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As a multi-disciplinary journal, The Palawan Scientist aims to publish high-quality and original research in the fields of agriculture, fisheries and aquatic sciences, environment, education, engineering, mathematics, sociology, and related disciplines (including arts and humanities).

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COVER PHOTO

Coral reefs provide various ecological and economic goods and services, including shoreline defense against storm surges, essential sources of food and shelter for numerous organisms, serving as important fishing grounds, and venues for recreation. The paper of Climaco et al. provides information about the status of coral reefs in Araceli and Dumaran as a basis for management. Photo courtesy of WWF-Philippines

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EDITORIAL

Dear Readers,

It is not a secret that global biodiversity is currently in peril, especially in South and Southeast Asia, due to threats posed by human activities such as habitat destruction, pollution, illegal wildlife trade, and greenhouse gas emissions. The collective outcome of these activities may result in the extinction of populations or even entire species. Even with the most conservative estimates, the current extinction rates are comparable with previous mass extinction rates (Barnosky et al. 2011). Therefore, some scientists recognize the current extinction crisis as the sixth mass extinction.

Some species are disappearing from the face of our planet Earth even before we formally recognize them as species new to science. Although Meegaskumbura et al. (2007) described two shrub frog species new to science from Sri Lanka based on collections made in the late 1800s, they failed to identify any extant populations. This may represent the tip of the iceberg. Many species may have been disappearing from diverse and unique communities in tropical Asia without giving any clues to us.

One way to slow down untimely extinctions is to catalog undocumented biodiversity in local, regional, national, and international scales. Formal recognition of species is the first step of conservation. Given the extreme species diversity in South and Southeast Asia and the prevalence of large tracts of scientifically unexplored areas, it is critical to get help from citizen scientists in addition to efforts by professional scientists in cataloging biodiversity, especially on local and regional scales. Global biodiversity cataloging programs such as iNaturalist (https://www.inaturalist.org/) based on a simple, effective and engaging cell phone app may play a critical role in bringing youth and the general public into this monumental task and constructing freely available local and regional biodiversity databases. iNaturalist records have already proved its effectiveness in finding new populations of rare species and finding species new to science (Winterton 2020; Zhang et al. 2022).

Additionally, providing an effective and free platform for conservation scientists and ecologists to publish their regional and national findings is critical for biodiversity conservation. I commend *The Palawan Scientist* for bridging the gap between regional biodiversity information and global conservation efforts. Even the present volume of *The Palawan Scientist* features several biodiversity and conservation-related articles such as seahorse trafficking in the Philippines (pp. 8-14) and the status of coral reefs and its fauna in the Philippines (pp. 54-64). This freely available information may also help conservation practitioners and policymakers by providing necessary local and regional data for state-level and national-level biodiversity assessments and implementing legislation to conserve biodiversity.

Long live *The Palawan Scientist*!

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References

Barnosky A, Matzke N, Tomiya S, Wogan GOU, Swartz B, Quental TB, Marshal C, McGuire JL, Lindsey EL, Maguire KC, et al. 2011. Has the Earth's sixth mass extinction already arrived? Nature, 471: 51-57. https://doi.org/10.1038/nature09678

Meegaskumbura M, Manamendra-Arachchi K, Schneider CJ and Pethiyagoda R. 2007. New species amongst Sri Lanka's extinct shrub frogs (Amphibia: Rhacophoridae: *Philautus*). Zootaxa, 1397(1): 1-15. https://doi.org/10.11646/zootaxa.1397.1.1

Winterton SL. 2020. New bee-mimicking stiletto fly (Therevidae) from China discovered on iNaturalist. Zootaxa, 4816: 361–369. https://doi.org/10.11646/zootaxa.4816.3.6

Zhang YM, SasanK, Okennon RJ and Kranz AJ. 2022. Discovery through iNaturalist: new species and new records of oak gall wasps (Hymenoptera: Cynipidae: Cynipini) from Texas, USA. Zootaxa, 5168: 63-74. https://doi.org/10.11646/zootaxa.5168.1.5

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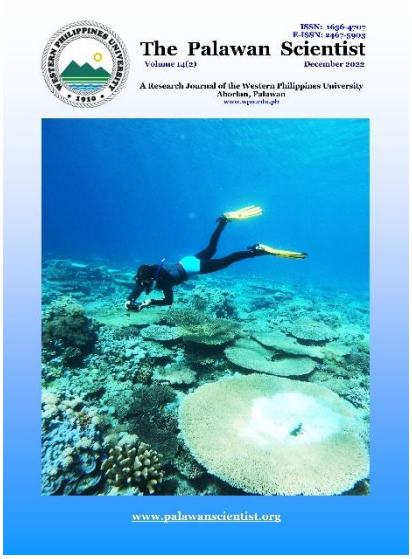

Bacteriological water analysis of Matutinao River in Badian, Cebu, Philippines

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ABSTRACT

As nature tourism becomes increasingly popular, especially in tropical countries, monitoring the environment's health and making it sustainable is essential. Hundreds of daily tourists visit a popular spot between Kawasan Falls and the Matutinao River in Cebu to participate in the canyoneering activity. This study assessed the bacteriological quality of water in Matutinao River. Obtained water samples were analyzed for heterotrophic plate count (HPC), total coliform, and presence of the *Escherichia coli* (Castellani and Chalmers 1919) bacteria. It was found that the river had an HPC of 212 to 4.57×10^5 CFU ml^{-1} and was contaminated with coliforms (1250-1800 MPN/100 ml). The presence of *E. coli* was also detected. These values exceed the maximum permissible limit for recreation waters (i.e. 100 CFU ml^{-1} for HPC and 1,000 MPN/100 ml for total coliforms). Ideally, *E. coli* should also be absent in recreation waters. Although not necessarily harmful, bacteria in recreational waters need to be regularly monitored to prevent potential outbreaks. It is further recommended to revisit existing local policies to help reduce sources of contamination in the river not just to protect the environment but also to promote sustainable tourism.

Keywords: bacterial water quality, coliforms, nature tourism

INTRODUCTION

Rivers are an essential platform for tourism because they can be a location for recreational activities and transport services, exposure to culture and local heritage, and connect people to the environment and the natural world (Winter et al. 2019). River tourism provides a substantial income to the world's tourism ventures, brought by cruises and rafting activities. Although these activities generate money for the locals and the government, such un dertakings need in-depth analysis for conservation and sustainability (Prideaux and Cooper 2009). In the Philippines, rivers that are increasingly used for tourism include Puerto Princesa Subterranean River, Loboc River in Bohol, and Hinatuan Enchanted River in Surigao del Sur (Aquino 2017), to name a few.

Today, tourists seek thrills of adventure to experience and enjoy trekking, scrambling, climbing, jumping, and abseiling near land formations and canyoneering and swimming in bodies of water. In particular, canyoneering has become very popular for tourists who visit Cebu. Most notably, Cebu tourists try canyoneering from Kanlaob River in Alegria to

Kawasan Falls in Badian. From Kawasan, water flows through the Matutinao River and then to the beaches of Badian.

Together, canyoneering and waterfall adventures generate millions of pesos a month for the municipality of Badian (Ambrad 2018; Erram 2020) and provide jobs for the locals who cater to the tourists' needs. But despite the upsurge in their economy, the ecological health status of these natural resources has been unattended. Studies on environmental quality, nature conservation, and sustainability are still scarce in their locality.

Song (2016) proved that the rapid growth of tourism contributes to environmental pollution resulting in a lack of long-term driving force. When there is a high influx of tourists, the river will likely become polluted by human waste without proper supervision from the local government (Savage et al. 2004). If this continues without appropriate mitigation efforts, the river may be closed off to tourists to undergo rehabilitation. Such action may result to the loss of livelihood especially for the locals in the area who only rely on tourism. As part of sustainable tourism, it is crucial to strengthen the quality of the environment and minimize pollution (Carbone and Yunis 2005). This study focused on bacterial pollution and the possible fecal contamination in Matutinao River during tourists' off-season and peak season. Thus, the objective of this study was to assess the water quality of the Matutinao River using coliform bacteria as indicators of contamination. Specifically, this study aimed to determine (1) the number of heterotrophic bacteria, (2) total coliform, and (3) detect the presence of *Escherichia coli*.

METHODS

Study Site

The sampling (Figure 1) was conducted in Matutinao River (9°48′36.8″N, 123°22′01.5″E), which is situated in the municipality of Badian, Cebu (9°52′9.7″N, 123°23′45.33″E). The river flows from Kawasan Falls, one of the most famous waterfalls in Cebu and popular with tourists, and empties into the Tañon Strait. The river, the waterfall, and their surrounding vegetation along Badian are considered natural reserves of Cebu (Bandel and Riedel 1998). Matutinao River was previously awarded by the Department of Environment and Natural Resources (DENR) as the cleanest inland body of water in the Philippines from 2000 to 2002 (Nuez 2018).

Sampling Collection and Handling

The first water sampling was done on 22 September 2019, an off-season for tourists. The sampling was made in two stations (Figure 1): one near Kawasan Falls (MR2, 9°47'59.05″N, 123°22'40.61″E) and one near the river bank (MR4, 9°48′35.3″N, 123°22′03.6″E) approximately 50 m away from where housing and commercial establishments are situated. Samples were collected from the center of the river and 15 cm below the water's surface, with the mouth of the sterile glass bottle facing the stream's flow when opened slightly and closed underneath the water. Each bottle contained 100 ml of the water sample with two replicates per station. Sample bottles were labeled and placed in an icebox with a thermometer for temperature monitoring. Regular ice replacement was also done to maintain the temperature inside the icebox between 0-4°C to prevent the bacteria from multiplying. Samples were then processed within 24 h in the laboratory (Baird et al. 2017). The second sampling was during the peak season in December 2019 when two more sites were added: one before (MR1, 9°47′59.3″N, 123°22′40.1″E) Kawasan Falls, where canyoneering ends, and one in between Kawasan Falls and Matutinao river bank (MR3, 9°48′40.9″N, 123°22′21.9″E). The off and peak seasons were decided based on experience and consultation with the Local Government Unit of Badian and with the Cebu Provincial Tourism Office. The off-season is during the rainy season (June to November; PAGASA 2021), and the peak season is during the dry season (December to May; PAGASA 2021).

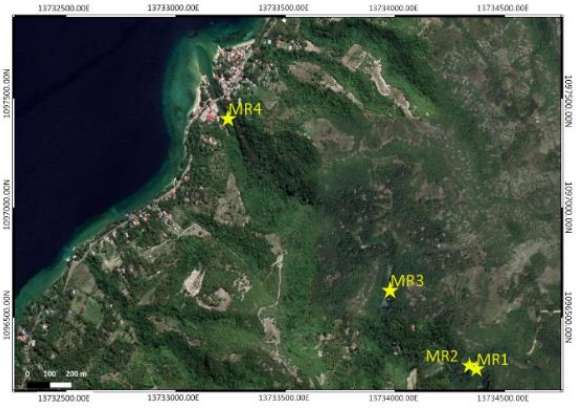

Figure 1. Sampling sites at Matutinao River, Badian, Cebu (Image lifted from Google Maps). MR2 and MR4 were the sampling sites during September, and MR1 and MR3 were the sampling sites in December.

Bacteriological Analyses

Heterotrophic plate count (HPC), multiple tube fermentation technique (MTFT), and *E. coli* detection using eosin methylene blue agar (EMBA; Sigma-Aldrich, USA) culture medium were conducted following the protocols from standard methods for the examination of water and wastewater (Baird et al. 2017) and were performed at the Microbiology Laboratory of the University of the Philippines Cebu.

HPC. To determine the number of heterotrophic bacteria, the HPC was performed by serially diluting water samples (10^0 and 10^{-2}) and spread plated onto nutrient agar (NA; HiMedia, India) plates. The plates were incubated at 37°C for 24 h, and the number of colonies was counted to calculate the CFU ml^{-1}.

MTFT. To determine the total coliforms, multiple tube fermentation technique, presumptive, confirmatory, and completed tests were performed. In the presumptive test, 10, 1, and 0.1 ml of the water samples were inoculated to 10 ml lauryl tryptose broth (Sigma-Aldrich, USA) tubes (containing an inverted Durham tube inside) and were incubated at 37°C for 24 h. An acidic reaction (i.e. yellow colored-medium) and the formation of gas bubbles inside the Durham tubes denotes a positive presumptive test. The positive presumptive tubes were subjected to the confirmatory test that undergoes the same method and interpretation as the presumptive test but uses the brilliant green lactose bile broth (Sigma-Aldrich, USA).

Escherichia coli Detection

To detect the presence of *E. coli,* positive confirmatory tubes then underwent the completed test using EMBA. Positive water samples were spread plated onto EMBA plates and were incubated at 37°C for 24 h. Typical coliform colonies (i.e. *E. coli*) had a green metallic sheen. All of these were performed in two replicates.

Data Analysis

The HPC and total coliform were determined by calculating its colony forming unit (CFU) and most probable number (MPN), respectively (Maturin and Peeler 2001; Feng et al. 2017). The differences in HPC and total coliform values were then compared across sampling events. Lastly, *E. coli* was only reported as present (+) or absent (-).

RESULTS

Heterotrophic Bacteria

As shown in Table 1, the heterotrophic bacterial counts in September ranged from 45 to 3,187 CFU ml^{-1}. These values had changed from 812 to 1,953 CFU ml^{-1} in the original sites in December. However, the new sampling locations recorded the highest HPC (i.e. 1.62×10^4 to 4.57×10^5). HPC was generally higher during December with an 8-43 fold increase.

Total Coliform

The total coliform were low in the morning and in the afternoon sampling at MR2 (< 1,000 MPN/100 ml) but high (i.e. 1,700 MPN/100 ml) at MR4 in September (Table 2). However, in December, all sites had high total coliform (> 1,000 MPN/100 ml). The most probable number (MPN) was also higher in December than in September, with an increased of 1-2-fold.

Escherichia coli

Escherichia coli was detected in all sampling locations in September but only during afternoon sampling in December (Table 3).

Table 1. Matutinao River (MR) mean heterotrophic plate count in September and December.

Location and Time (AM/PM)	HPC (CFU ml^{-1}) in September 2019	HPC (CFU ml^{-1}) in December 2019
MR1 (AM)	No samples collected	16,178
MR1 (PM)	No samples collected	457,500
MR2 (AM)	212	1,691
MR2 (PM)	45	1,953
MR3 (AM)	No samples collected	479
MR3 (PM)	No samples collected	1,574
MR4 (AM)	3187	1,521
MR4 (PM)	100	812

Table 2. Matutinao River (MR) mean total coliform in September and December.

Location and Time (AM/PM)	Total Coliform (MPN/100 ml) in September 2019	Total Coliform (MPN/100 ml) in December 2019
MR1 (AM)	No samples collected	1,250
MR1 (PM)	No samples collected	1,800
MR2 (AM)	865	1,800
MR2 (PM)	975	1,800
MR3 (AM)	No samples collected	1,700
MR3 (PM)	No samples collected	1,800
MR4 (AM)	1,700	1,800
MR4 (PM)	1,700	1,800

Table 3. Presence of *Escherichia coli* in Matutinao River (MR) in September and December.

Location and Time (AM/PM)	*E. coli* in September 2019	*E. coli* in December 2019
MR1 (AM)	No samples collected	-
MR1 (PM)	No samples collected	+
MR2 (AM)	+	-
MR2 (PM)	+	+
MR3 (AM)	No samples collected	-
MR3 (PM)	No samples collected	+
MR4 (AM)	+	-
MR4 (PM)	+	+

DISCUSSION

Heterotrophic Plate Count

A high HPC indicates that the environment is suitable for bacterial growth. However, an increased number of HPC bacterium, such as *E. coli*, can be detrimental to human health (Allen et al. 2004). This implies that humans exposed to these bacteria are at risk of infection. MR1 is the last point of the canyoneering activity, where many tourists swim and wash their muddy footwear. Tourists were particularly many in the afternoon, attributed to the higher HPC value of MR1 (Table 1). Vignesh et al. (2014) noted a proportional relationship between water recreational activities and bacteria density. As observed in this study, bacterial density is relatively higher during the tourist peak season in December than in the off-season in September. This also coincides with what Zao et al. (2017) reported that local contamination sources (i.e. land use, population density, and economic development) could lead to an increase in total bacterial numbers (HPC). The HPC at MR4 (AM) could be attributed to its proximity to the residential area. This is supported by Pepper et al. (2004) where they reported that the major source of bacteria is from the household distribution system or the household tap and that the average number of bacteria in household tap is 3,072 CFU ml^{-1}, which is quite close to the value obtained in the current study.

Based on available data cited in Edberg and Allen (2004), there are concerns of infection from drinking or exposure to contaminated water such as: some species of HPC bacteria are associated with disease (e.g. gastroenteritis) and physical contact with pathogenic HPC bacteria can cause illness than ingesting water. However, they did point out that HPC concentration must be high (i.e. 10^4-10^8 CFU ml^{-1}) to cause infection.

As seen in Table 1, most of the HPC concentrations are within 10^3 or below. At this concentration, the risk of disease is low, and thus, the concern for public safety is lessened. The acceptable limit set by the World Health Organization for HPC is only 100 CFU ml^{-1} (Bartram et al. 2003). Nonetheless, the HPC concentration was observed to reach 10^4-10^5 CFU ml^{-1}, within the infectious dose range (Edberg and Allen 2004). The spike in HPC concentration could be attributed to the nearby human establishment downstream and human activities upstream, where tourists engage in recreation activities like swimming, bathing, and canyoneering. This is congruent to the findings of Glińska-Lewczuk et al. (2016), who reported an increase in river HPC near households and recreational areas by locals and tourists. Tourist and domestic wastes might also contribute to the increase of bacteria count in waterways and the resuspension of bacteria from the sediment due to water activities (Mwanamoki et al. 2014).

Total Coliform

The Matutinao River can be classified as a body of water for recreational purposes (Class B) under DAO No. 34 (EMB-DENR 1990). Under this classification, the permissible limit for total coliform is 1,000 MPN/100 ml. Like HPC, a high MPN value suggests plausible risks of infection if the coliform number exceeds the permissible limit (Leclerc et al. 2001). As recorded in September (Table 2), upstream of Matutinao River (MR2) nearly reached the maximum acceptable limit for total coliforms in recreational waters. In contrast, the downstream of the Matutinao River (MR4) exceeded the limit. In December, all sites had MPN values that exceeded the limit. As mentioned, MR1 is the terminal for canyoneering activities. Restrooms had been established in the vicinity of Kawasan Falls at MR2. At MR3, local fauna such as birds and monkeys might have contributed to an increase in total coliform if they defecated directly to the river or bacteria from their feces were transported to the river by surface runoffs (Divya and Solomon 2016). Furthermore, MR4 is near the residential areas. Similarly, some local butchers, livestock and poultry are near the river. These are all possible sources of contamination (Hoyer et al. 2006) that might have resulted in the high total coliform observed in this study. Nevertheless, the results of this study resemble the study of Zao et al. (2017), where total coliform did not differ by stream location (i.e. upstream, midstream, and downstream).

Total coliform levels of more than 1,000 MPN/100 ml indicate a considerable and growing risk of infectious disease transmission (Kapwata et al.

2018). Moreover, the high total coliform count obtained in the samples might indicate that the water sources were contaminated with fecal matter (Suthar et al. 2009; Shittu et al. 2010; Mabvouna et al. 2020). Miao et al. (2018) reported that total coliforms could also indicate the presence of enteroviruses that cause waterborne diseases, such as gastroenteritis and hepatitis. Although a high total coliform may not necessarily result in health problems, the presence of coliforms denotes that pathogens might be present in the water (Leclerc et al. 2001; Suthar et al. 2009; Mabvouna et al. 2021). Pathogenic coliforms could cause gastrointestinal, respiratory, skin, eye, ear, nose, and throat diseases (Donovan et al. 2008). Hoyer et al. (2006) reported that high total coliform is correlated with *Pseudomonas aeruginosa* Migula 1900, which causes skin rashes and otitis externa in swimmers.

Presence of *E. coli*

The presence of *E. coli* was also confirmed in the two sampling sites. *Escherichia coli* has been an indicator organism for fecal contamination since the 1890s (Abdullah et al. 2018). Its mere presence renders water unfit for drinking. When *E. coli* counts are high in recreational waters, bathing, swimming, or even fishing will no longer be allowed (O'Flaherty et al. 2019; Rossi et al. 2020). Usually, other animals only act as a reservoir for *E. coli* but occasionally cause diarrhea (Ramos et al. 2020). This bacterium also could reproduce and survive for long periods in the environment (Jang et al. 2017). This implies a greater risk of harboring waterborne infections resulting in possible morbidities. Human exposure to high quantities of fecal bacteria such as *E. coli* in recreational waters has increased the risk of illness and disease, including gastrointestinal and respiratory disorders and skin, ear, and eye infections (Mwanamoki et al. 2014). According to Khan et al. 2018, fecal bacteria could also cause hepatitis, intestinal disorders, diarrhea, dysentery, cholera, typhoid fever, jaundice, scabies, and vomiting in children, older and younger adults, as well as people with weak immune systems/immunocompromised. *Escherichia coli* could also cause abscesses, urinary tract and wound infections (Suthar et al. 2009) and might be associated with *Vibrio cholerae* Pacini 1854, the causative agent of cholera (Mabvouna et al. 2020).

In a study by Stocker et al. (2016), *E. coli* detection is not affected by sampling time throughout the day. This corresponds to the result of the current study during the September sampling but not during December, where *E. coli* was only detected in the afternoon samples. Moreover, Blaustein et al. (2013) discussed that a decline of *E. coli* could be brought about by its prokaryotic and eukaryotic predators. They noted that *E. coli* has higher nutritional value than indigenous microorganisms, and these predators can even select their prey based on nutritional value (Balustein et al. 2013). The researchers infer that an influx of tourists in the afternoon can disrupt this prey-predator interaction, add more *E. coli*, and allow the bacterium to multiply.

In the Philippines, the rainy season is from June to November, and the dry season is from December to May (PAGASA 2021). The absence of *E. coli* in the morning sampling in December can be attributed to sunlight, which is an essential factor in controlling the bacterial population in tropical countries with high solar radiation intensities during the dry season and the high light penetration depths in clear river waters (Conan et al. 2008; Cho et al. 2010). Troussellier et al. (2004) tested this on river-isolated *E. coli* and showed that the bacterium's survival significantly decreased. The presence of *E. coli* can also vary with increasing time scales (Muirhead and Meenken 2018).

In conclusion, the microbiological water quality of the once cleanest rivers in the Philippines is now contaminated with fecal coliforms. Both HPC and MPN displayed values that exceeded the maximum permissible limits of bacteria, 100 CFU ml^{-1} (Bartram et al. 2003) and 1,000 MPN/100 ml (EMB-DENR 1990), respectively wherein some of which can potentially be pathogenic or opportunistic. Hence, the river needs regular monitoring to ensure safety for both locals and tourists from waterborne infections. It is our hope that the result of this study will push the local government of Badian for an immediate response to mitigate the river contamination with proper waste disposal and wastewater treatment. Furthermore, quarterly bacteriological tests must also be conducted in the river to monitor the effectiveness of the mitigation efforts toward the conservation of the tourist site.

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REFERENCES

Abdullah SA, Gul SA, Farheen S, Kibrea T, Saleem A, Gul SS and Ahmad U. 2018. Detection of *Escherichia coli* and total microbial population in River Siran water of Pakistan using EMB and TPC agar. African Journal of Microbiology Research, 12(38): 908–912. https://doi.org/10.5897/AJMR2018.8955

Allen MJ, Edberg SC and Reasoner DJ. 2004. Heterotrophic plate count bacteria—What is their significance in drinking water? International Journal of Food Microbiology, 92(3): 265–274. https://doi.org/10.1016/j.ijfoodmicro.2003.08.017

Ambrad LM. 2018. Kawasan to close for cleanup Aug. 12-18. The Freeman. https://www.pressreader.com/philippines/the-freeman/20180622/281487867073546. Accessed on 31 October 2021.

Aquino J. 2017. Eight enchanting rivers in the Philippines that will make you skip the beach. https://www.tripzilla.com/enchanting-rivers-philippines/54645. Accessed on 30 March 2022.

Baird RB, Eaton AD and Rice EW. 2017. Standard Methods for the Examination of Water and Wastewater, 23rd Edition. American Public Health Association, American Water Works Association, and Water Environment Federation. 1796pp.

Bandel K and F Riedel. 1998. Ecological zonation of gastropods in the Matutinao River (Cebu, Philippines), with focus on their life cycles. International Journal of Limnology, 34(2): 171–191. http://dx.doi.org/10.1051/limn/1998017

Bartram J, Cotruvo J, Exner M, Fricker C and Glasmacher A (eds). 2003. Heterotrophic Plate Counts and Drinking-water Safety: The Significance of HPCs for Water Quality and Human Health. London, UK: IWA Publishing. https://doi.org/10.2166/9781780405940

Blaustein RA, Pachepsky Y, Hill RL, Shelton DR and Whelan G. 2013. *Escherichia coli* survival in waters: Temperature dependence. Water Research, 47(2): 569–578. https://doi.org/10.1016/j.watres.2012.10.027

Carbone G and Yunis E. 2005. Making Tourism More Sustainable: A Guide for Policy Makers. United Nations. http://www.unep.fr/shared/publications/pdf/DTIx0592xPA-TourismPolicyEN.pdf. Accessed on 29 January 2020.

Cho KH, Cha SM, Kang JH, Lee SW, Park Y, Kim JW and Kim JH. 2010. Meteorological effects on the levels of fecal indicator bacteria in an urban stream: A modeling approach. Water Research, 44: 2189–2202. https://doi.org/10.1016/j.watres.2009.12.051

Conan P, Joux F, Torreton JP, Pujo-Pay M, Douki T, Rochelle-Newall E and Mari X. 2008. Effect of solar ultraviolet radiation on bacterio- and phytoplankton activity in a large coral reef lagoon (southwest New Caledonia). Aquatic Microbial Ecology, 52: 83–98. https://doi.org/10.3354/ame01204

Divya AH and Solomon PA. 2016. Effects of some water quality parameters especially total coliform and fecal coliform in surface water of Chalakudy River. Procedia Technology, 24: 631–638. https://doi.org/10.1016/j.protcy.2016.05.151

Donovan E, Unice K, Roberts JD, Harris M and Finley B. 2008. Risk of gastrointestinal disease associated with exposure to pathogens in the water of the Lower Passaic River. Applied and Environmental Microbiology, 74(4): 994–1003. https://doi.org/10.1128/AEM.00601-07

Edberg SC and Allen MJ. 2004. Virulence and risk from drinking water of heterotrophic plate count bacteria in human population groups. International Journal of Food Microbiology, 92(3): 255–263. https://doi.org/10.1016/j.ijfoodmicro.2003.08.012

EMB-DENR (Environmental Management Bureau-Department of Environment and Natural Resources). 1990. DENR Administrative Order No. 34 Series of 1990. https://emb.gov.ph/wp-content/uploads/2016/04/DAO-1990-34.pdf. Accessed on 29 January 2020.

Erram MM. 2020. Badian has yet to accept canyoneering guests. https://cebudailynews.inquirer.net/338043/badian-has-yet-to-accept-canyoneering-guests. Accessed on 31 October 2021.

Feng P, Weagant SD, Grant MA, and Burkhardt W. 2017. Enumeration of *Escherichia coli* and the Coliform Bacteria. https://www.fda.gov/food/laboratory-methods-food/bam-chapter-4-enumeration-escherichia-coli-and-coliform-bacteria. Accessed on 24 September 2019.

Glińska-Lewczuk K, Gołaś I, Koc J, Gotkowska-Płachta A, Harnisz M and Rochwerger A. 2016. The impact of urban areas on the water quality gradient along a lowland river. Environmental Monitoring and Assessment, 188(11): 1–15. https://doi.org/10.1007/s10661-016-5638-z

Hoyer MV, Donze JL, Schulz EJ, Willis DJ and Canfield DE. 2006. Total coliform and *Escherichia coli* counts in 99 Florida lakes with relations to some common limnological factors. Lake and Reservoir Management, 22(2): 141–150. https://doi.org/10.1080/07438140609353891

Jang J, Hur HG, Sadowsky MJ, Byappanahalli MN, Yan T and Ishii S. 2017. Environmental *Escherichia coli*: Ecology and public health implications-a review. Journal of Applied Microbiology, 123(3): 570–581. https://doi.org/10.1111/jam.13468

Kapwata T, Mathee A, Le Roux WJ and Wright CY. 2018. Diarrhoeal disease in relation to possible household risk factors in South African villages. International Journal of Environmental Research and Public Health, 15(8): 1–12. https://doi.org/10.3390/ijerph15081665

Khan K, Lu Y, Saeed MA, Bilal H, Sher H, Khan H, Ali J, Wang P, Uwizeyimana H, Baninla Y, et al. 2018. Prevalent fecal contamination in drinking water resources and potential health risks in Swat, Pakistan. Journal of Environmental Sciences, 72: 1–12. https://doi.org/10.1016/j.jes.2017.12.008

Leclerc H, Mossel DA, Edberg SC and Struijk CB. 2001. Advances in the bacteriology of the coliform group: Their suitability as markers of microbial water safety. Annual Review of Microbiology, 55: 201–234. https://doi.org/10.1146/annurev.micro.55.1.201

Mabvouna RB, Béchir Adogaye SB, Nkamedjie Pete PM, Sanou Sobze M, Kemogne JB and Colizzi V. 2020. Microbiological quality of water sources in the West region of Cameroon: Quantitative detection of total coliforms using Micro Biological Survey method. BMC Public Health, 20(1): 1–7. https://doi.org/10.1186/s12889-020-8443-0

Mabvouna RB, Béchir Adogaye SB, Nkamedjie Pete PM, Wondeu ALD, Sanou Sobze M, Kemogne JB and Colizzi V. 2021. Microbiological quality and genotoxicity of domestic water sources: A combined approach using Micro Biological Survey method and mutagenesis assay (micronucleus test) in root tips of *Vicia faba* in the West region of Cameroon. PLOS ONE, 16(2): 1–12. https://doi.org/10.1371/journal.pone.0245379

Maturin L and Peeler JT. 2001. Aerobic Plate Count. In: United States Food and Drug Administration. Bacteriological Analytical Manual. https://www.fda.gov/food/laboratory-methods-food/bam-chapter-3-aerobic-plate-count. Accessed on 24 September 2019.

Miao J, Guo X, Liu W, Yang D, Shen Z, Qiu Z, Chen X, Zhang K, Hu H, Yin J, et al. 2018. Total coliforms as an indicator of human enterovirus presence in surface water across Tianjin City, China. BMC Infectious Diseases, 18(1): 1–9. https://doi.org/10.1186/s12879-018-3438-5

Mwanamoki PM, Devarajan N, Thevenon F, Atibu EK, Tshibanda JB, Ngelinkoto P, Mpiana PT, Prabakar K, Mubedi JI, Kabele CG, et al. 2014. Assessment of pathogenic bacteria in water and sediment from a water reservoir under tropical conditions (Lake Ma Vallée), Kinshasa Democratic Republic of Congo. Environmental Monitoring and Assessment, 186(10): 6821–6830. https://doi.org/10.1007/s10661-014-3891-6

Muirhead RW and Meenken ED. 2018. Variability of *Escherichia coli* concentrations in rivers during base-flow conditions in New Zealand. Journal of Environment Quality, 47(5): 967–973. https://doi:10.2134/jeq2017.11.0458.

Nuez O. 2018. BadianWINKS. The Freeman. https://www.pressreader.com/philippines/the-freeman/20180805/281689730628743. Accessed on 29 January 2020.

O'Flaherty E, Solimini A, Pantanella F and Cummins E. 2019. The potential human exposure to antibiotic resistant-*Escherichia coli* through recreational water. Science of The Total Environment, 65: 786–795. https://doi.org/10.1016/j.scitotenv.2018.09.018

PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration). 2021. "Climate of the Philippines." https://www.pagasa.dost.gov.ph/information/climate-philippines. Accessed on 24 November 2021.

Pepper IL, Rusin P, Quintanar DR, Haney C, Josephson KL and Gerba CP. 2004. Tracking the concentration of heterotrophic plate count bacteria from the source to the consumer's tap. International Journal of Food Microbiology, 92(3): 289–295. https://doi.org/10.1016/j.ijfoodmicro.2003.08.021

Prideaux B and Cooper M. 2009. River Tourism. Wallingford, United Kingdom. Centre for Agriculture and Bioscience International. 288pp.

Ramos S, Silva V, Dapkevicius MdeLE, Caniça M, Tejedor-Junco MT, Igrejas G and Poeta P. 2020. Escherichia coli as commensal and pathogenic bacteria among food-producing animals: Health implications of extended spectrum β-lactamase (Esbl) production. Animals, 10(12): 1–15. https://doi.org/10.3390/ani10122239

Rossi A, Wolde BT, Lee LH and Wu M. 2020. Prediction of recreational water safety using *Escherichia coli* as an indicator: Case study of the Passaic and Pompton Rivers, New Jersey. Science of The Total Environment, 714: 1–7. https://doi.org/10.1016/j.scitotenv.2020.136814

Savage VR, Huang S and Chang TC. 2004. The Singapore River thematic zone: Sustainable tourism in an urban context. The Geographical Journal, 170(3): 212–225 https://doi.org/10.1111/j.0016-7398.2004.00121.x

Shittu OB, Olaitan JO and Amusa TS. 2010. Physico-chemical and bacteriological analyses of water used for drinking and swimming purposes in Abeokuta, Nigeria. African Journal of Biomedical Research, 11(3): 285–290. https://doi.org/10.4314/ajbr.v11i3.50739

Song D. 2016. Countermeasure study on sustainable utilization of tourism resources and tourism environmental pollution in coastal areas of the Pearl River Delta, China. Nature Environment and Pollution Technology, 15(3): 873–879. https://neptjournal.com/upload-images/NL-57-15-(13)G-90.pdf.

