DAVAO RESEARCH JOURNAL

https://davaoresearchjournal.ph P-ISSN 2244-4432 E-ISSN 2984-7125

# Local Knowledge on the distribution, exploitation, and threats to *Centropyge* species (Pomacanthidae) in the Philippines

Manilyn E. Laya-og[1], Christine Marie V. Casal[2], Jaime Q. Guihawan[1], Wella T. Tatil[1], Daisy Lou L. Polestico[3], Maria Theresa M. Mutia[4], Armi G. Torres[1]

[1]*Department of Environmental Science, School of Interdisciplinary Studies, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Philippines. ORCID: Manilyn Laya-og, https://orcid.org/0009-0001-0083-4991; Jaime Q. Guihawan, https://orcid.org/0000-0003-3485-3549; Wella T. Tatil, https://orcid.org/0009-0007-2025-3653; Armi G. Torres, https://orcid.org/0000-0001-6720-9165*

[2] *School of Environmental Science and Management (SESAM), University of the Philippines Los Baños, Los Baños, Laguna, 4030, Philippines. ORCID: Christine Marie V. Casal, https://orcid.org/0000-0001-6107-7368*

[3]*Department of Mathematics and Statistics, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Philippines, ORICD: Daisy Lou L. Polestico, https://orcid.org/0000-0003-0238-9366*

[4]*National Fisheries and Research Institute- Freshwater Fisheries Research and Development Center (NFRDI-FFRDC), Department ofAgriculture, Butong, Taal, Batangas, 4208 Philippines. ORCID: Maria Theresa M. Mutia, https://orcid.org/0000-0002-8019-4452*

Submitted: 28 Oct 2024
Revised: 25 Nov 2024
Accepted: 20 Dec 2024
Published: 27 Dec 2024

*Corresponding author: manilyn.laya-og@g.msuiit.edu.ph

OPEN ACCESS

## ABSTRACT

The Philippines is a top exporter of marine ornamental fish in the world. Angelfishes (Pomacanthidae) are among the most valuable in the marine ornamental fish trade, particularly the species of *Centropyge*. Assessment of their conservation status is vital to regulate harvesting, prevent extinction, and sustain the ornamental industry. Critical information for their assessment is limited. Thus, this study used local knowledge to determine the distribution, exploitation, and threats to *Centropyge bispinosa*, *C. heraldi*, and *C. bicolor*. A total of 157 ornamental fish divers, 8 exporters, and 18 middlemen were interviewed from 12 municipalities covering eight provinces identified as major producers of marine ornamental fish in the Philippines. Results indicate a wide distribution of these species in the Philippines. These species were utilized for aquarium trading only. Zambales fisherfolk has the highest catch number for all three *Centropyge* species, with an average weekly catch of 72 pieces of *C. bispinosa,* 60 pieces of *C. heraldi,* and 36 species of *C. bicolor*. Their conservation status is Least Concern based on 2009-2010 IUCN assessments which are outdated. Illegal fishing, water pollution, natural disasters, and crown-of-thorns starfish infestation could drive them toward the threatened category. Information from this study will be used to re-assess the current conservation status using IUCN Red List Categories and Criteria. The result of this study will provide crucial information for advancing the conservation of marine biodiversity, sustainable management resources, and evidence-based policy formulation.

*Keywords:* Angelfish, *Centropyge bispinosa, Centropyge heraldi, Centropyge bicolor*, Philippines, IUCN Red List Categories and Criteria, Marine ornamental fish

**How to cite:** Laya-og, M. E., Casal, C. M. V., Guihawan, J. Q., Tatil, W. T., Polestico, D. L. L., Mutia, M. T. M., Torres, A. G. (2024). Local knowledge on the distribution, exploitation, and threats to *Centropyge* (Pomacanthidae) species in the Philippines *Davao Research Journal*, 15(4), 161-175. https://doi.org/10.59120/drj.v15i4.286

## INTRODUCTION

The Philippines, an archipelagic country in Southeast Asia with 7,641 islands, is located within the Coral Triangle, a hotspot for coral reef biodiversity (Reyes and Licuanan, 2022; Sobha et al., 2023). This makes the country one of the most diverse in terms of marine life. The Philippines is a major player in marine ornamental fish exportation, offering promising livelihood opportunities for fisherfolk (Biondo and Burki, 2019; Priyashadi et al., 2023). An estimated 60% of marine ornamental fish traded internationally originate from the Philippines (Biondo and Burki, 2019; Mulyati et al., 2023; Pouil et al., 2019). Most of the marine ornamental fish are taken from the wild (Dominguez and Botella, 2014; Yan, 2016; Evers et al., 2019) and exported to different countries such as the United States, Europe, and Japan (Olivier, 2003; Leal et al., 2015).

The Family Pomacanthidae is one of the most popular marine ornamental fish harvested for the aquarium trade (Affonso and Galetti, 2007). According to the Global Marine Database, from 1997 to 2002, it was the second most imported family in marine ornamental trading (Wabnitz, 2003). Within the pomacanthid family, the genus *Centropyge* is one of the major highly traded marine angelfishes (Baensch and Tamura, 2009). This is due to its small body size and bright coloration (Olivotto et al., 2006; Baensch and Tamaru, 2009). However, collecting these species is challenging as some are usually found beyond conventional scuba depths (Gaither et al., 2014). The *Centropyge* genus is a territorial coral reef inhabitant that adapts well to aquariums over an extended period of more than 8 years (Bauer and Bauer,1981; Pyle, 2001; Pyle, 2003). Thus, this makes the genus *Centropyge* highly exported in the aquarium fish trade (Mendoca et al., 2020), particularly the *C. bispinosa, C. heraldi,* and *C. bicolor*. These species were included in the list of the highly exported species in the aquarium trade (Biondi et al., 2024), and their manageable size makes them excellent choices for aquarium enthusiasts (Bauer and Bauer,1981). In the recent evaluation, *C. bispinosa and C. bicolor* were included in the top 20 species imported into the European Union, highlighting *C. bicolor* as the top 3 and *C. bispinosa* as the top 11 between 2014 and 2021 assessment (Biondo et al., 2024). Moreover, *C. bicolor* was included in the top 10 most vulnerable fish species associated with its biological productivity and susceptibility to overfishing imported into the United States (Dee et al., 2019). Additionally, the Bureau of Fisheries and Aquatic Resource - National Fisheries Research and Development Institute (BFAR-NFRDI) conducted an assessment in 2017 showed that these three selected species were included in the top 30 most traded marine ornamental fish, *C. bispinosa* in the top 10 (28,053 pieces), *C. heraldi* as the top 21 (14,309 pieces), and *C. bicolor* in the top 27 (13, 231 pieces) exported in different countries (unpublished data provided by BFAR-NFR-DI). Thus, the high market demand for these species may raise concerns about potential overharvesting in the wild, given that larval development for aquaculture is not yet available. The last extinction risk assessment of these species using the IUCN Red List Criteria and Categories was in 2009-2010 with the category Least Concern (IUCN, 2024), indicating that these species are less concerned than species in other threat categories. Given the outdated IUCN assessments and ongoing environmental pressure, this study provides critical updates needed for informed conservation planning.

