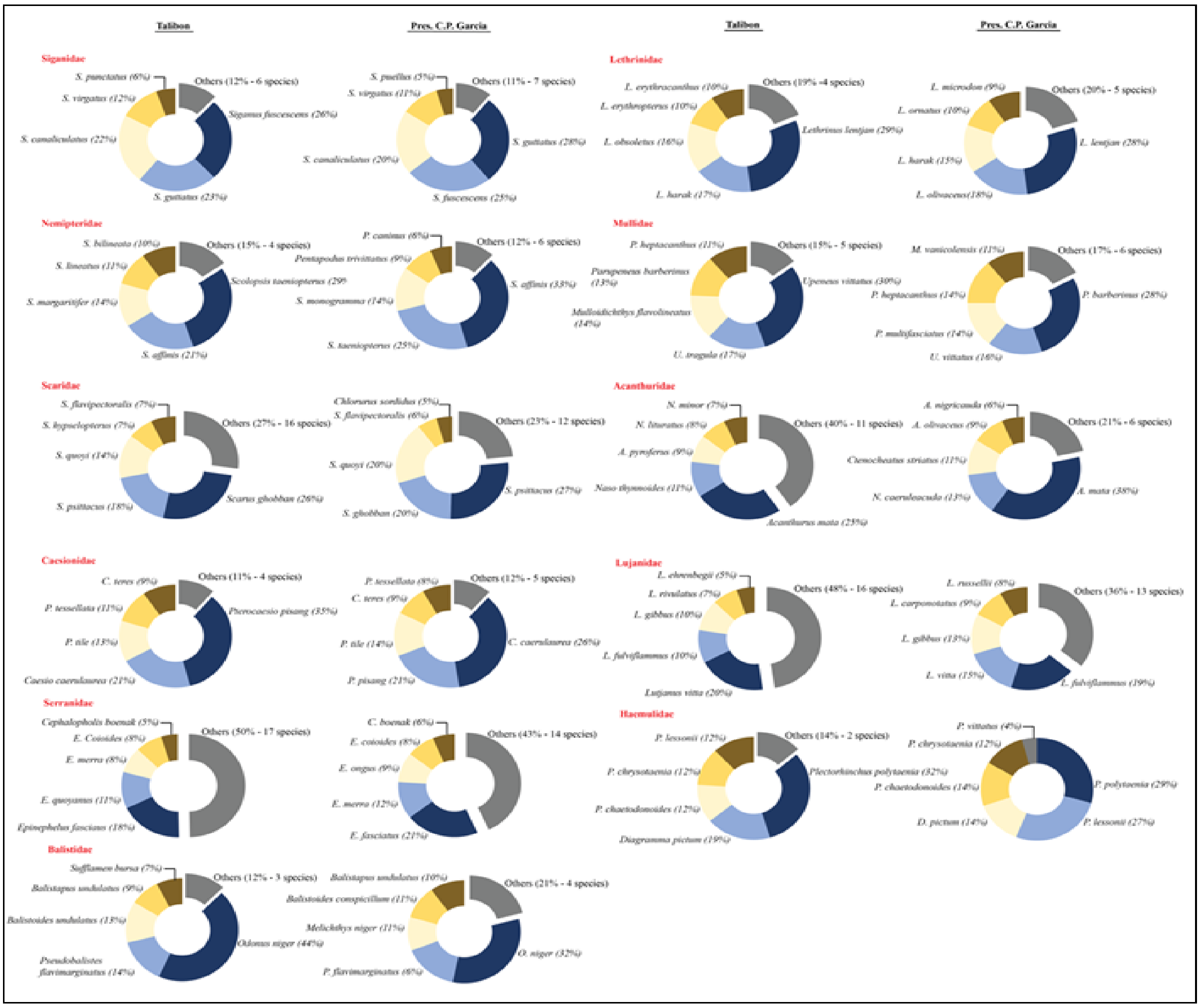

Fig. 4. Top 5 reef species per family of the surveyed sites.

According to Nair *et al*. (1989) study, the H' was found to have a positive correlation with species richness, as their study showed the same relationship of high species diversity and species richness or reef species recorded per sampling (day) in this study. Further analysis revealed high evenness and low dominance in both sites. Therefore, the distribution of sold reef fishes in the market was slightly uniform. This was supported by the low dominance of sold fishes, as the cumulative relative abundance was < 5.6%. High species diversity and species richness often correlate with high evenness and low dominance values (Hu *et al*., 2019).

The difference in species diversity in the surveyed sites could be attributed to two factors; coral reef conditions through anthropogenic impact (described by Nañola *et al*., 2011) and the accessibility of market routes (market and fish landing data).

Anthropogenic in nature as described by Nañola *et al.* (2011) that species diversity decreases with increasing distance from the center. Carpenter and Springer (2005) describe the Philippines as the center of the Coral Triangle, which is considered the origin of marine biodiversity. Accordingly, the province of Bohol is situated at the center of the Visayas Region (VR) and holds the only barrier reef in the Philippines (Armada *et al*., 2004; Christie *et al*., 2009). Contrary to the report of Nañola *et al*. (2011) that historical overfishing in the VR has led to localized species loss. Nonetheless, the findings of the present study still suggest high species diversity, at least in surveyed sites, despite reports on overexploitation of resources in VR and shifting the center of biodiversity in the Sulu Region (Muallil *et al*., 2020). Coral reef conditions of the surveyed sites may be varied, which may affect municipal captured fisheries as reef fishes are closely associated with the habitats (Chapman and Kramer, 2000).

The difference in species diversity of commercial coral reef fishes in the Market of Talibon and Pres. C.P. Garcia may also be attributed to the accessibility of market routes. Interview from local traders explained that fishers often trade their fish products nearer to the mainland, especially in Talibon, which is considered with well-established fish landing sites (Armada *et al*., 2004).

Traders often wholesaled fish cargo boxes to local or commercial warehouses in Tagbilaran City, particularly to most in-demand market fishes.

The study findings on diversity indices provide a comparison of the condition of reef species diversity between the sites. Unfortunately, studies on species composition and relative abundance in market and fish landing sites were limited. Studies conducted in Tawi-Tawi (Muallil *et al*., 2020), Panay Is. (Motomura *et al*., 2017) and Palawan (Gonzales, 2013) emphasized species inventory.

Conclusion

The present study showed the richness of commercial coral reef fishes in the market of Talibon and Pres. C.P. Garcia. Shannon diversity profile indicates that the study sites have high species diversity, and the evenness was low. The relative abundance of fish for each site was dominated by the coral reef family of Siganidae or Nemipteridae. However, more species could be found with extended sampling duration that expands to other coastal municipalities, as well as examines the temporal distribution of fishes in the region. Moreover, the results indicate that species composition, distribution of relative abundance and species diversity of the surveyed sites were varied. Species richness and diversity were higher in Talibon compared to Pres. C.P. Garcia which possibly driven by environmental variables and, to some extent, accessibility of market routes. Therefore, management policies may differ between sites more holistically, for example, coral reef restoration, aquaculture land management and marine sanctuary protection.

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