Stocker MD, Rodriguez-Valentín JG, Pachepsky YA and Shelton DR. 2016. Spatial and temporal variation of fecal indicator organisms in two creeks in Beltsville, Maryland. Water Quality Research Journal, 51(2): 167–179. https://doi.org/10.2166/wqrjc.2016.044

Suthar S, Chhimpa V and Singh S. 2009. Bacterial contamination in drinking water: A case study in rural areas of northern Rajasthan, India. Environmental Monitoring and Assessment, 159(1–4): 43–50. https://doi.org/10.1007/s10661-008-0611-0

Troussellier M, Got P, Bouvy M, M'Boup M, Arfi R, Lebihan F, Monfort P, Corbin D and Bernard C. 2004. Water quality and health status of the Senegal River estuary. Marine Pollution Bulletin, 48: 852–862. https://10.1016/j.marpolbul.2003.10.028

Vignesh S, Dahms HU, Emmanuel KV, Gokul MS, Muthukumar K, Kim BR and James RA. 2014. Physicochemical parameters aid microbial community? A case study from marine recreational beaches, Southern India. Environmental Monitoring and Assessment, 186: 1875–1887. https://doi.org/10.1007/s10661-013-3501-z

Winter PL, Selin S, Cerveny L and Bricker K. 2019. Outdoor Recreation, nature-based tourism, and sustainability. Sustainability, 12(1): 1–12. https://doi.org/10.3390/su12010081

Zhao T, Chen Y, Yao W, Ye B and Song B. 2017. The spatiotemporal distribution of two bacterial indexes in a small Tibetan plateau watershed. Water, 9(11): 1–17. https://doi.org/10.3390/w9110823

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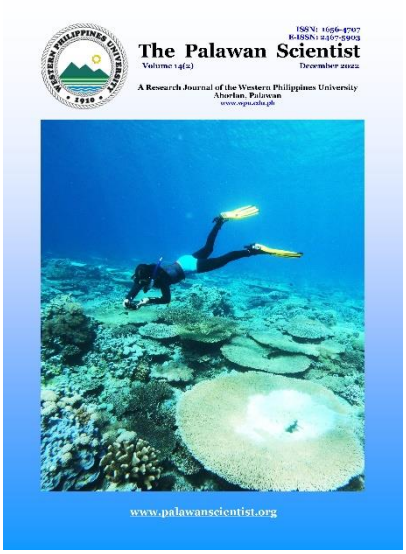

Status review of seahorse (Syngnathidae: *Hippocampus*) trafficking in the Philippines

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ABSTRACT

Seahorses *Hippocampus* spp. are a unique group of fish characterized by their unusual morphology and male pregnancy. The current 48 seahorse species occur mainly in shallow seawaters globally, of which 10 species occur in the Philippines. Estimated annual seahorse collection in the Philippines for the traditional medicine trade was 4,000,000 individuals and up to 1,000,000 individuals for the live aquarium trade prior to 2004. Due to the significant international trade threatening the survival of seahorses in the wild, the genus *Hippocampus* was listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendix II in 2004. Although seahorses are protected nationally under the Philippine Fisheries Code of 1998 and Wildlife Act of 2001, large-scale illegal collection in the wild continues. It was estimated that 1.7 million seahorse individuals were collected in the Philippines per year after 2004. Open-source seizure data were collated and official seizure records from 2010 to 2021 were analyzed to provide a status review on seahorse trade dynamics and analyze Philippine law enforcement efforts. Nineteen seizure incidents involving approximately 658 kg of dried seahorses (approximately 280,318 individuals) were recorded in the study period. In addition, 181 kg of dried pipefishes and sea dragons were recorded. While seizures occurred across eight islands, 13 incidents (68%) were documented in the central Philippines (Visayas and Palawan). Preliminary analysis of the seizure data suggests the following: 1) a significant portion (95–100%) of the illegal seahorse trade is not detected by law enforcement activities; 2) National Capital Region and Cebu are important exit points for international trade, and 3) pipefishes and sea dragons may be targeted as an alternative to seahorses.

Keywords: CITES, pet trade, traditional medicine, wildlife trade

INTRODUCTION

Seahorses *Hippocampus* spp. are a group of fish with distinctive morphology, including a tubular snout, upright body posture, prehensile tail, and characteristic male pregnancy (Vincent 1996; Lourie et al. 2004). Along with pipefishes and sea dragons, they belong to the family Syngnathidae, where the current 48 seahorse species occur mainly in shallow temperate and tropical seawaters worldwide (Vincent et al. 2011; Froese and Pauly 2021). The International Union for Conservation of Nature Red List of Threatened Species had assessed 42 seahorse species ranging from Data Deficient to Vulnerable (IUCN 2021). In the Philippines, ten species are known to occur throughout the archipelago, with populations

concentrated mainly in the central Visayas (Foster and Apale 2016; Project Seahorse 2019).

Globally, the survival of seahorses in the wild is mainly threatened by habitat loss and overexploitation (Foster and Vincent 2004). For centuries, seahorses have been believed to cure various diseases and provide health benefits when consumed, making them a highly sought-after ingredient in traditional Chinese medicine (TCM), and resulting in the collection of millions of individuals annually (Vincent 1996; Vincent et al. 2011). A significant surge in demand was noted since the mid-1980s (Vincent 1996). This trade occurred in large quantities to meet the high demand for TCM, especially in China, Hong Kong, and Taiwan. It was estimated that 45,000 kg of dried seahorses (approximately 16,000,000 individuals) were consumed within Asian countries per year (Vincent 1996). To a lesser extent, seahorses are also traded as curios, amulets, and live as aquarium pets. Overexploitation may cause the decline of seahorse population and seahorse fishery was hypothesized to be unsustainable due to the dwindling catch (Vincent 1996; Pajaro and Vincent 2015; Yasué et al. 2015; Foster et al. 2019). Attempts have been made to breed seahorses in captivity; however, seahorse aquaculture is challenging with high production cost, technical difficulties, and increased susceptibility of seahorses to diseases resulting in mass mortality (Koldeway and Martin-Smith 2010; Koning and Hoeksema 2021). Currently, the vast majority of seahorses in the trade are still collected from the wild (Craig et al. 2011; UNEP-WCMC 2011; Vincent et al. 2011).

Due to the threat of overexploitation, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has regulated the international commercial seahorse trade by listing the genus in CITES Appendix II since 2004 (CITES 2003). In the Philippines, national legislation and regulations such as the Republic Act 8550 as amended by RA 10654 (Philippine Fisheries Code of 1998), RA 9147 (Wildlife Act of 2001), and Fisheries Administrative Order. 208 of 2001 (Conservation of rare, threatened, and endangered fishery species) are in place to protect endangered wildlife and their habitats by imposing a total ban on seahorse collection and trade since 2004. Although strong national legislation and regulations are in place, illegal collection and trafficking of seahorses continue due to the lucrative nature of the trade, particularly to intermediaries and exporters, and very limited alternative livelihoods to fishers who derive an essential portion of their meager income from seahorse fishery (Pajaro and Vincent 2015).

The Philippines is one of the major sources of dried and live seahorses in the international market. The three main collection sites are Palawan, central Visayas (including Cebu, Bohol, and Negros), and Sulu Archipelago (Vincent 1996). It was estimated that 10,000 kg of dried seahorses (approximately 4,000,000 individuals) and up to 1,000,000 live seahorses were traded per year prior to 2004 (pre-CITES) (Pajaro and Vincent 2015; Foster and Apale 2016). Since the collection ban, it was estimated that 1.7 million seahorse individuals were collected in the Philippines per year after 2004 (Foster et al. 2019). Dried seahorses are sold at USD 460 (Vincent et al. 2011; Yasué et al. 2015; Foster et al. 2019;) to USD 600 per kg in 2018. In Manila City, TCM stores sell dried seahorses for USD 7–8 per individual (Sy unpubl. data).

Previous seahorse studies in the Philippines have provided critical information on seahorse fishery. However, limited information is available on trade routes, smuggling methods, and law enforcement activities. This study aimed to provide a status review on seahorse trafficking dynamics and law enforcement efforts by analyzing seizure data.

METHODS

Seizure records from 2010 to 2021 were collated from open-source news reports. In addition, unpublished seizure records of the Department of Environment and Natural Resources - Biodiversity Management Bureau (DENR-BMB), Bureau of Customs – Ninoy Aquino International Airport (BOC-NAIA), Palawan Council for Sustainable Development Staff (PCSDS), and Bureau of Fisheries and Aquatic Resources (BFAR) region VI, VII, and IX were reviewed. When an official record and news article reported different quantities, the official record was followed. Information was collated to determine the seizure location, quantity, date, commodity type (e.g. live, dried), and, if available, source, transit, and destination locations. A seizure incident involving six fishers on Dumaran Island mentioned "seahorses" were seized but did not specify the quantity (Taboada, 2019). In the absence of information on the exact seized quantity in this case, the quantity of at least two individuals were estimated. A previous study estimated 300–1,000 individuals per 1 kg of dried seahorses depending on species and source locations in the Philippines (Vincent 1996). This study used 426 individuals per 1 kg of dried seahorses based on the average quantity of test counts on seized seahorses conducted by BFAR Bacolod and Zamboanga in 2018 (Abeto and Munap pers. comm.). When reports only mentioned the number of containers (i.e. number of sacks or boxes), the weight using its minimum threshold value, based on previous seizures involving similar-sized containers was conservatively estimated. Informal interviews of TCM store personnel were also conducted to gather information such as prices and sources in 2018.

RESULTS

Seizure Records

Nineteen seizure incidents involving at least 62 live and 658 kg of dried seahorses (approximately 280,318 individuals) were documented from 2010 to 2021 (Table 1). No seizures were recorded in 2010–2011, 2013, and 2015–2016. Four incidents involved the seizure of live seahorses – three incidents while seahorses were being collected at sea and one incident in a pet market in Pasay City, Luzon. Fifteen seizure incidents (79%) involved dried seahorses – eight incidents while being transported in seaports or airports; five incidents while in the storage facilities of traffickers, and one incident in Manila City in a TCM store and another while being transported by a land vehicle.

Table 1. Seizure incidents per year and estimated dry weight (kg) quantity from 2010 to 2021.

YEAR	NO. OF INCIDENTS	ESTIMATED QUANTITY (KG)
2010	-	-
2011	-	-
2012	1	3.50
2013	-	-
2014	3	77.34
2015	-	-
2016	-	-
2017	3	149.03
2018	3	211.04
2019	5	173.61
2020	3	28.25
2021	1	15.25
TOTAL	**19**	**658.02**

While seizures occurred across eight islands, the majority of incidents (n = 13) occurred in the Visayas and Palawan region (Figure 1A), accounting for 68.4% of the total seahorse seizure incidents in the study period. Seizure incidents also peaked in 2017–2019, with a total of 11 incidents involving at least 57 live and 533.54 kg of dried seahorses, accounting for 81.1% of the total seizure quantity in dry weight in the past 12 years. This was mainly due to the three large dried seahorse seizures that involved 130 kg (estimated) in Manila City in 2017, 152.94 kg in Zamboanga City in 2018, and 104.54 kg in Puerto Princesa City, Palawan in 2019 (Figure 1B).

Other Syngnathids (sea dragons and pipefishes) have also been confiscated along with seahorses or separately. Four seizure incidents in Masbate and Palawan Province involved 181.27 kg of dried pipefishes and sea dragons between 2014 and 2020.

Smuggling Routes and Modus Operandi

Wildlife traffickers mainly utilized seaports and airports when transporting large quantities (> 10 kg) of dried seahorses. The contrabands are typically first packed in plastic, then in opaque sacks or cardboard boxes, and misdeclared as other dried fish or concealed with scrap plastic in closed van containers or trucks. In a four-year period (2017–2020), six dried seahorse smuggling attempts were documented in the Philippines. One incident each by commercial airline and cargo ship from Negros Occidental to the National Capital Region (NCR); two incidents by ship from Zamboanga City to the NCR; and two incidents from Cebu to Macau via commercial airlines in 2019 (Figure 2).

Arrests and Outcomes

A total of 70 individuals, of which 44 fishers were involved in seahorse poaching and 26 others involved in transporting or trafficking, were arrested and detained during the study period. The only case with a known resolution was the smuggling attempt of 53 kg of dried seahorses as reported by the Bureau of Customs with a wholesale market value of PHP 1,590,000 (USD 31,176) by two Chinese nationals with Macau passports in Cebu in 2019. The suspects only paid a total of PHP 30,000 (USD 588) fine. They were allowed to leave the country without facing a criminal case or undergoing deportation proceedings for violating RA 9147, RA 8550, and RA 10863 or the Customs Modernization and Tariff Act (CMTA).

DISCUSSIONS

Seizure Records

During the 12-year period from 2010 and 2021, only seven years had law enforcement activities involving seahorses. The average seized quantity was approximately 23,360 seahorses per year. Comparing the average seized quantity with the latest estimate of 1.7 million seahorses collected per year in the Philippines (Foster et al. 2019), law enforcement activities could only detect 0%–5.3% of illicit seahorse trade per year. A drop in seahorse seizure incidents recorded from 2020–2021 compared to 2017–2019 may be due to a combination of various factors – undetected smuggling activities, insufficient enforcement efforts, reduced poaching activities,

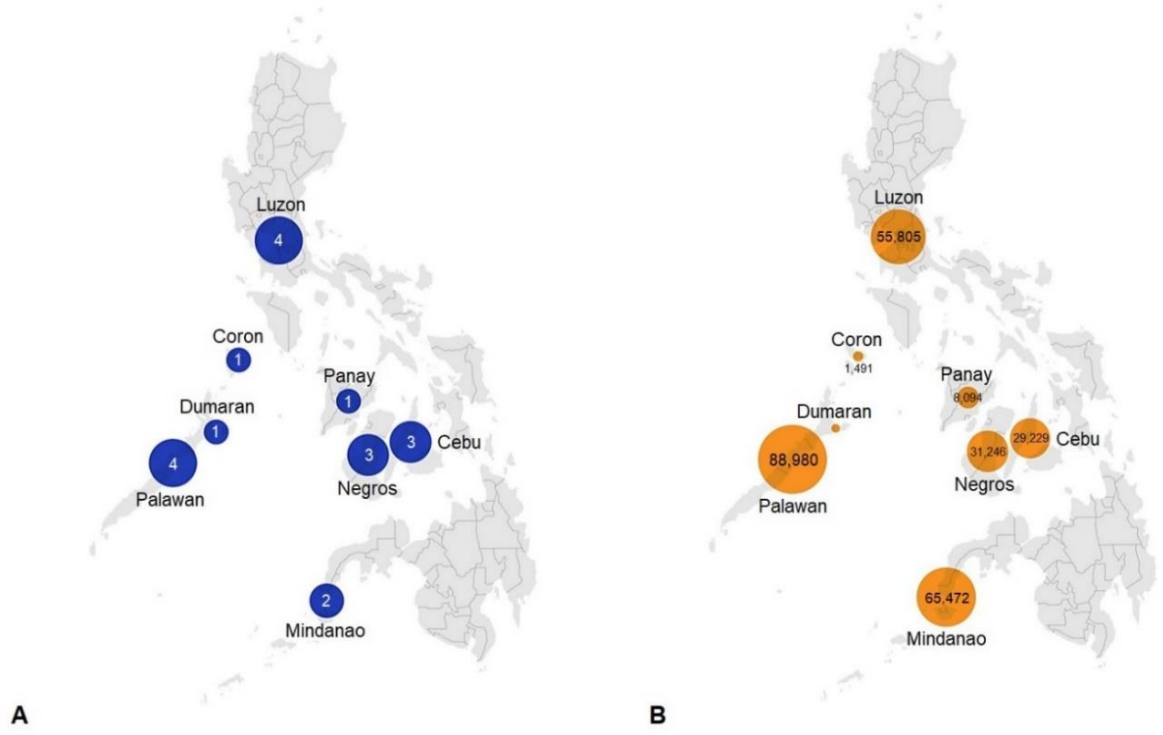

Figure 1. Location and number of seahorse seizure incidents (A) and estimated seized seahorse individuals (B). Note: All dried seahorse seizure records were converted to individuals based on the most recent estimate of 426 individuals = 1 kg dried seahorses. Authorities did not identify seized seahorses to species level.

and/or artifact of COVID-19 pandemic lockdown. While seizure data can provide critical trafficking information, it is only an indicative on wildlife trafficking and law enforcement efforts (Sy et al. 2020; Sy 2021). As such, it should be interpreted with caution due to imperfect detection rates, variable enforcement efforts, and incomplete reporting. The discovery of other Syngnathids that are not protected by law in seizure incidents indicates that they may be targeted as alternatives to seahorses and be threatened by overexploitation.

Smuggling Routes and Modus Operandi

Seahorse poaching and trafficking continue to threaten the survival of seahorses in the Philippines despite these national and international protections (Pollom et al. 2020). Although it is challenging to ascertain seahorse population decline due to limited population studies, previous surveys and interviews with people involved in the trade chain in the Philippines indicated up to 70% decline in catch rate from 1985–1995 (Pajaro and Vincent 2015). The persistent high demand for seahorses for TCM from the Philippines (Figure 3) and abroad could be a major factor driving the perceived or actual population decline.

The NCR was implicated in the seahorse smuggling route as a destination in 50% of dried seahorse seizure incidents, but it could be a transit location for international smuggling. Dried seahorses are likely smuggled abroad for processing before being reimported in smaller quantities by TCM stores in the NCR for domestic trade and consumption (Vincent 1996). The TCM store personnel who participated in short and informal interviews conducted in Manila in 2018 revealed that they sourced dried seahorses overseas.

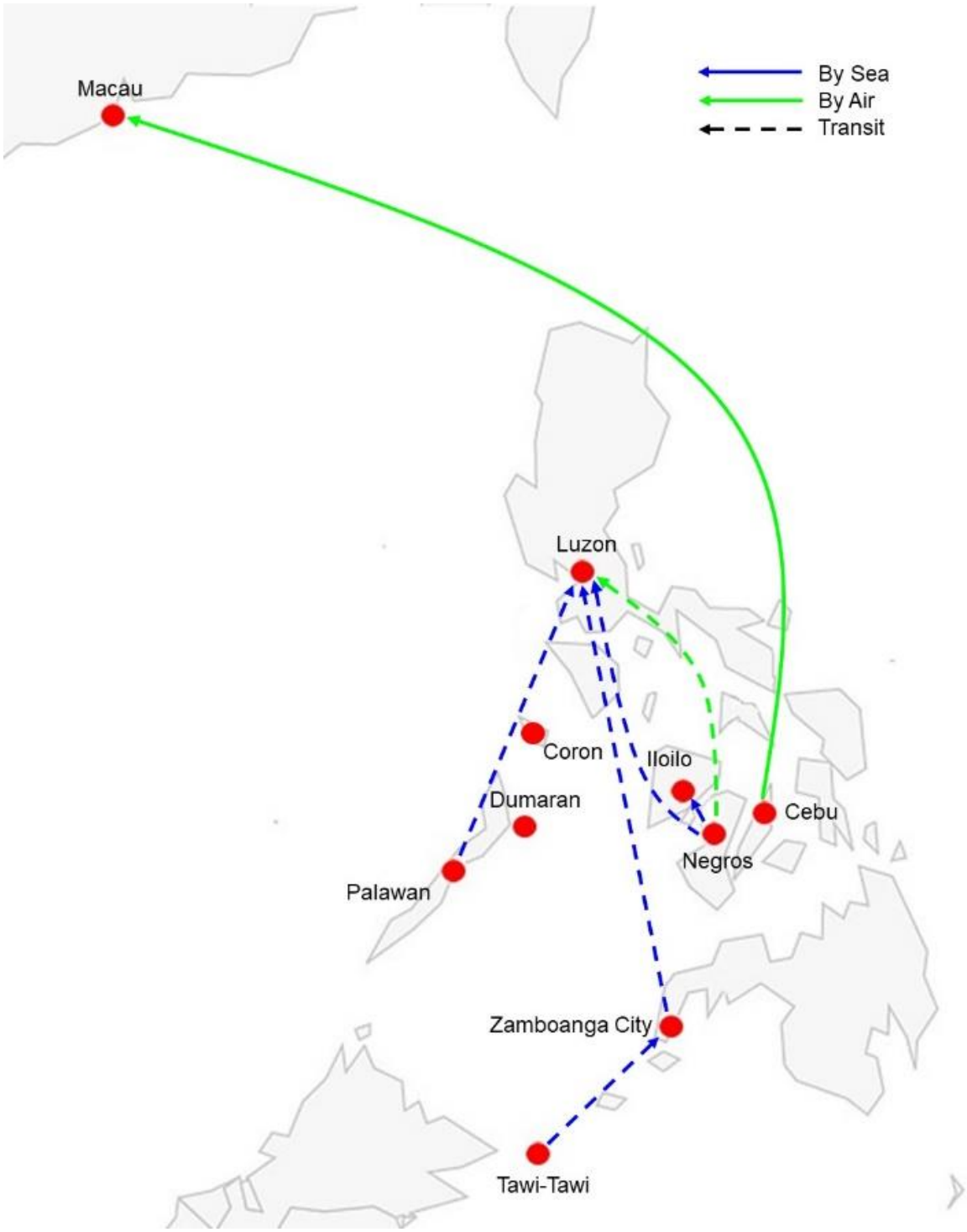

Figure 2. Smuggling routes of dried seahorses in the Philippines between 2017 and 2021.

Figure 3. Dried seahorses in the TCM trade in Manila City.

Law Enforcement

While the Philippines has strong national laws (i.e. RA 10654, RA 9147) to protect seahorses, ineffective implementation and low conviction rates and penalties undermine their usefulness. Seahorses are prohibited from all catch and trade, and violators may be meted with a heavy monetary fine and lengthy jail sentence—section 102(b) of RA 10654 makes it unlawful to "fish, take, catch, gather, sell, purchase, possess, transport, export, forward or ship out aquatic species listed in CITES Appendices II and III. If scientific assessments show that population of the species in the wild cannot remain viable under the pressure of collection and trade". Violators may be penalized with three times the value of seized wildlife or up to PHP3,000,000 (USD58,824), whichever is higher, and sentenced to jail for five to eight years. Heavy penalties can serve as an effective deterrent if applied appropriately. However, violators typically receive significantly less severe penalties, as exemplified by the two foreign nationals caught with 53 kg of dried seahorses in 2019. The violators could have been fined PHP4,770,000 (USD93,529), sentenced up to eight years of imprisonment, and underwent deportation proceedings after serving the jail sentence. After the administrative hearing, the imposed total fine of PHP30,000 (USD588) was less than 1% of the maximum fine allowed under the law. The Philippines, together with other countries, have declared a seahorse trade ban since 2004 but continues to play a significant role as a source country in the international trade chain (Christie et al. 2011; Foster et al. 2016; Kuo and Vincent 2018; Foster and Vincent 2021). The CITES trade records showed that the Philippines did not report seahorse exports after 2004. Between 2011 and 2016, the United States reported sourcing 253 seahorse individuals from the Philippines for educational and scientific purposes. In addition, Portugal and the United States reported seizure of 3.37 kg and 6,859 individual seahorses from the Philippines respectively (CITES Trade Database 2021).

Among the many threats to aquatic species, poaching and trafficking remain the primary threats to Syngnathids, particularly seahorses. Aquatic wildlife authorities should increase visibility and monitoring especially in known hot spot areas to prevent poaching. Information gathering and detection measures at seaports and airports should be enhanced to address illegal transporting of seahorses and other wildlife. An assessment of seahorse availability in TCM stores in the Philippines can provide additional insights into the sources, demand, and supply chains for seahorses in the country. Biologists, researchers, local coastal communities, fishers, and law enforcers should collaborate to raise seahorse awareness to conserve seahorses in the Philippines.

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REFERENCES

Christie P, Oracion EG and Eisma-Osorio L. 2011. Impact of the CITES listing of seahorses on the status of the species and on human well-being in the Philippines: a case study. FAO Fisheries and Aquaculture Circular No. 1058. Rome. 44pp.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). 2003. Proposals for the amendment of Appendices I and II. Results of the 12th Meeting of the Conference of the Parties 2002. Convention on International Trade in Endangered Species of Wild Fauna and Flora, Geneva, Switzerland. http://www.cites.org/eng/news/world/cop12_prop_results.pdf. Accessed on 16 August 2021.

Craig V, Allan C, Lyet A, Brittain A and Richman E. 2011. Review of trade in ornamental coral, coral products and reef associated species to the United States. World Wildlife Fund, Washington DC. USA.

Fisheries Administrative Order No. 208. 2001. Conservation of rare, threatened, and endangered fishery species. Department of Agriculture, Quezon City, Philippines. https://www.bfar.da.gov.ph/bfar/download/fao/FAO208.pdf. Accessed on 09 July 2021.

Foster SA and Vincent AC. 2004. Life history and ecology of seahorses: implications for conservation and management. Journal of Fish Biology, 65(1): 1–61. https://doi.org/10.1111/j.1095-8649.2004.00429

Foster SJ and Vincent ACJ. 2021. Holding governments accountable for their commitments: CITES review of significant trade for a very high-volume taxon. Global Ecology and Conservation, 27: e01572.

Foster SJ, Stanton LM, Nellas AC, Arias MM and Vincent AC. 2019. The catch and trade of seahorses in the Philippines post-CITES. Fisheries Centre Research Reports 27(2): 1–45.

Foster S, Wiswedel S and Vincent A. 2016. Opportunities and challenges for analysis of wildlife trade using CITES data–seahorses as a case study. Aquatic Conservation: Marine and Freshwater Ecosystems, 26(1): 154–172.

Foster SJ and Apale CM. 2016. Exploitation, trade, conservation and management of seahorses in the Philippines. Project Seahorses and ZSL-Philippines. 40pp.

Froese R and Pauly D (eds). 2021. FishBase, version 08-2021. www.fishbase.org. Accessed on 30 June 2021.

IUCN (International Union for Conservation of Nature). 2021. The IUCN Red List of Threatened Species. Version 2021-1. https://www.iucnredlist.org. Accessed on 26 June 2021.

Koldewey HJ and Martin-Smith KM. 2010. A global review of seahorse aquaculture. Aquaculture, 302(3–4): 131–152. https://doi.org/10.1016/j.aquaculture.2009.11.010

Koning S and Hoeksema BW. 2021. Diversity of seahorse species (*Hippocampus* spp.) in the international aquarium trade. Diversity, 13(5): 187 https://doi.org/10.3390/d13050187

Kuo TC and Vincent A. 2018. Assessing the changes in international trade of marine fishes under CITES regulations – A case study of seahorses. Marine Policy, 88: 48–57. https://doi.org/10.1016/j.marpol.2017.10.031

Lourie SA, Foste SJ, Cooper EW and Vincent AC. 2004. A Guide to the Identification of Seahorses. Project Seahorse and TRAFFIC North America. Washington D.C.: University of British Columbia and World Wildlife Fund.

Pajaro MG and Vincent ACJ. 2015. The catch and export of the seahorse trade in the Philippines, pre-CITES. Fisheries Centre Working Paper, 1(2): 27.

Pollom RA, Ralph GM, Pollock CM and Vincent AC. 2021. Global extinction risk for seahorses, pipefishes and their near relatives (Syngnathiformes). Oryx, 55(4): 497–506. https://doi.org/10.1017/S0030605320000782

Project Seahorse. 2019. Seahorses in the Philippines. IUCN SSC seahorse, pipefish and seadragon specialist group. https://www.iucn-seahorse.org/seahorsephilippines. Accessed on 13 July 2021.

Republic Act No. 8550. 1998. The Philippine Fisheries Code of 1998. https://www.officialgazette.gov.ph/1998/02/25/republic-act-no-8550/. Accessed on 09 July 2021.

Republic Act No. 9147. 2001. Wildlife Resources Conservation and Protection Act. https://www.officialgazette.gov.ph/2001/07/30/republic-act-no-9417/. Accessed on 09 July 2021.

Republic Act No.10654. 2015. Amendment of the Philippine Fisheries Code of 1998. https://www.officialgazette.gov.ph/2015/02/27/republic-act-no-10654/. Accessed on 09 July 2021.

Republic Act No. 10863. 2016. Customs Modernization and Tariff Act. https://www.officialgazette.gov.ph/2016/05/30/republic-act-no-10863/. Accessed on 09 July 2021.

Sy EY. 2021. Wildlife from forests to cages: an analysis of wildlife seizures in the Philippines. USAID Philippines, Manila. 45pp.

Sy EY, Schoppe S, Diesmos MLL, Lim TMS and Diesmos AC. 2020. Endangered by trade: seizure analysis of the critically endangered Philippine Forest Turtle *Siebenrockiella leytensis* from 2004–2018. Philippine Journal of Systematic Biology, 14(2): 1–8. https://doi.org/10.26757/pjsb2020b14003

Taboada JJ. 2019. Six fishermen nabbed for illegal fishing in Dumaran. Palawan News, Palawan. https://palawan-news.com/six-fishermen-nabbed-for-illegal-fishing-in-dumaran/. Accessed on 15 September 2021.

UNEP-WCMC (United Nations Environment Programme World Conservation Monitoring Centre). 2011. Review of species selected on the basis of a new or increased export quota in 2011. SRG 57. UNEP-WCMC, Cambridge. https://ec.europa.eu/environment/cites/pdf/reports/Review_of_species_selected_on_the_basis_of_the_analysis_of_2016_CITES_export_quotas.pdf. Accessed on 26 June 2021.

Vincent AC. 1996. The international trade in seahorses. TRAFFIC International, Cambridge, U.K. 162pp.

Vincent AC, Foster SJ and Koldewey HJ. 2011. Conservation and management of seahorses and other Syngnathidae. Journal of Fish Biology, 78(6): 1681–1724. https://doi.org/10.1111/j.1095-8649.2011.03003

Yasué M, Nellas A, Panes H and Vincent ACJ. 2015. Monitoring landed seahorse catch in a changing policy environment. Endangered Species Research, 27(2): 95–111. https://doi.org/10.3354/esr00643

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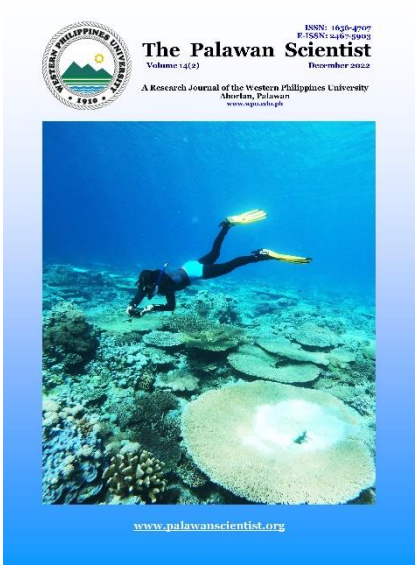

Comparison of predicted and measured levels of organic material input from a commercial cage farm in Western Turkey

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ABSTRACT

In this study, two different sediment trap trials were carried out to determine the deposition rate (flux) of particulate organic materials (POM) from marine cage farms. Flux predicted using a commercial software (Meramod), measured almost two-fold higher (1,355.5 g m^{-2} yr^{-1}) in 2009 compared to that in 2008 (765.0 g $m^{-2}yr^{-1}$). Predicted levels of flux were higher than measured values in all trials and ranged between 1,251.6 g m^{-2} yr^{-1} in 2008 and 1,811.9 g m^{-2} yr^{-1} in 2009. There were also considerable differences in measured and predicted rates of flux at each station. High variations of flux in repeated measures indicated the need for strict control of farm maintenance routines during long-term trap studies. Near bottom current speeds, periodic resuspension events and the presence of wild fish assemblages were considered as major factors that may have effects in predicting the accumulation rates of POM.

Keywords: Meramod, modeling, net-pens, particulate organic material, waste solid flux.

INTRODUCTION

Waste from marine cage farms is directly discharged into the environment in the form of dissolved and particulate organic material (POM) which, in turn, causes nutrient enrichment and eutrophication. Indicator parameters have potential drawbacks and no single indicator parameter conclusively describes the enrichment status of the farm sites. For example, concentrations of inorganic nutrients such as nitrogen, phosphate and other chemical parameters have short memories due to high flushing rates (Karakassis et al. 2005; Neofitou and Klaoudatos 2008) and may provide inconsistent data at low levels for site evaluation (Rapp et al. 2007) despite reported increased concentrations at farm sites with no signs of eutrophication (Karakassis et al. 2001; Mantzavrakos et al. 2007; Neofitou and Klaoudatos 2008). Biological parameters such as benthic faunal composition and succession, on the other hand, is a factor of complex interactions between depth, sediment type, current speed, farm capacity and also is subject to different conclusions (Kalantzi and Karakassis 2006).

Deposition of POM over the sediment derived from cage farms is considered as the major component of negative environmental impacts creating anoxic conditions that adversely affect the abundance and composition of benthic organisms (Pillay 1992; Troel and Norberg 1998; Read and Fernandes 2003; Gyllenhammar and Håkanson 2005). The particulate materials are primarily composed of waste solids originating from uneaten feed and fecal material (Holmer 1991; Iwama 1991) that can easily be

collected by traps deployed underneath the cages. Therefore, the rate at which POM accumulates is being increasingly used to determine the impacts of cage aquaculture (Dudley et al. 2000; Henderson et al. 2001; Cromey et al. 2002a,b; 2012). The large signal and traceability of POM accumulation over the sediment has also resulted in its use for modeling studies as an important component of aquaculture management processes (Henderson et al. 2001; Silvert and Cromey 2001; Pérez et al. 2002; Chamberlain and Stucchi 2007; Weise et al. 2009; Cromey et al. 2012). The current work was conducted to determine the accumulation rate of POM from a commercial cage farm using two different sediment traps and then evaluation of the usability of the software by comparing the accumulation models made using on-site measurements and cage farm technical information with real data.

An important aspect of this study is the ability to predict and verify the organic load accumulation of a commercial cage farm through computer simulations using a commercial software.

METHODS

Study Area

In the present study, the accumulation rate of organic materials underneath a commercial marine cage farm rearing European seabass, *Dicantarchus labrax*, and gilthead sea bream, *Sparus aurata* has been investigated using sediment traps. The representative fish farm was located in the Gulf of Gerence (Çeşme, İzmir, Turkey) an area characterized by intensive cage farming during the last two decades (Figure 1). Due to difficulties in isolating a single cage in a commercial farm, the whole cage system receiving solids from all directions was used as an experimental unit rather than a single cage.

Husbandry Data

The farm site was comprised of 20 circular cages with a diameter of 24 m and a net depth of 8 m corresponding to a volume of 3617 m^3 $cage^{-1}$. The reported production capacities of the farm were 184 and 100 t in 2008 and 2009, respectively (Table 1). The reduction in reported total biomass was due to relocation of the farm from near-shore site to the off-shore site in late 2008. The biomass corresponds to a stocking density of 2.5 kg m^{-3} in 2008 and 1.3 kg m^{-3} in 2009. However, due to uncertainties in total biomass as a result of unreported capacity increases, routine fish stocking, and mortality and harvesting, simulations on accumulation of organic load were based on monthly husbandry logs for each cage provided by the farm management. All of these data were entered in the modelling software.