Local Knowledge (LK) is a breadth of knowledge that provides salient information, especially when scientific data is limited (Beaudreau and Levin, 2014; Lima et al., 2017; Pita et al., 2020; Truchet et al., 2019). The knowledge of fishers acquired over generations through hands-on experience and observation can shed light on fishing practices, distribution, species habitat, ecology, and threats (Ribeiro et al., 2021; Lima et al., 2017; Renck et al., 2023). Many studies have shown that Local Knowledge

 DOI: https://doi.org/10.59120/drj.v15i4.286

successfully provides conservation status data for endangered species such as sea lions, sharks, and sea turtles (Cook et al., 2015; Gallagher et al., 2015; Wedemeyer et al., 2021). Moreover, Local Knowledge (LK) helps to reveal unobserved declines in the species population, which is essential in developing effective fisheries conservation strategies and management plans for sustainability (Poissant et al., 2024). Thus, this study aims to determine the spatial distribution and exploitation of the three *Centropyge* species based on Local Knowledge and to determine threats to the population of the three *Centropyge* from the perspective of local fish divers, middlemen, and exporters involved in ornamental fish trading. The data obtained from LK will be used to assess the current conservation status of these three selected marine ornamental fish species of *Centropyge*. Involving fishers and integrating their knowledge into scientific assessments can help develop effective conservation strategies, ensuring the protection of fish populations and the communities that rely on them.

## MATERIALS AND METHODS

### Description of the study

The Philippines is one of the leading exporters of marine ornamental fish (Biondo et al., 2024). It has several key provinces actively involved in this industry. Pangasinan, Cagayan, Zambales, Quezon, Batangas, Eastern Samar, Cebu, and Davao del Sur were recognized as the major collection areas for marine ornamental species (Muyot et al., 2018; Muyot et al., 2019). These provinces are spread across different regions of the country and serve as centers for collecting marine ornamental fish species for international trade (Muyot et al., 2018). Therefore, interviews with ornamental fish divers, middlemen, and exporters were conducted in these identified areas (Figure 1).

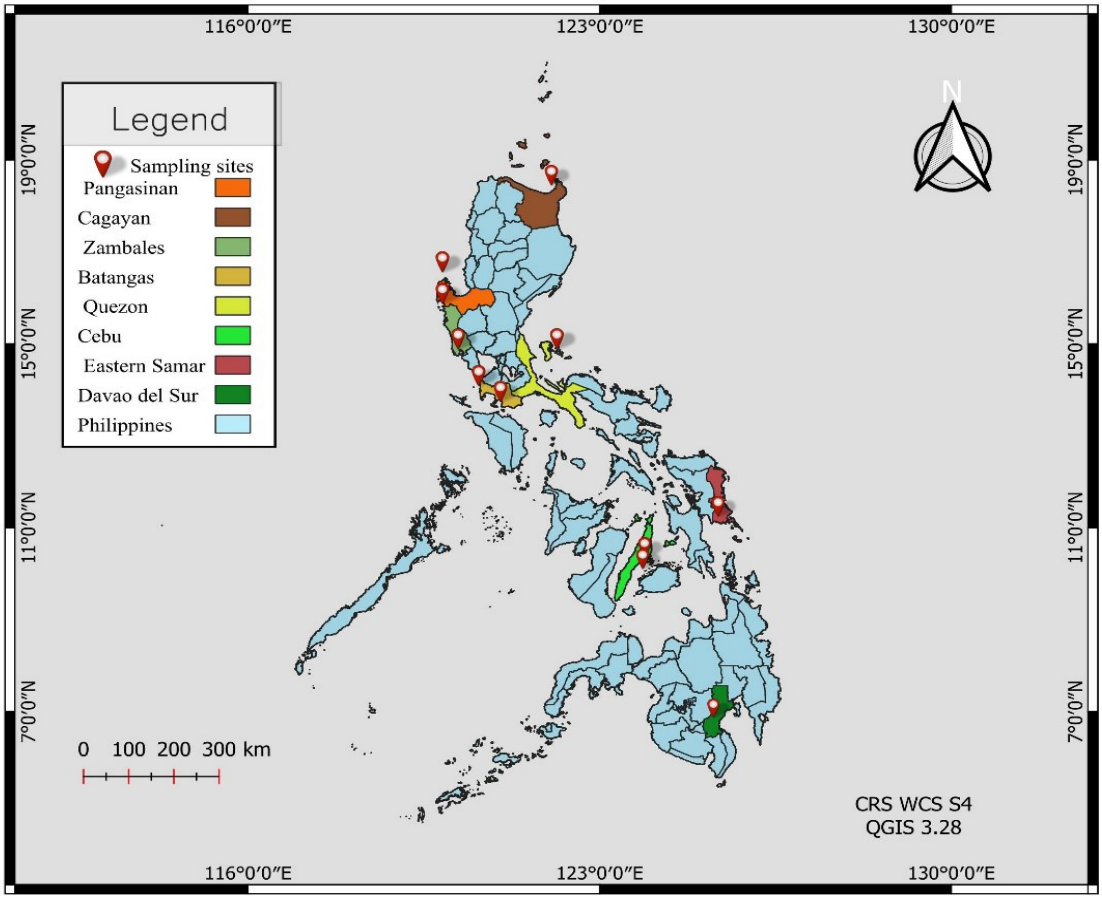



**Figure 1.** Map of major marine ornamental fish-producing areas in the Philippines.

**Data collection**

Face-to-face interviews from March 2024 to June 2024 in the selected villages of 8 provinces in the Philippines, where there is an active collection operation of marine ornamental fish were conducted (Table. 1). Snowball sampling was performed in selecting the respondents as there was no available information on the total population of fisherfolk engaged in marine ornamental fish in each province. The researcher obtained a list of accredited exporters from the Bureau of Fisheries and Aquatic Resource- Quarantine Division and employed it as a reference point in tracing the marine ornamental fish divers. Exporters were individually called by phone and asked for the details of their middleman trader posed in the villages. Subsequently, the middleman referred their ornamental fish divers for an interview. The networking and referral characteristics of the snowball sampling method are efficient in identifying the ornamental fish divers participants, especially in remote areas where it is hard to access information. However, snowball sampling has a limitation in selecting respondents, as it relies solely on the referred ornamental fish diver participants by the middlemen and exporters, which may result in a non-representative sample. Thus, it could exclude fishers who are not connected to the identified exporters or middlemen. Despite this constraint, this study can still provide reliable data on the distribution, exploitation, and threats that potentially affect the conservation status of these species.

A semi-structured interview was used to obtain the local knowledge (LK) on the habitat, abundance, distribution, uses and trade, and threats of the three selected species of genus *Centropyge* in their locality. Before the interview began, each respondent was asked for consent to participate in the activity. The questionnaire was pre-tested in the Municipality of Davao del Sur on March 2, 2024. This was done to test its validity and the respondents' time to answer questions (Macusi et al., 2017). Subsequently, it was modified based on the interview results. Additionally, a picture of the three *Centropyge* species was integrated into the questionnaire to guide the ornamental fish divers in identifying these species. During the interview, the researchers translated the questionnaire based on the local language of the ornamental fish divers, middlemen, and exporters (Tagalog in the Luzon areas and Cebuano in the Visayas and Mindanao areas) during the interview. This was done to prevent misinterpretation of the question.

Although a questionnaire was prepared, an open-ended question was allowed to encourage informants to share their knowledge and comments freely. Hence, this will elicit more information about the three *Centropyge* species. A total of 157 ornamental fish divers were interviewed in the provinces of Pangasinan (n= 8), Cagayan (n=14), Zambales (n=42), Batangas (n=41), Quezon (n=12), Cebu (n=30), Eastern Samar (n= 6), and Davao del Sur (n= 4). Additionally, researchers conducted key informant interviews with exporters (n=8) and middleman traders (n=18) posed in the village sites (Table 1) to gather further data and validate the information obtained from the ornamental fish divers.

A grid map of each sampling site was included in the questionnaire to help the ornamental fish divers identify their usual fishing ground where the three *Centropyge* species frequently collected. The data points from interviews were transcribed by locating the sites on a Google Earth map, after which the coordinates were traced and recorded. In addition, occurrence data points from the Global Biodiversity Information Facility (GBIF) and Ocean Biodiversity Information System (OBIS) databases were gathered. The collected secondary data were combined with estimated data point coordinates provided by ornamental fish divers to collate all occurrence records of the three *Centropyge* species in the Philippines.


DOI: https://doi.org/10.59120/drj.v15i4.286

**Table 1.** Distribution of respondents by province and Municipality.

| Provinces | Municipality | Fisherfolk diver respondents | Exporters respondents | Middlemen respondents |
|---|---|---|---|---|
| Pangasinan | Bolinao | 8 | - | 2 |
| Cagayan | Santa Ana | 14 | - | 3 |
| Zambales | Subic | 8 | - | 1 |
| | Masinloc | 15 | - | 1 |
| | Santa Cruz | 19 | - | 1 |
| Batangas | Calatagan Batangas | 17 | - | - |
| | Isla Verde Batangas City | 24 | - | 5 |
| Quezon | Patnanungan | 12 | - | 3 |
| Cebu | Olango Island | 22 | 5 | - |
| | Lapu-Lapu City | 8 | 3 | - |
| Eastern Samar | Giporlos | 6 | - | 1 |
| Davao del Sur | Santa Cruz | 4 | - | 1 |
| **Total** | | 157 | 8 | 18 |

**Data analyses**

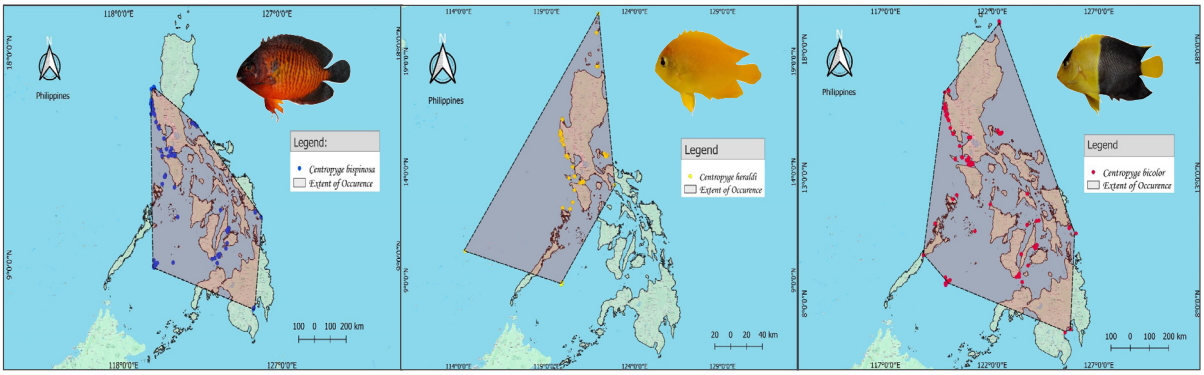
Researchers analyzed both quantitative and qualitative responses of the respondents. They were encoded and summarized using Microsoft Excel (2019). The quantitative data (utilization and threats) were analyzed through descriptive statistics, and the findings were visualized through graphs. The Shapiro-Wilk-Test was applied to determine the normality test of the gathered data. The Mann- Whitney U-Test was employed to determine the influence of gear type in the total weekly catch of the ornamental fish divers for the three *Centropyge* species. Kruskal Wallis Test was also performed to determine the threats affecting the total weekly catch collections of the three selected *Centropyge* species. A confidence level of 0.05 was set in all analyses. These statistical analyses were run through RStudio software 4.2.1. In addition, the Likert scale was used to analyze the observation of the occurrence of these species in each sampling area. Corresponding scores such as 1- Never, 2- Rarely, 3- Sometimes, 4- Frequently, and 5- always were set to measure the perceptions of fish divers. Subsequently, average scores were calculated and interpreted based on this mean range: 1.0 -2.9 – Low or Weak agreement, 3.0-4.4 Moderately agree, and 4.5-5 Strongly agree on its species occurrence. Moreover, the distribution data points were analyzed through Geospatial Conservation Assessment Tool software (GeoCAT) developed by Kew Garden (Batchman, 2011) as recommended software by the IUCN Red List Mapping Standards and Data Quality for the IUCN Red Spatial Data (IUCN 2024). This analysis was employed to calculate the extent of occurrence (EOO) using the minimum convex polygon method (IUCN, 2024). Subsequently, the Quantum Geographic Information System (QGIS) software version 3.36.3 generated the geographic distribution representation map of the three selected *Centropyge* species.

**RESULTS**

**Distribution**

The three marine ornamental species were widely distributed in the Philipines. *C. bicolor* species has the broadest distribution among the three species with an extent of occurrence of 664,637.562 $km^2$., followed by *C. heraldi* covering 601 983.961 $km^2$ concentrated in the Western and Central part of the country, and *C. bispinosa* with 457,189.338 $km^2$ (Figure 2). The *C. bicolor* species is present in all sampling sites and has a high occurrence in Zambales and Cagayan. Moreover, Quezon, Davao del Sur, Cebu, and Eastern Samar revealed moderate occurrence of this species in their areas

(Table 4). Meanwhile, fisherfolk revealed the absence of C. heraldi in Cebu, Samar, and Davao del Sur provinces. This information was further confirmed by the exporters and middlemen, who said they never have a supply of C. heraldi coming from the these provinces. This species was consistently observed in Zambales, Cagayan, and Quezon provinces (Table 3). The rest of the fisherfolk in Pangasinan and Cagayan have low observation of *C. heraldi* in their fishing ground. The *C. bispinosa* species is highly presence in Zambales and moderately observed in Pangasinan, Batangas, Quezon, Cebu, and Davao del Sur (Table 2).




*Centropyge bispinosa* 457,189.338 km² (EOO)

*Centropyge heraldi* 601,983.961 km² (EOO)

*Centropyge bicolor* 664,637.562 km²(EOO)

**Figure 2.** Distribution of the three Centropyge species in the Philippines.

**Table 2.** Perceived occurrence for *C. bispinosa* fish species.

| Sampling sites | Mean | SD | Interpretation |
|---|---|---|---|
| Pangasinan | 4.0 | 1.15 | Moderately agree |
| Cagayan | - | - | - |
| Zambales | 4.7 | 0.67 | Strongly agree |
| Batangas | 3.67 | 1.03 | Moderately agree |
| Quezon | 4.08 | 1.08 | Moderately agree |
| Cebu | 3.77 | 1.08 | Moderately agree |
| Eastern Samar | 2.67 | 1.36 | Low or weak agree |
| Davao del Sur | 4.0 | 1.15 | Moderately agree |