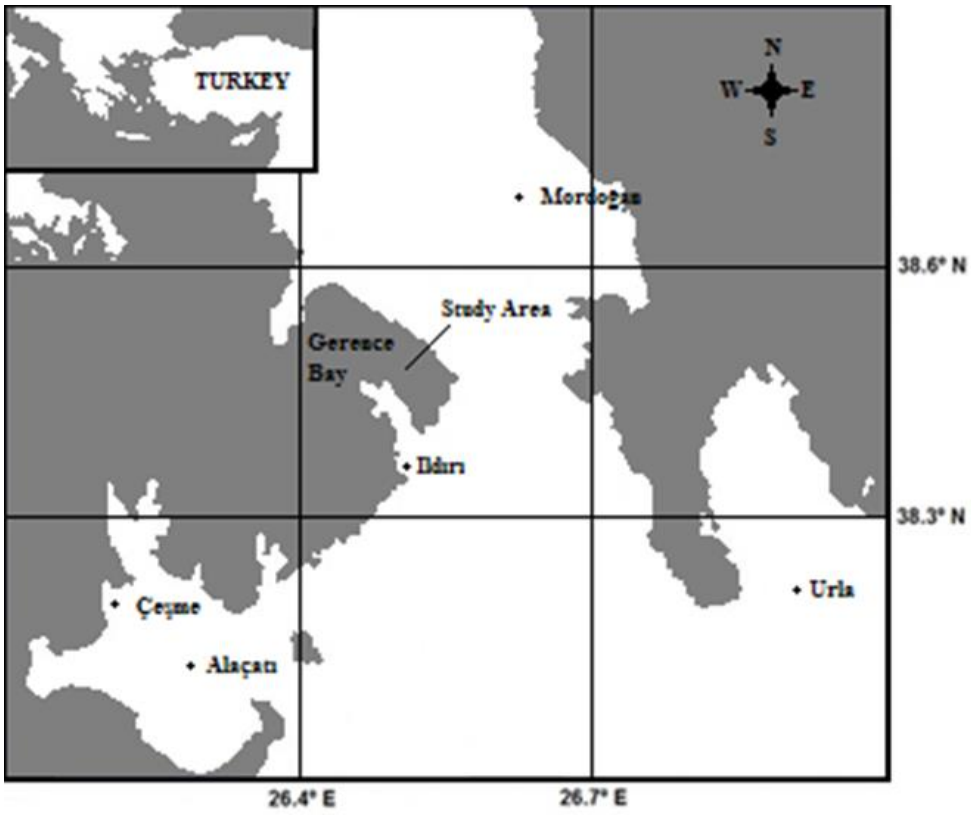

Figure 1. Study area in Gerence Bay (Aegean Sea, Western Turkey).

Table 1. Summary of fish farm characteristics in 2008 and 2009.

Year	Total Number of Cages	Total biomass (tons yr^{-1})	Feeding rate (tons yr^{-1})	FCR (Feed Conversion Rate)	Stocking rate
2008	20	184	387	2.10	2.5 kg m^{-3}
2009	20	100	184	1.84	1.3 kg m^{-3}

Hydrographic Measurements

The current speed and direction were measured monthly (for periods ranging from 2 hours to 3 days) and during sediment trap trials (28-33 days). For this purpose, an acoustic doppler current profiler (Teledyne RD Instruments, USA) was deployed on the mooring system 70 m away from the cage site and 1 m below surface. The measurement interval was 20 min in all trials. Current speeds and direction throughout the Gerence Bay were also measured (data not given) along predetermined transects using a current meter (Workhorse Sentinel; Teledyne RD Instruments, USA) attached to a fishing boat to characterize major hydrodynamic behavior of water masses.

Deployment of Sediment Traps

In order to determine onsite accumulation rate of organic load and for validation, five separate sediment trap studies were conducted in April-August 2008 and also one in September 2009 to symbolize the autumn period when the fish harvest has not yet taken place during the said dates. Sedimentation rates of solids (organic waste input) from cages were determined for a period 28-33 days and at the end of each trial, the contents of the traps were collected and the traps were redeployed. Different trap designs were used in two experiments; in 2008, traps were made up of polyvinyl chloride (PVC) pipes with a diameter of 12.5 cm and consisted of a main body and a removable collector. The main body of trap was 75 cm long and was cylindro-conical in shape. The aspect ratio was 6.00. In the first trial, each trap was fixed to a rope at 3 m above the seabed and only one trap was deployed to each predetermined station. The rope was attached to a concrete weight in one end and to a buoy at the other end. The buoy was kept 2 m below surface in order to minimize the effects of waves. Sampling stations were established at 0 (center), 50, and 100 m intervals along two perpendicular transects on the North to South (NS) and West to East (WE) axis. A total of 9 traps were deployed at each trial. Two different control traps were established at 1 km on the WE and NS axes to determine the background levels of organic material accumulation (Figure 2).

In 2009, relatively smaller-sized traps were used and each sediment trap was consisted of a main body, a collector and a holder in order to evaluate the resuspension event more realistically. The main body of each trap was constructed out of a PVC pipe 7 cm in diameter and 60 cm in length. The aspect ratio was 8.57. A removable collector made of a PVC pipe 5 cm in diameter and 30 cm in length was attached at the bottom of the main body. A single unit contained 4 PVC pipes (4 replicates) connected to a 120 cm long metal bar (holder) using brackets. When the traps were deployed, the mouth of each trap was 110 cm above the sea floor. A semi-circular metal ring was welded on the upper end of each metal bar for rope attachment. Each trap unit was deployed at a predetermined sampling station using ropes and the location of each station was marked with plastic buoys attached to ropes. Sampling stations were established at 0 (center), 25, 50, 75, 100 and 200 m intervals along two perpendicular transects on the NS and WE axis. A total of 21 traps were deployed for a period of 28 days. Two different control traps were established at 1 km (Figure 3).

Data Collection and Modeling

At the end of each trial all traps were manually removed. Accumulated material in each trap was sieved to remove particles > 500 µm and the amount of material collected was determined gravimetrically. Deposition obtained over the study period was then scaled up to obtain flux. Flux was expressed in terms of ash free dry weight (AFDW) as g m^{-2} yr^{-1}.

The solid accumulation over the sea bed was predicted using a computer model, Meramod, that was developed to predict the waste solids flux of sea bass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus auratus*) cage farms (Cromey et al. 2012) considering hydrodynamic conditions in the Mediterranean. General model set up was similar to earlier studies reported by others (Cromey et al. 2002a; Cromey and Black 2005; Cromey et al. 2012). The model is composed of four different subsequent modules: grid generation module, particle tracking module, resuspension module and the benthic impact module. Briefly, the grid generation module generates a map of the farm area using data from bathymetric measurements and farm layout (orientation, number and dimensions of cages). Particle tracking module then, calculates total flux of solids (g m^{-2} yr^{-1}) by taking into consideration current speed and direction, as well as feed input. Resuspension module recalculates total flux based on near bottom current speeds that exceed 9.5 cm sec^{-1}. The benthic impact module which is used to establish relationships between modeled solid flux

and benthic fauna was not employed in the present study.

The modeling results were compared with the real data of organic material accumulation obtained in the last stage of the study.

RESULTS

Current Speed and Direction

Data indicate current speeds ranging between a minimum of 0.5 cm s^{-1} (August 2008; June 2008; May 2009; June 2009) and a maximum of 10.5 cm s^{-1} (November 2008) throughout the water column. The mean current speed over the 3-year period was 2.6 cm s^{-1}. Monthly changes in current speed and direction in 2008-2009 are given in Table 2. In general, the residual current direction was southerly except in November 2008 when the residual current direction was easterly (Table 2).

Comparison of Measurement and Prediction

In 2008, mean observed deposition values per trap ranged between 163.0 and 1663.0 g m^{-2} yr^{-1} whereas predicted deposition values ranged between 25.0 and 3179.0 g m^{-2} yr^{-1} (Table 3). Table 4 shows predicted and observed solid fluxes for the farm site in 2008 and 2009. There were considerable differences (0 -4133 g m^{-2} yr^{-1}) in accumulated material collected from the same traps deployed at different times through March-August 2008 (Table 3). In addition,

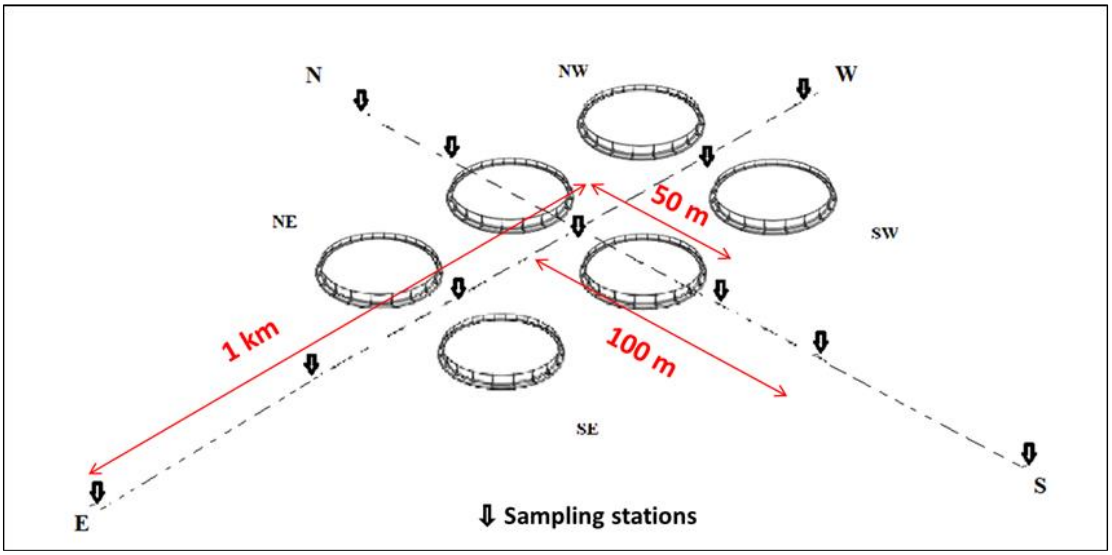

Figure 2. Schematic representation of station locations in 2008.

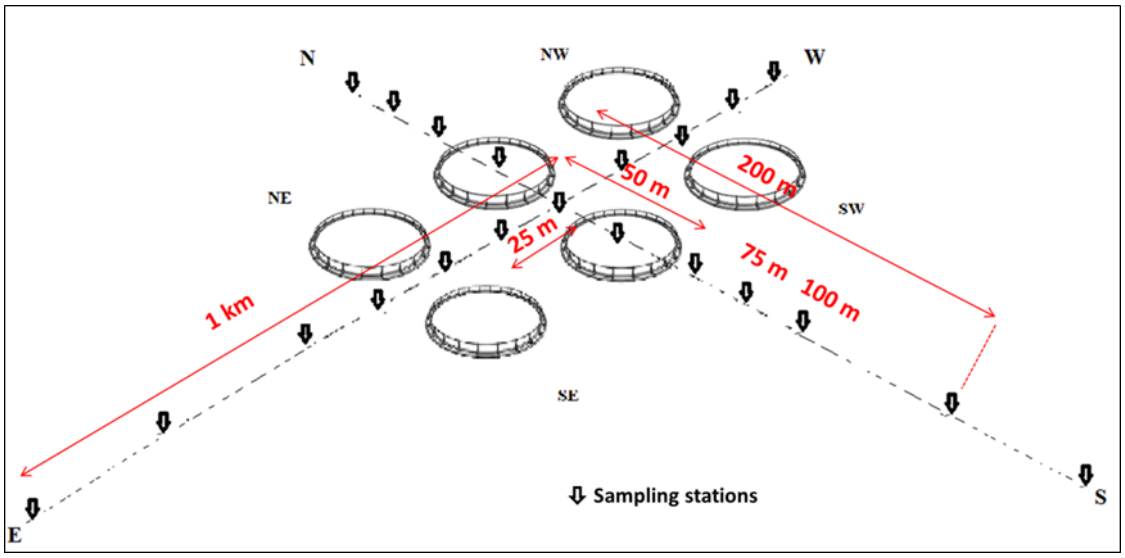

Figure 3. Schematic representation of station locations in 2009.

monthly mean fluxes ranged from a minimum of 336.7 ± 317 g m^{-2} yr^{-1} in April to a maximum of 1598.1 ± 1593 g m^{-2} yr^{-1} in June with an average of 845.0 ± 491 g m^{-2} yr^{-1} month. In 2008, due to limited number of traps, there was no data available on solid flux beyond 100 m from the center of the farm. However, flux simulation was indicated in 2008, the sphere of predicted deposition as defined by the 340 g m^{-2} yr^{-1} contour extends 110 m to the SSE and 120 m to the NW of the cages. There was no significant displacement of footprint due to lack of residual current in any direction (Figure 4) with no significant differences in observed solid flux among 4 different axes. Although the center traps received the highest deposition (1662.9 ± 1173 g m^{-2} yr^{-1}), there was no deposition gradient towards the periphery of the cages between 50 m (646.2 ± 363) and 100 m (660.3 ± 327). Control traps located 1 km away had a mean flux of 452.1 g m^{-2} yr^{-1}.

In 2009, the total mean of observed deposition rate was almost two-fold higher than that in 2008 (Table 4). Observed mean flux from 21 traps ranged from a minimum of 467.3 to a maximum of 4754.6 g m^{-2} yr^{-1} (Table 4). Deposition predictions were also higher and ranged between 9 to 4763 g m^{-2} yr^{-1}. In 2009, the sphere of predicted deposition as defined by the 400 g m^{-2} yr^{-1} contour extended 90 m to the SSE and 180 m to the NW of the cages indicated a slight displacement of the footprint due to southerly residual current (Figure 5).

Observed solid accumulation was considerably higher on the west axis (mean: 2148.48 g m^{-2} yr^{-1}) followed by the east (mean: 1334.85 g m^{-2} yr^{-1}), north (mean: 963.07 g m^{-2} yr^{-1}) and south (mean: 878.98 g m^{-2} yr^{-1}) axes. The observed deposition gradient from the center to the periphery of the cages along each transect reduced as indicated by the mean deposition rates except at 200 m. The observed deposition at the center trap was 1825.7 g m^{-2} yr^{-1} and was the third highest deposition rate after trap W1 (4754.6 g m^{-2} yr^{-1}) and E2 (1922.9 g m^{-2} yr^{-1}). Control traps located 1 km away from the cages had a mean deposition rates of 916.0 g m^{-2} yr^{-1}.

Table 2. Hydrographic data between 2007-2009. * Indicates period when sediment trap trials were carried out.

Month/Year	Mean current (cm s^{-1})	Min-max current (cm s^{-1})	Residual current direction
July/07	2.0	1.5-5.8	135.0
August/07	1.9	0.5-6.4	177.3
September/07	1.7	1.3-4.4	170.2
October/07	2.1	1.6-4.5	137.1
November/07	2.9	2.7-10.5	47.8
December/07	2.7	2.0-6.1	131.7
January/08	2.6	2.4-5.9	161.1
February/08	3.4	2.2-6.0	176.1
*March/08	2.3	2.2-4.5	179.7
*April/08	3.1	1.8-7.7	143.9
*May/08	3.6	1.7-9.5	179.3
*June/08	1.7	0.5-4.5	176.9
*August/08	4.3	1.7-6.8	191.2
September/08	3.1	1.9-7.0	133.7
January/09	3.3	3.1-5.4	177.8
March/09	1.9	1.5-2.1	142.7
April/09	1.9	1.8-7.7	158.6
May/09	2.3	0.5-5.9	130.4
June/09	1.9	0.5-2.9	131.0
*September/09	3.0	1.9-7.0	129.3
October/09	2.5	0.8-6.4	139.4

Table 3. Accumulation rate of measured organic material flux (g m^{-2} yr^{-1}) in 2008. Data are ash free dry weight (AFDW). Negative or zero values are due to subtraction from the control stations. NA: Not available due to loss of trap.

Station	March 2008	April 2008	May 2008	June 2008	August 2008	Station Mean
Center	1004	866	2912	572	2961	1662.9 ± 1173
North 1	688	11	18	4133	142	998.5 ± 1774
North 2	455	245	397	286	NA	345.6 ± 97
East 1	170	0	22	566	60	163.4 ± 234
East 2	277	162	824	3032	NA	1073.8 ± 1337
South 1	399	317	1607	1000	NA	830.7 ± 600
South 2	353	249	1371	NA	1081	763.6 ± 549
West 1	493	842	0	NA	1034	592.3 ± 454
West 2	551	339	518	NA	424	458.1 ± 96
Monthly Mean	487.8 ± 246	336.7 ± 317	852.1 ± 969	1598.1 ± 1593	950.4 ± 1076	

Table 4. Mean accumulation rate of measured and predicted organic material (g m^{-2} yr^{-1}) in sediment traps underneath the commercial farm in 2008 and 2009. Data are ash free dry weight (AFDW). Negative values are due to subtraction from control station. NA: Not available due to loss of trap.

Stations	2008 Measured (g m^{-2} yr^{-1})	2008 Predicted (g m^{-2} yr^{-1})	2009 Measured (g m^{-2} yr^{-1})	2009 Predicted (g m^{-2} yr^{-1})
Center	1663	3179	1825.7	4894
North 1	998	2425	483.5	4870
North 2	346	185	NA	4591
North 3	-	-	1148.9	2473
North 4	-	-	1256.8	682
North 5	-	-	NA	0
East 1	163	1729	807.7	3986
East 2	1074	35	1922.9	1862
East 3	-	-	1512.6	52
East 4	-	-	NA	2
East 5	-	-	1096.2	0
South 1	831	2112	467.3	4118
South 2	764	69	723.5	2130
South 3	-	-	1006.7	173
South 4	-	-	722.0	6
South 5	-	-	1475.4	0
West 1	592	1505	4754.6	4644
West 2	458	25	1278.2	3151
West 3	-	-	1516.2	393
West 4	-	-	1044.9	24
West 5	-	-	NA	0
Mean	765	1251.6	1355.5	1811.9

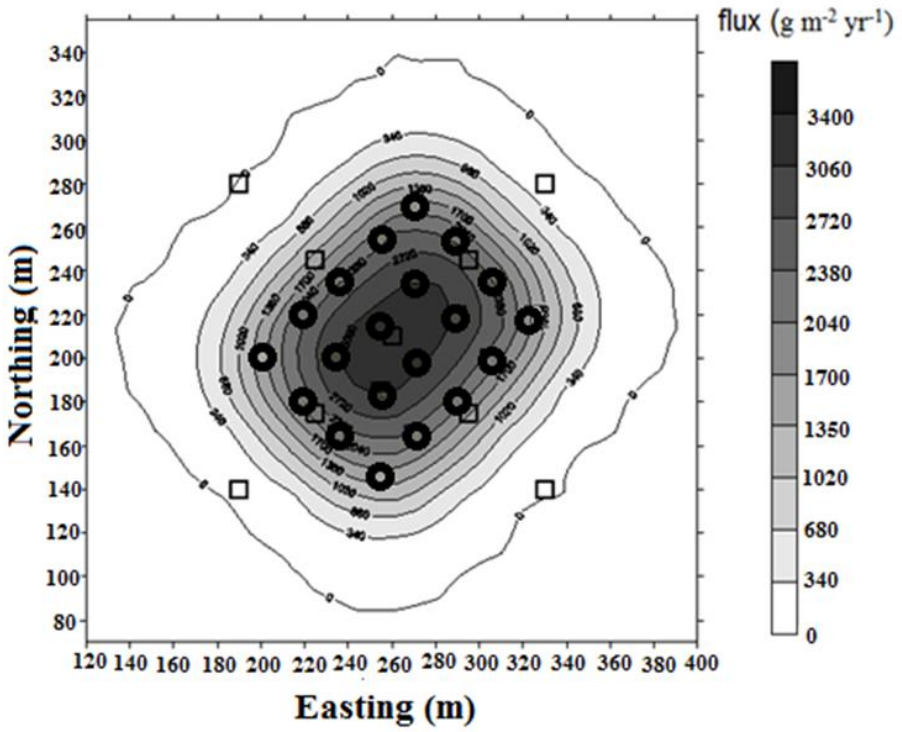

Figure 4. Predicted deposition rate (flux) of particulate organic materials derived from fecal waste and uneaten feed (g m^{-2} yr^{-1}) based on data collected in May 2008.

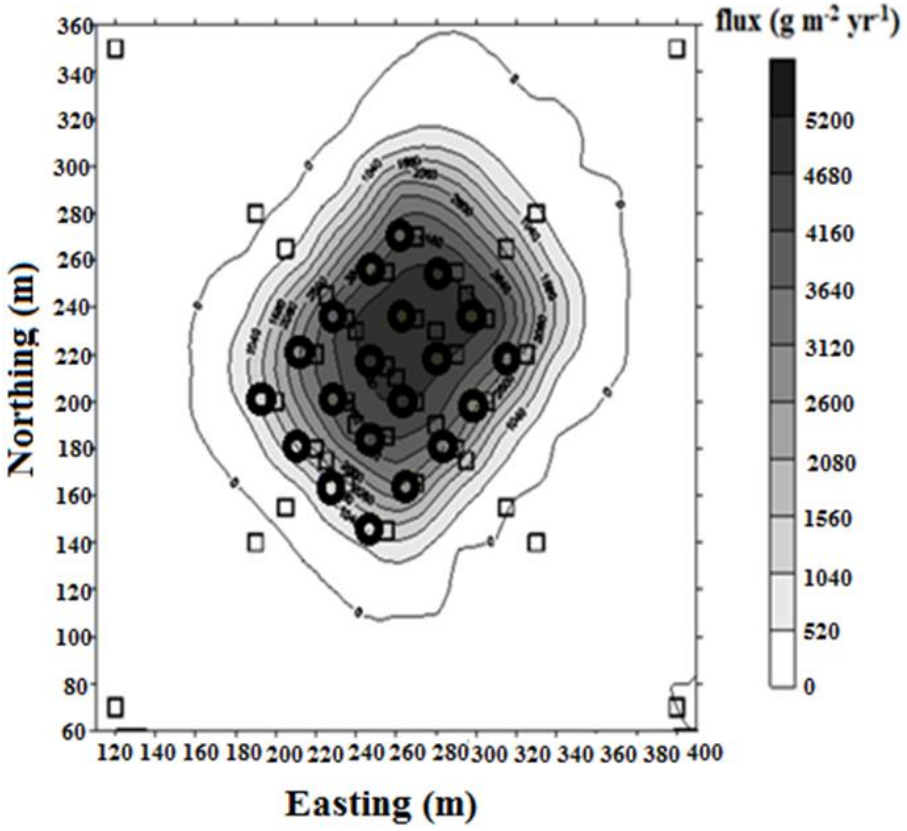

Figure 5. Predicted deposition rate (flux) of particulate organic materials derived from fecal waste and uneaten feed (g m^{-2} yr^{-1}) based on data collected in September 2009.

DISCUSSION

Current Speed and Direction

Current speeds are critical on the extent of environmental impact of cage farms as a mechanism by which organic material accumulation over the seabed is reduced and oxygen delivery to the sediment is increased (Findlay and Watling 1997). A minimum mean current speed of 10 cm s^{-1} has been reported for sustainable aquaculture and no excessive accumulation of organic material has been reported at current speeds > 8 cm s^{-1} (Yokoyama et al. 2006). Based on recording durations of min 2h and max 33 days, our results showed that over the three-year period, the mean current speed was 2.6 cm s^{-1} with min 0.5 and max 10.5 cm s^{-1} near the farm site. Short-term (for periods ranging from 2 hours to 3 days) data on current speed and direction collected every month was in good agreement with those of long-term measurements obtained during the sediment trap trials except in November 2007. Such differences in current direction are expected especially during fall and spring which are typical wet seasons in the Mediterranean when weather conditions change frequently before episodic rain events. Overall, measured current speeds do not indicate the presence of no-flow conditions and dead zones underneath the cages. However, for practical considerations, field work in the present study was performed under no wind or low wind conditions. Therefore, the influence of extreme weather conditions on current speed throughout the water column may have been underestimated. In addition, current measurements from ship board indicated bottom currents > 60 cm s^{-1} in the vicinity of the fish farm and in different parts of Gerence Bay and suggest sporadic if not regular occurrences of strong bottom currents in Gerence Bay. Such trends have limited effects on organic enrichment of the sediment (Findlay and Watling 1997) and indicate the importance of accurate and representative current measurements in farm sites with particular emphasis on near-bottom currents.

The existence of sporadic high bottom currents is also a possible explanation for differences in measured and predicted levels of flux. With such increases in current velocity, resuspension, dispersion and reduction of particulate materials on the seabed will occur (Findlay and Watling 1997; Cromey et al. 2002a). On the other hand, reported values of current speeds at which resuspension occurs are contradictory. For example, Cromey et al. (2002a) reported the critical limit for resuspension as 9.5 cm s^{-1}. In marine sediments, resuspension occurs at bottom speeds of 20-40 cm s^{-1} (Tengberg et al. 2003) whereas Dudley et al. (2000) reported a higher threshold of 33-66 cm s^{-1} for resuspension. In contrast, Doglioli et al. (2004) reported no resuspension at current speeds < 4 cm s^{-1} at depths > 30 m. Factors such as bottom topography, substrate composition and consolidation may affect the current speed at which resuspension occurs at a given site.

Comparison of Measurement and Prediction

There were discrepancies between mean measured and predicted levels of organic material flux in both experiments. In 2008, the mean predicted level of flux (1251.6 g m^{-2} yr^{-1}) was higher than the mean measured level (765.0 g m^{-2} yr^{-1}). Similarly, in 2009, the mean measured level of flux (1355.5 g m^{-2} yr^{-1}) was lesser than the predicted value (1811.9 g m^{-2} yr^{-1}). In addition, there were considerable discrepancies between measured and predicted levels of flux at each station. In this study, the measured levels of particulate waste flux in 2008 and 2009 were within reported values (133.6 - 46355 g m^{-2} yr^{-1}) (Gowen and Bradbury 1987; Kalantzi and Karakassis 2006; Kutti et al. 2007). The simulations on the dispersion of organic load was considerably lesser and indicated that a substantial proportion of the material was deposited within 50-75 m of the farm compared to observed impact area. The poor prediction by some traps especially those located on stations at 200 m from the center may be due to absence of a process in the model. Similar discrepancies have been reported (Chamberlain and Stucchi 2007; Weise et al. 2009; Cromey et al. 2012) and various factors may play a major role in discrepancies between measured and predicted levels of organic material accumulation. Among these factors, the bottom topography can be excluded as the depth underneath the cages was uniform with a flat bathymetry. It has been reported that the presence of steep underwater gradients may cause periodic slumping of material down the slope (Klaucke et al. 2000; Cromey et al. 2002a). Also, shallower sites with a depth of < 15 m may be subjected to resuspension by wind-wave activity caused by orbital fluid velocities (Cromey et al. 2002a) which was out of the scope of simulations due to the fixed depth of 50 m.

Overtime, substrate composition underneath newly established farms changes and once the farm is established, texture of the sediment underneath the cages become loose. The loose surface layer contains unconsumed feed and feces (Pawar et al. 2001) and has higher water content (88.8-95%) compared to the control station (20%) (Karakassis et al. 1998; Yokoyama et al. 2006) which is more likely to resuspended. Farm sediment thickness also changes seasonally as a factor of feeding with differences up to 50% between January and June (Karakassis et al. 1998) that indicates higher potential for resuspension when feed input is higher in warmer temperatures. These factors have varying effects on the resuspension of accumulated material and therefore, may affect the rate of solid accumulation. Location of traps from the surface of the seabed is, therefore, critical in sediment trap studies. In this study, the observed differences in the accumulated material recovered from traps in 2008 and 2009 may be due to the distance of traps from the

surface of the seabed. In 2008, the mouths of traps were 300 cm off the bottom whereas in 2009, trap mouths were 110 cm off the seabed. Therefore, the higher accumulation rates in 2009 may have been due to resuspended material reaching to the mouth of the traps in comparison to lower accumulation rates observed in 2008. Therefore, for the most accurate, site specific data, visual observations by divers or Remotely Operated Vehicles are required to determine at which current speeds resuspension occur.

Another reason for differences between measured and predicted levels of organic load is the duration of sediment trap trials. Deployment of sediment traps for shorter periods (2-5 days) is preferred to prevent or minimize potential errors due to daily cage management routines such as harvesting and net changing that potentially cause erroneous measurements. Excess biofouling and debris fallout from nets have been reported as important sources of deposit (McKindsey et al. 2009; Weise et al. 2009; Cromey et al. 2012). However, short-term trap deployments less than 2-3 days may not be practical due to the amount of material collected at stations located in low flux zones and particularly in farms with lower production capacity. For most accurate results, only feeding activity should be allowed and all other maintenance routines should be postponed including harvesting and cage maintenance during sediment trap studies. In this study, such daily routines may also explain outlier values observed in all trials and high variations in repeated monthly measures of solid accumulation in traps deployed at the same stations over March-August 2008. Although long-term experiments may provide more reliable data, strict control of experimental conditions over a period of 30 days may not be possible under commercial operations. Timing of trap studies with periods when feeding rates are highest, i.e. during summer. This may help minimize potential errors and duration of trap studies.

Another important factor that may have an effect on discrepancies between measured and predicted levels of flux is the presence of wild fish assemblages around the cage farms. Studies carried out before and after establishment of cage farms indicated a considerable increase in wild fish populations following establishment (Pearson and Black 2000; Machias et al. 2004; Vita et al. 2004; Felsing et al. 2005; Tuya et al. 2006). Daily feeding routine of stocked biomass within the cages is considered as the major factor for increased densities of wild fish assemblages (Tuya et al. 2006). The aggregative effect of fish farms on the densities of wild fish assemblages during operation are considerable and may account to 50 times higher compared to those of controls after cessation of operation (Tuya et al. 2006). The wild fish assemblages attracted to cage farms consume uneaten particles and reduce the organic load derived from feeding activity and defecation and thus may have a considerable effect on the amount of accumulated matter. For example, Vita et al. (2004) reported that up to 80% of organic particulate material may be consumed by wild fishes around cage farms and no accumulation of fish feed or feces over the sediment under cages. However, despite improved performance of their model when the effect of wild fish assemblages on feeding was accounted for in their simulations (Cromey et al. 2012) in modeling studies, due to seasonal differences in the number and species of wild fish assemblages, it may be difficult to incorporate the effects of reduction in organic material derived from cage farms. Therefore, although no such effect is expected in newly established farms, the effects of wild fish assemblages on accumulation and distribution of particulate organic materials remain to be the most important latent variable in established cage farms.

In conclusion, sediment trap studies offer a practical and inexpensive approach to characterize organic load derived from cage farms. However, validation efforts by modeling prove problematic. In this study, near-bottom currents in the farm site, resuspension of accumulated material and the presence of wild-fish assemblages are identified as three major factors that have effects on organic material accumulation and validation of model outputs. Repeated measurements of flux over a period of one month have resulted in considerable variations in consecutive trials and indicated uncontrollable temporal physical changes in sea conditions and the need for strict control of the maintenance routines in the farm site. Short-term sediment trap trials, give high capacity farms with deposition rates i.e. > 1.000 g m^{-2} yr^{-1}, may eliminate any input of particulate material due to routine farm operations and minimize variations due to seasonal differences in physical conditions of the sea. However, long-term sediment trap trials are also required for low-capacity farms and low-flux zones to determine dispersal boundaries. While only 9 traps may be adequate to measure deposition in high flux zones (i.e. 50 m from the center), > 20 traps with two replicates per station are recommended to determine the dispersal boundaries of POM. In addition to long-term, site-specific data on current speeds throughout the water column, data on near-bottom current speeds are essential and visual observations are required for verification of resuspension events underneath the cages. The effect of wild fish assemblages on the accumulation of organic material remains to be a latent variable and is unlikely to be a feasible approach in modeling studies in established farms.

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REFERENCES

Chamberlain J and Stucchi D. 2007. Simulating the effects of parameter uncertainty on waste model predictions of marine finfish aquaculture. Aquaculture, 272(1): 296-311. https://doi.org/10.1016/j.aquaculture.2007.08.051

Cromey C, Nickell T, Black K, Provost P and Griffiths C. 2002a. Validation of a fish farm waste resuspension model by use of particulate tracer discharged from a point source in a coastal environment. Estuaries, 25(5): 916-929. https://doi.org/10.1007/BF02691340

Cromey C, Nickell TD and Black KD. 2002b. DEPOMOD-modelling the deposition and biological effects of waste solids from marine cage farms. Aquaculture, 214(1): 211-239. https://doi.org/10.1016/S0044-8486(02)00368-X

Cromey CJ and Black KD. 2005. Modelling the Impacts of Finfish Aquaculture. In: Hargrave BT (ed.). Environmental Effects of Marine Finfish Aquaculture. Springer Verlag, Berlin, pp 129-155. https://doi.org/10.1007/b136008

Cromey JC, Thetmeyer H, Lampadariou N, Black KD, Kögeler J and Karakassis I. 2012. MERAMOD: predicting the deposition and benthic impact of aquaculture in the eastern Mediterranean Sea. Aquaculture Environment Interactions, 2(2): 157-176. https://doi.org/10.3354/aei00034

Doglioli AM, Magaldi MG, Vezzuli L and Tucci S. 2004. Development of a numerical model to study the dispersion of wastes coming from a marine fish farm in the Ligurian Sea (Western Mediterranean). Aquaculture, 231(1-4): 215-235. https://doi.org/10.1016/j.aquaculture.2003.09.030

Dudley R, Panchang V and Newell C. 2000. Application of a comprehensive modeling strategy for the management of net-pen aquaculture waste transport. Aquaculture, 187(3-4): 319-349. https://doi.org/10.1016/S0044-8486(00)00313-6

Felsing M, Glencross B and Telfer T. 2005. Preliminary study on the effects of exclusion of wild fauna from aquaculture cages in a shallow marine environment. Aquaculture, 243(1-4): 159-174. https://doi.org/10.1016/j.aquaculture.2004.09.033

Findlay RH and Watling L 1997. Prediction of benthic impact for salmon net-pens based on the balance of benthic oxygen supply and demand. Marine Ecology Progress Series, 155(1): 147-157. https://doi.org/10.3354/meps155147

Gowen R and Bradbury NB. 1987. The ecological impact of salmonid farming in coastal waters: a review. Oceanography and Marine Biology Annual Review, 25(1): 563-575. https://doi.org/10.1016/0198-0254(88)92716-1

Gyllenhammar A and Håkanson L. 2005. Environmental consequence of fish farm emissions related to different scales and exemplified by data from the Baltic- a review. Marine Environmental Research, 60(2): 211-243. https://doi.org/10.1016/j.marenvres.2004.10.005

Henderson A, Gamito S, Karakassis I, Pederson P and Smaal A. 2001. Use of hydrodynamic and benthic models for managing environmental impacts of marine aquaculture. Journal of Applied Ichthyology, 17(4): 163-172. https://doi.org/10.1046/j.1439-0426.2001.00313.x

Holmer M. 1991. Impacts of aquaculture on surrounding sediments: generation of organic-rich sediments. In: De Pauw N and Joyce, J (eds). Aquaculture and the environment. Special Publication European Aquaculture Society, pp. 155-175.