**Table 3.** Perceived occurrence for *C. heraldi* fish species.

| Sampling sites | Mean | SD | Interpretation |
|---|---|---|---|
| Pangasinan | 2.81 | 1.57 | Low weak agree |
| Cagayan | 3.57 | 1.16 | Moderately agree |
| Zambales | 4.09 | 1.33 | Strongly agree |
| Batangas | 2.5 | 1.62 | Low or weak agree |
| Quezon | 3.92 | 1.62 | Moderately agree |
| Cebu | - | - | - |
| Eastern Samar | - | - | - |
| Davao del Sur | - | - | - |

**Table 3.** Perceived occurrence for *C. bicolor* fish species.

| Sampling sites | Mean | SD | Interpretation |
|---|---|---|---|
| Pangasinan | 2.71 | 1.70 | Low or weak agree |
| Cagayan | 4.64 | 0.49 | Strongly agree |
| Zambales | 4.3 | 1.02 | Strongly agree |
| Batangas | 3.05 | 1.46 | Moderately agree |
| Quezon | 3.83 | 1.75 | Moderately agree |
| Cebu | 3.16 | 0.53 | Moderately agree |
| Eastern Samar | 3.33 | 0.82 | Moderately agree |
| Davao del Sur | 4.0 | 1.15 | Moderately agree |


DOI: https://doi.org/10.59120/drj.v15i4.286

## Exploitation

The *C. bispinosa*, *C. heraldi*, and *C. bicolor* species are used only for commercial aquarium trading and are exported to different countries. Generally, ornamental divers carry out small barrier nets made of monofilament mesh nets (Figure 4a) to collect these species. The small barrier nets with a length of less than 5 meters and lead weights along the bottom were established in a 'V' shape. Then, ornamental divers carefully "drove" the fish into the center of the net and immediately collected the fish using a scoop net (Figure 4b). The collected fish were placed in the bucket with a zipper net (Figure 4c). The majority of the ornamental divers in Davao del Sur (100%), Zambales (70%), Cagayan (71%), and Quezon (58%) have employed compressors to supply air at depth. In comparison, in the provinces of Eastern Samar (100%), Cebu (60%), Batangas (61%), and Pangasinan (75%), most of the ornamental divers carried out skin diving or "mano-mano" (Figure 4f), which they only used improvised fins made of plywood, PVC, or Fiber to dive (Figure 4d).

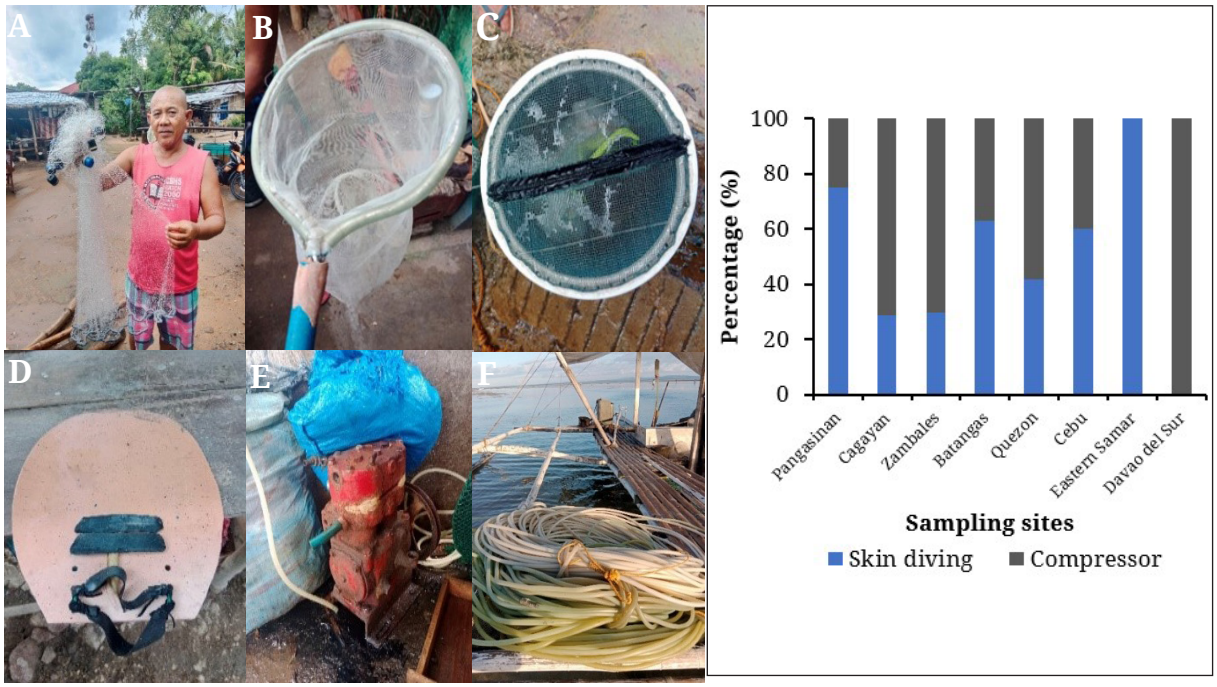



**Figure 4.** Gears used in collecting the three *Centropyge* species including mesh-size nets (A); Scoop net (B); Bucket with zipper net (C); Improvised fins (D); Compressors equipment (E); and percentage of ornamental fish divers employed compressors and skin diving (F).

The total weekly catch per species was 4 381 pieces for *C. bispinosa*, 3,192 pieces (*C. heraldi*), and 2,740 pieces for *C. bicolor*. The ornamental divers in Zambales stand out as the major collectors of the three *Centropyge* species, with an average weekly catch of *C. bispinosa* (72 pieces) *C. heraldi* (60 pieces), and *C. bicolor* (36 pieces), followed by Quezon ornamental divers, with 27 pieces (*C. bispinosa*), 44 pieces, (*C. heraldi*), and 45 pieces (*C. bicolor)*. Notably, there were no catches of *C. heraldi* in Cebu, Eastern Samar, and Davao del Sur. However, *C. bispinosa* and *C. bicolor* were collected in these provinces, and they had less than 30 pieces of average weekly catch. Batangas, Pangasinan, and Cagayan divers catch less than ten pieces of the three *Centropyge* fish species (Figure 5). The Mann -Whitney U test analysis revealed a statistically significant difference in weekly catch between those divers who used compressors and those who practiced skin diving. This implies that ornamental fish divers using compressors achieved higher catches than those who relied on skin diving (Figure 6).