Iwama G. 1991. Interactions between aquaculture and the environment.Critical Review in Environmental Control, 21(2): 177-216. https://doi.org/10.1080/10643389109388413

Kalantzi L and Karakassis I. 2006. Benthic impacts of fish farming: meta-analysis of community and geochemical data. Marine Pollution Bulletin, 52(5): 484-493. https://doi.org/10.1016/j.marpolbul.2005.09.034

Karakassis I, Pitta P and Krom MD. 2005. Contribution of fish farming to the nutrient loading of the Mediterranean. Scientia Marina, 69(2): 313-321. https://doi.org/10.3989/scimar.2005.69n2313

Karakassis I, Tsapakis M and Hatziyanni E. 1998. Seasonal variability in sediment profiles beneath fish farm cages in the Mediterranean. Marine Ecology Progress Series, 162(1): 243-252. https://doi.org/252. 10.3354/meps162243

Karakassis I. 2001. Ecological Effects of Fish Farming in the Mediterranean. In: Uriarte A and Basurco B (eds). Environmental Impact Assessment of Mediterranean Aquaculture Farms. Zaragoza: CIHEAM, Cahiers Options Méditerranéennes, 55(2): 15-22. http://om.ciheam.org/article.php?IDPDF=1600217

Klaucke I, Savoye B and Cochonat P. 2000. Patterns and processes of sediment dispersal on the continental slope off Nice, SE France. Marine Geology, 162(2-4): 405-422. https://doi.org/10.1016/S0025-3227(99)00063-8

Kutti T, Ervik A and Hansen PK. 2007. Effects of organic effluents from a salmon farm on a fjord system. I. Vertical export and dispersal processes. Aquaculture, 262(2-4): 367-381. https://doi.org/10.1016/j.aquaculture.2006.10.010

Machias A, Karakassis I, Labropoulou M, Somarakis S, Papadopoulou KN and Papaconstantinou C. 2004. Changes in wild fish assemblages after the establishment of a fish farming zone in an oligotrophic marine ecosystem. Estuarine, Coastal and Shelf Science, 60(4): 771-779. https://doi.org/10.1016/j.ecss.2004.03.014

Mantzavrakos E, Kornaros M, Lyberatos G and Kaspiris P. 2007. Impacts of a marine fish farm in Argolikos Gulf (Greece) on the water column and the sediment. Desalination, 210(1-3): 110-124. https://doi.org/10.1016/j.desal.2006.05.037

McKindsey CW, Lecuona M, Huot M and Weise AM. 2009. Biodeposit production and benthic loading by farmed mussels and associated tunicate epifauna in Prince Edward Island. Aquaculture, 295(1-2): 44-51. https://doi.org/10.1016/j.aquaculture.2009.06.022

Neofitou N and Klaoudatos S. 2008. Effect of fish farming on the water column nutrient concentration in a semi-enclosed gulf of the Eastern Mediterranean. Aquaculture Research, 39(5): 482-490. https://doi.org/10.1111/j.1365-2109.2008.01900.x

Pawar V, Matsuda O, Yamamoto T, Hashimoto T and Rajendran N. 2001. Spatial and temporal variations of the sediment quality in and around fish cage farms: a case study of the Seto Inland Sea, Japan. Fisheries Science, 67(4): 619-627. https://doi.org/10.1046/j.1444-2906.2001.00298.x

Pearson TH and Black KD. 2000. The Environmental Impacts of Marine Fish Cage Culture. In: Black KD (ed). Environmental Impacts of Aquaculture. Sheffield Academic Press, Sheffield, pp. 1-31.

Pérez OM, Telfer TC, Beveridge MCM and Ross LG. 2002. Geographical information system (GIS) as a simple tool to aid modeling of particulate waste distribution at marine fish cage farms. Estuarine, Coastal and Shelf Science, 54(4): 761-768. https://doi.org/10.1006/ecss.2001.0870

Pillay TVR. 1992. Aquaculture and the Environment. John Wiley and Sons, Inc., New York. 180-188. https://doi.org/10.2134/jeq1992.00472425002100040039x

Rapp P, Ramírez WR, Rivera JA, Carlo M and Luciano R. 2007. Measurement of organic loading under an open-ocean aquaculture cage, using sediment traps on the bottom. Journal of Applied Ichthyology, 23(6): 661–667. https://doi.org/10.1111/j.1439-0426.2007.00900.x

Read P and Fernandes T. 2003. Management of environmental impacts of marine aquaculture in Europe. Aquaculture, 226(1-4): 139-163. https://doi.org/10.1016/S0044-8486(03)00474-5

Silvert W and Cromey CJ. 2001. Modelling Impacts. In: Black KD (ed.). Environmental Impacts of Aquaculture. Sheffield Academic Press, Sheffield, pp. 154-181.

Tengberg A, Almroth E and Hall P. 2003. Resuspension and its effects on organic carbon recycling and nutrient exchange in coastal sediments: in situ measurements using new experimental technology. Journal of Experimental Marine Biology and Ecology, 285(2): 119-142. https://doi.org/10.1016/S0022-0981(02)00523-3

Troel M and Norberg J. 1998. Modelling output and retention of suspended solids in an integrated salmon-mussel culture. Ecological Modelling, 110(1): 65-77. https://doi.org/10.1016/S0304-3800(98)00042-8

Tuya F, Sanchez-Jerez P, Dempster T, Boyra A and Haroun RJ. 2006. Changes in demersal wild fish aggregations beneath a sea-cage farm after the cessation of farming. Journal of Fish Biology, 69(3): 682-697. https://doi.org/10.1111/j.1095-8649.2006.01139.x

Vita R, Marin A, Madrid JA, Jimenez-Bringuis B, Cesar A and Marin-Guirao L. 2004. Effects of wild fishes on waste exportation from a Mediterranean fish farm. Marine Ecology Progress Series, 277(1): 253-261. https://doi.org/10.3354/meps277253

Weise AM, Cromey CJ, McKindsey CW, Callier MD and Archambault P. 2009. Shellfish-DEPOMOD: modelling the biodeposition from suspended shellfish aquaculture and assessing benthic effects. Aquaculture, 288(1): 239-253. https://doi.org/10.1016/j.aquaculture.2008.12.001

Yokoyama H, Abo K and Ishihi I. 2006. Quantifying aquaculture-derived organic matter in the sediment in and around a coastal fish farm using stable carbon and nitrogen isotope ratios. Aquaculture, 254: 411-425. https://doi.org/10.1016/j.aquaculture.2005.10.024

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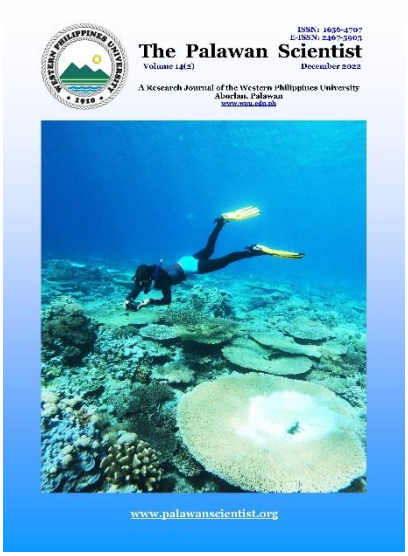

Length-weight relationships of eight discarded flatfish species from Gallipoli Peninsula (Northern Aegean Sea, Türkiye): An evaluation for ecosystem-based fisheries management

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ABSTRACT

The fishing management authorities are in need of some biometric throughput and analysis with a view to the administration and protection of fishery stocks. The inputs regarding the lengths and weights of fish species have frequently been taken into account in order to divulge biological information. In the present research, length-weight relationships were extrapolated for discarded eight flatfishes off Gallipoli Peninsula (Northern Aegean Sea, Türkiye). From January 2017 to December 2017, a total of 142 individuals of eight species (*Arnoglossus imperialis*, *Arnoglossus laterna*, *Arnoglossus rueppelii*, *Arnoglossus thori*, *Symphurus nigrescens*, *Microchirus ocellatus*, *Microchirus varieagatus*, *Monochirus hispidus*) belonging to three families (Bothidae, Cynoglossidae, Soleidae) were collected from commercial fishermen's catches. The length-weight relationships' slopes (*b*) varied from 2.64 to 3.41. Every length-weight relationships was statistically significant ($P < 0.0001$). This paper embodies preliminary data on the LWRs of discarded eight flatfishes for the Gallipoli Peninsula (Northern Aegean Sea, Türkiye). Hence, data on the discarded fish species is of importance when keeping in view sustainable ecosystem-based fisheries management and, in the continuation of the long-dated investigations of the length-weight relationships of the fish species in question. This must be performed on an ongoing basis so as to monitor the current state of fish stocks. The stakeholders could utilize the results of the present research in the coming times.

Keywords: Fish biology, Gallipoli Peninsula, Northern Aegean Sea, Türkiye

INTRODUCTION

Since the late 1800s, researchers have been studying the length-weight relationships (LWRs) of fish species, and the method in question has been regarded as a valuable tool for characterizing numerous biological characteristics (Le Cren 1951; Froese 2006; Freitas et al. 2017) and to understand the management and sustainable exploitation of fish communities (Anene 2005; Al Kamel et al. 2020), up to the present. When estimating population increase in fish stocks, the length-weight relationship is frequently the initial step (Hercos et al. 2021) and because regional or temporal differences may have occurred, it should be examined and reviewed on a regular basis. As a result, information regarding the length-weight relationship is critical for the conservation of fish stocks and the implementation of

fisheries management plans (Acarli et al. 2022). They are helpful for (1) figuring out weights from smoother length measurements (Santos et al. 2002), (2) deciding if either somatic growth is allometric or isometric (Ricker 1975), (3) estimating weight-at-age, (4) conjecturing fish condition, and (5) figuring out morphologic analogies of species from various areas (Ricker 1975; Petrakis and Stergiou 1995; Stergiou and Moutopoulos 2001). Additionally, the studies of the length-weight relationships become important because of the requirement to understand the fish life cycle, particularly in areas where fishing is one of the most significant sectors and fish populations are the primary food supply for many traditional people (Freitas et al. 2014).

The number of studies regarding fisheries has traditionally focused on commercially important fish stocks, whereas the attention towards less economically significant fishery sources has decreased in recent years (Jørgensen et al. 2016). Most low-value fishes have an environmentally vital function in the marine ecosystem, and several of these animals are used as fish food in many coastal nations (FAO 2019; Han et al. 2021). For ecosystem-based fisheries management, it is critical to conceive the biological data of these animals (Pikitch et al. 2004; Zhang et al. 2016).

The order Pleuronectiformes were first named in 1758 by Linnaeus; “pleuro” meaning “on side” and “necto” meaning “swim”. The flatfishes are easy to recognize since this is the only group of fishes that is not bilaterally symmetrical. The ventral side of the body is eyeless and white, while the dorsal is dark and has both eyes. They swim by the undulation of the body, and usually remain close to the bottom of the continental shelf (Aung et al. 2019). It encapsulates 793 species in 16 families, worldwide (Froese and Pauly 2022). As far as it is known, 26 species in six families (Bothidae, Citharidae, Pleuronectidae, Scopthalmidae, Soleidae, Cynoglossidae) from Turkish territorial waters were reported (Bilecenoğlu et al. 2014).

Although Gallipoli Peninsula (Northern Aegean Sea, Türkiye) exhibits the diversity in terms of the species’composition, information concerning the length-weight relations (LWRs) of the fish species in the area is still inadequate, especially for discarded fish species. This study included preliminary data on the LWRs of eight flatfishes [*Arnoglossus imperialis* (Rafinesque, 1810); *Arnoglossus laterna* (Walbaum, 1792); *Arnoglossus rueppelii* (Cocco, 1844); *Arnoglossus thori* (Kyle, 1913); *Symphurus nigrescens* (Rafinesque, 1810); *Microchirus ocellatus* (Linnaeus, 1758); *Microchirus varieagatus* (Donovan, 1808); *Monochirus hispidus* (Rafinesque, 1814)], which are discarded fish species in the Gallipoli Peninsula (Northern Sea, Türkiye) commercial fisheries and compares these results with the previous studies in different areas of Mediterranean Basin. The studies on the LWRs of the species at issue have been carried out in different regions of the Mediterranean Basin (Lamprakis et al. 2003; Karakulak et al. 2006; Özaydın and Taskavak 2006; Özaydın et al. 2007; Bayhan et al. 2008; Çakır et al. 2008; Ilkyaz et al. 2008; Karachile and Stergiou 2008; Özekinci et al. 2009; Giacalone et al. 2010; Bilge et al. 2014; Altın et al. 2015; Yapıcı et al. 2015). Hence, the data on these species are vastly needed to have a better understanding of the functioning of any marine ecosystem and will make a significant contribution to the scientific literature for fisheries managers.

METHODS

The Mediterranean Basin has an oligotrophic feature, whereas the eastern Mediterranean exists its highest oligotrophic part (Psarra et al. 2000). Along the North-South line of the Aegean Sea, there is a tendency parallel to declining basic production values (Antoine et al. 1995; Gönülal and Dalyan 2017). That's why, the northern Aegean territories are qualified by a long oceanic crust, flat sandy/muddy land, and high nutrient contents (Maravelias and Papaconstantinou 2006) and when compared with the southern Aegean territories, these areas are higher for zooplankton and phytoplankton abundance (Theocharis et al. 1999). The northern Aegean coasts of Türkiye are separated into sub-regions to be the Edremit and Saros Bays, the Bozcaada and Gökceada Islands and the Gallipoli Peninsula (Cengiz 2021; Cengiz and Paruğ 2021). For the reasons stated above, the Gallipoli Peninsula exhibits diversity in terms of the species’ composition and is also considered an important fishing area (Cengiz et al. 2012) (Figure 1).

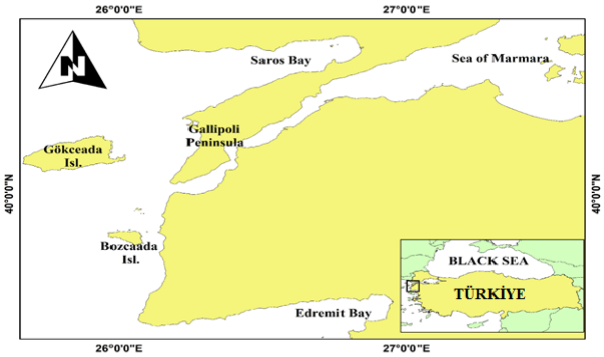

Figure 1. Gallipoli Peninsula and the northern Aegean coasts of Türkiye.

Samples were obtained from commercial fishermen’s catches around Gallipoli Peninsula during the period of January 2017 - December 2017. The criteria of Mater et al. (2011) were used to identify the

fish. In agreement with Froese and Pauly (2022), the scientific names for each species were checked. The individuals were measured to the nearest centimeter (total length) and weighed to the nearest 0.01 g (total weight). Length-weight relationships were calculated by applying an exponential pattern, $W = aL^b$ (Le Cren 1951). The exponential curve's parameters *a* and *b* were calculated using the least-squares method over log-transformed data $\log W = \log a + b \log L$, where *W* is total weight (g), where *b* is the slope of the linear regression (exponent indicating the growth type), *a* is the intercept (coefficient related to body form), and *W* is the total weight (g), *L* is the total length (cm), using the least-squares method. The determination coefficient, R^2, was used to calculate the degree of correlation between the variables. Excel 2010 for Windows was used to calculate the variables of linear relationships. Student's t-test was used to determine fish growth types using the equation of Sokal and Rohlf (1987): ts = (*b* – 3) / SE(b), where SE(*b*) is the standard error of the slope, *b* is the slope, and ts is the t-test value. The growing style of fish is determined by the *b* value. Hereby, $b > 3$ denotes positive allometric growth, whereas $b < 3$ denotes negative allometric growth. When the value of *b* equals 3, the growth is isometric (Bagenal and Tesch 1978). SPSS 19 was used to assess all statistical analyses at a 5% significance level.

RESULTS

During the research period, 142 individuals of eight species (*Arnoglossus imperialis*, *Arnoglossus laterna*, *Arnoglossus rueppelii*, *Arnoglossus thori*, *Symphurus nigrescens*, *Microchirus ocellatus*, *Microchirus varieagatus*, *Monochirus hispidus*) belonging to three families (Bothidae, Cynoglossidae, Soleidae) was evaluated. For each species, the sample size, length and weight ranges, estimated parameters of LWR (*a* and *b*), 95% confidence intervals and standard error of *b* value and coefficient (R^2) are shown in Table 1, respectively. Length values of the catch varied from 8.2 cm (*Arnoglossus rueppelii*) to 18.0 cm (*Arnoglossus laterna*) whereas values of weight observed between 8.78 g (*Arnoglossus rueppelii*) to 234.82 g (*Arnoglossus laterna*). The coefficients of determination (R^2) ranged from 0.95 to 0.98, and all regressions were highly significant ($P < 0.0001$). While three species (*Arnoglossus imperialis*, *Arnoglossus laterna*, *Arnoglossus thori*) showed positive allometry growth regarding the growth type, four species (*Arnoglossus rueppelii*, *Microchirus ocellatus*, *Microchirus varieagatus*, *Monochirus hispidus*) displayed negative allometry growth. One species (*Symphurus nigrescens*) presented isometric growth. The values of *b* were observed from 2.64 to 3.41, while values of *a* varied between 0.0037 to 0.0681 (Figure 2).

Table 1. Length-weight relationships for discarded eight flatfish species from Gallipoli Peninsula (Northern Aegean Sea, Türkiye). N: Sample size; *a* and *b*: intercept and slope of length-weight relations; CI: confidence interval; SE: standard error; R^2: the coefficient of determination

Family	Species	N	Length range (cm)	Weight range (g)	*a*	*b*	95% *CI* of *b*	*SE*(*b*)	R^2
Bothidae	*Arnoglossus imperialis*	23	8.4-14.8	5.00-27.77	0.0045	3.26	2.88-3.64	0.1809	0.95
	Arnoglossus laterna	30	8.8-18.0	4.59-42.79	0.0044	3.18	3.03-3.34	0.0742	0.98
	Arnoglossus rueppelii	10	8.2-15.1	4.00-25.00	0.0078	2.92	2.56-3.29	0.1575	0.97
	Arnoglossus thori	16	8.3-13.4	4.85-25.00	0.0037	3.41	3.01-3.80	0.1826	0.96
Cynoglossidae	*Symphurus nigrescens*	10	9.1-12.1	9.00-19.00	0.0112	3.00	2.42-3.55	0.2449	0.95
Soleidae	*Microchirus ocellatus*	11	10.2-13.5	17.78-39.00	0.0321	2.70	2.34-3.05	0.1581	0.97
	Microchirus variegatus	25	9.8-15.2	12.20-37.00	0.0226	2.74	2.35-3.12	0.1877	0.95
	Monochirus hispidus	17	9.6-14.0	13.55-33.01	0.0681	2.64	2.25-3.02	0.1153	0.96

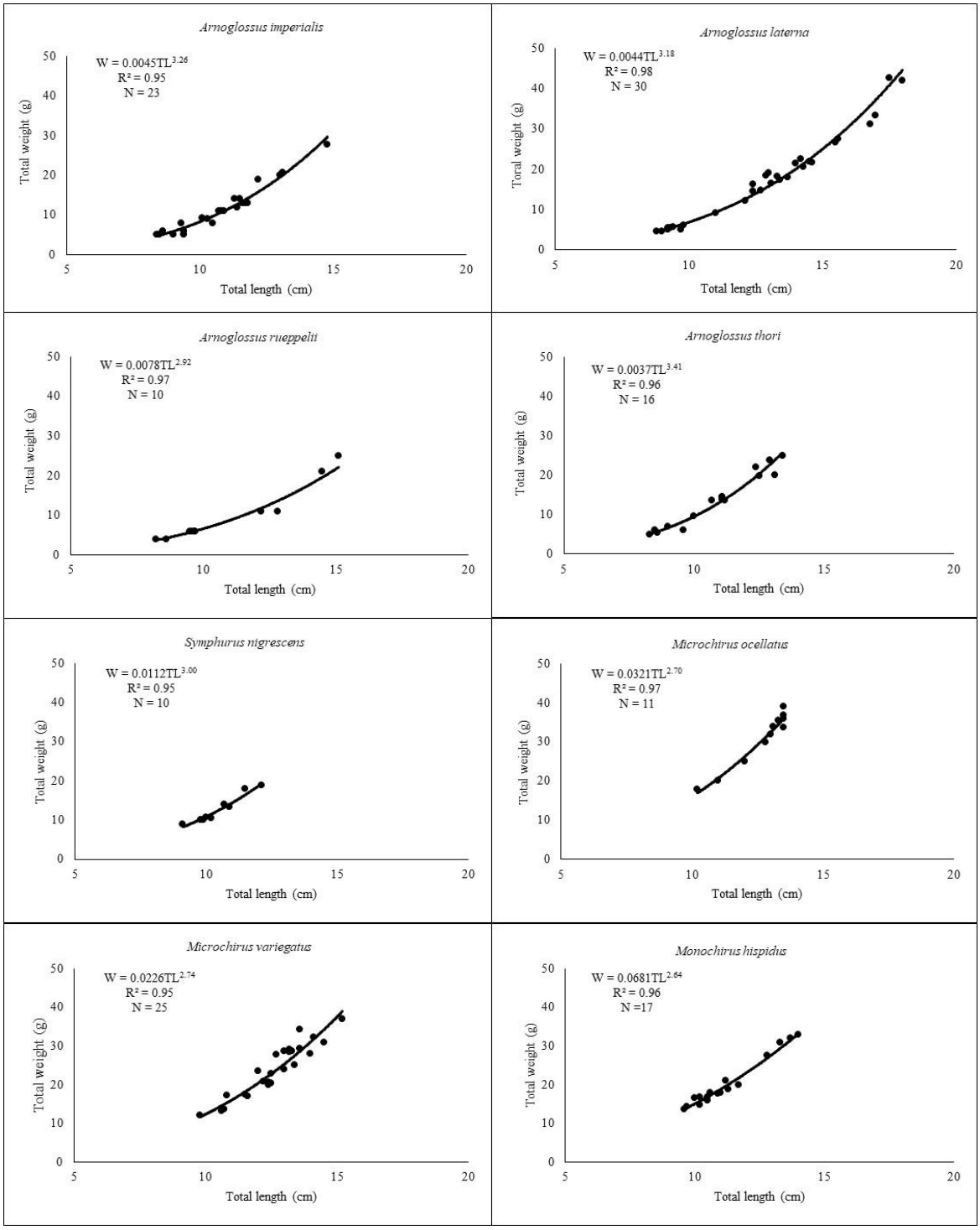

Figure 2. The curves of length-weight relationships of discarded eight flatfish species from Gallipoli Peninsula (Northern Aegean Sea, Türkiye).

DISCUSSION

Table 2 displays the comparison of the present study with the previous ones. In LWRs, the values of *b* ranged from 2.5 to 3.5 (Carlander 1969) or between 2 and 4 (Tesch 1971). The values of *b* ranged between 2.64 (*Monochirus hispidus*) and 3.41 (*Arnoglossus thori*) in this research. The tested fish species' *b* values were within these predicted limits. Although Jellyman et al. (2013) and Valle et al. (2021) accentuated that numerous reasons like season, location, fishing gear, and sex can affect length-weight relationships, Ricker

(1975) and Cengiz et al. (2019) explained that differences in *b* values can be influenced by ecological factors such as species-specific biological properties, environmental factors, and survey period. Likewise, Moutopoulos and Stergiou (2002) explained that variances in *b* values might be connected to sample size, seasonal circumstances, and sampling area, but Cabbar and Yigin (2021) justified that fishing gears' selectivity and depth of sampling have also influenced the results. The coefficient of determination (R^2) ranged between 0.95 and 0.98. While Silva-Junior et al. (2011) noted that small determination coefficients (under 0.95) might appear when a population has a small range of size, Cabbar and Yigin (2021) pointed out that a large determination coefficient indicates a wide range of sizes and a large number of individuals.

Jørgensen et al. (2016) emphasized that in recent years, with the exercise of ecosystem-based fisheries management (EBFM), interest in the conservation of resources with little or no economic importance has grown. Discards are commonly consist of undersized individuals of commercial species and non-commercial species (Demestre et al. 2018; Soykan et al. 2019). Because discarded fish species are important for biodiversity and also could influence the abundance of target species, the understanding of their population dynamics and/or life history is significant both due to interspecific relationships (Yapıcı and Filiz 2014) and for ecosystem-based fisheries management to conserve the marine ecosystems and their continuation (Browman and Stergiou 2004; Gullestad et al. 2014). As a result, extensive research on discarded fish species is both keystone for sustainable fisheries management and essential for uncovering their ecological features on the marine food chain (Alverson et al. 1994).

The present study extrapolated, for the first time, the length-weight relationships of discarded eight flatfishes in the gillnet fishery for the Gallipoli Peninsula. These values own major significance since they specify fish growth patterns, which in turn are requisite for improving of ecosystem-based fisheries management and could be used as a reference for further biological investigations and management of species in question in different regions of the Mediterranean, Aegean Sea, or worldwide. Moreover, further legislative efforts for ecosystem-based fisheries management in Gallipoli Peninsula must reveal essential biological parameters such as growth, age, feeding, and reproduction of these species, as well as discard data such as discarded ratios and discarded amount. In addition, more researches need to be performed to figure out the intraspecific/interspecific relations of discarded species. Lastly, the information obtained from the present study should be disseminated to stakeholders (fisheries scientists, fishing management authorities, etc.).

Table 2. The length-weight relationships of discarded flatfishes from previous studies in different areas. N: Sample size; *a* and *b*: intercept and slope of length-weight relationships. [1] first L-W relationships reference for the Gallipoli Peninsula, Northern Aegean Sea, Türkiye.

Species	References	Area	Sampling gear	Sampling period	N	Length range (cm)	Weight range (g)	*a*	*b*
Arnoglossus imperialis[1]	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	36	7.6-15.2	3.00-28.64	0.0039	3.29
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	23	8.4-14.8	5.00-27.77	0.0045	3.26
Arnoglossus laterna[1]	Karakulak et al. (2006)	Gökceada Island (Türkiye)	Gill net	March 2004 - February 2005	8	7.6-18.3	-	0.0150	2.74
	Özaydın & Taşkavak (2006)	Izmir Bay (Türkiye)	Beach seine, Gill net, Bottom trawl	1998 - 2001	721	6.8-21.9	2.30-79.40	0.0052	3.16
	Özaydın et al. (2007)	Izmir Bay (Türkiye)	Bottom trawl	February 2005 - December 2005	1078	4.5-14.9	-	0.0097	2.90
	Bayhan et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	January 2002 - December 2002	796	5.6-17.1	1.20-37.83	0.0073	3.00
	Çakır et al. (2008)	Edremit Bay (Türkiye)	Bottom trawl	September 1997 - September 2000	328	5.5-20.5	8.40-392.41	0.00002	3.24
	İlkyaz et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	June 2005 - May 2006	1629	5.5-19.8	-	0.0071	3.05

Species	References	Area	Sampling gear	Sampling period	N	Length range (cm)	Weight range (g)	*a*	*b*
	Karachle & Stergiou (2008)	Thermaikos Gulf (Grecee)	Gill net, Purse seine, Trawl	June 2001 - January 2006	212	4.5-16.9	-	0.0032	3.32
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	57	8.8-20.2	4.31-62.42	0.0046	3.18
	Giacalone et al. (2010)	Gulf of Castellammare (Italy)	Bottom trawl	Summer 2004 - Spring 2005	1455	4.0-16.0	-	0.0093	2.97
	Bilge et al. (2014)	Southern Aegean Sea (Türkiye)	Bottom trawl	December 2009 - November 2010	1305	4.5-14.9	-	0.0092	2.92
	Altın (2015)	Gökceada Island (Türkiye)	Beach seine, Beam trawl	June 2013 - June 2014	11	4.3-10.7	0.49-11.21	0.0050	3.23
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	30	8.8-18.0	4.59-42.79	0.0044	3.18
Arnoglossus rueppelii[1]	Lamprakis et al. (2003)	Thracian Sea (Grecee)	Bottom trawl	1996 - 1998	72	5.5-15.7	-	0.0077	2.88
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	13	7.5-16.2	3.00-33.00	0.0081	2.91
	Giacalone et al. (2010)	Gulf of Castellammare (Italy)	Bottom trawl	Summer 2004 - Spring 2005	26	5.0-10.0	-	0.0049	3.08
	Bilge et al. (2014)	Southern Aegean Sea (Türkiye)	Bottom trawl	December 2009 - November 2010	126	4.7-11.9	-	0.0037	3.17
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	10	8.2-15.1	4.00-25.00	0.0078	2.92
Arnoglossus thori[1]	Lamprakis et al. (2003)	Thracian Sea (Grecee)	Bottom trawl	1996 - 1998	572	3.8-12.6	-	0.0060	3.15
	Karakulak et al. (2006)	Gökceada Island (Türkiye)	Gill net	March 2004 - February 2005	8	8.5-11.2	-	0.0068	3.12
	Özaydın et al. (2007)	Izmir Bay (Türkiye)	Bottom trawl	February 2005 - December 2005	20	6.17.9	-	0.0288	2.47
	Bayhan et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	January 2002 - December 2002	6	6.7-9.0	2.52-5.04	0.0442	2.16
	Çakır et al. (2008)	Edremit Bay (Türkiye)	Bottom trawl	September 1997 - September 2000	170	6.5-22.5	1.59-83.87	0.00001	2.94
	İlkyaz et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	June 2005 - May 2006	371	4.4-12.5	-	0.0054	3.26
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	15	8.0-13.1	3.84-23.80	0.0026	3.56
	Giacalone et al. (2010)	Gulf of Castellammare (Italy)	Bottom trawl	Summer 2004 - Spring 2005	73	6.5-10.5	-	0.0108	2.98
	Bilge et al. (2014)	Southern Aegean Sea (Türkiye)	Bottom trawl	December 2009 - November 2010	121	6.8-9.9	-	0.0328	2.39
	Altın (2015)	Gökceada Island (Türkiye)	Beach seine, Beam trawl	June 2013 - June 2014	71	3.9-12.4	0.45-18.15	0.0060	3.14
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	16	8.3-13.4	4.85-25.00	0.0037	3.41
Symphurus nigrescens[1]	Lamprakis et al. (2003)	Thracian Sea (Grecee)	Bottom trawl	1996 - 1998	406	4.7-13.0	-	0.0029	3.45

Species	References	Area	Sampling gear	Sampling period	N	Length range (cm)	Weight range (g)	*a*	*b*
	İlkyaz et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	June 2005 - May 2006	182	7.3-12.2	-	0.0088	2.98
	Karachle & Stergiou (2008)	Thermaikos Gulf (Grecee)	Gill net, Purse seine, Trawl	June 2001 - January 2006	10	6.4-11.9	-	0.0024	3.41
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	7	9.8-10.09	10.09-14.02	0.0075	3.15
	Yapıcı et al. (2015)	Southern Aegean Sea (Türkiye)	Bottom trawl	October 2011 - December 2011	10	7.8-10.6	-	0.0027	3.49
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	10	9.1-12.1	9.00-19.00	0.0112	3.00
Microchirus ocellatus[1]	İlkyaz et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	June 2005 - May 2006	6	7.7-12.7	-	0.0079	3.25
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	8	10.3-13,7	18.81-42.43	0.0326	2.72
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	11	10.2-13.5	17.78-39.00	0.0321	2.70
Microchirus variegatus[1]	Karakulak et al. (2006)	Gökceada Island (Türkiye)	Gill net	March 2004 - February 2005	10	10.1-14.6	-	0.0137	3.02
	İlkyaz et al. (2008)	Izmir Bay (Türkiye)	Bottom trawl	June 2005 - May 2006	36	8.1-14.1	-	0.0044	3.31
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	29	10.1-15.5	12.20-39.40	0.0162	2.87
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017-December 2017	25	9.8-15.2	11.98-37.00	0.0226	2.74
Monochirus hispidus[1]	Karachle & Stergiou (2008)	Thermaikos Gulf (Grecee)	Gill net, Purse seine, Trawl	June 2001 - January 2006	24	9.2-12.8	-	0.0537	2.45
	Özekinci et al. (2009)	Saros Bay (Türkiye)	Bottom trawl	September 2006 - September 2008	15	9.7-13.7	14.40-32.01	0.0565	2.43
	This study	Gallipoli Peninsula (Türkiye)	Gill net	January 2017 - December 2017	17	9.6-14.0	13.55-33.01	0.0681	2.64

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REFERENCES

Acarli D, Kale S and Çakır K. 2022. Length-weight relationships of eighteen fishes and a cephalopod from Gökçeada Island, Northern Aegean Sea, Turkey. Thalassas, 38(1): 479-486. https://doi.org/10.1007/s41208-022-00408-6

Al Kamel NAM, Becheker A and Kara HM. 2020. Length-weight relationship of three commercially important fish species from Mocka water, southern Red Sea, Yemen. Journal of Applied Ichthyology, 36(3): 366-368. https://doi.org/10.1111/jai.14012

Altın A, Ayyıldız H, Kale S and Alver C. 2015. Length-weight relationships of forty-nine fish species from shallow waters of Gokceada Island, northern Aegean Sea. Turkish Journal of Zoology, 39(5): 971-975. https://doi.org/10.3906/zoo-1412-15

Alverson DL, Freeberg MH, Pope JG and Murawski SA. 1994. A global assesment on fisheries bycatch and discards. FAO Fisheries Technical Paper, No: 339, Rome. 223pp.

Anene A. 2005. Condition factors of four cichlid species of a man-made lake in Imo stat, Southeast, Nigeria. Turkish Journal of Fisheries Aquatic Sciences 5(1): 43-47.

Antoine D, Morel A and André JM. 1995. Algal pigment distribution and primary production in the eastern Mediterranean as derived from coastal zone color scanner observations. Journal of Geophysical Research, 100(C-8): 16193-16209. https://doi.org/10.1029/95JC00466

Aung TH, Latt MM and Oo YN. 2019. Diversity and similarity of flatfishes (Order- Pleuronectiformes) in Mon State, Myanmar. International Marine Science Journal, 1(1): 28-37. https://doi.org/10.14302/issn.2643-0282.imsj-18-2486

Bagenal TB and Tesch FW. 1978. Methods for Assessment of Fish Production in Fresh Waters. In: Bagenal T (ed). Age and growth. Oxford: IBP Handbook No. 3, Blackwell Science Publications, pp. 101-136.

Bayhan B, Sever TM and Taşkavak E. 2008. Length-weight relationships of seven flatfishes (Pisces: Pleuronectiformes) from Aegean Sea. Turkish Journal of Fisheries Aquatic Sciences, 8(2): 377-389.

Bilecenoğlu M, Kaya M, Cihangir B and Çiçek E. 2014. An updated checklist of the marine fishes of Turkey. Turkish Journal of Zoology, 38(6): 901-929. https://doi.org/10.3906/zoo-1405-60

Bilge G, Yapıcı S, Filiz H and Cerim H. 2014. Weight-length relations for 103 fish species from the southern Aegean Sea, Turkey. Acta Ichthyologica et Piscatoria, 44(3): 263-269. https://doi.org/10.3750/AIP2014.44.3.11

Browman H and Stergiou K. 2004. Perspectives on ecosystem-based approaches to the management of marine resources. Marine Ecology Progress Series, 274: 269-303. https://doi.org/10.3354/meps274269

Cabbar K and Yigin C.Ç. 2021. Length-weight relationships of elasmobranch species from Gökçeada Island in the Northern Aegean Sea. Thalassas, 37(5): 497-504. https://doi.org/10.1007/s41208-021-00350-z

Carlander KD. (1969). Handbook of freshwater fishery biology, volume 1, The Iowa State University Press, Ames, IA. 752pp.

Cengiz Ö, Öztekin A and Özekinci U. 2012. An investigation on fishes spreading along the coasts of Gallipoli Peninsula and Dardanelles (North-eastern Mediterranean, Turkey). Fırat University Journal of Science, 24(2): 47-55.

Cengiz Ö, Paruğ ŞŞ and Kızılkaya B. 2019. Weight-length relationship and reproduction of bogue (*Boops boops* Linnaeus, 1758) in Saros Bay (Northern Aegean Sea, Turkey). Kahramanmaraş Sütçü İmam University Journal of Agriculture and Nature, 22(4): 577-582. https://doi.org/10.18016/ksutarimdoga.vi.516700

Cengiz Ö. 2021. Opercular girth, maximum girth and total length relationships for eight fish species from the Saros Bay (northern Aegean Sea, Turkey). The Palawan Scientist, 13(2): 25-36.

Cengiz Ö and Paruğ Ş. 2021. Growth parameters of blotched picarel (*Spicara maena* Linnaeus, 1758) from Saros Bay (Northern Aegean Sea, Turkey). Acta Natura et Scientia, 2(1): 40-48. https://doi.org/10.29329/actanatsci.2021.314.7

Çakır DT, Koç HT, Başusta A and Başusta N. 2008. Length-weight relationships of 24 fish species from Edremit Bay Aegean Sea. e-Journal of New World Sciences Academy Natural and Applied Sciences, 3(1): 47-51.

Demestre M, Sartor P, Garcia-de-Vinuesa A, Sbrana M and Maynou MA. 2018. Ecological importance of survival of unwanted invertebrates discarded in different NW Mediterranean trawl fisheries. Scientia Marina, 82(S1): 189-198. https://doi.org/10.3989/scimar.04784.28A

FAO (Food and Agriculture Organization of the United Nations). 2019. FAO Yearbook: Fishery and Aquaculture Statistics, 2017. Rome, Italy.

Freitas TMS, Souza JB, Prudente BS and Montag LFA. 2017. Length-weight relationships in ten fish species from the Nhamunda River, the Amazon Basin, Brazil. Acta Amazonica, 47(1): 75-78. https://doi.org/10.1590/1809-4392201601272

Freitas TMS, Prudente BS, Fontoura NF and Montag LFA. 2014. Length-weight relationships of dominant fish species from Caxiuanã National Forest, Eastern Amazon, Brazil. Journal of Applied Ichthyology, 30(5): 1081-1083. https://doi.org/10.1111/jai.124366

Froese R. 2006. Cube law, condition factor and weight–length relationships: History, meta-analysis and recommendations. Journal of Applied Ichthyology, 22(4): 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Froese R and Pauly D (eds). 2022. FishBase. World wide web electronic publication. https://www.fishbase.org. version (02/2022). Accessed on 25 March 2022.

Giacalone VM, Anna GD, Badalamenti F and Pipitone C. 2010. Weight-length relationships and condition factor trends for thirty-eight fish species in trawled and untrawled areas off the coast of northern Sicily (central Mediterranean Sea). Journal of Applied Ichthyology, 26(6): 954-957. https://doi.org/10.1111/j.1439-0426.2010.01491.x

Gönülal O and Dalyan C. 2017. Deep-Sea Biodiversity in the Aegean Sea, In Mediterranean Identities-Environment, Society, Culture, Bjelovar: IntechOpen, pp. 149-178. https://doi.org/10.5772/intechopen.70492

Gullestad P, Aglen A, Bjordal JA, Blom G, Johansen S, Krog J, Misund OA and Røttingen I. 2014. Changing attitudes 1970-2012: evolution of the Norwegian management framework to prevent overfishing and to secure long-term sustainability. ICES Journal of Marine Science, 71(2): 173-182. https://doi.org/10.1093/icesj ms/ fst094

Han D, Ma Q, Richard K and Gao C. 2021. Length-weight relationships of 10 fish species from the coastal waters of the East China Sea. Journal of Applied Ichthyology, 37(2): 347-349. https://doi.org/10.1111/jai.14148

Hercos AP, Prado-Valladares AC, del Favero JM, Zuchi NA, Teixeira TF, Albuquerque FEA and de Queiroz HL. 2021. Length-weight relationships of ornamental fish species from Amanã Lake, Amanã Reserve, Amazonas, Brazil. Journal of Applied Ichthyology, 37(6): 985-988. https://doi.org/10.1111/jai.14217

Ilkyaz T, Metin G, Soykan O and Kinacigil HT. 2008. Length-weight relationship of 62 fish species from the Central Aegean Sea. Turkey. Journal of Applied Ichthyology, 24(6): 699-702. https://doi.org/10.1111/j. 1439- 0426. 2008. 01167.x

Jellyman PG, Booker DJ, Crow SK, Bonnett ML and Jellyman DJ. 2013. Does one size fit all? An evaluation of length-weight relationships for New Zealands freshwater fish species. New Zealand Journal of Marine and Freshwater Research, 47(4): 450-468. https://doi.org/10.1080/00288330.2013.781510

Jørgensen LL, Planque B, Thangstad TH and Certain G. 2016. Vulnerability of megabenthic species to trawling in the Barents Sea. ICES Journal of Marine Science, 73(suppl_1): i84-i97. https://doi.org/10.1093/icesjms/fsv107

Karachle KP and Stergiou KI. 2008. Length-length and length-weight relationships of several fish species from the North Aegean Sea (Greece). Journal of Biological Research, 10: 149-157.

Karakulak FS, Erk H and Bilgin B. 2006. Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. Journal of Applied Ichthyology, 22(4): 274-278. https://doi.org/10.1111/j.1439-0426.2006.00736.x

Lamprakis MK, Kallianiotis AA, Montopoulos DK and Stergion KI. 2003. Weight-length relationships of fshes discarded by trawlers in the North Aegean Sea. Acta Ichthyologica et Piscatoria, 33(2): 145-152.

Le Cren ED. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Jounal of Animal Ecology, 20(2): 201-219. https://doi.org/10.2307/1540

Maravelias CD and Papaconstantinou C. 2006. Geographic, seasonal and bathymetric distribution of demersal fish species in the eastern Mediterranean. Journal of Applied Ichthyology, 22(1): 35-42. https://doi.org/10.1111/j.1439-0426.2006.00695.x

Mater S, Kaya M and Bilecenoğlu M. 2011. Türkiye Deniz Balıkları Atlası (4th ed). Ege Üniversitesi Basımevi, İzmir, Turkey. 169pp.

Moutopoulos DK and Stergiou KI. 2002. Length-weight and length-length relationships of fish species of the Aegean Sea (Greece). Journal of Applied Ichthyology, 18(3): 200-203. https://doi.org/10.1046/j.1439-0426. 2002. 00281.x

Özaydin O and Taskavak E. 2006. Length-weight relationships for 47 fish species from Izmir Bay (eastern Aegean Sea, Turkey). Acta Adriatica, 47(2): 211-216.

Özaydin O, Uçkun D, Akalın S, Leblebici S and Tosunoglu Z. 2007. Length-weight relationships of fishes captured from Izmir Bay, Central Aegean Sea. Journal of Applied Ichthyology, 23(6): 695-696. https://doi.org/10.1046/j.1439-0426. 2002. 00281.x

Özekinci U, Cengiz O, Ismen A, Altinagac U and Ayaz A. 2009. Length-weight relationships of thirteen flatfishes (Pisces: Pleuronectiformes) from Saroz Bay (North Aegean Sea, Turkey). Journal of Animal and Veterinary Advances, 8(9): 1800-1801.

Petrakis G and Stergiou KI. 1995. Weight-length relationships for 33 fish species in Greek waters. Fisheries Research, 21(3-4): 465-469. https://doi.org/10.1016/0165-7836(94)00294-7

Pikitch EK, Santora C, Babcock EA, Bakun A, Bonfil R, Conover DO, Dayton P, Doukakis P, Fluharty D, Heneman B, et al. 2004. Ecosystem-based fishery management. Science, 305(5682): 346-347. https://doi.org/10.1126/science.1098222

Psarra S, Tselepides A and Ignatiades L. 2000. Primary productivity in the oligotrophic Cretan Sea (NE Mediterranean): Seasonal and interannual variability. Progress in Oceanography, 46(2): 187-204. https://doi.org/10.1016/S0079-6611(00)00018-5

Ricker WE. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin Fisheries Research Board of Canada 191. Department of the Environment Fisheries and Marine Service, Otawa, Canada, pp. 392.

Santos MN, Gaspar MB, Vasconcelos P and Monteir CC. 2002. Weight-length relationships for 50 selected fsh species of the of the Algarve coast (southern Portugal). Fisheries Research, 59(1-2): 289-295. https://doi.org/10.1016/S0165-7836(01)00401-5

Silva-Junior LC, Andrade AC and Vianna M. 2011. Length-weight relationships for elasmobranchs from southeastern Brazil. Journal of Applied Ichthyology, 27(6): 1408-1410. https://doi.org/10.1111/j.1439- 0426.2011.01791.x

Sokal RR and Rohlf FJ. 1987. Introduction to biostatistics, 2nd edition, New York.

Soykan O, Bakır K and Kınacıgil HT. 2019. Demersal trawl discards with spatial and bathymetric emphasis in the Turkish coast of the Aegean Sea. Marine Biology Research, 15(1): 113-123. https://doi.org/10.1080/17451000.2019.1576902

Stergiou KI and Moutopoulos DK. 2001. A review of weight-length relationships of fishes from Greek marine waters. Naga ICLARM Quarterly, 24(1-2): 23-39.

Tesch FW. 1971. Age and Growth. In: Ricker WE (ed). Methods for Assessment of Fish Production in Fresh Waters. Oxford: Blackwell Scientific Publications, pp. 98-130.

Theocharis A, Balopoulos E, Kioroglou S, Kontoyiannis H and Iona A. 1999. A synthesis of the circulation and hydrography of the South Aegean Sea and the Straits of the Cretan Arc (March 1994–January 1995). Progress in Oceanography, 44(4): 469-509. https://doi.org/10.1016/S0079-6611(99)00041-5

Valle M, Rosas-Puchuri U and Velez-Zuazo X. 2021. Improving data deficiencies in length-weight relationships for fish species around an artificial breakwater and adjacent soft-bottom at the central coast of Peru. Journal of Applied Ichthyology, 37(1): 150-157. https://doi.org/10.1111/jai.14089

Yapıcı S and Filiz H. 2014. Estimation of age, growth and reproduction of boarfish, *Capros aper*, in the South Aegean Sea. Pakistan Journal of Zoology, 46(4): 1061-1068.

Yapıcı S, Karachle PK and Filiz H. 2015. First length–weight relationships of 11 fish species in the Aegean Sea. Journal of Applied Ichthyology, 31(2): 398-402. https://doi.org/10.1111/jai.12459

Zhang C, Chen Y, Thompson K and Ren YP. 2016. Implementing a multispecies size-spectrum model in a data-poor ecosystem. Acta Oceanologica Sinica, 35(4): 63-73. https://doi.org/10.1007/s13131-016-0822-0

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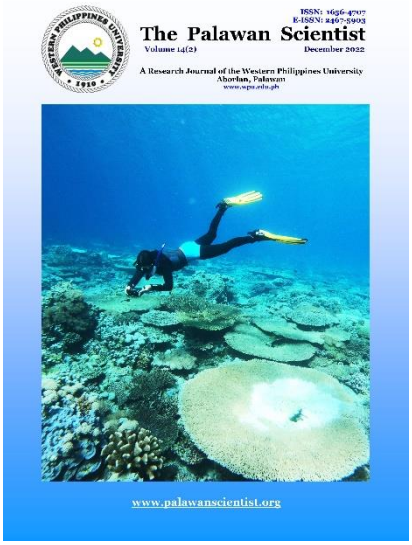

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Growth and survival of juvenile gold-lip pearl oyster *Pinctada maxima* (Jameson, 1901) at different depths with and without regular cleaning

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ABSTRACT

The lucrative commercial culture of gold-lip pearl oyster *Pinctada maxima* (Jameson, 1901) for pearl production has been in existence in the Philippines for several decades, however, no growth studies for this species has been published in the country as of this writing. To fill this gap, the results of two consecutive 60-day growth trials were conducted in the island province of Palawan. The first experiment (E1) examined the growth and survival of 4-month-old hatchery-produced pearl oysters in net trays (200 individuals per tray or 583 individuals m^{-2}) hung in a long line at three different depths (2, 4, and 6 m) below the water surface subjected to cleaning and without cleaning regimes. The second experiment (E2) was a continuation of E1, except that the 6-month-old pearl oysters were raised in 30-individual pocket net baskets. Average shell length increments (SLI) and survival rates (SR) in E1 did not significantly vary among depths ($P > 0.05$) and between cleaning conditions ($P > 0.05$). In E2, the SLI did not significantly vary among depths ($P > 0.05$) and between cleaning conditions ($P > 0.05$), while the SR was statistically similar among depths ($P < 0.05$) but not between cleaning conditions ($P > 0.05$). The results suggest that instead of the usual single row, the three rows of net baskets at different depths and the absence of cleaning could be considered in the early stage of gold-lip pearl oyster farming.

Keywords: biofouling, intermediate culture, long line method, Palawan, Philippines

INTRODUCTION

Among the different pearl oyster species used in the pearl farming industry (Southgate et al. 2008; Tisdell and Poirine 2008; Nagai 2013; Cartier and Carpenter 2014; Zhu et al. 2019; Johnston et al. 2022) the gold-lip pearl oyster *Pinctada maxima* (Jameson, 1901) is popularly cultured in Australia and many other countries (Taylor 1999; Yukihira et al. 2006; Tisdell and Poirine 2008) including the Philippines (Bondad-Reantaso et al. 2007). Of the 30 registered pearl farms in the Philippines (Bondad-Reantaso et al. 2007), 11 farms are found in Palawan (Baltazar and Dalusung-Rodrigues 2016) engaging in the rearing of *P. maxima*.

The pearl oysters are cultured using a long line method, where a series of spherical or cylindrical floats are attached to long lines moored with anchors to keep the distances between the rows of ropes and floats. Long lines in some pearl farms in Palawan are installed at depths ranging between 25 and 55 m, while only single rows of net baskets are hung 3-12 m below the water surface, thus creating plenty of available spaces below the grow-out farms. Pearl oysters inhabit clear waters under the influence of currents at depths up to 60 m but are most common from 5 to 30 m (Poutiers 1998). They can grow fast within 5 m deep (Lee 2010). The large spaces under the rows of long lines could be maximized by having two or three rows of suspended net baskets at different depths to potentially help reduce the leased area without affecting the production of pearls.

The growth out culture of pearl oyster requires regular removal of biofouling organisms to improve the growth and survival rates (SR). However, this activity constitute a major cost in pearl farm operations (Taylor et al. 1997b). Several studies however, have found that the effects of biofouling vary between localities and sizes of cultured species (Southgate and Beer 2000; Milione and Southgate 2011; Cueba et al. 2022). Hence, the economic costs associated with biofouling control and prevention could be minimized by understanding its site-specific influence on the cultured pearl oysters.

While many growth studies have been published about *P. maxima* (Taylor et al. 1997a, b; Lee 2010; Deng et al. 2013; Hao et al. 2018), no growth studies for the species has been done in the Philippines, in spite of the country's significant contribution to the global pearl production (Zhu et al. 2019). This study determined the growth and survival of hatchery-produced *P. maxima* hanged at 2, 4, and 6 m below the water surface, subjected to cleaning and without cleaning conditions.

METHODS

Study Site

The two 60-day experiments were conducted in the grow-out facility of a small-scale pearl farm in Honda Bay, Puerto Princesa City (Figure 1). The grow-out area is about 8-10 m deep with moderate wave action, having an annual average water temperature (31.11 ± 1.26°C) and salinity (34.58 ± 0.37 ppt) falling within the optimum requirements for pearl oyster farming (Lucas 2008; Deng et al. 2013).

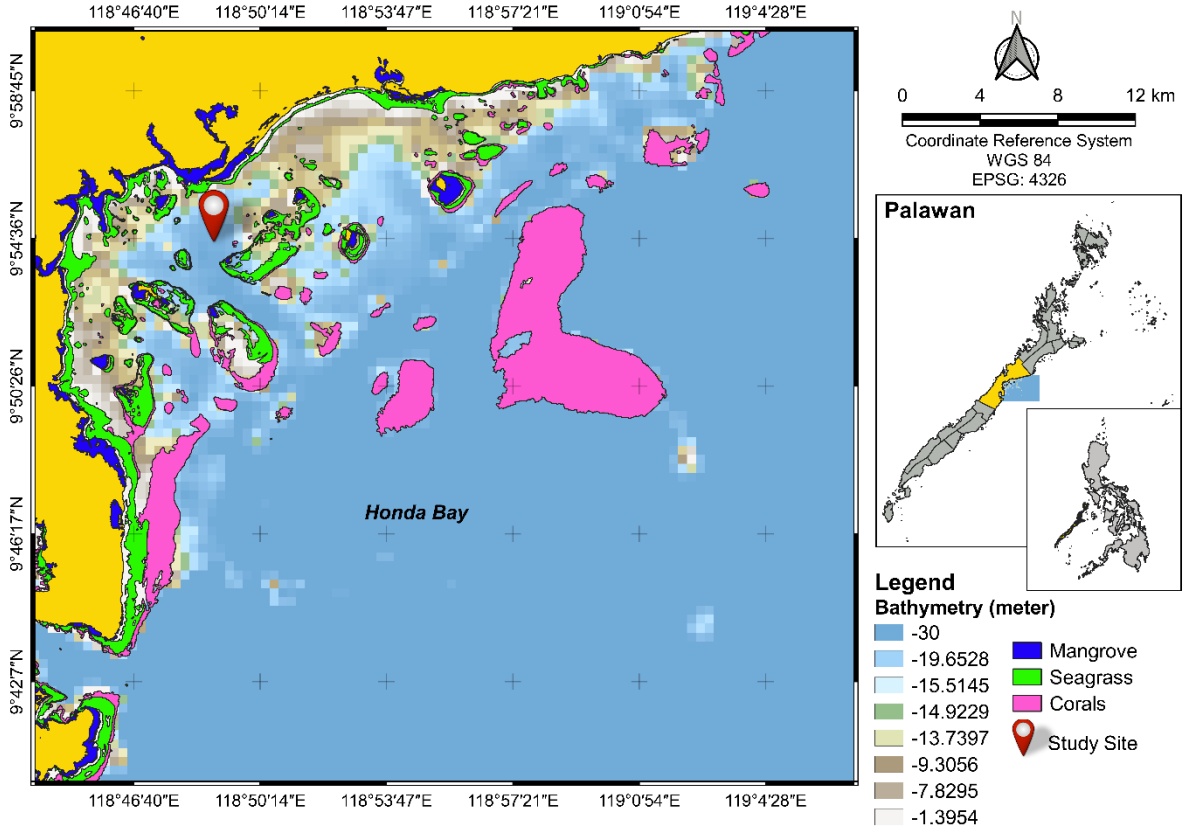

Figure 1. Map of Honda bay in Puerto Princesa City, Palawan showing the site ( ) of the study, the nearby coastal ecosystems and the elevation of the coast.

Experimental Design

The first (E1) and second (E2) experiments used a 3 x 2 factorial design. For E1, 4-month-old hatchery-produced *P. maxima* measuring 30.22 ± 3.73-32.59 ± 3.92 mm, average shell lengths (SL) were raised in net trays (48.26 cm x 71.12 cm) hanged at three different depths (2, 4, and 6 m) in a long line, subjected to two management options (with and without monthly cleaning). Each net tray served as a replicate contained 200 individuals (583 ind. m^{-2}) pearl oysters (Table 1). Each tray was wrapped with a 5 mm meshed-size black net to keep the pearl oysters inside the tray. The trays subjected to cleaning and without cleaning conditions were alternately suspended at 1-meter interval in a 20-m vacant longline of the pearl farm. The net trays were triple-hung vertically at 2-m intervals. The experiment was terminated after 60 days. During monthly sampling, pearl oysters that received monthly cleaning underwent manual removal of marine growth and other unwanted species. Net used for wrapping the trays was replaced every 30 days to ensure adequate water exchange essential for the growth and survival of the cultured species.

The second experiment (E2) was also conducted for another 60 days (Table 2), involving a total of 540 individuals taken from E1. The density was 30 individuals (ind.) per net basket (48.26 cm x 71.12 cm) or 87 ind. m^{-2}. The net baskets were triple-hung at 2 m interval with three replications. Net baskets subjected to cleaning and without cleaning conditions were alternately suspended at 1-meter interval within a 20-m longline. Monthly cleaning was carried out using a pressurized water sprayer without removing the pearl oysters on the net baskets. The net baskets without regular cleaning were inspected monthly to dislodge any predatory species. The study was terminated after 60 days.

Sampling

Due to the delicate nature of the young oyster shell, the initial measurement of shell lengths (Hwang et al. 2007) in E1 only involved 10 samples from each replicate. Succeeding monthly sampling for E1 and all samplings for E2 involved 20 individuals per replicate. The SL were measured using a caliper to a precision of 0.01 mm. Monthly survival was determined by counting the number of live pearl oysters.

Data Analysis

The average monthly SL from each replicate of both E1 and E2 were computed. After which, the SL increment was obtained by subtracting the averages of the preceding month to the next month's data. Shell length increments (SLI) and SR were transformed as needed to satisfy the test for normality before conducting a 2-way ANOVA. The survival in E2 did not meet the test for normality even after data transformations; hence comparison was carried out using the non-parametric Kruskal Wallis test. All computations were carried out using the SPSS trial version.

Table 1. The first experimental (E1) set-up used for the 4-month-old gold-lipped pearl oyster *Pinctada maxima* raised in net trays from August to October 2017.

Particulars	With cleaning			Without cleaning		
Depth (m)	2	4	6	2	4	6
Replication	3	3	3	3	3	3
Initial stock per replicate or net bag	200	200	200	200	200	200
Density (ind. m^{-2})	583	583	583	583	583	583
Initial average (±sd) shell length (mm); n = 10	31.43 (±4.24)	31.47 (±4.23)	31.62 (±4.68)	30.22 (±3.73)	32.59 (±3.92)	30.39 (±4.30)

Table 2. The second experimental (E2) set-up used for the 6-month-old gold-lip pearl oyster *Pinctada maxima* raised in 30-pocket net baskets from October to December 2017.

Particulars	With cleaning			Without cleaning		
Depth (m)	2	4	6	2	4	6
Replication	3	3	3	3	3	3
Initial stock per replicate or net basket	30	30	30	30	30	30
Density (ind. m^{-2})	87	87	87	87	87	87
Initial average (±sd) shell length (mm); n = 20	43.80 (±5.58)	42.20 (±5.47)	44.85 (±5.47)	43.50 (±4.81)	44.30 (±4.65)	44.18 (±5.34)

RESULTS

Growth and Survival in Net Trays for Experiment 1

The *P. maxima* grew at a similar rate from 30.22-32.59 mm initial SL into 42.20-44.85 mm after 60 days of culture (Figure 2). The average monthly SLI (5.36-6.89 mm; Figure 3) did not significantly vary among depths ($P < 0.05$), between cleaning conditions ($P > 0.05$) and depth x cleaning conditions ($P > 0.05$).

The SR largely dropped (32.67-51.00%) during the first 30 days, followed by a minimal decline (24.67-45.67%) on the 60th day (Figure 4). The SR did not significantly vary among depths ($P > 0.05$), between cleaning conditions ($P > 0.05$) and depths x cleaning conditions ($P > 0.05$).

Growth and Survival in 30-pocket Net Baskets for Experiment 2

The growth was relatively increasing within the culture period. From an average initial SL ranging between 42.20 and 44.85 mm, the pearl oyster reached 60.01-66.54 mm after 60 days of culture (Figure 5). The average monthly SLI ranged between 7.86 and 10.99 mm (Figure 6). The SLI did not significantly vary among depths ($P > 0.05$), between cleaning conditions ($P > 0.05$) and depth x cleaning conditions ($P > 0.05$).

The average SR in E2 was relatively high (67.78-98.89%; Figure 7) and did not significantly vary among depths ($P > 0.05$) but differed between cleaning conditions ($P < 0.05$).

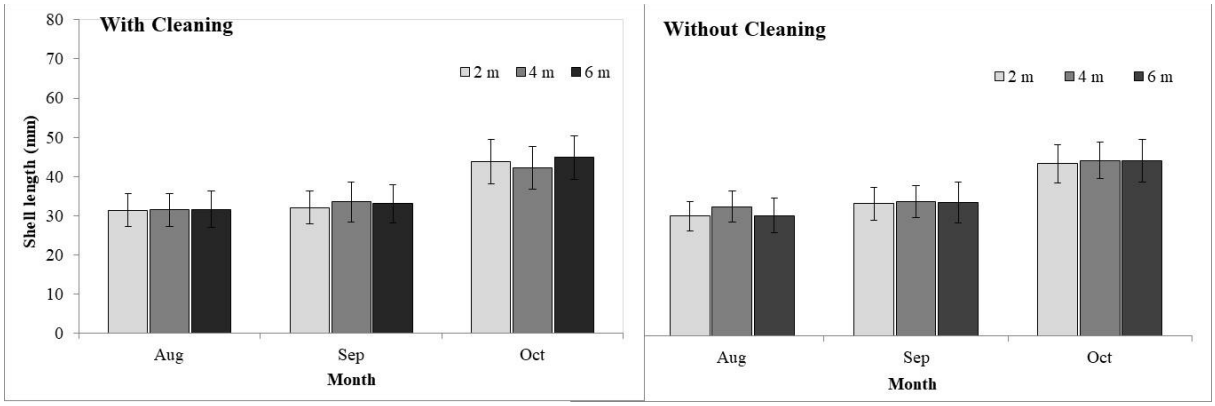

Figure 2. Monthly average (±sd) shell lengths of 4-month-old *Pinctada maxima* kept in net trays hung in a long line at three different depths subjected to cleaning and without cleaning conditions.

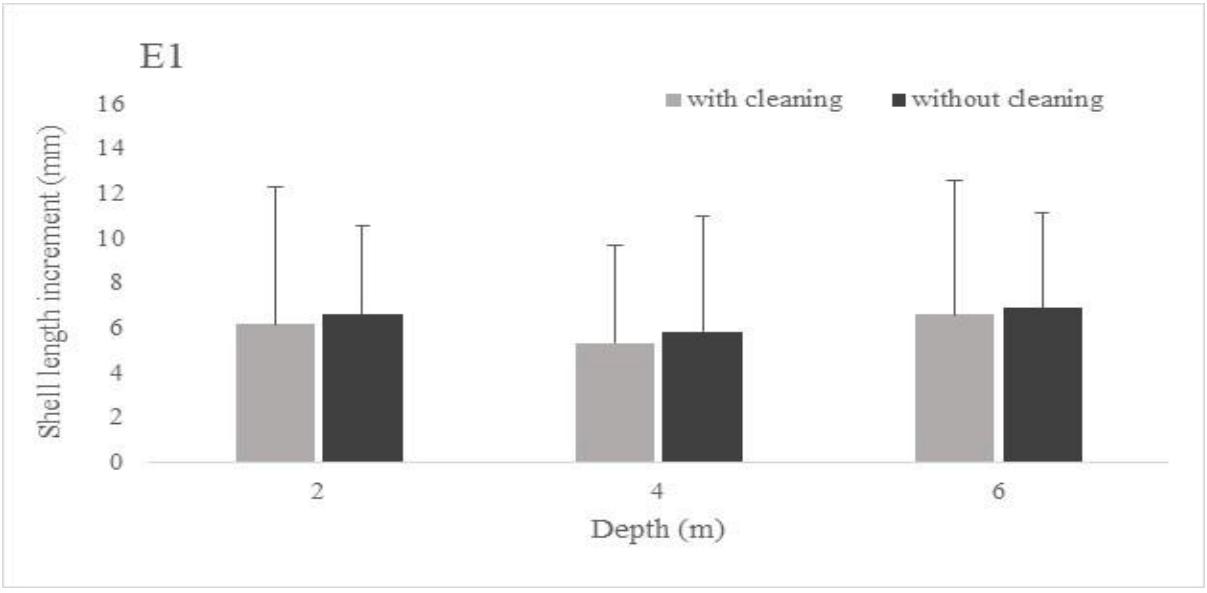

Figure 3. Average (±sd) shell length increments of 4-month-old *Pinctada maxima* kept in net trays for 60 days, subjected to cleaning and without cleaning conditions.

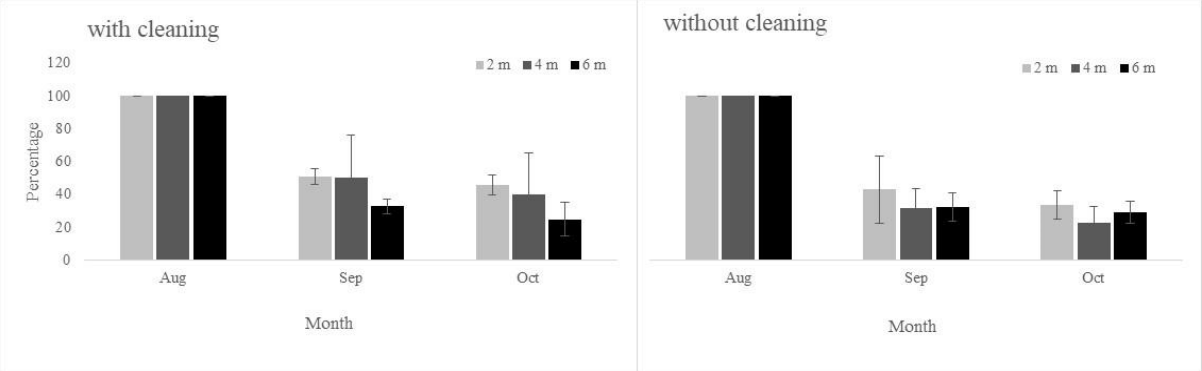

Figure 4. Average (±sd) survival rate of 4-month-old *Pinctada maxima* kept in net trays hung in a long line at three different depths, subjected to cleaning and without cleaning conditions.

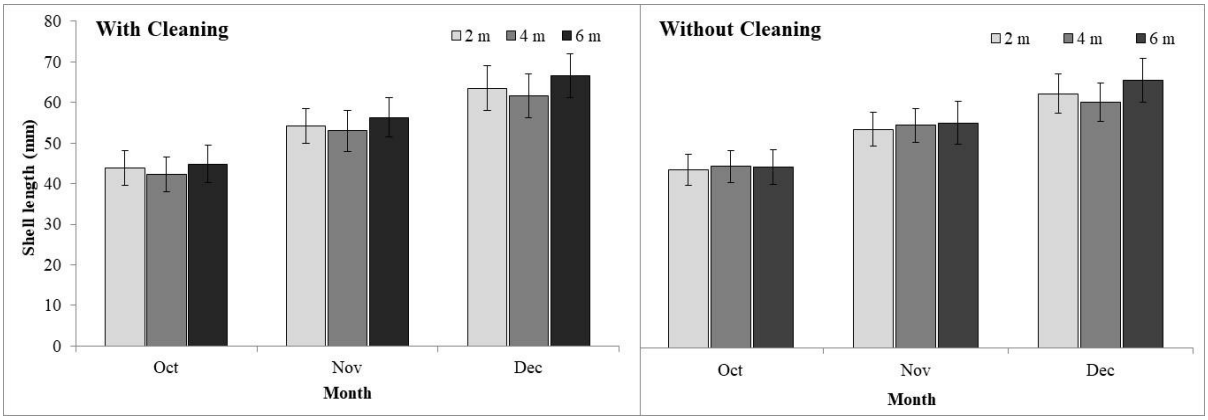

Figure 5. Monthly average (±sd) shell lengths of 6-month-old *Pinctada maxima* kept in 30-pocket net baskets hung in a long line at three different depths subjected to cleaning and without cleaning conditions.

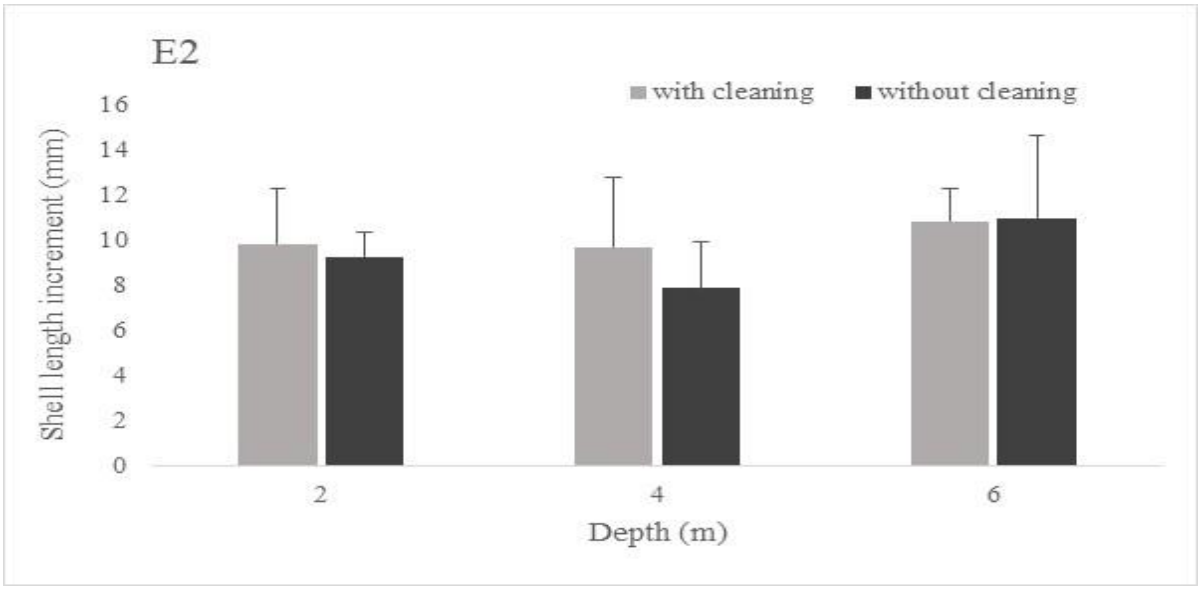

Figure 6. Average (±sd) shell length increments of 6-month-old *Pinctada maxima* held in 30-pocket net baskets for 60 days, hung in a long line at three different depths subjected to cleaning and without cleaning conditions.