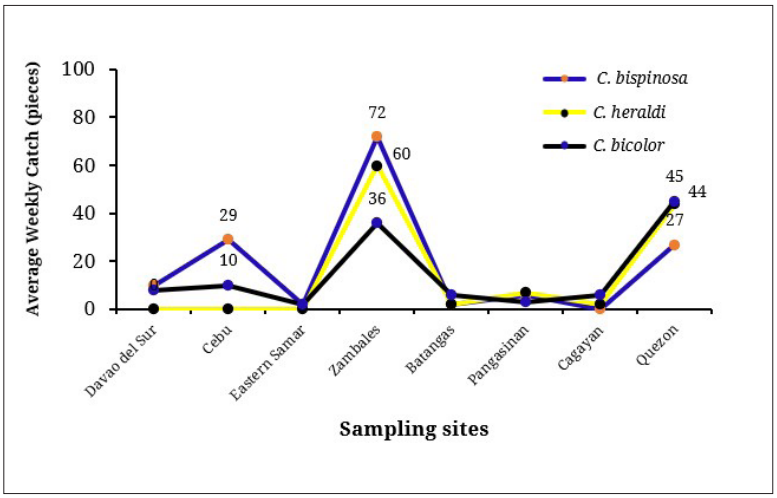



**Figure 5.** Average weekly catch of the *Centropyge* species within eight regions.

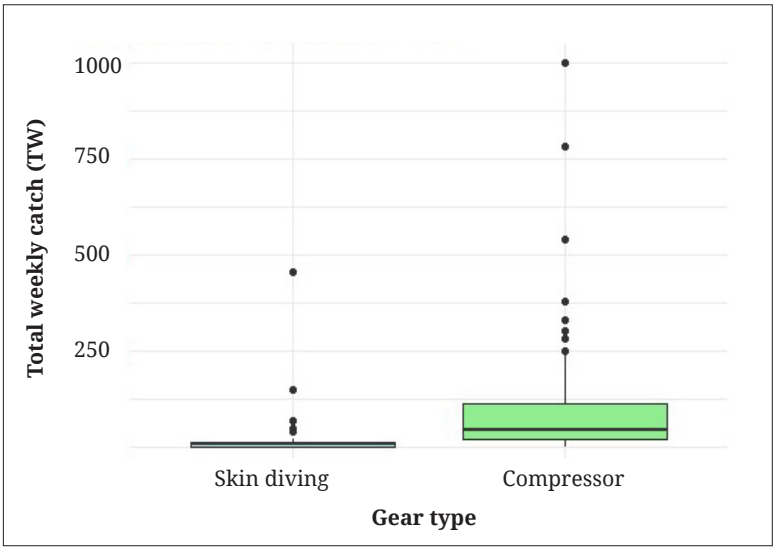



**Figure 6.** Total Weekly Catch (TWC) comparison between Skin Diving and Compressor gear types.

## Threats

Each sampling site faces different environmental threats that are perceived to damage the coral reef habitat and affect the population of the three *Centropyge* species. Ornamental divers in Davao del Sur (100%), Cebu (63%), Zambales (50%), and Pangasinan (50%) revealed that they were affected by the water pollution caused by anthropogenic activities (fish cages, garbage waste, siltation from mining activity), surrounded in their fishing areas. In addition, ornamental fish divers in Cebu (90%), Cagayan (100%), and Eastern Samar (33%) reported that natural disasters, particularly typhoons primarily the threats observed caused the reduction in the population of the three *Centropyge* species as typhoons significantly destroyed or damage the coral reefs structures according to the ornamental fish divers. Coral bleaching was also mentioned by the divers in Cebu (57%), Eastern Samar (33%), Zambales (24%), Pangasinan (38%), and Cagayan (29%). Biological threats (Crown of Thorns starfish infestation) were reported in Davao del Sur (75%), Batangas (55%),

 DOI: https://doi.org/10.59120/drj.v15i4.286

and Cagayan province (29%). Zambales divers (28%), Pangasinan (13%), and Quezon (8%) also informed the presence of illegal fishing in their locality (Figure 7). In Kruskal-Wallis analysis, the findings showed that Illegal fishing (0.034), Water pollution (0.0003), Natural disasters (0.014), and Biological threats (Crown-of-thorns starfish infestation) (0.015) with p-values below 0.05 indicated that these threats significantly affect the total weekly catch of the three *Centropyge* species (Table 3). This implies that ornamental fish divers facing these identified threats tend to catch lesser number of the three *Centropyge* species.

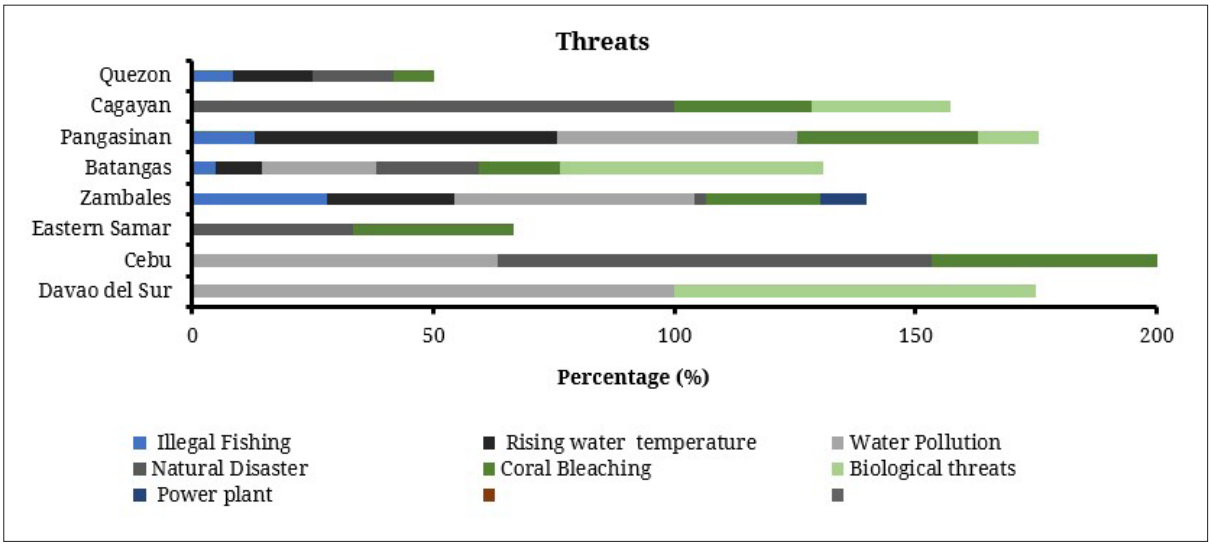



**Figure 7.** Threats identified by the ornamental fish divers.

**Table 3.** Kruskal-Wallis analysis results examining the effects of various threats on the total weekly catch for the three *Centropyge* species, displaying chi-square values, p-values, and the corresponding significance levels based on a 0.05 threshold.

| Threats | X2 | p-value | Interpretation |
|---|---|---|---|
| Illegal Fishing | 4.4841 | 0.034 | Significant |
| Rise in seawater Temperature | 0.33914 | 0.560 | Not significant |
| Water pollution | 13.147 | 0.0003 | Significant |
| Natural disasters (Typhoon) | 6.0523 | 0.014 | Significant |
| Coral bleaching | 0.18097 | 0.670 | Not significant |
| Biological threats (crown-of-thorns starfish infestation) | 5.9301 | 0.015 | Significant |
| Power plant | 0.078056 | 0.779 | Not significant |

## DISCUSSION

The local knowledge of ornamental fish divers is invaluable in uncovering the present status of the three *Centropyge* species. The three *Centropyge* species were widely distributed in the Philippines with an extent of occurrence of 457,189.338km$^2$ (*C. bispinosa*), 601,983.961km$^2$ (*C. heraldi*), and 664,637.562km$^2$ (*C. bicolor*). The good and fair status of coral cover in each study site (Licuanan et al., 2017) may contribute to the wide occurrence of the three *Centropyge* species in the Philippines. For instance, in Zambales province, the three *Centropyge* species were highly collected, particularly in the villages of Masinloc, Palauig, and Santa Cruz, which exhibit good and fair conditions of coral ecosystem (Paz-Albierto et al., 2021). Furthermore, *Centropyge* heraldi species were surprisingly