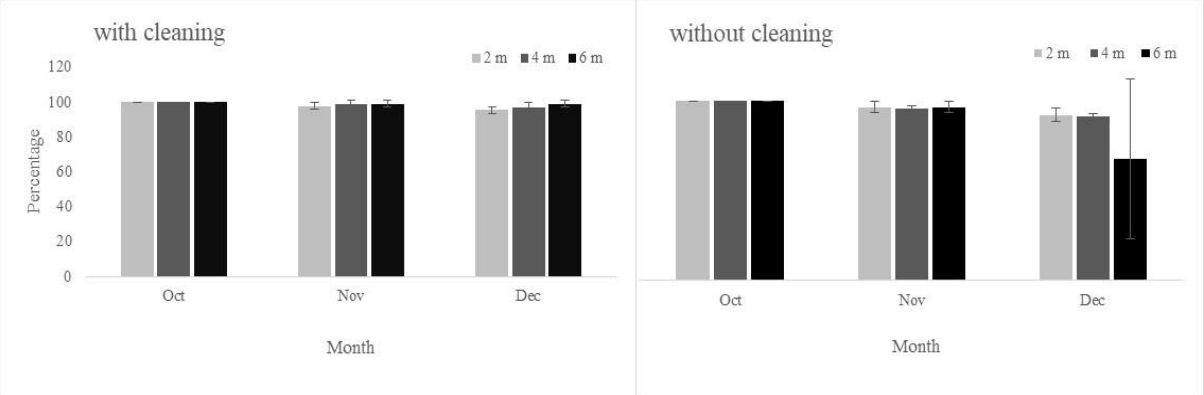

Figure 7. Survival rates of 6-month-old *Pinctada maxima* raised in 30-pocket net baskets at three different depths in a long line from October to December 2017.

DISCUSSION

Growth

The growth rates among *P. maxima* were highly variable. In E1, the pearl oyster having initial SL of 30.21-32.59 mm, reached 43.50-44.18 mm in two months, representing a monthly increment ranging between 5.36 and 6.89 mm. While in the study of Yukihira et al. (2006) pearl oyster measuring about 29.2 mm shell height, had slower growth. It only reached 40 mm shell height after 7 or 8 months (~1.54 mm increment per month). As for the case of E2, the pearl oyster reached 60.01-66.53 mm after 60 days, representing 7.50-8.31 mm monthly SLI. The final size we obtained in E2 or when the pearl oysters were 8-month-old, were comparable to the initial size (59.2 ± 0.5 mm shell height) of 1-year-old *P. maxima* placed in 10-pockets panel nets suspended at 3 m from the long line (Taylor et al. 1997a). If the monthly SLI increment in E2 is maintained in the succeeding four months, the pearl oyster would measure 90.00-99.72 mm after reaching 1-year of age. This estimate is about 10 mm shorter compared to the observed sizes of fast-growing 1-year old *P. maxima* (100-110 mm) in some commercial farms in Palawan.

The fast growth and absence of significant variation among growths at three depths for both E1 and E2 suggest the abundance of food in the study area. While no plankton monitoring was conducted to validate this claim, the presence of thick mangrove forest and estuaries within Honda Bay is favorable to the growth of natural food for oyster (Saifullah et al. 2015; Lan et al. 2021). The sea surface waters contain abundant and diverse phytoplankton species than deeper areas (Taylor 1999), thus promoting faster growth for pearl oysters (Haws 2002; Lee 2010) and of other bivalve species (Ogilvie et al. 2000; Joubert et al. 2014). Similarly, Yukihira et al. (2006) attributed the better growth of *P. maxima* to the high suspended particulate matter.

Biofouling can cause adverse effect on the growth of pearl oyster (Taylor et al. 1997b; Pit and Southgate 2003). However, there was no significant variation in the growth of *P. maxima* subjected to cleaning and without cleaning conditions. Several studies also reported that the absence of regular cleaning does not affect the growth of black-lip pearl oyster *Pinctada margaritifera* (Lacoste et al. 2014; Hulot et al. 2019; Cueba et al. 2022).

In Pioneer Bay, Orpheus Island, north Queensland, Australia, depth had no significant effect on growth, survival or fouling of *Pteria penguin* cultured for six months in three types of culture units deployed at 3 and 6 m deep (Milione and Southgate 2011). In the study site, the biofouling organisms were mostly hydroids, macro-algae and sponges which did not adversely affect the oyster's feeding activity and growth in general. The barnacles and other oyster species which can reduce the growth and cause mortalities on pearl oysters (Fitridge et al. 2012) were not noted during the study.

Survival

The low survival in E1 (24.67-45.67%) is comparable to the study of Yukihira et al. (2006) which obtained 30-50% survival after 14 months for *P. maxima* (29.2 and 28 mm shell heights) raised in two dissimilar environments in the Great Barrier Reef lagoon. However, these mortalities were attributed to low temperature during the winter season. The net trays of E1 was covered with net, hence it is unlikely that the mortalities were caused by predatory crab such as the *Acanthocyclus albatrossis.* Predatory crab feeds on the recruits and seeds of other bivalve such as the mussel *Mytilus chilensis* (Uzkiaga et al. 2022). It is speculated that the mortality could have been associated with density and suffocation from accumulated dirt on the trays' net cover as also been observed in several studies (see Southgate 2008). The reduction in density as an effect of 32.67-51.00% SR during the first 30 days could have helped reduce the

stress brought about by overcrowding and suffocation, the reason for improved SRs (24.67-45.67%) on the 60th day. In this instance, the survival could be improved by reducing the density and regular change of net cover. Grading and density reduction also promoted higher survival among small groups of *Pinctada martensii* (Fan et al. 2021), groupers (Villanueva et al. 2021a) and siganids (Villanueva et al. 2021b).

As expected, the survival in E2 was higher (Figure 6) than in E1. Survival rates for pearl oysters tend to increase with age or size as also been observed for the pearl oyster *Pteria hirundo* (Albuquerque et al. 2012) and many other organisms (Pauly 1998; Ridgway et al. 2011). The significant variation in the SR between cleaned and uncleaned trays could have been influenced by the low survival in one of the replicates of uncleaned net baskets at 6 m deep. Only 5 ind. (16.67% survival) remained in one of the replicates while the other two replicates had 28 ind. (93.33% survival). The hairy triton (*Cymatium* spp.), considered as serious pest in pearl farms (see Humphrey et al. 1998), occurred in each net basket conditions. However, its low number (3-5 ind. per cleaned net basket and 3-6 ind. per uncleaned net basket) may not be associated with the observed high mortality. The crab *Charybdis* sp. also considered as serious pest (see Humphrey et al. 1998), but these were not noted during the study. Another pest in pearl oyster is the polycad flatworm *Stylochus* sp. which had caused the isolated 100% mortality in one of the replicates for the cultured rainbow pearl oyster *Pteria sterna* (Monteforte et al. 2005), but these was also not observed in the net basket. Inventory of predatory species in a pearl farm could aid in deciding specific farm management strategies.

The absence of significant variation among SR at three different depths suggests that during the early stage of pearl oyster culture, the net baskets could be tripled hung in a long line at 2-6 m deep. Similar studies involving larger or older individuals is suggested to maximize the use of space occupied by the pearl farms. An image analysis method such as the use of Coral Point Count with Excel extension (CPCe) software is highly recommended to increase the number of measurements on oysters without manipulating the samples one by one.

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REFERENCES

Albuquerque MCP, Alves R, Zanandrea ACV, Ferreira JF, Melo CMR and Magalhães ARM. 2012. Growth and survival of the pearl oyster *Pteria hirundo* (L., 1758) in an intermediate stage of culture in Santa Catarina, Brazil. Brazilian Journal of Biology, 72(1): 175-180. https://doi.org/10.1590/S1519-69842012000100021

Baltazar TM and Dalusung-Rodrigues MC. 2016. Preliminary studies on coral reefs of pearl farms as closed-access areas in the Province of Palawan. Our Palawan, 2(1): 20-27.

Bondad-Reantaso MG, McGladdery SE, Ladra D and Chongming W. 2007. Pearl Oyster Health: Experiences from the Philippines, China, the Persian Gulf and the Red Sea. In: Bondan-Reantaso MG, McGladdery SE and Berthe FCJ (eds). Pearl Oyster Health Management: A Manual. FAO Fisheries Technical Paper. No. 503. Rome, FAO, pp. 111-121.

Cartier LE and Carpenter KE. 2014. The influence of pearl oyster farming on reef fish abundance and diversity in Ahe, French Polynesia. Marine Pollution Bulletin, 78: 43-50. http://dx.doi.org/10.1016/j.marpolbul.2013.11.027

Cueba FRA, Diaz RD, Villanueva EG, Mecha NJMF, Anunciado SRP and Dolorosa RG. 2022. Growth and survival of black-lip pearl oyster *Pinctada margaritifera* (Linnaeus, 1758) in bamboo and metal-framed pocket net baskets subjected to cleaning and without cleaning conditions. The Philippine Journal of Fisheries, 29:1-10. https://doi.org/10.31398/tpjf/29.1.2021-0007

Deng Y, Fu S, Liang F, Du X and Xie S. 2013. Growth and survival of pearl oyster *Pinctada maxima* spat reared under different environmental conditions. Journal of Shellfish Research, 32(3): 675–679. http://dx.doi.org/10.2983/035.032.0308

Fan C, Zhang X, Tang L, Zhang X, Li J, Li Q and Wang Z. 2021. Effects of size grading on survival, metamorphosis, and growth of the Chinese pearl oyster, *Pinctada martensii*. Aquaculture Reports, 21: 100892. https://doi.org/10.1016/j.aqrep.2021.100892

Fitridge I, Dempster T, Guenther J and de Nys R. 2012. The impact and control of biofouling in marine aquaculture: A review. Biofouling 28(7): 649-669. https://doi.org/10.1080/08927014.2012.700478

Hao R, Wang Z, Yang C, Deng Y, Zheng Z, Wang Q and Du X. 2018. Metabolomic responses of juvenile pearl oyster Pinctada maxima to different growth performances. Aquaculture, 491: 258-265. https://doi.org/10.1016/j.aquaculture.2018.03.050

Haws M. 2002. The Basic Methods of Pearl Farming: A Layman' s Manual. Center for Tropical and Subtropical Aquaculture. Publication No. 127. 84pp

Hulot V, Saulnier D, Latchere O, Maihota N and Gaertner-Mazouni N. 2019. Phenotype plasticity, local adaptation, and biofouling influence on growth of the pearl oyster *Pinctada margaritifera*: A common garden approach. Aquaculture, 512: 734309. https://doi.org/10.1016/j.aquaculture.2019.734309

Humphrey JD, Norton JH, Jones JB, Barton MA, Connell MT, Shelley CC and Creeper JH. 1998. Pearl Oyster (*Pinctada maxima*) Aquaculture: Health Survey of Northern Territory, Western Australia and Queensland Pearl Oyster Beds and Farms. Project No. 94/079: 113pp

Hwang JJ, Yamakawa T and Aoki I. 2007. Growth of wild pearl oysters *Pinctada fucata*, *Pinctada margaritifera* and *Pinctada sugillata* (Bivalvia: Pteriidae) in Taiwan. Fisheries Science, 73: 132-141. https://doi.org/10.1111/j.1444-2906.2007.01311.x

Johnston W, Gordon SE, Wingfield M, Halafihi T and Southgate PC.

2022. Influence of production method on the profitability of mabé pearl farming using traditional and research-informed nucleus implanting practices with the winged pearl oyster, *Pteria penguin*. Aquaculture, 546: 737280. https://doi.org/10.1016/j.aquaculture.2021.737280

Joubert C, Linard C, Le Moullac G, Soyez C, Saulnier D, Teaniniuraitemoana V, Ky CL and Gueguen Y. 2014. Temperature and food influence shell growth and mantle gene expression of shell matrix proteins in the pearl oyster *Pinctada margaritifera*. PLoS One 9: e103944. https://doi.org/10.1371/journal.pone.0103944

Lacoste E, Le Moullac G, Levy P, Gueguen Y and Gaertner-Mazouni N. 2014. Biofouling development and its effect on growth and reproduction of the farmed pearl oyster *Pinctada margaritifera*. Aquaculture, 434: 18-26. https://doi.org/10.1016/j.aquaculture.2014.07.012

Lan NT, Kovyazin VF and Huan PT. 2021. Phytoplankton composition of the mangrove ecosystem in Khanh Hoa province, Vietnam. IOP Conference Series: Earth and Environmental Science, 876:012063. https://doi:10.1088/1755-1315/876/1/012061

Lee AM. 2010. Spatio-temporal factors affecting the growth of cultured silver-lip pearl oyster, *Pinctada maxima* (Jameson) (Mollusca: Pteriidae) in West Papua, Indonesia. PhD Thesis. James Cook University. 403pp.

Lucas JS. 2008. Environmental Influences. In: Southgate PC and Lucas JS (eds). The Pearl Oyster. Elsevier Science, Amsterdam, The Netherlands, pp. 187-229.

Milione M and Southgate P. 2011. Environmental conditions and culture method effects on growth and survival of juvenile winged pearl oyster, *Pteria penguin*. Journal of Shellfish Research, 30(2): 223-229. https://doi.org/10.2983/035.030.0205

Monteforte M, Bervera H, Ramirez JJ, Saucedo P and Lopez CO. 2005. Effect of stocking density on growth and survival of the rainbow pearl oyster *Pteria sterna* (Gould 1852) during nursery and late culture in Bahai de La Paz, Baja California Sur, Mexico. Aquaculture International, 13: 391-407. https://doi.org/10.1007/s10499-005-1265-3

Nagai K. 2013. A history of the cultured pearl industry. Zoological Science, 30: 783–793. https://doi.org/10.2108/zsj.30.783

Ogilvie SC, Ross AH and Schiel DR. 2000. Phytoplankton biomass associated with mussel farms in Beatrix Bay, New Zealand. Aquaculture 181: 71-80. https://doi.org/10.1016/S0044-8486(99)00219-7

Pauly D. 1998. Tropical fishes: patterns and propensities. Journal of Fish Biology, 53: 1-17. https://doi.org/10.1111/j.1095-8649.1998.tb01014.x

Pit JH and Southgate PC. 2003. Fouling and predation; how do they affect growth and survival of the blacklip pearl oyster, *Pinctada margaritifera*, during nursery culture? Aquaculture International, 11: 545-555. https://doi.org/10.1023/B:AQUI.0000013310.17400.97

Poutiers JM. 1998. Bivalves. Acephala, Lamellibranchia, Pelecypoda. In: Carpenter KE and Niem VH (eds). FAO Species Identification Guide for Fishery Purposes. The living marine resources of the Western Central Pacific. Volume 1. Seaweeds, corals, bivalves, and gastropods. Food and Agriculture Organization of the United Nations, Rome, pp. 123-362.

Ridgway ID, Richardson CA and Austad SN. 2011. Maximum shell size, growth rate, and maturation age correlate with longevity in bivalve molluscs. Journal of Gerontology: Biological Sciences, 66A(2): 183-190. https://doi.org/10.1093/gerona/glq172

Saifullah ASM, Kamal AHM, Idris MH, Rajaee AH and Bhuiyan MKA. 2015. Phytoplankton in tropical mangrove estuaries: role and interdependency. Forest Science and Technology, 12(2): 104-113. http://dx.doi.org/10.1080/21580103.2015.1077479

Southgate PC. 2008. Pearl Oyster Culture. In: Southgate PC and Lucas JS (eds). The Pearl Oyster. Elsevier, pp. 231-272. https://doi.org/10.1016/B978-0-444-52976-3.00007-3.

Southgate PC and Beer AC. 2000. Growth of blacklip pearl oyster (*Pinctada margaritifera*) juveniles using different nursery culture techniques. Aquaculture, 187(1-2):97-104. https://doi.org/10.1016/S0044-8486(99)00392-0

Southgate PC, Strack E, Hart A, Wada KT, Monteforte M, Cariño M, Langy S, Lo C, Acosta-Salmón H and Wang A. 2008. Exploitation and Culture of Major Commercial Species. In: Southgate PC, Lucas JS (eds). The Pearl Oyster. Elsevier, pp. 303-355. https://doi.org/10.1016/B978-0-444-52976-3.00009-7

Taylor JJ, Rose RA, Southgate PC and Taylor CE. 1997a. Effects of stocking density on the growth and survival of juvenile silver-lip pearl oysters (*Pinctada maxima*, Jameson) in suspended nursery culture. Aquaculture, 153(1-2): 41-49. https://doi.org/10.1016/S0044-8486(97)00015-X

Taylor JJ, Southgate PC and Rose RA.1997b. Fouling animals and their effect on the growth of silver-lip pearl oysters, *Pinctada maxima* (Jameson) in suspended culture. Aquaculture, 153(1-2): 31-40. https://doi.org/10.1016/S0044-8486(97)00014-8

Taylor JJU. 1999. Juvenile production and culture of the silver-lip pearl oyster, *Pinctada maxima* (Jameson). PhD Thesis, James Cook University. Townsville, Australia. 222 pp.

Tisdell CA and Poirine B. 2008. Economics of Pearl Farming. In: Southgate P and Lucas J (eds). The Pearl Oyster. Elsevier, pp. 473-495. https://doi.org/10.1016/B978-0-444-52976-3.00013-9

Uzkiaga N, Gebauer P, Niklitschek E, Montory J, Paschke K, Garcés C and Lázaro-López O de. 2022. Predation of the crab *Acanthocyclus albatrossis* on seeds of the bivalve *Mytilus chilensis* under different environmental conditions: Importance of prey and predator size. Journal of Experimental Marine Biology and Ecology, 551: 151730. https://doi.org/10.1016/j.jembe.2022.151730

Villanueva EG, Hoevenaars K, Van Veijnen J, Gonzales AP, Dolorosa RG and Creencia LA. 2021a. Protocol development for the improved hatchery propagation of Tiger grouper *Epinephelus fuscoguttatus* (Forsskål, 1775) in Palawan, Philippines. The Palawan Scientist, 13(1): 132-147.

Villanueva EG, Hoevenaars K, Van Veijnen J, Gonzales AP, Creencia LA and Dolorosa RG. 2021b. Simplified hatchery protocols for culture of Orange-Spotted Spinefoot *Siganus guttatus* (Bloch, 1787) in Palawan, Philippines. Asian Fisheries Science, 34(3): 217-224. https://doi.org/10.33997/j.afs.2021.34.3.003

Yukihira H, Lucas JS and Klumpp DW. 2006. The pearl oysters, *Pinctada maxima* and *P. margaritifera*, respond in different ways to culture in dissimilar environments. Aquaculture, 252: 208-224. https://doi.org/10.1016/j.aquaculture.2005.06.032

Zhu C, Southgate PC and Li T. 2019. Production of Pearls. In: Smaal A, Ferreira J, Grant J, Petersen J and Strand Ø (eds). Goods and Services of Marine Bivalves. Springer, pp. 73-93. https://doi.org/10.1007/978-3-319-96776-9_5

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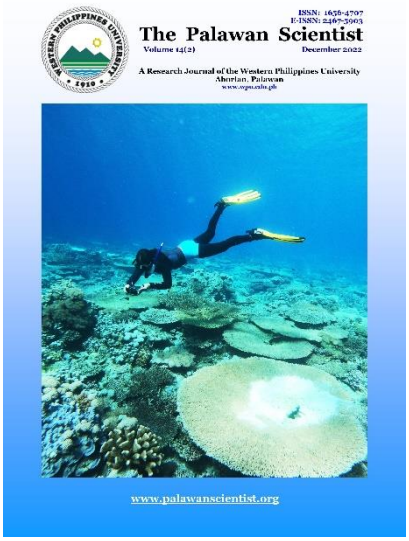

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Behavioral responses of Irrawaddy dolphins, *Orcaella brevirostris* (Owen in Grey, 1866) to fishing boats in a globally important marine mammal area in central Philippines

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ABSTRACT

The Irrawaddy dolphins, *Orcaella brevirostris* (Owen in Grey 1866) of Guimaras Strait, Philippines, have been known to utilize a core habitat within a coastal area surrounding the Bago River estuary in Negros Occidental. The dolphins' close dependence on coastal waters often makes unavoidable direct interaction with human communities. Daily human activities in the coastal areas can pose serious threats to the dolphins, including high risk of entanglement in fishing nets, pollution, and disturbances caused by fishing boats and larger vessels. This study determined the behavior of dolphins toward different kinds of boats present in Bago-Pulupandan coastal waters. Factors identified to affect dolphin behavior towards boats include boat type (motorized or not), size, and distance from dolphins. Dolphin behavior towards boats were categorized as either positive, negative, or neutral. Results showed that the dolphins mostly exhibited neutral behavior towards boats, regardless of state and boat type. The dolphins' passive behavior around vessels may make them more vulnerable to boat strikes, especially from speeding motorized boats. Recommendations include strict regulation of boat speed and traffic within their core habitat to minimize injuries, net entanglement, and avoid mortality.

Keywords: behavioral responses, boat traffic, fishing gears, habituation, Guimaras Strait

INTRODUCTION

Behavioral studies on geographically-isolated wildlife populations are often an important consideration in localized conservation efforts. Various subpopulations of a particular species respond differently to specific environmental factors and thus require varied approaches to their management. In the Philippines, 26 species of marine mammals (Alava et al. 2012) are distributed into several fragmented subpopulations across seas, straits, estuaries, bays, and gulfs, separated by 7,641 islands. Consequently, this makes efforts to assess each species and their subpopulations a difficult task. Presently, protection of

these species is covered in encompassing laws and policies based on a limited number of studies and the precautionary principle (Hoyt 2005). Marine mammals in the Philippines are protected under several laws. Among these are the Philippine Fisheries Code of 1998 (Republic Act 8550 and revised through RA 10654), the Wildlife Protection and Conservation Act of 2001 (RA 9147), and the Department of Environment and Natural Resources Administrative Order (DAO) 55 of 1991 (for dugongs), and Fisheries Administrative Order (FAO) 185-1 (for cetaceans). However, the enforcement of these laws may apply differently for geographically distinct subpopulations facing a variety of threats in their localized habitats. Moreover, the reality of wildlife law enforcement in the Philippines also largely depends on the local government agency in which the subpopulation is located (Whitty 2015).

The Irrawaddy dolphin *Orcaella brevirostris* (Owen in Grey 1866) population in the Philippines has been identified to exist in at least three geographically-isolated subpopulations: Iloilo-Guimaras Straits in the Visayas (Dolar et al. 2018; de la Paz et al. 2020), Malampaya Sound (Smith et al. 2004), and Quezon, Palawan (Dolar and Matillano unpublished data). The first two subpopulations are listed as Critically Endangered (CR) under the Red List of Threatened Species of the International Union for the Conservation of Nature (IUCN) (Smith and Beasley 2004; Minton et al. 2017; Dolar et al. 2018). Similarly, the habitats of these two subpopulations are recognized globally as Important Marine Mammal Areas (IMMAs) (MMPATF 2019).

Irrawaddy dolphins in the Philippines live in habitats that often overlap with human fishing grounds (Whitty 2015; Casipe et al. 2016; Dolar et al. 2018; de la Paz et al. 2020). Impacts of boat activity on marine mammals on coastal areas are of particular concern because of the large number of vessels operating in the area, their widespread use, and high noise production that can affect marine mammal behavior. Some marine mammal species exhibit tolerance to watercraft but apparent disturbance reactions have also been documented (Nowacek et al. 2001). Beluga *Delphinapterus leucas* (Pallas, 1776) abundance in the St. Lawrence Estuary in Canada declined after several years of increasing boat activity (Caron and Sergeant 1988); Killer whales *Orcinus orca* (Linnaeus, 1758) likewise observed in an area of increasing boat traffic off British Columbia, increased their swimming speed and adopted erratic swimming behavior (Kruse 1991). Behavioral responses in other small cetaceans include changes in dive length (Evans et al. 1992), surfacing patterns (Janik and Thompson 1996; Kreb 2004), group cohesiveness (Morimura and Mori 2019), and changes in foraging habitat selection (Allen and Read 2000).

Continuous disturbance from boat activities is likely to cause long-term population-level effects such as decreased ability to capture prey, avoidance of critical feeding or breeding areas, and changes in social activities (Morimura and Mori 2019). It is essential to understand the behavioral response of these dolphins to establish mitigation schemes against excessive exposure to disturbances. This study aimed to characterize the human activities, particularly those that utilize boats, in the Irrawaddy dolphins' habitat and investigate their behavioral response towards boats. In addition, semi-experimental observations were conducted to imitate dolphin-watching boats that intentionally move close to dolphins, to see how dolphins might react in the event that such eco-tourism program is considered by the local governments.

METHODS

Study Area

The adjacent coastal waters of Bago City and the Municipality of Pulupandan in Negros Occidental comprise a shallow, silty estuarine habitat that drains the Bago River, one of the largest river systems in Negros Island. It includes the southeastern part of Guimaras Strait, a narrow body of water that separates Negros and Guimaras Islands. A small area (approximately 12 km^2) outside the mouth of Bago River has been identified as a core habitat of Irrawaddy dolphins, where they have been observed feeding around stake nets (Casipe et al. 2016; de la Paz et al. 2020). This area overlaps with the fishing grounds of at least five fishing communities that line most of the coastal area (Figure 1). On the eastern side of Pulupandan, ferryboats travel to and from San Lorenzo in Guimaras Island 3-5 times a day, and large cargo ships occasionally dock in Pulupandan port.

Data Collection

Mapping of fishing grounds. In order to characterize human activities in the habitat, information on fishing grounds, gears used, and patterns of fishing activities within the habitat were collected through focus group discussions (FGD) (Nyumba et al. 2017). Fishers from five communities (Bago: Sampinit and Punta Playa; Pulupandan: Tapong, Zone 1A, and Cavan) adjacent to the known habitat of the Irrawaddy dolphins were asked to point the location of their fishing grounds on maps of the surrounding areas. Mapping of fishing grounds was also conducted by following local fishers out at sea and recording the fishing locations using a GPS (ESSC 1998).

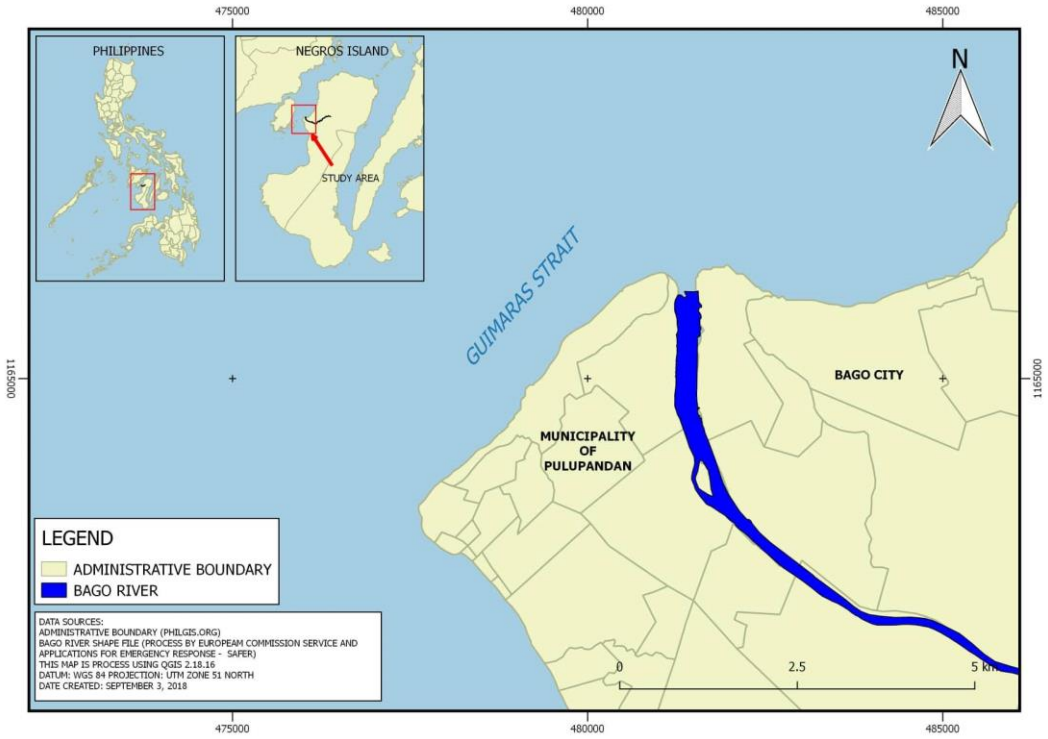

Figure 1. Map of the study site in Guimaras Strait and the coastal waters of Bago-Pulupandan relative to location in Negros Island and the Philippines (inset).

Survey method. Observations of dolphin-boat interactions were carried out by 3-4 observers during boat-based surveys from April to November 2015 and May to November 2018. These coincided with the transition period from the northeast monsoon (Amihan) to the southwest monsoon (Habagat). The research boat used was a 6 m outrigger fishing boat fitted with an outboard motor. Surveys commenced at around 0600 h and were only conducted during favorable weather conditions (Beaufort Sea State < 3) and lasted for 3-4 h, depending on the continued presence and behavior of the dolphins in the study area. The survey followed a pre-determined route 500 m parallel from the coastline from Barangay Zone 1A going north to the mouth of Bago River at an average speed of 12 kph, employing focal follow techniques (de la Paz et al. 2020). The types of boats observed in the area were listed and are described in Table 4. During the 2015 survey, the number and type of boats seen within a 200 m radius of the research boat were tallied every hour. Dolphin behavior was recorded at every 5 min interval and was categorized as either foraging, traveling, resting, or socializing (Table 1). The dominant behavior was determined based on which behavior they exhibited the longest within the 5 min observation time (Mann 1999). The locations of dolphin sightings were recorded using a handheld Global Positioning System (GPS) (Garmin GPSMap 78s) and were plotted using Quantum Geographic Information System (QGIS) 2.18.

Behavioral sampling. Behavioral responses of dolphins toward boats were observed between the nearest dolphin and the nearest boat and were classified as positive, negative, or neutral (Hashim and Jaaman 2011) (Table 2). In 2018, semi-control experiments were performed using two research boats. Observations of dolphin responses toward the second (control) boat were recorded to test their behavioral responses to a boat that would deliberately follow them, just as a research or tour boat would. These were observed from the first boat which kept a farther distance (approximately >50 m) from the control boat. The speed of the control boat did not go faster than 10 kph, but observing a 50 m distance between the control boat and the dolphins was not entirely practiced as dolphins would sometimes surface very near any boat unexpectedly.

Data Analysis

Chi-square was used to determine if a significant relationship existed between the behavioral responses of dolphins and the vessel types it encounters. The same test was used on the behavioral responses of dolphins and the boat status of vessels it encounters. When Chi-square values indicated that there was a significant relationship, Cramer's V was used to measure the strength of the association. Statistical Package for the Social Sciences (SPSS) was used for the statistical analysis.

Table 1. Ethogram of dolphin behaviors observed during the survey (Adapted from Casipe et al. 2017).

Group behavior	Description
Feeding/foraging	Frequent asynchronous dives in varying directions in one location; surfacing and respiration display no obvious pattern; dolphins often chase fish and occasional fish capture can be observed; prey is often tossed high out of the water and caught by the dolphins; flippering often observed to herd fish.
Traveling	All dolphins move in one direction, surfacing and diving synchronously; chasing fish or even social behavior extremely uncommon; movement in a faster pace usually over a larger distance while swimming when foraging; porpoising often observed; a displacement of at least 100 m from the initial location.
Resting	Low level of activity, with the dolphins apparently floating stationary and motionless at the surface, with some occasional slow forward movement, regular surfacing and diving while in one location.
Socializing and playing	Various vigorous activities including leaping out of the water, high speed movement with frequent direction changes and prolonged body contact with other dolphins; occasional splashes in aggregations of dolphins.

Table 2. Dolphin responses to oncoming vessels (adapted from Hashim and Jaaman 2011).

Response	Description
Positive	Boat-chasing behavior, actively approaching vessel
Negative	Actively moving away from boat, boat-avoiding behavior
Neutral	Dolphin continues to perform an ongoing activity or no changes in behavior observed

RESULTS

Boat Traffic and Fishing Activities

The fisheries in Bago-Pulupandan are mostly small-scale. Fishing grounds are located within respective municipal waters (<5 km from shore), or oftentimes to the neighboring waters of Guimaras Island (Figure 2). Gillnets were the most common gear used and were deployed with the use of motorized outrigger boats. Other gear types that were identified (beach seine net, lift or skimming net, cast net, bag net, and hand dredge net) were mostly operated in shallow waters in wading depths to capture fish fry and invertebrates (Table 3).

There were seven boat types operating in the study site (Table 4). The average number of boats recorded during encounters with dolphins was 14.89 boats per hour. Boat traffic was densest during the 0630-0729 h with an average of 18.38 boats, and gradually decreased as the day progressed, with the least number recorded during 0930-1029 h, with an average of just 9.89 boats (Figure 3). Small paddle boats (Type A) and motorized outrigger fishing boats that can reach a speed of up to 12-15 kph (Types B and C) were the most common in the area, with an average of 2.8 and 8.08 boats per hour respectively. An average of 1.7 passenger ferry boats (>3 gross tons) were recorded every hour. Other boat types had an average of less than one boat per hour.

Table 3. Fishing gears used in Bago and Pulupandan, as identified during the focus group discussion.

Fishing Gear Type	Local Name
Gill net	Pukot
a. Drift gill net	Bahol; gusawan/pangusawan; kasagan; nipisan; tabagakan; tuluyan; punot
b. Floating set gill net	Palanas
c. Drive-in gill net	Palagbong; panglantong/langtungan
Beach/drag sein net	Hila-hila; pakarus; suwayang
Cast net	Laya
Hook and line	Panglabay/ labay; panongkit
Lift net/ skimming net	Talangkaan; hudhud
Bag net	Paduyan
Crab lift net	Bintol
Hand dredge net	Karuy
Hand line	Bunit

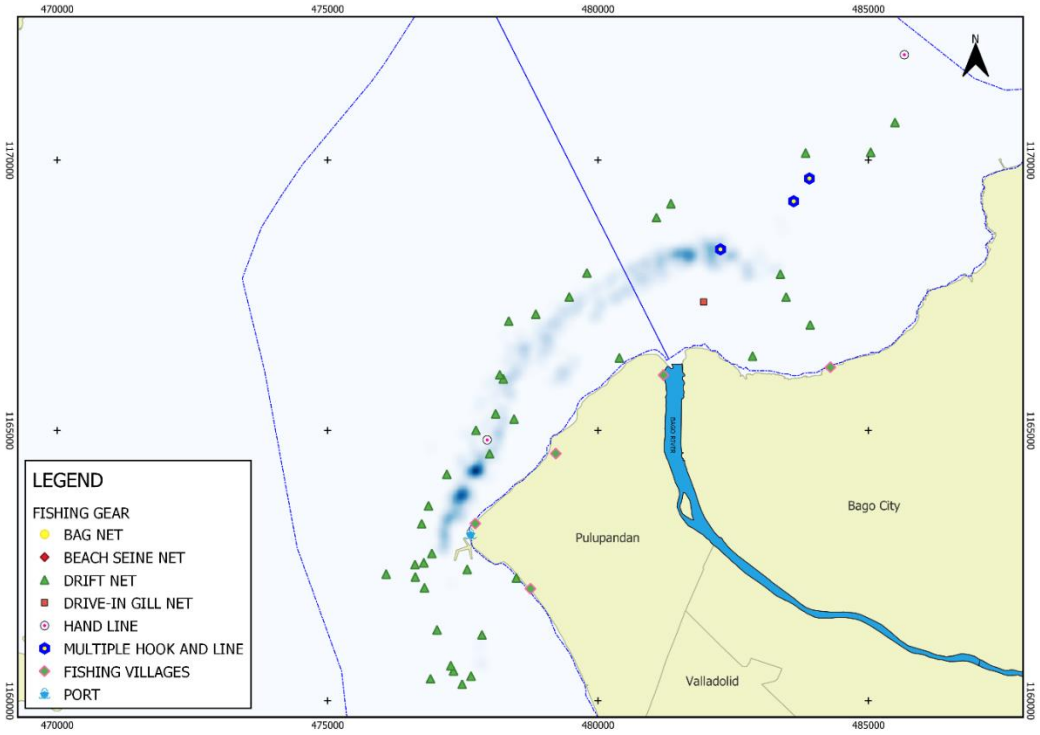

Figure 2. Map showing the distribution of fishing grounds in Bago-Pulupandan overlapping with Irrawaddy dolphin habitat (sighting density in dark blue).

Table 4. Types of vessels operating in the Bago-Pulupandan coastal waters. Some vessel's horsepower (hp) were referenced from [1]Aguilar 2006 and [2]Dinh 1999.

Type of Vessel		Description
A	Paddle / sailboat	non-motorized, semi-dugout outrigger boat; propelled by paddle or sail; 3-7 m length; 0.1-0.2 gross ton[1], usually holds 1-2 persons
B	Motorized fishing boat	5-18 m length; 0.5-2.9 gross tons; 3-16 hp[1], <3 gross tons, operated by 2-3 persons
C	Researchers' boat	motorized outrigger boat utilized by researchers to follow dolphins at a minimum distance; 5-18 m length; 0.5-2.9 gross tons; 3-16 hp[1]
D	Passenger ferry	15-30 m length; 5-20 gross tons; 80-94 hp[1]; >3 gross tons
E	Dredger	utilized for excavation operations; up to 1000 horsepower[2]
F	Tugboat	motorized boat intended for maneuvering or towing other vessels; 680-3400 horsepower
G	Cargo ship	capacity of up to 45 tons and carrying various cargo

Dolphin Response and Associated Behaviors

A total of 810 and 214 dolphin-boat interactions were recorded from the 2015 and 2018 surveys, respectively. Dolphins were usually encountered in groups ranging from 1 - 7 individuals. Foraging was the most frequently observed behavior of dolphins when sighted around the vicinity of boats, with 709 out of 812 (87.32%) recorded interactions in 2015 and 105 out of 214 (49.06%) interactions in 2018 (Figure 4). Other behaviors observed include traveling (6.28% in 2015 and 23.83% in 2018), socializing (5.05% in 2015 and 16.35% in 2018), and milling (1.35% in 2015 and 10.75% in 2018) (Figure 4). Irrawaddy dolphins mostly exhibited neutral or passive behavior toward boats, especially when foraging (80.39 % in 2015 and 65.71% in 2018) (Figure 5). However, the dolphins in 2015 were observed avoiding or swimming away from boats (47.06%) during most of the time that they were traveling but exhibited more neutral behavior (62.75%) towards the pursuing research boat in 2018. The dolphins also showed almost exclusively neutral behavior towards boats during socializing (100% in 2015 and 71.42% in 2018) and milling (100% in 2015 and 82.61% in 2018) (Figure 5).

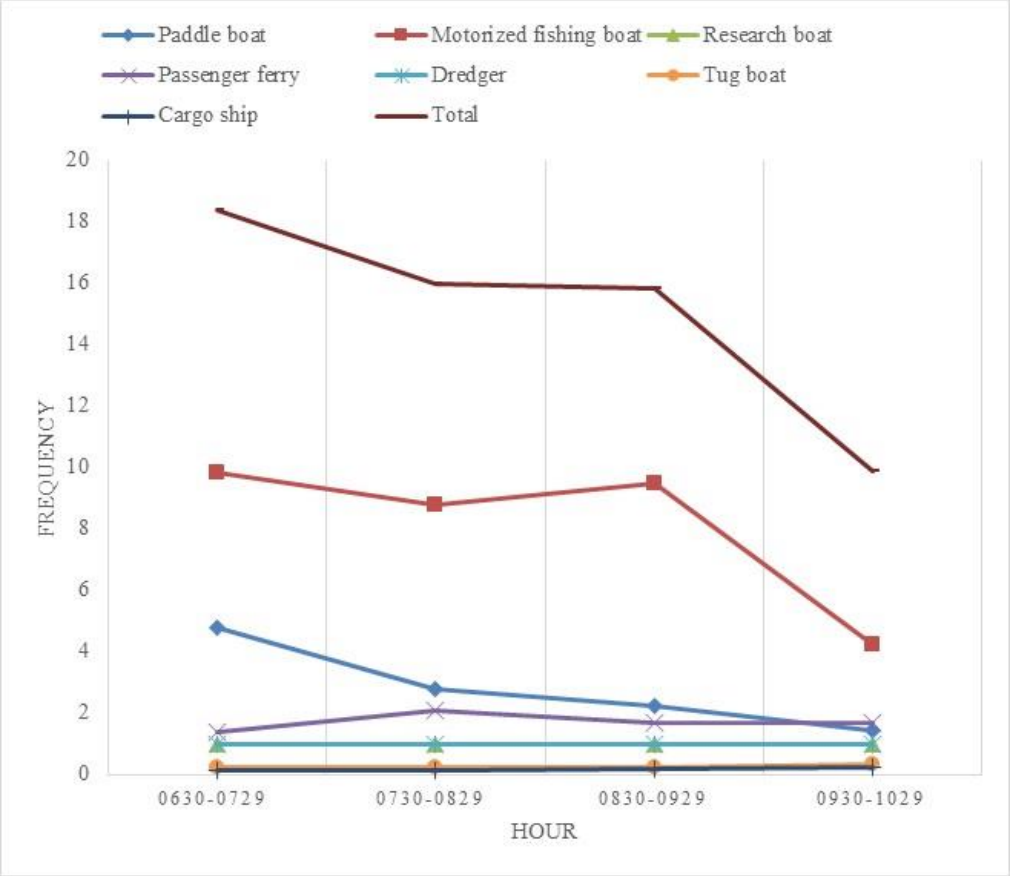

Figure 3. Mean number of boats operating per hour during the 2015 survey.

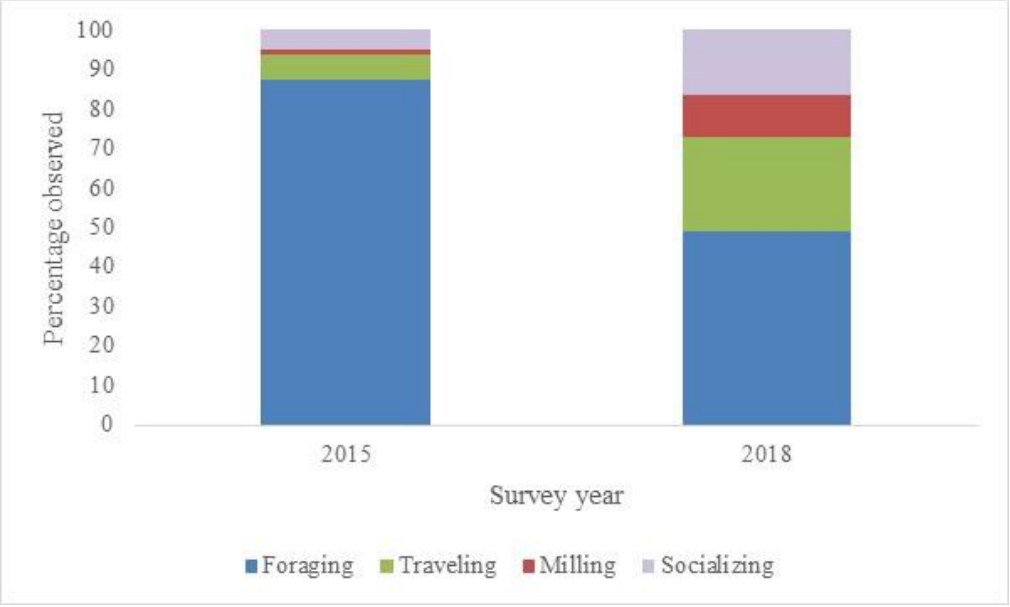

Figure 4. Percentage of observed Irrawaddy dolphin behaviors during the 2015 and 2018 boat surveys.

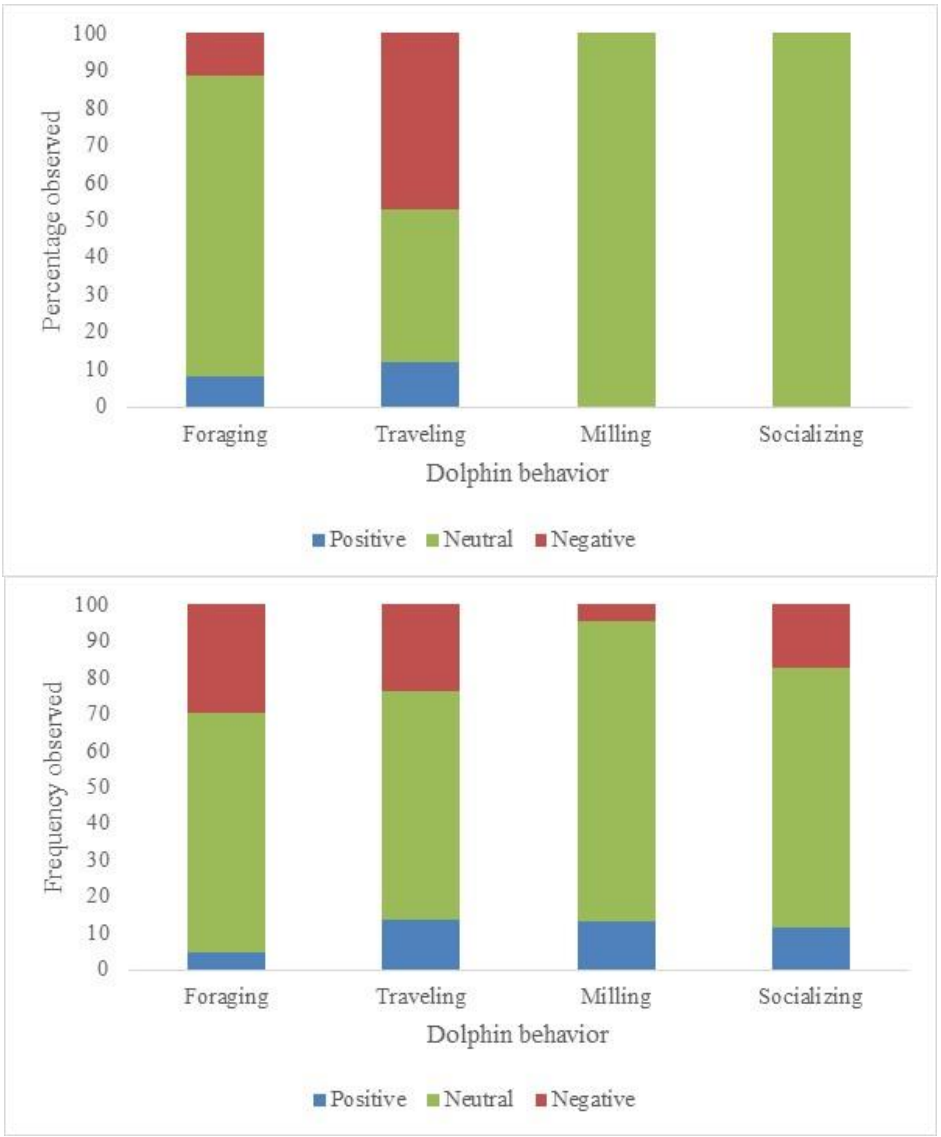

Figure 5. Percentage of Irrawaddy dolphin responses and their associated behavior during interaction with different boats in 2015 (top) and the research boat in 2018 (bottom).

Behavioral Responses toward Different Boat Types

Data analysis shows that the behavioral responses of the Irrawaddy dolphins towards different types of vessels had a significant relationship (Chi-square value = 32.866; $P = 0.0001$) (Table 5). Neutral behavior towards boats was the most prevalent response observed regardless of boat type nor movement state (Figure 6). As with the dredger, the dolphins mostly appeared unbothered (neutral response = 74.07%) despite its excavating activities and noise during operations. Positive response was observed in all boat types except in ferryboats, which were always moving when passing through the study area, although these observations with the ferry only occurred on three occasions. Positive response was usually observed during foraging, when dolphins congregate in large groups of 6-7 individuals.

Negative response was seldom observed with motorized boats (Type B: 8.66%; Type C: 15.04%) and dredger (3.70%). For the experimental research boat, dolphins tended to avoid (15.04%) the boat more than approach (5.76%) it, although negative behavior was only second to neutral behavior (79.20%). This, however, may be attributed to the tendency of the researcher's boat to follow the dolphins when they travel.

Table 5. Chi-Square tests on the relationship of Irrawaddy dolphin behavior toward different types of boats (7 cells (46.7%) have expected count less than five). The minimum expected count is 0.23.

	Value	df	*P*-value
Pearson Chi-square	32.866[a]	8	.0001
Likelihood Ratio	33.624	8	.00005
N of valid cases	810		

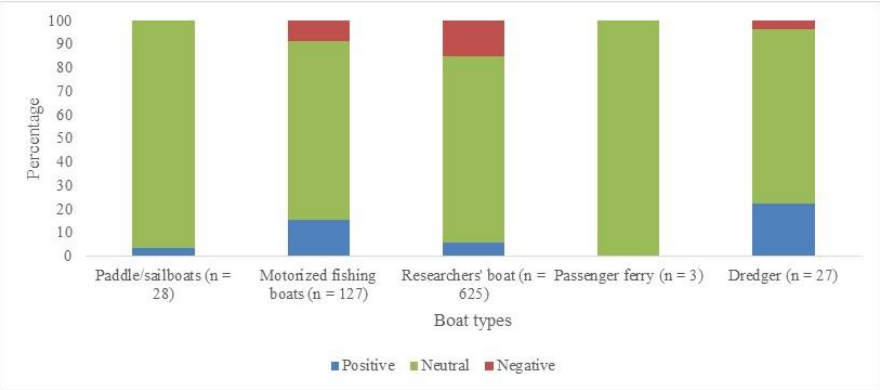

Figure 6. Percentage of Irrawaddy dolphin responses toward different types of boats in 2015.

Behavioral Responses toward Stationary vs Moving Boats

Despite the dolphins' predominantly neutral behavior towards boats, dolphins tended to avoid moving boats more than stationary boats (Figure 7). This was true, especially with motorized fishing boats (Types B and D), which usually had the noisiest engines among all the other boats. However, dolphins were more likely to swim closer to the boats when its engines were turned off. These were observed especially when fishers set their nets to catch fish. Their responses towards stationary and moving vessels demonstrated a significant relationship (Chi-square value = 31.829; $P = 0.0000001$) (Table 6). The strength of association towards both variables, however, was weak. Although stationary and moving boats had a greater strength of association with dolphin response than with different vessel types.

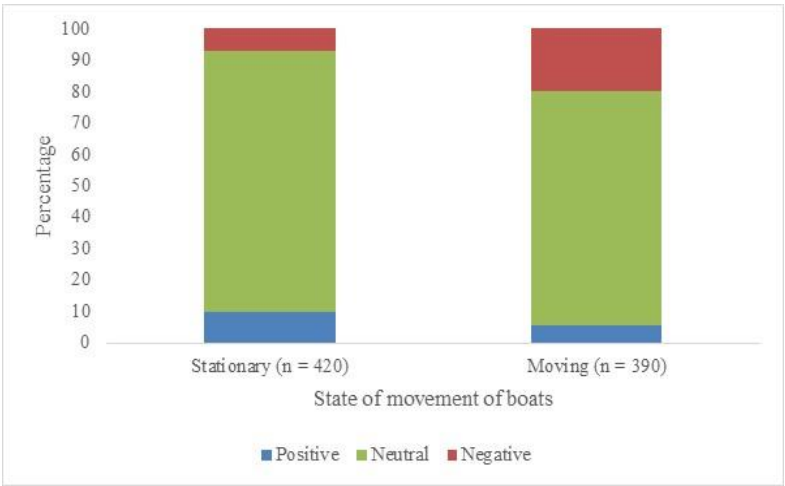

Figure 7. Irrawaddy dolphin responses toward stationary and moving boats in 2015.

Table 6. Chi-Square tests on the relationship of Irrawaddy dolphin behavior toward stationary and moving boats (0 cells (.0%) have expected count less than five. The minimum expected count is 30.33).

	Value	**df**	***P*-value**
Pearson Chi-square	31.829[a]	2	.0000001
N of valid cases	810		

DISCUSSION

Boat traffic is among the top factors that threaten Irrawaddy dolphins (Minton et al. 2017). It is a recurring factor in most Irrawaddy dolphin habitats, as their populations often overlap with fishing and navigational areas (Kreb 2004; Smith and Beasley 2004; Hashim and Jaaman 2011; Peter et al. 2016). There are at least five fishing communities adjacent to the dolphins' habitat in this study. Fishers maximize better weather conditions during the Habagat monsoon to go out and fish, and dolphins were frequently observed in this area during both seasons. Boat traffic in Bago and Pulupandan (mean = 15.02 boats per hour) was a lot busier than that in Balikpapan Bay (3.2 boats per hour); although less busy than in the Mahakam River (20.7 boats per hour), where dolphins significantly decrease their surfacing rates in the presence of boats (Kreb 2004).

Arguably, the presence of the researcher's boats may have influenced the behavior of the dolphins and affected the results of the study. However, the dolphins' apparent passive behavior towards most boats may already indicate a form of habituation, a common behavior among dolphin groups living in highly utilized navigational and fishing areas (Kreb 2004). Dolphins often benefit when foraging alongside human fishers and have been known to prioritize the availability of prey over the risks of interacting with humans (Corkeron et al. 1990). They have been known to feed on the nets set by fishers (Norris and Prescott 1961; D'Lima et al. 2013) and even be involved in cooperative fishing (Tun 2004). This may also explain why the Irrawaddy dolphins did not appear bothered by dredging activities, as such disturbance of the sediment may also attract potential prey.

The dolphins avoided moving boats more than stationary ones. They swam away from moving boats when these intercepted their path while they were traveling, suggesting that the dolphins were aware of the effects of crossing a boat's path, or that the boat's noise elicit flight response from the dolphins. Irrawaddy dolphins have been known to use acoustic cues to gauge the distance to the approaching boat and based on that knowledge, plan their dives accordingly (Hashim and Jaaman 2011). Although noise was not included in the scope of this study, motorized boats produce high-frequency noise and are likely to affect the underwater acoustic environment. One of the common fishing methods in Bago and Pulupandan is the drive-in drift net, or "palagbong". This involves fishers circling around the net on a motorized boat and striking the water surface with a paddle to drive fish toward the gillnet. Such noise-generating practice could potentially interfere with the acoustic cues of dolphins and affect their diving patterns.

Implications for Conservation

The preference of the Irrawaddy dolphins for coastal habitats puts them at risk of boat collisions and net entanglement. The dolphins forage near the local port of Pulupandan, where large vessels docked and small motorized fishing boats frequently passed. Boat strikes through impacts with hulls and lacerations from propellers have been implicated as sources of injuries on many marine mammals (Wells and Scott 1997), and the dolphins' apparent habituation with boats may increase the chances of collision.

Due to the vulnerability of the dolphins' behavior towards boats, precaution is of utmost importance. We recommend management protocols to all users in the dolphins' core habitat, zoning of fishing grounds, and the identification of boat routes around the core habitat to minimize dolphin-boat collisions as much as possible. Boaters operating within the habitat are recommended to observe a maximum speed limit and be aware of the presence of dolphins when traversing their habitat. Boats must maintain a 100-meter distance from the dolphins in accordance with the guidelines set by the Departments of Tourism, Agriculture, Interior and Local Government, and Environment and Natural Resources (Joint Memorandum Circular No. 01 Series of 2020). Boat traffic management can be done through community orientation, establishment of widespread information materials, and strict monitoring by law-enforcement agencies (e.g. Bantay Dagat, Coast Guard). Dolphin-focused tourism activities are recommended to be limited to land-based observations so as not to add further boat traffic in the habitat.

While there has been no conclusive evidence of mortalities caused by net entanglement in Bago-Pulupandan, the myriad of gillnets spread throughout their habitat can still pose potential danger to the dolphins in this area. Pacalioga et al. (2017) recorded

three types of gillnets in the area, the drift gillnet, floating gillnet, and the drive-in gillnet used to catch different kinds of fish, some of which are also consumed by Irrawaddy dolphins (e.g. ponyfishes and conger eels) (Postrado et al. 2019). Gillnets are usually set 2-3 km from shore to catch pelagic fishes. There were on average 37 gillnets/day that were used by fishers in the study area. Gillnets can stretch from 1,500-2,500 m, thus can cover an extensive area inhabited by dolphins. An overlap of preferred fishes by the dolphins and those caught in nets can lead to higher risks of entanglement, a problem already implicated as one of the most common causes of mortalities in Irrawaddy dolphin populations elsewhere (Minton et al. 2017). The establishment of marine protected areas and proper zoning where gillnets can be prohibited can lessen risks of entanglement, as well as allow protection of vulnerable fish recruitment habitats.

There have never been reports of a fishery targeting dolphins in Bago and Pulupandan (Silliman University 2014). However, there has been a gradual increase in the number of fishers over the past years and fish catch data by Pacalioga et al. (2017) also indicate that fish stocks in the area are experiencing severe fishing pressure. Overfishing in these coastal areas may also affect prey availability for Irrawaddy dolphins.

This study aimed to characterize the impact of boat traffic on the behavior of Irrawaddy dolphins despite having some limitations such as the possible influence of the researcher's boats to the dolphins' responses. Other non-invasive methods to observe dolphin-boat interaction such as with the use of drones and hydrophones, or even land-based observations, may further allow us to understand this issue better. There is also a need to confirm if depredation from nets occur with Irrawaddy dolphins, as this may lead to net entanglement and even consumption of nylon net parts.

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REFERENCES

Alava MNR, Dolar MLL, Sabater ERS, Aquino MTR and Santos MD. 2012. Red List Status of Marine Mammals in the Philippines. Bureau of Fisheries and Aquatic Resources-National Fisheries Research and Development Institute. 194pp.

Aguilar GD. 2006. The Philippine Indigenous Outrigger Boat: scaling up, performance and safety. Marine Technology Society Journal, 40 (3): 49-58. https://doi.org/10.4031/002533206787353277

Allen MC and Read AJ. 2000. Habitat selection of foraging bottlenose dolphins in relation to boat density near Clearwater, Florida. Marine Mammal Science, 16(4): 815-824. https://doi.org/10.1111/j.1748-7692.2000.tb00974.x

Caron LMJ and Sergeant DE. 1988. Yearly variation in the frequency of passage of beluga whales (*Delphinapterus leucas*) at the mouth of the Saguenay River, Quebec, over the past decade. Naturaliste Canada, 115(2): 111-116.

Casipe KP, Espinosa KES, Jarabello CJM and de la Paz MEL. 2016. Foraging behavior association between Irrawaddy dolphins (*Orcaella brevirostris*) and tidal net fisheries in the coastal waters of Pulupandan, Negros Occidental, Philippines. Sylvatrop The Technical Journal of Philippine Ecosystems and Natural Resources, 26(1&2): 67-92.

Corkeron PJ, Bryden MM and Hedstrom KE. 1990. Feeding of Bottlenose Dolphins in Association with Trawling Operations in Moreton Bay, Australia. In: Leatherwood S and Reeves RR (eds). The Bottlenose Dolphin. Academic Press, pp. 329-336.

Department of Environment and Natural Resources Administrative Order No. 55. 1991. Declaring Dugong or Sea cow (Dugong dugon) as Protected Marine Mammal of the Philippines. https://bmb.gov.ph/index.php/resources/downloadables/laws-and-policies/denr-administrative-orders/dao-1987-1996?download=99:denr-administrative-order-1991-55&start=20. Accessed on 27 September 2022.

D' Lima C, Marsh H, Hamman M, Sinha A and Arthur R. 2013. Positive interactions between Irrawaddy dolphins and artisanal fishers in Chilika Lagoon of Eastern India are driven by ecology, socioeconomics, and culture. AMBIO, 43: 614-624 (2014). https://doi.org/10.1007/s13280-013-0440-4

de la Paz MEL, Abesamis NP, Sabater E, Señoron JA and Dolar ML. 2020. Habitat use and site fidelity of Irrawaddy dolphins (*Orcaella brevirostris*) in the coastal waters of Bago-Pulupandan, Negros Occidental, Philippines. Raffles Bulletin of Zoology, 68: 562-573. https://doi.org/10.26107/RBZ-2020-0072

Dinh T. 1999. Tugs & Towboats, Dredge Vessels and Others. https://www.scribd.com/document/497636859/Tug-Boat. Accessed on 30 March 2022.

Dolar MML, de la Paz MEL and Sabater E. 2018. *Orcaella brevirostris* (Iloilo-Guimaras Straits Subpopulation). The IUCN Red List of Threatened Species 2018: e.T123095978A123095988. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T123095978A123095988.en

ESSC (Environmental Science for Social Change). 1998. Community mapping manual for resource management. Quezon City, Philippines: GEBA Printing Press. 43pp.

Evans PGH, Canwell PJ and Lewis EJ. 1992. An experimental study of the effects of pleasure craft noise upon bottle-nosed

dolphins in Cardigan Bay, West Wales. European Research on Cetaceans, 6: 43-46.

Fisheries Administrative Order No. 185-1. 1997. Amending Sections 1 and 2 of FAO. 185 by adding whales and porpoises in the ban on the taking or catching, selling, purchasing and processing, transporting and exporting of dolphins. https://www.bfar.da.gov.ph/laws-regulations-issuances/administrative-orders/. Accessed on 27 September 2022.

Hashim N and Jaaman S. 2011. Boat effects on the behavior of Indo-Pacific Humpback (*Sousa chinensis*) and Irrawaddy dolphins (*Orcaella brevirostis*) in Cowie Bay, Sabah, Malaysia. Sains Malaysiana, 40(12): 1383-1392.

Hoyt E. 2005. Marine Protected Areas for Whales, Dolphins and Porpoises: A World Handbook for Cetacean Habitat Conservation. New York, USA. 464pp.

Janik VM and Thompson PM. 1996. Changes in surfacing patterns of bottlenose dolphins in response to boat traffic. Marine Mammal Science, 12(4): 597-602. https://doi.org/10.1111/j.1748-7692.1996.tb00073.x

Joint Memorandum Circular No. 01. 2020. Rules and regulations governing the conduct of marine wildlife tourism interactions in the Philippines. https://bmb.gov.ph/index.php/resources/downloadables/laws-and-policies/denr-administrative-orders/dao-2017-2022. Accessed on 27 September 2022.

Kreb D. 2004. Facultative river dolphins: Conservation and social ecology of freshwater and coastal Irrawaddy dolphins in Indonesia. PhD thesis. University of Amsterdam, Netherlands. 230pp. https://pure.uva.nl/ws/files/4034668/35320_thesis.pdf. Accessed on 30 March 2022.

Kruse S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. In: Norris KS and Pryor K (eds). Dolphin Societies: Discoveries and Puzzles. University of California Press, Berkely, pp. 141-159.

Mann J. 1999. Behavioral sampling methods for cetaceans: A review and critique. Marine Mammal Science, 15(1): 102-122. https://doi.org/10.1111/j.1748-7692.1999.tb00784.x

Minton G, Smith BD, Braulik GT, Kreb D, Sutaria D and Reeves R. 2017. *Orcaella brevirostris.* The IUCN Red List of Threatened Species 2017. https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T15419A50367860.en

MMPATF (Marine Mammal Protected Areas Protected Areas Task Force). 2019. Iloilo and Guimaras Straits IMMA. www.marinemammalhabitat.org/portfolio-item/iloilo-guimaras-straits. Accessed on 12 November 2021.

Morimura N and Mori Y. 2019. Social responses of travelling finless porpoises to boat traffic risk in Misumi West Port, Ariake Sound, Japan. PLoS ONE, 14(1): e0208754. https://doi.org/10.1371/journal.pone.0208754

Norris KS and Prescott JH. 1961. Observations on Pacific cetaceans of Californian and Mexican waters. University of California Publications in Zoology, 63: 291-402.

Nowacek SM, Wells RS and Solow AR. 2001. Short-term effects of boat traffic on Bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science, 17(4): 673-688. https://doi.org/10.1111/j.1748-7692.2001.tb01292.x

Nyumba TO, Wilson K, Derrick CJ and Mukherjee N. (2017). Qualitative methods for eliciting judgements for decision making: The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods in Ecology and Evolution, 9: 20-32.

Pacalioga J, Gulayan D and Leonares S. 2017. Fishery Profile of Bago-Pulupandan Coastal Waters. In: The Conservation and Management Enhancement of Irrawaddy dolphin Habitats in Negros Occidental, Philippines. Technical Report submitted to GIZ-DENR Protected Areas Management Enhancement Program. University of St. La Salle. 39pp.

Peter C, Poh ANZ, Ngeian J, Tuen A and Minton G. 2016. Identifying habitat characteristics and critical areas for Irrawaddy dolphin, *Orcaella brevirostris*: Implications for conservation. In: Das I and Tuen AA (eds). Naturalists, Explorers and Field Scientists in Southeast Asia and Australasia. Springer, pp. 225-238. https://doi.org/10.1007/978-3-319-26161-4_15

Postrado JFL, Jover KMA, Mabulac HJ, Velasco JSB, de la Paz MEL, Pereda, JM Ventolero MF and Santos MD. 2019. Identification of fish prey of an Irrawaddy dolphin (*Orcaella brevirostris*) using mitochondrial cytochrome c oxidase sequence analysis. The Philippine Journal of Fisheries, 26(1): 1-7.

Republic Act No. 8550. 1998. The Philippine Fisheries Code of 1998. https://www.officialgazette.gov.ph/1998/02/25/republic-act-no-8550/. Accessed on 26 September 2022.

Republic Act No. 9147. 2002. Wildlife Resources Conservation and Protection Act. https://www.officialgazette.gov.ph/2001/07/30/republic-act-no-9417/. Accessed on 26 September 2022.

Republic Act No. 10654. Amendment of the Philippine Fisheries Code of 1998. https://www.officialgazette.gov.ph/2015/02/27/republic-act-no-10654/#:~:text=Unregulated%20Fishing.,within%20and%20beyond%20national%20jurisdiction. Accessed on 26 September 2022.

Silliman University. 2014. Development of a Conservation Program for the Irrawaddy Dolphins (*Orcaella brevirostris*) in the Visayas in line with the Coral Triangle Initiative National Plan of Action. Dumaguete City, Philippines. 332pp.

Smith BD and Beasley I. 2004. *Orcaella brevirostris* (Malampaya Sound subpopulation). The IUCN Red List of Threatened Species 2004: e.T44187A10858619. https://doi.org/10.2305/IUCN.UK.2004.RLTS.T44187A10858619.en

Smith BD, Beasley I, Buccat M, Calderon V, Evina R, de Valle JL, Cadigal A, Tura E and Visitacion Z. 2004. Status, ecology, and conservation of Irrawaddy dolphins (*Orcaella brevirostris*) in Malampaya Sound, Palawan, Philippines. Journal of Cetacean Research and Management, 6(1): 41-52.

Tun T. 2004. Irrawaddy Dolphins in Hsithe–Mandalay segment of the Ayeyarwady River and Cooperative Fishing between Irrawaddy Dolphin, *Orcaella brevirostris*, and Cast-net Fishermen in Myanmar. Wildlife Conservation Society, Myanmar. 61pp.

Wells RS and Scott MD. 1997. Seasonal incidence of boat strikes on bottlenose dolphins near Sarasota, Florida. Marine Mammal Science, 13(3): 475-480. https://doi.org/10.1111/j.1748-7692.1997.tb00654.x

Whitty TS. 2015. Governance potential for cetacean by-catch mitigation in small-scale fisheries: A comparative assessment of four sites in Southeast Asia. Applied Geography, 59: 131-141. https://doi.org/10.1016/j.apgeog.2015.01.003

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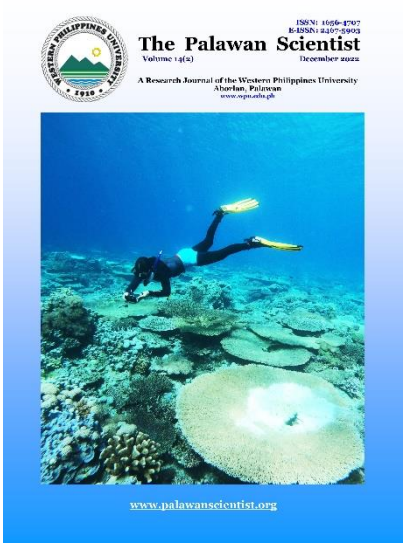

Status of coral reefs, butterflyfishes, and benthic macro-invertebrates in Araceli and Dumaran, Palawan, Philippines

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ABSTRACT

As a major fishing ground in Palawan, the reefs in the municipal waters of Araceli and Dumaran are continuously facing anthropogenic and climate-related threats. Hence, to provide information about the reef conditions, surveys were undertaken in three sites of each municipality as the basis for management. Data collection used the C30 method where a 75 m × 25 m sampling area was established at the upper reef slope (2-5 m deep) of each site. Substrates were photo-documented at predetermined random positions and the photos were processed using Coral Point Count with excel extension software (CPCe) to determine the percent substrate categories. Identification and counting of butterflyfishes and benthic macro-invertebrates were also undertaken. The hard-coral cover (HCC) ranged between 27.10 and 53.88% (fair to very good) for Araceli and 22.66 and 48.62% (fair to good) for Dumaran. The number of species and density of butterflyfishes largely varied across reefs. The benthic macro-invertebrates only included the blue *Linckia* starfish and giant clams. The current reef condition calls for urgent management actions.

Keywords: C30 methods, *Chaetodon baronessa*, *Chaetodon melannotus*, giant clams, island reefs

INTRODUCTION

Coral reefs provide various ecological and economic goods and services, including shoreline defense against storm surges, essential sources of food and shelter for various organisms, serving as important fishing grounds, and venues for recreation (Burke et al. 2011; Maulil et al. 2014). The total net benefits of the world's coral reefs are about US$29.8 billion, wherein tourism and recreational activities accounted for US$9.6 billion, US$9 billion for coastal protection, US$5.7 billion for fisheries, and US$5.5 billion for its biodiversity (Burke et al. 2002; 2011). In the Philippines, coral reefs have total economic value of about US$4 billion per year arising from reef fisheries, tourism and biodiversity (Tamayo et al. 2018).