not observed and collected in Cebu, Eastern Samar, and Davao del Sur provinces. The absence of *C. heraldi* in Visayas and Mindanao sampling sites is probably influenced by factors such as physical and chemical parameters requirement for this species. Similarly, these parameters are essential for species survival when keeping marine ornamental fish in an aquarium (Nair et al., 2020). In addition, substrate requirement may also contribute to its absence in several sampling sites. The study of Nanami (2023) emphasized that *C. heraldi* is mostly found in exposed reefs associated with substrates characterized by acroporid corals, specifically bottle-brush Acropora with greater coverage of rock. On the other hand, *C. bicolor* is found in all sampling sites, but fishers mentioned that they have a hard time collecting this species as they were mostly found in coral reefs with strong waves and currents. Thus, it reflects that the estimated total weekly catch (2 740 pieces) of this species was lower than the catch of *C. bispinosa* (4,381 pieces) and *C. heraldi* (3,192 pieces). Meanwhile, *C. bispinosa* was observed in all sampling sites except in Cagayan province, where all ornamental fish divers responded that they were unsure about the occurrence of *C. bispinosa* in their locality. This was because it was not included in their target species to collect due to the lower price value. Furthermore, ornamental fish divers use minimal equipment to catch these species, as they need to carefully collect the fish without physical damage and less stress to trade the species in the market. Several ornamental fish divers employed compressors to collect these species as they are depth generalist species (Bridge et al., 2016; Biondi et al., 2024). The Philippine Fisheries Code (Republic Act No. 8550), amended by Republic Act No. 10654, in section 6 stipulated that Local Government Units (LGUs) have the discretion to implement rules and regulations for fisheries activities in their municipal water areas in collaboration with the Fisheries and Aquatic Resources Management Council (FARMC). Hence, Pangasinan, Zambales, Batangas, Quezon, and Eastern Samar has implemented the ban on using compressor equipment for ornamental fishing. In addition, Memorandum Circular No. 2023, 012 by the Department of the Interior and Local Government in 2023 stipulated the unlawful use of this gear in fishing. Furthermore, inadequate compressor training, low equipment maintenance, and inspection may increase the likelihood of diving-related injuries like decompression illness and barotrauma (Kithome, 2021; Javier, 2022). Despite the legal and health risks involved, ornamental fish divers continue to engage in this practice as it allows them to collect a higher catch and earn enough income for daily sustenance.

The ornamental fish divers reported several threats that were perceived to affect the coral reef habitat of the three *Centropyge* species in their locality. Environmental threats, such as illegal fishing, water pollution from aquaculture, mining siltation, and garbage; natural disasters, particularly typhoons; and biological threats, like crown-of-thorns starfish infestation, were reported to threaten their marine ornamental operation, affecting their total weekly catch. These threats are recurrent problems in the Philippines that contribute to the depletion of marine resources, leading to broader environmental and economic repercussions. For instance, a study conducted by Paz-Alberto et al., 2020 found that illegal fishing activity in Zambales caused a 50% reduction in fish caught in the areas based on the local ecological knowledge of fishers. This threat contributed to the decline of the coral ecosystem in the region (Paz-Alberto et al., 2021), thereby supporting the results of this study. Further, the case study in Santa Cruz, Zambales, where mining activities destroyed the marine ecosystem of the locality due to the siltation of the river system that exacerbates flood problems during typhoons (Migo et al., 2018). The excessive nutrient loading due to aquaculture effluents indirectly affects the coral settlement as it promotes the growth of another biota, leading to

 DOI: https://doi.org/10.59120/drj.v15i4.286

reduce availability of suitable substrate (Quimpo et al., 2020) and a prevalence problem of marine litter that may have extensive effects to the marine ecosystem (Dey et al., 2024; Razzaq et al., 2024). In addition, natural disasters such as typhoons have frequently increased, devasting the coral reef ecosystem, particularly in Cebu (Esteban et al., 2022). Ornamental fish divers emphasized that typhoon Odette wiped out an estimated 80-90% of their corals, which they said was the cause of the reduction in their collection of the *Centropyge bispinosa*, *C. bicolor*, and other marine ornamental species. This is similar to the case in Northern Palawan due to typhoon Odette in 2021, where there was a reduction in the coral cover that significantly affected the species richness and abundance of macroinvertebrates, particularly small giant clam species in the area (Dolorosa et al., 2023). The Crown of Thorns starfish infestation is a biological threat, significantly contributing to biodiversity and coral reef crises (Hillberg, 2024; Uthicke et al., 2023). Ornamental divers, particularly in Batangas, Pangasinan, Cagayan, and Davao del Sur, reported that crown-of-thorns starfish species outbreaks led to coral losses as they fed on corals. Similarly, the study by Deaker and Byrne (2022) explained this observation that these species are known for their destructive consumption of coral reefs. Additionally, ornamental divers faced difficulties in collecting marine ornamental fish because they had to avoid the harmful spines of the crown-of-thorns starfish. For instance, Acanthaster solaris found in the country have severe toxicity to humans, causing permanent abscesses, apoptosis, hemolysis, and bone-destroying processes (Birkeland and Lucas, 1990; Haszprunar et al., 2017). This reduces the overall weekly catch. Thus, reported threats have a substantial impact on the health of the coral reef ecosystem. These should be addressed immediately to prevent a decline in the populations of marine ornamental species, particularly the three *Centropyge* species.

## CONCLUSION AND RECOMMENDATION

The findings of this study provide valuable insights into assessing the conservation status of the three *Centropyge* species (Pomacanthidae) in the Philippines. Local knowledge from ornamental fish divers has emphasized that these three species are widely distributed in the country. The current exploitation of these species is for marine ornamental trade only, and fish divers use minimal equipment to collect them. Being inhabitants of deep water has added extra protection for these *Centropyge* species from overfishing. Reported threats to these species include local illegal fishing, water pollution, natural disasters, and predation of crown-of-thorns starfish, which may lead to the decline of these species' populations. Results from this study support the need for stricter regulation of ornamental fish collection in areas where *Centropyge* species are vulnerable to overexploitation, particularly in Zambales, where occurrence was highest. Additionally, it emphasizes the need for further investigations into exportation activities and the species' ecological habitat requirements to ensure sustainable utilization and conservation. Indeed, the findings of this study are essential baseline data required for assessing the conservation status of these species using IUCN Categories and Criteria. It is crucial in guiding conservation actions and policy formulation for the long-term protection and sustainability of *Centropyge* species in the Philippines.

## ACKNOWLEDGMENT

The authors would like to express their gratitude to the NFRDI and BFAR personnel for guidance and assistance throughout the study, the Municipal Agriculture Offices for permitting the activities at all sampling sites.

**FUNDING SOURCE**

The study was funded by the Department of Science and Technology—Accelerated Science and Technology Human Resource Development Program (DOST-ASTHRDP)

**REFERENCES**

Affonso, PRAM., and Galetti Jr., PM. (2007). Genetic diversity of three ornamental reef fishes (families Pomacanthidae and Chaetodontidae) from the Brazilian coast. *Brazilian Journal of Biology*, 67(4 suppl), 925–933. https://doi.org/10.1590/s1519-69842007000500017

Baensch, F., and Tamaru, C. S. (2009). Spawning and development of larvae and juveniles of the rare blue Mauritius Angelfish, centropyge debelius (1988), in the hatchery. *Journal of the World Aquaculture Society*, 40(4), 425–439. https://doi.org/10.1111/j.17497345.2009.00273.x

Bauer Jr, J. A., and Bauer, S. E. (1981). Reproductive biology of pigmy angelfishes of the genus *Centropyge* (Pomacanthidae). *Bulletin of Marine Science*, 31(3), 495-513.

Bachman, S., Moat, J., Hill, A. W., De La Torre, J., and Scott, B. (2011). Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys*, (150), 117.

Bañez, M. A. B., and Ramos, J. M. (2023). Artisanal compressor dive fishing. *SPMC J Health Care Serv*, 9(1), 5. http://n2t.net/ark:/76951/jhcs4ru7a8

Beaudreau, A. H., and Levin, P. S. (2014). Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. Ecological Applications, 24(2), 244 256. https://doi.org/10.1890/13-0817.1

Biondo, M. V., and Burki, R. P. (2019). Monitoring the trade in marine ornamental fishes through the European trade control and expert system TRACES: Challenges and possibilities. *Marine Policy*, 108, 103620. https://doi.org/10.1016/j.marpol.2019.103620

Biondo, Monica Virginia, Burki, R. P., Aguayo, F., and Calado, R. (2024). An updated review of the marine ornamental fish trade in the European Union. *Animals*, 14(12), 1761. https://doi.org/10.3390/ani14121761

Birkeland, C., and Lucas, J. S. (1990). *Acanthaster planci: Major management problem of coral reefs*. CRC Press.

Bridge, T. C., Luiz, O. J., Coleman, R. R., Kane, C. N., and Kosaki, R. K. (2016). Ecological and morphological traits predict depth-generalist fishes on coral reefs. *Proceedings of the Royal Society B: Biological Sciences*, 283 (1823), 20152332. https://doi.org/10.1098/rspb.2015.2332

Cook, T. C., James, K., and Bearzi, M. (2015). Angler perceptions of California sea lion (Zalophus Californianus) depredation and marine policy in Southern California. *Marine Policy*, 51, 573–583. https://doi.org/10.1016/j.marpol.2014.09.020

Deaker, D. J., and Byrne, M. (2022). Crown of thorns starfish life-history traits contribute to outbreaks, a continuing concern for coral reefs. *Emerging Topics in Life Sciences*, 6(1), 67–79. https://doi.org/10.1042/etls20210239

Dee, L. E., Karr, K. A., Landesberg, C. J., and Thornhill, D. J. (2019). Assessing vulnerability of fish in the U.S. Marine Aquarium Trade. *Frontiers in Marine Science*, 5. https://doiorg/10.3389fmars.2018.00527

Dey, U., Chell, S., Mondal, M., Das, K., Raj, D., Pandey, G., Meraj, G., Kumar, P., Almazroui, M., and Verma, S. (2024). Potential threat of microplastic pollution on coastal-marine ecosystem–an emerging economic setback and question to Blue Economy? *Earth Systems and Environment*. https://doi.org/10.1007/s41748-024-00485-y

Dolorosa, R. G., Climaco, R. B., Miguel, J. A., Aludia, G. M., and Florida Mecha, N. J. M. (2023). Impact of Super Typhoon Odette on the Reefs of Northeastern Palawan, Philippines. *Journal of Fisheries & Environment*, 47(1).

Domínguez, L. M., and Botella, Á. S. (2014). An overview of marine ornamental fish breeding as a potential support to the aquarium trade and to the conservation of natural fish populations. *International Journal of Sustainable Development and Planning*, 9(4), 608–632. https://doi.org/10.2495/sdp-v9-n4-608-632

Eagle, J. V., Jones, G. P., and McCormick, M. I. (2001). A multi-scale study of the relationships between habitat use and the distribution and abundance patterns of three coral reef angelfishes (Pomacanthidae). *Marine Ecology Progress Series,* 214, 253-265.

Esteban, M., Valdez, J., Tan, N., Rica, A., Vasquez, G., Jamero, L., Valenzuela, P., Sumalinog, B., Ruiz, R., Geera, W., Chadwick, C., Spatarau, C., and Shibayama, T. (2022). Field survey of 2021 Typhoon Rai – odette- in the Philippines. *Journal of Coastal and Riverine Flood Risk*. https://doi.org/10.48438/jcrfr.2023.0001

Evers, H., Pinnegar, J. K., and Taylor, M. I. (2019). Where are they all from?–sources and sustainability in the ornamental freshwater fish trade. *Journal of Fish Biology,* 94(6), 909916. https://doi.org/10.1111/jfb.13930

Froese, R. and D. Pauly. Editors. 2024.Fish Base. World Wide Web electronic publication. www.fishbase.org, ( 06/2024 )

Gaither, M. R., Schultz, J. K., Bellwood, D. R., Pyle, R. L., DiBattista, J. D., Rocha, L. A., and Bowen, B. W. (2014). Evolution of pygmy angelfishes: Recent divergences, introgression, and the usefulness of color in taxonomy. *Molecular Phylogenetics and Evolution,* 74, 38 47. https://doi.org/10.1016/j.ympev.2014.01.017

Gallagher, A., Cooke, S., and Hammerschlag, N. (2015). Risk perceptions and conservation ethics among recreational anglers targeting threatened sharks in the subtropical Atlantic. *Endangered Species Research*, 29(1), 81–93. https://doi.org/10.3354/esr00704

Haszprunar, G., Vogler, C., and Wörheide, G. (2017). Persistent gaps of knowledge for naming and distinguishing multiple species of crown-of-thorns-seastar in the Acanthaster planci species complex. *Diversity*, 9(2), 22. https://doi.org/10.3390/d9020022

Hillberg, A. (2024). Investigation of Crown-of-Thorns Starfish (Acanthaster species complex) semiochemicals (Doctoral dissertation, University of the Sunshine Coast,Queensland).https://doi.org/10.25907/00873

Javier, M. E. (2022). Compliance on the implementation of diving safety guidelines in dive resorts in Anilao, Mabini in Batangas, Philippines: an explanatory sequential mixed method design study. [Master's thesis, De La Salle Medical and Health SciencesInstitute].

Kithome, K. M. (2021). Knowledge, Perception and Practices of Diving Fishermen in Relation to Decompression Sickness: A Cross Sectional Survey of the Diving Fishermen of Vanga, Kwale County, Kenya (Doctoral dissertation, Uon).

IUCN 2024. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org

IUCN Standards and Petitions Committee. 2024. Guidelines for Using the IUCN Red List Categories and Criteria. Version 16. Prepared by the Standards and Petitions Committee. Downloadable from https://www.iucnredlist.org/documents/RedListGuidelines.pdf./

Leal, M. C., Vaz, M. C., Puga, J., Rocha, R. J., Brown, C., Rosa, R., and Calado, R. (2015). Marine ornamental fish imports in the European Union: An Economic Perspective. *Fish and Fisheries*, 17(2), 459–468. https://doi.org/10.1111/faf.12120

Licuanan, A. M., Reyes, M. Z., Luzon, K. S., Chan, M. A. A., and Licuanan, W. Y. (2017). Initial findings of the nationwide assessment of Philippine coral reefs. *Philippine Journal of Science,* 146(2), 177-185.

Lima, M. S., Oliviera, J. E., De Nobrega, M. F., and Lopes, P. F. (2017). The use of local ecological knowledge as a complementary approach to understandthe temporal and spatial patterns ofFishery Resources Distribution. *Journal of Ethnobiology and Ethnomedicine*, 13(1).https://doi.org/10.1186/s13002-017-0156-9

Macusi, E. D., Abreo, N. A. S., and Babaran, R. P. (2017). Local ecological knowledge (LEK) on fish behavior around anchored FADs: the case of tuna purse seine and ringnet fishers from Southern Philippines.

*Frontiers in Marine Science*, 4, 188.

Mendonça, R. C., Chen, J. Y., Zeng, C., and Tsuzuki, M. Y. (2020). Embryonic and early larval development of two marine angelfish, *centropyge bicolor* and *centropyge bispinosa*. *Zygote*, 28(3), 196–202. https://doi.org/10.1017s0967199419000789

Migo, V. P., Mendoza, M. D., Alfafara, C. G., and Pulhin, J. M. (2018). Industrial water use and the associated pollution and disposal problems in the Philippines. *Global Issues in Water Policy*, 87–116. https://doi.org/10.1007/978-3-319-70969-7_5

Mulyati, S., Herdianto, T., Suhermanto, A., and Sofian, A. (2023). The prospects of business development in ornamental fish in Southeast Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, 23(12). https://doi.org/10.13057/biodiv/d231239

Muyot, F., Mutia, M. T., Manejar, A. J., Guirhem, G., and Muñez, M. (2019). Status of ornamental fish industry in the Philippines: Prospects for Development. *The Philippine Journal of Fisheries*, 26(2), 82–97. https://doi.org/10.31398/tpjf/26.2.2019a0011

Muyot, F., Mutia, M. T., Manejar, A. J., Guirhem, G., and Muñez, M. (2018). Value chain analysis of marine ornamental fish industry in the Philippines. *The Philippine Journal of Fisheries*, 25(2), 57–74. https:/doi.org/10.31398/tpjf/25.2.2018a0005

Nair, S., Vidhya, V., and Gopukumar, S. (2020). Importance of optimum water quality indices in successful ornamental fish culture practices. Parishodh J, 9(2), 516-31.

Olivier, K. (2003a). Part II/ Progress and Current trends. *In World Trade in Ornamental Species* (First, pp. 49–63). essay, Iowa State Press.

Olivotto, I., Holt, S. A., Carnevali, O., and Holt, G. J. (2006). Spawning, early development, and first feeding in the lemonpeel Angelfish *Centropyge* Flavissimus. *Aquaculture*, 253(1–4), 270–278.https://doi.org/10.1016/j.aquaculture.2004.12.009

Paz-Alberto, A. M., Capones, J. A., and Juganas, D. A. (2021). Status of selected coral reef ecosystem in Zambales, Philippines. *Asian Journal of Biodiversity*, 12(1). https://doi.org/10.7828/ajob.v12i1.1398

Paz-Alberto, A. M., Parico, O. B., Alberto, R. P., Ponce, C. D., and, Juganas, D. A. (2020). Changes in the Coastal and Fishery Resources and Local Ecological Knowledge (LEK) About Fishery Practices as Perceived by the Fisher Folks in Selected Coastal Municipalities of Zambales, Philippines. *Silliman Journal*, 61(2).

Pita, P., Antelo, M., Hyder, K., Vingada, J., and Villasante, S. (2020). The use of recreational fishers' ecological knowledge to assess the conservation status of marine ecosystems. *Frontiers in Marine Science*, 7. https://doi.org/10.3389/fmars.2020.00242

Poissant, D., Coomes, O. T., Robinson, B. E., and Vargas Dávila, G. (2024). Fishers' ecological knowledge points to fishing-induced changes in the Peruvian Amazon. *Ecological Applications*, 34(5). https://doi.org/10.1002/eap.2964

Pouil, S., Tlusty, M. F., Rhyne, A. L., and Metian, M. (2019). Aquaculture of marine ornamental fish: Overview of the production trends and the role of academia in Research Progress. *Reviews in Aquaculture*, 12(2), 1217–1230. https://doi.org/10.1111/raq.12381

Pyle, R. (2001). Pomacanthidae: angelfishes. FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, 5(3), 3266-3286.

Pyle, R. L. (2003). A systematic treatment of the reef-fish family Pomacanthidae (*Pisces: Perciformes*). University of Hawai'i at Manoa.

Priyashadi, M. S. V. H., Deepananda, K. H. M. A., and Jayasinghe, A. (2023). Socio-ecological status of marine ornamental reef fishery in Trincomalee, Sri Lanka - An application of strategic SWOT analysis. *Davao Research Journal* (DRJ), 14(2), 103-115. https://doi.org/10.59120/drj.v14i2.117

Quimpo, T. J., Ligson, C. A., Manogan, D. P., Requilme, J. N., Albelda, R. L., Conaco, C., and Cabaitan, P. C. (2020). Fish farm effluents alter reef benthic assemblages and reduce coral settlement. *Marine Pollution Bulletin*, 153, 111025. https://doi.org/10.1016/j.mar-

polbul.2020.111025

Razzaq, N., Nazish, N., Rehman, M. A., Shafqat, A., and Awan, R (2024). The Causes and Impact of Litter Pollution on Marine Life: A List of Concerns. *Biological Times*, 3(4): 7-8.

Renck, V., Ludwig, D., Bollettin, P., Reis-Filho, J. A., Poliseli, L., and El-Hani, C. (2023). Taking fishers' knowledge and its implications to fisheries policy seriously. *Ecology and Society*, 28(2). https://doi.org/10.5751/es-14104-280207

Reyes, M., Robles, R., and Licuanan, W. Y. (2022). Multi-scale variation in coral reef metrics on four Philippine Reef Systems. *Regional Studies in Marine Science*, 52, 102310. https://doi.org/10.1016/j.rsma.2022.102310

Ribeiro, A. R., Damasio, L. M. A., and Silvano, R. A. M. (2021). Fishers' ecological knowledge to support conservation of reef fish (groupers) in the Tropical Atlantic. *Ocean & Coastal Management*, 204, 105543 https://doi.org/10.1016/j.ocecoaman.2021.105543

Sobha, T. R., Vibija, C. P., and Fahima, P. (2023). Coral reef: A hot spot of marine biodiversity. *Sustainable Development and Biodiversity*, 171–194. https://doi.org/10.1007/978-981-19 5841-0_8

Truchet, D. M., Noceti, M. B., Villagrán, D. M., Orazi, M. M., Medrano, M. C., and Buzzi, N. S. (2019). Fishers' ecological knowledge about marine pollution: What can FEK contribute to ecological and conservation studies of a southwestern Atlantic Estuary? *Journal of Ethnobiology*, 39(4), 584. https://doi.org/10.2993/0278-0771-39.4.584

Uthicke, S., Pratchett, M. S., Bronstein, O., Alvarado, J. J., and Wörheide, G. (2023). The crown of-thorns seastar species complex: Knowledge on the biology and ecology of five corallivorous Acanthaster species. *Marine Biology*, 171(1). https://doi.org/10.1007/s00227-023-04355-5

Wabnitz, C. (2003). From ocean to aquarium: the global trade in marine ornamental species (No.17). *UNEP/Earthprint*.

Wedemeyer-Strombel, K. R., Seminoff, J. A., Liles, M. J., Sánchez, R. N., Chavarría, S., Valle, M., Altamirano, E., Gadea, V., Hernandez, N., Peterson, M. J., Smith, K. J., Trueman, C. N., Peterson, T. R., and Newsome, S. D. (2021). Fishers' ecological knowledge and stable isotope analysis reveal mangrove estuaries as key developmental habitats for critically endangered sea turtles. *Frontiers in Conservation Science*, 2. https://doi.org/10.3389/fcosc.2021.796868

Yan, G. (2016). Saving Nemo–Reducing mortality rates of wild-caught ornamental fish.