Despite the promising benefits of coral reefs, its status continues to decline globally (Gardner et al. 2003). The degradation of these reef areas are mainly brought by anthropogenic threats and pressures (Alcala and Russ 2002; Licuanan et al. 2019). As of 2019, hard coral cover (HCC) for Philippine reefs falls

under Category C (22-33% HCC) which is lower than the average of Tubattaha Reefs Natural Park- a well-protected marine area in the country (Licuanan et al. 2019; Licuanan 2020).

The island province of Palawan is located between the West Philippines Sea and the Sulu Sea – this region has the highest remaining hard coral cover in the Philippines (Licuanan et al. 2019) and making it known as the apex of marine biodiversity (ADB 20 14). Further, the area is also home to 505 species of coral (WWF-Philippines 2019) and more than a thousand reef fishes (Allen and Erdmand 2009; Gonzales 2013; Balisco and Dolorosa 2019) and benthic macro-invertebrates species (Ardines et al. 2020; Balisco et al. 2020).

Reef monitoring is vital to measure the management effectiveness and early warnings of threats to coral ecosystems (Licuanan et al. 2021). Its information could be used in formulating sound management strategies for coral reef conservation (WWF-Philippines 2019). Practical reef conservation actions can help realize the Sustainable Goal Development (SGD) 14 or life below the water of the United Nation's 17 SGDs (UN 2015). In Palawan, reef monitoring surveys have been done in many localities (i.e. WWF-Philippines 2012, 2013; Dolorosa et al. 2015a; Dolorosa 2016; Balisco et al. 2017); however, little has been done in Araceli and Dumaran.

The reefs within the municipal waters of Araceli and Dumaran are among the richest fishing grounds in Palawan (WWF-Philippines 2010). However, according to local communities anthropogenic activities such as illegal fishing and illegal entry from nearby municipality continues to threaten the reefs of these two areas. This study provides the latest data on the reefs' condition in the two municipalities in terms of coral cover, species richness and density of butterflyfishes, and abundance of benthic macro-invertebrates. The findings may serve as the basis for local policymakers to formulate management systems and prioritize areas for conservation.

METHODS

Study Sites

The survey was conducted in November 2021 in the municipalities of Araceli and Dumaran, Palawan. These municipalities are known for the relatively good coral covers compared to other areas (pers. obs.). Survey sites in Araceli included the Cambari, Cotad, and Langoy, while Camangyan, Mayabaka, and Syed for Dumaran (Figure 1).

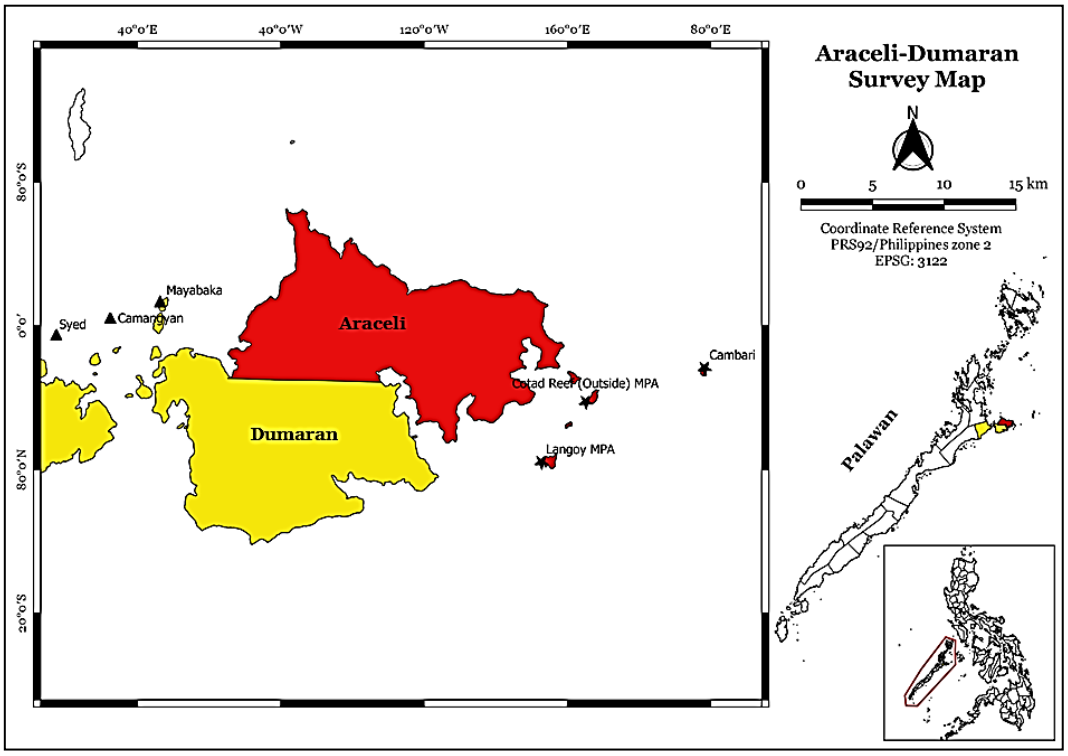

Figure 1. Map of the Philippines and Palawan (inset) and the locations of sampling sites in the municipalities of Araceli (★) and Dumaran (▲), Palawan.

Cambari island. This is located about 11 km away from Barangay Poblacion, Araceli. A fringing reef between 2-9 m deep (Figure 2A), which harbored numerous coral species and marine fauna. Water is relatively clear during sampling with up to 10 m horizontal visibility. The sightings of adult and juvenile manta rays, makes the waters of Cambari a potential diving destination.

Cotad island. This is located in the southeastern portion of Araceli and is approximately 4 km away from the town center. Water is relatively clear with good visibility (Figure 2B). The reef harbored a diverse species of marine flora and fauna.

Langoy island. This is located in the southern part of the town center and about 6 km away from Bgy. Poblacion of Araceli. Corals flourished near the shoreline at depths ranging between 3 and 8 m (Figure 2C). Water is relatively clear with high visibility.

Camangyan reef. This reef flat is within the jurisdiction of Dumaran, and approximately 5 km from Barangay Danleg. Corals generally *Acropora* spp. flourished at about 4-5 m deep with good visibility (Figure 2D). Some portions of the reef exhibited damage possibly due to the outbreak of crown-of-thorn starfish and boat anchorage.

Mayabaka reef. This is located about 400-500 m off Mayabaka Island, Barangay Poblacion, Dumaran. The reef is about 4-5 m deep (Figure 2E).

Syed reef. This is located east of Barangay Culasian, Dumaran. This shallow reef (4-5 m deep) dominated with *Acropora* spp. is approximately 80 m away from the shoreline (Figure 2F). Water is relatively clear with a visibility of 5-10 m.

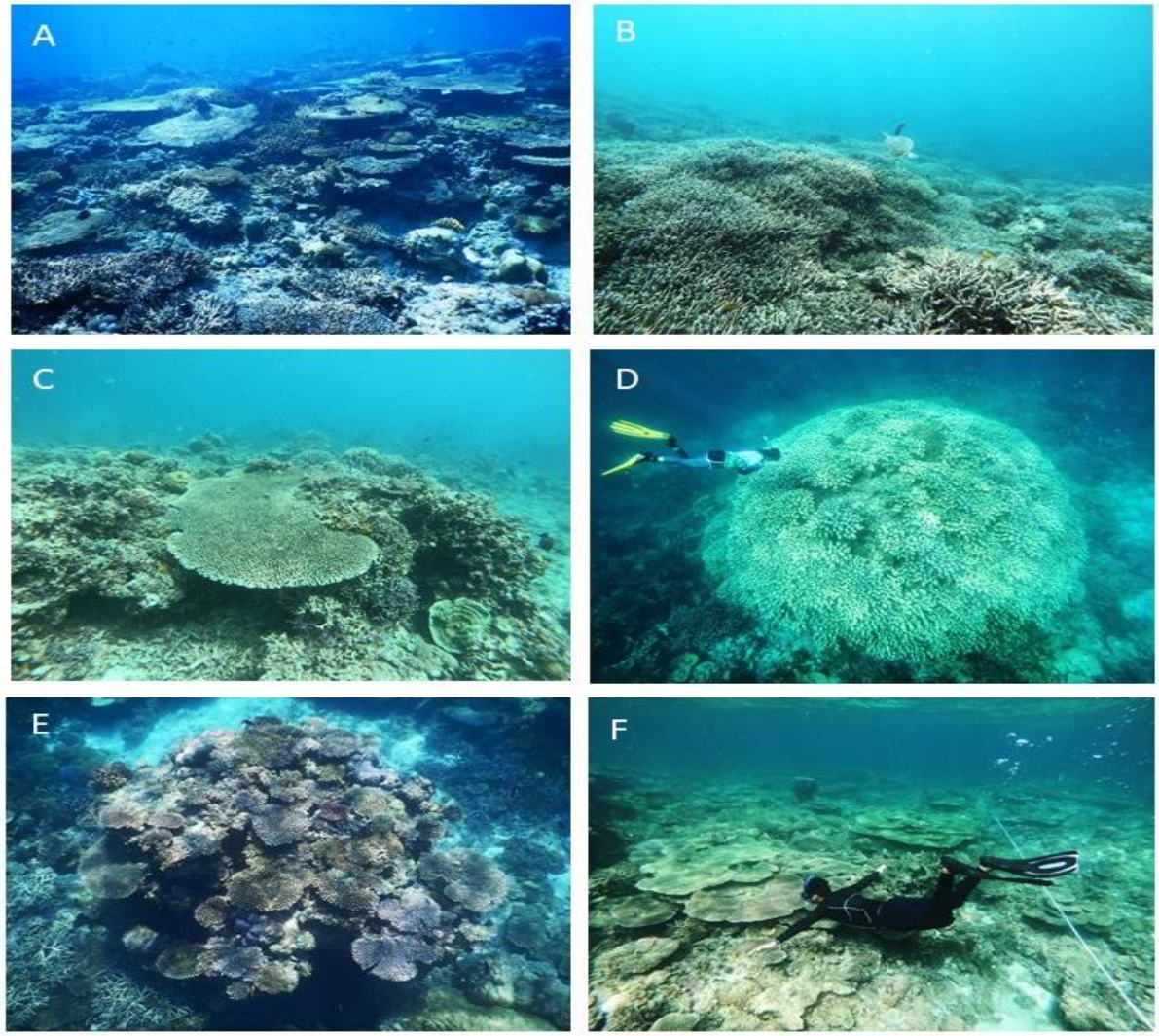

Figure 2. The reefs in Cambari (A), Cotad (B), Langoy (C), Camangyan (D), Mayabaka (E) and Syed (F).

Data Collection

Before the data collection, a reconnaissance survey was conducted on all sites to identify sampling stations that fall under the C30 criteria (Licuanan et al. 2021) for site establishment. At each site during the survey, a 75 m × 25 m transect line was laid parallel to the shoreline. Each corner was marked with floating buoys serving as the parameter of the station. Each sampling station was established at the upper reef slope at 2-5 m deep (Licuanan et al. 2021).

The HCC and other substrates were quantified using the C30 method (Licuanan et al. 2021). This method involved two skin divers: 1) the navigator who holds the buoy marker and guides the photographer on where to take a photo of the substrate, and 2) the photographer who takes photos of the substrate using a monopod (Figure 3) at predetermined random positions or imaging spots in the sampling stations. The random positions were generated through MS excel using the formula =randbetween (1,8) for directions and =randbetween (1,10) for the distance. The directions were guided by a compass (e.g. 1 = north, 2 = Northeast, 3 = East, etc.), while the distances (in meters) were calibrated to several flipper kicks (1 flipper kick =1-meter distance). The direction and distance of each swim were relative to starting position at the center of the reef sampling station facing the shore/mainland. Each substrate spot was photographed with the base of the monopod facing the shore/mainland. When the random number led the divers to the outer boundary, the diver swam back to the original direction until the remaining distance is completed. These randomization steps were repeated until 50 pictures were captured within each station.

The species and density of butterflyfishes and target benthic macro-invertebrates (i.e. *Linckia*, *Protoreaster*, crown of thorns, feather star, and giant clam) were noted and counted within the 75 m × 25 m sampling station. The counting of butterflyfishes was done by dividing the width (25 m) of the sampling station into two segments (12.5 m). Three (3) skin divers then swam along the length of the first segment up to the endpoint, the second segment then continued back to the starting point. All butterflyfishes observed were counted and identified to species level using the laminated identification field guide containing photos of 37 species of butterfly fishes (Licuanan 2021). Butterfly fishes are reef health indicators and can be used to describe the health of the reef (Reese 1981), without taking into account the other reef fishes. Giant clam size classification was determined using the A4 laminated field guide wherein one-half the width of the field guide is considered as small (<10.5 cm), (medium 10.6 cm to 29.7 cm – full width) while an individual that is larger than the full width is considered as large (29.7>).

Figure 3. The navigator (left) and photographer (right) researchers while photo-documenting the substrate using the C30 method.

Data Analysis

For HCC, all captured images of the substrate were processed using the CPCe software (Kohler and Gill 2006), which helped determine the HCC from relative frequencies of ten randomly-positioned scoring points per image. The averages (±sd) were determined using MS Excel. Graphs were generated to visually compare the data among sites.

RESULTS

Coral Cover

Both municipalities HCC were generally variable, but the averages only differed by about 4%. For Araceli, the HCC ranged between 27.10 and 53.88% with an average (±sd) of 37.25 ± 14.52%, while in Dumaran, the HCC ranged between 22.66 and 48.62% with an average of 33.39 ± 13.55%. Cotad in Araceli and Syed in Dumaran had the highest HCC of 53.88% and 48.62%, respectively. However, algal assemblages (AA) for Araceli and Dumaran were higher than HCC. In Araceli, AA ranged between 41.56 and 59.47% (mean: 47.79 ± 0.12%), while it is between 34.44 and 56.56% (mean: 44.83 ± 11.12%) in Dumaran. Other abiotic components were relatively low compared to HCC and AA (Figure 4).

Species Richness and Density of Butterflyfishes

Out of the 37 species of butterflyfishes included in the datasheet, only ten species were recorded. Seven species were observed in Araceli, while five species in Dumaran (Figure 5). Only *Chaetodon baronessa* and *Chaetodon melannotus* occurred in both municipalities. Among the seven species encountered in Araceli, *C. baronessa, Chaetodon vagabundus* and *Chaetodon lunulatus* were more common than the other species observed in all three sites (Cambari, Cotad, and Langoy). Cambari had the highest number of species (6), followed by Cotad (5). Langoy only registered three species.

Among the three sites in Dumaran, Syed registered the highest density and number of butterflyfishes. *Chaetodon octofasciatus* had the highest density among the five species, with the same species that occurred in all three sites (Kamangyan, Mayabaka, and Syed) whileonly two species (*C. octofasciatus* and *Chelmon rostratus*) appeared in Kamangyan.

Benthic Macro-Invertebrates

The recorded benthic macro-invertebrates only included the blue *Linckia* starfish and giant clams for Dumaran, while only blue *Linckia* starfish were noted in Araceli. Giant clams in Kamangyan recorded the highest density with 88.5 individuals per 1,875 $m^{2,}$ further, it was observed that most of the giant clams in Dumaran are relatively small in size. Other species of interest, such as crown-of-thorns (COT) starfish, chocolate chip sea star *Protoreaster nodosus*, and feather stars, were only noted outside the established 75 m × 25 m sampling areas.

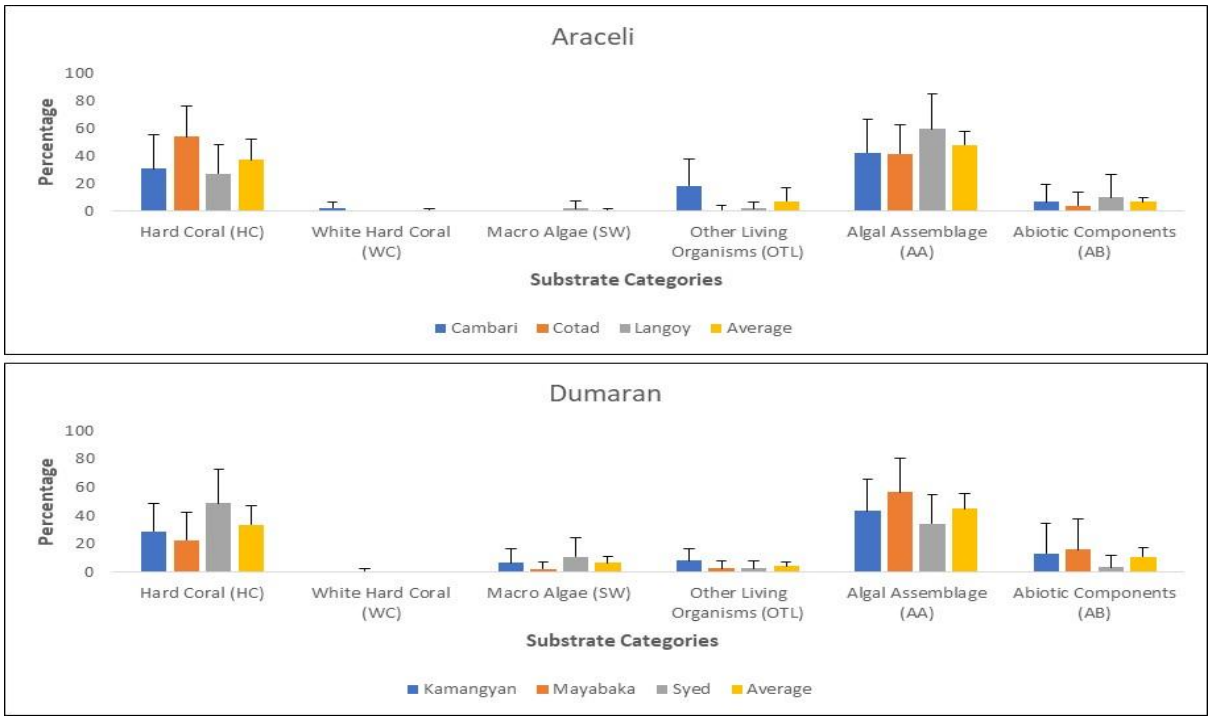

Figure 4. Percent substrate cover in Araceli and Dumaran, Palawan.

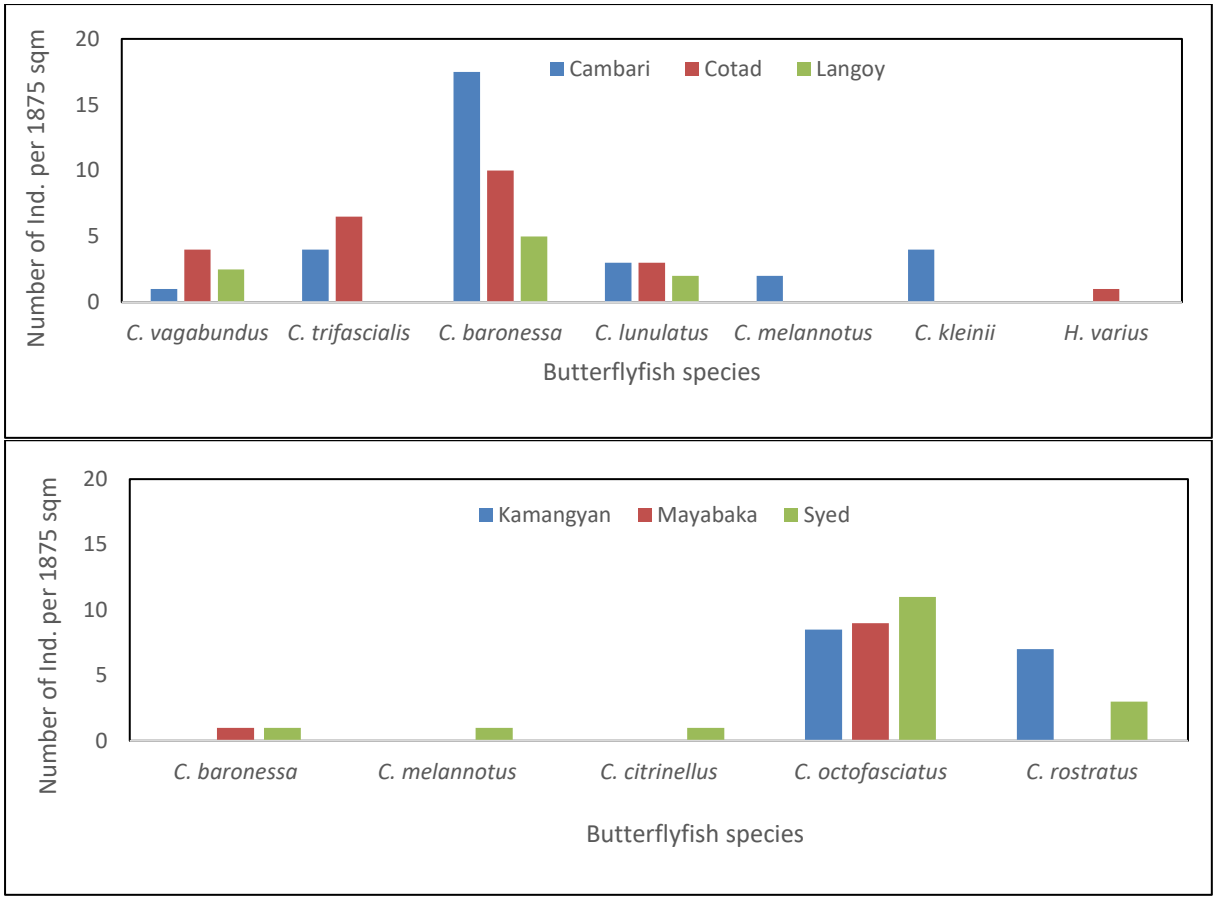

Figure 5. Species richness and density of butterflyfish species (individuals per 1875 m^2) in Araceli (top) and Dumaran (bottom), Palawan.

Table 1. Density (individuals per 1,875 m^2) of targeted benthic macro-invertebrates in surveyed sites in Araceli and Dumaran, Palawan.

Species	Araceli			Dumaran		
	Cambari	Cotad	Langoy	Kamangyan	Mayabaka	Syed
Blue *Linckia* starfish	4.50 (±2.12)	2.50 (±0.71)	1.00 (±1.41)			
Giant Clam *Tridacna* spp.						
Small (<21 cm)	1.00 (±0.00)	1.00 (±0.00)	3.50 (±2.12)	88.50 (±27.58)	41.50 (±37.48)	18.67 (±19.14)
Medium (22 to 29.7 cm)				2.00 (±1.41)	3.00 (±2.12)	1.33 (±2.31)

DISCUSSION

Coral Cover

The average percentage HCC in Araceli (37.25 ± 14.52%) and Dumaran (33.39 ± 13.55%) falls within the Category B conditions (>33-44% HCC) which is higher than the average HCC in Tubattaha Reefs Natural Park (see Licuanan et al. 2019; Licuanan 2020). However, a previous survey in 2017 (Figure 6) indicated a decline of more than 10% in both Cambari and Langoy (WWF-Philippines 2017). A similar condition was also observed in other areas in Palawan (WWF-Philippines 2012, Gonzales et al. 2014a, Gonzales et al. 2014b, Dolorosa et al. 2015a,

WWF-Philippines 2017) However, the comparison should be treated with caution due to variation in survey methods and the surveyed sites, the general trend for coral reefs is declining, globally, 20% of coral reefs have already been destroyed, and 50% are in danger of being destroyed in the near future (van der Meer et al. 2013). The key drivers of coral loss include anthropogenic and changes in climatic conditions, which cause portions of otherwise connected reefs to die, fragmenting reef growth, and causing a decrease in the continuity of shelter for fish (Pratchett et al. 2013; van der Meer et al. 2013). The reefs in Langoy, Araceli showed numerous marks of boat anchorage, which, if left uncontrolled could bring further damage to the reef ecosystem. A study conducted by Palaganas V. (1991) on the impacts of boat anchors on the coral reef in Sombrero Island, Batangas Philippines revealed that a total of 15.4164 m^2 of corals were damaged by a boat anchor, 13.4164 m^2 of which was caused by anchor droppings and 2.3370 m^2 from anchor retrieval. If left unchecked, this activity would lead to the further decline of reef productivity. In a similar study conducted in the British Virgin Islands, hard coral colonies in highly anchored sites were 40% smaller in surface area and ~60% less dense than areas with little boat anchorage incidence. Furthermore, highly anchored sites supported only ~60% of the species richness of little anchored areas, ~60% as structurally complex, and supported less than half fish biomass with those rarely anchored (Flynn and Forrester 2019).

The percent HCC in Dumaran was comparable to the reef conditions in other areas of Palawan which have been monitored six or seven years ago (WWF unpublished data; Figure 4). The three-dimensional coral cover can be almost 100% when undisturbed, as observed in some reef slopes in the Green Island Bay in the municipality of Roxas and Tubattaha Reefs Natural Park, Cagayancillo Palawan (pers. obs.) When fully protected from all forms of human disturbance, damaged coral reefs may take decades to fully recover (Burke et al. 2002). Thus, restoring damaged reefs requires strengthened and effective enforcement mechanisms. Regular monitoring of the reef is crucial in detecting changes in the reef's condition and as a measure of management success (Uychiaoco et al. 2010). Regular patrolling can help deter illegal fishers, thus allowing marine resources to recover over time.

The higher percent composition of AA (44.83-47.79%) than HCC (33.39-37.25%) in the reefs of Araceli and Dumaran is an indication of disturbed reefs (Goatley and Bellwood 2013). It can be attributed to run-off and unsustainable fishing practices which affect the coral reef ecosystem in the area. According to River and Edmunds (2001), reef disturbances and run-offs provide suitable substrates for the attachment of algal species that hinders coral growth by shading and abrasion to coral polyps. In addition, a study conducted by McCook (1996), on the Great Barrier Reef revealed that the loss of herbivores due to overfishing can cause a shift from coral to algal-dominated reefs.

A drastic decline in coral cover can negatively affect fish biodiversity, both in protected and open-access areas. This can lead to permanent reef degradation and extinction of rare coral-specialist (Jones et al. 2004).

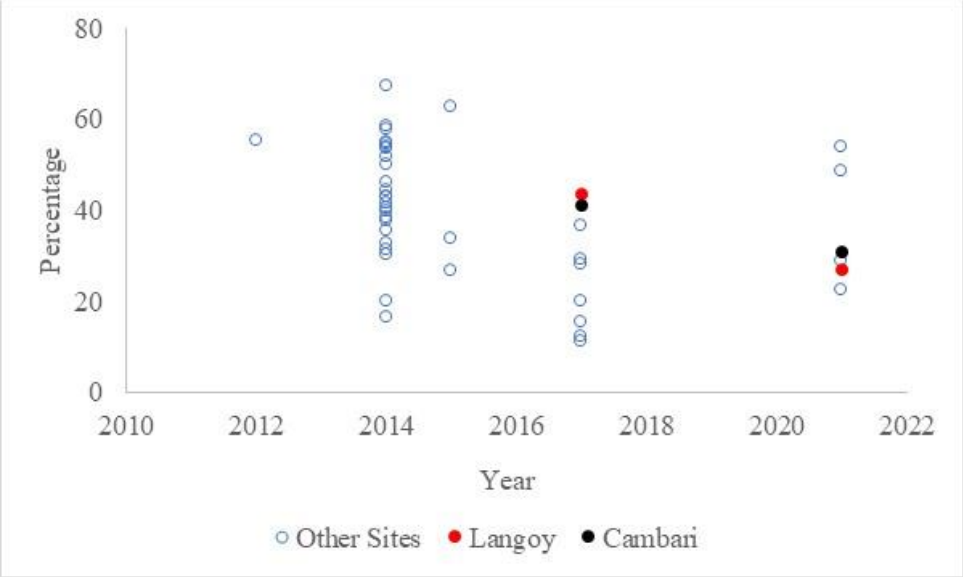

Figure 6. Percentage of hard coral cover (HCC) in some parts of Palawan in 2012, 2014, 2015, Araceli in 2017 (WWF unpublished data) and in Araceli and Dumaran in 2021.

Species Richness and Density of Butterflyfishes

The species richness of butterflyfishes in both study sites, Araceli (7 species) and Dumaran (5 species) was higher than in Coron, Culion, El Nido, Linapacan, and Taytay, which composed only of two species (Verdadero et al. 2017). However, the combined species richness (10 species) in Araceli and Dumaran was much lower than the species richness (17-20 species) reported in other areas (Table 2). In terms of density, the study recorded a total of 20 individuals 1000 m^2 which is relatively lower than the study conducted by Verdadero et al. 2017 with 40 individuals per 1000 m^2. The number of butterflyfish species may vary in accordance with the size of the reef and the available food. The recorded butterfly species were either obligate (restricted food/habitat) or facultative (wide range of food/habitat). *C. baronessa* is an obligate species, feeding exclusively on the polyps of the tubular *Acropora* corals (Berumen et al. 2005). This species occurred abundantly in the reefs of Araceli, but were seldom found in Dumaran. By contrast, the obligate *C. octofasciatus*, which exclusively feeds on coral polyps (Madduppa et al. 2014), occurred abundantly in all sites in Dumaran but not in Araceli. The uneven distribution of obligate and the low numbers of facultative species (*Chaetodon citrinellus, Chaetodon kleinii*, *Chaetodon vagabundus*, and *Heniochus varius*) need further investigation.

Butterflyfishes are considered reef health indicators (Crosby and Reese 1996; Pratchett et al. 2006; Leahy 2016). They are sensitive to the change in their habitats, particularly those species under obligate corallivores (Crosby and Reese 1996; Brooker et al. 2013). The absence of these species in coral reefs indicates an early warning that changes are coming (Crosby and Reese 1996). In the Southern Great Barrier Reef, the populations of butterflyfishes decreased by 50% when live coral cover declined by only 12% (Andrews and Kownacki 2021). Specialized coral-dependent fishes are highly vulnerable to coral loss caused by climate-induced coral bleaching. Moreover, the structural collapse of dead coral colonies may have significant but more variable impacts across a wide range of fishes (Graham et al. 2009).

Benthic Macro-Invertebrates

Following the global trends for shellfish harvesting, giant clams – the largest living bivalves, are highly prized (Shang et al. 1991; Lucas 1994) for their meat and shells (Gomez and Mingoa-Licuanan 2006; Neo et al. 2017). They occur in nearshore habitats, especially in coral reef and seagrass ecosystems, making them highly vulnerable to harvesting (Newman and Gomez 2000; Mecha and Dolorosa 2020). Many livelihood activities, especially in developing countries like the Philippines, depend on artisanal fisheries, including the harvesting of giant clams (Juinio et al. 1987). These speciesserve as a cheap source of protein, especially for offshore small island inhabitants (Ardinez et al 2020).

Table 2. Species richness and density of butterflyfishes in various localities in Palawan in comparison to this study sites.

Location	Species Richness	Fish Density (ind/ 1000 m^{-2})	Sources
Pagasa Island, Kalayaan	20	4	Pagliawan et al. 2008
Snake island, Honda Bay, PPC	17	19	Gonzales et al. (2014a)
Apulit island, Taytay,Palawan	5	5	Gonzales et al. (2014b)
Coron, Culion, El nido Linapacan, Taytay	2	40	Verdadero et al. (2017)
Roxas	18	3	Balisco et al. (2017)
Araceli	7	20	This study
Dumaran	5		

The presence of giant clams in the reefs of Dumaran makes the areas suitable for resource conservation, by providing a substrate for colonization for epibionts, increasing the topographic heterogeneity of the reef, and acting as a reservoir of zooxanthellae (Neo et al. 2014). Meanwhile, the absence of medium and large size giant clams in Araceli may be attributed to the local collection of giant clams in the area.

There has been a surge in collecting fossilized giant clam shells in Palawan in recent years. Between 2019 and 2021, the government has confiscated thousands of tons of shells valued at PHP2.7 billion (BBC News 2021; Magdayao 2021; Noriega 2021). Giant clam shells are in high demand in the carving industry and substitute for elephant ivory (Larson 2016; Neo 2017). Unearthing these fossilized giant clam shells can destabilize the substrate and cause disturbance to the ecosystem (Bale 2016). While the government prohibits the collection and trade of giant clams (DA 2001, RA 10654), illegal trade continues to threaten the last remaining populations thus requiring an effective surveillance and monitoring system. However, considering the value of giant clam shells, it is sad to note some allegations regarding the involvement of government officials in the activity (Fabro 2021).

Apart from vigorous monitoring of macrobenthic invertebrates such as giant clams, establishing Marine Protected Areas (MPA) is viewed as an effective strategy for protecting the remaining populations of macrobenthic organisms, coral reefs, and other marine life. Further, Cabaitan et al. (2008) claimed that an increase in the density of giant clams can influence fish biomass, thus benefiting fishing communities.

On the other hand, target benthic macro-invertebrates such as blue *Linckia* starfish were only observed in the Araceli, while the rest of the target macroinvertebrates such as COT, feather star, and chocolate chip sea stars were not noted in both areas. According to Scheibling and Metaxas (2008), chocolate chip sea star *P. nodosus* are less frequent on the reef as they are more abundant in the seagrass bed areas. There is no known ongoing local collection and market for the blue *Linkia* and chocolate chip sea star; hence it is improbable that the observed low density is due to exploitation. The absence of COT is a good sign but continued monitoring is needed to detect early signs of COT outbreak.

The findings of this study suggest that the coral reefs in Araceli and Dumaran are still in good condition as it has a higher average HCC compared to the baseline HCC in various bioregions in the Philippines (see Licuanan et al. 2019; Licuanan 2020). Therefore, a sound management approach should be available and implemented to protect and manage these areas. With this, the natural restoration of coral reefs from its recruit would continue and save a lot of investment and mortality of corals from coral transplantation/gardening (Reyes et al. 2017). In addition, effective marine resource management strategies will also help replenish the fish population and other macro-benthic invertebrates in the area. Moreover, information and education campaigns on proper boat anchorage for coastal fishers and boat operators of fishing boats and in tourism could help minimize coral damage.

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REFERENCES

ADB (Asian Development Bank). 2014. State of the Coral Triangle: Philippines. Mandaluyong City, Philippines. 128pp.

Alcala A and Russ G. 2002. Status of Philippine coral reef fisheries. Asian Fisheries Science, 15: 177-192. https://doi.org/10.33997/j.afs.2002.15.2.009

Allen GR and Erdmann MV. 2009. Reef fishes of El Nido, Palawan, Philippines. Primex Printers Inc., El Nido Foundation Inc.

Andrews BM and Kownacki AKS. 2021. Quantification of the effect of coral reef degradation on butterflyfish populations in the Southern Great Barrier Reef. Journal of Marine Science Research and Oceanography, 4: 154-158.

Ardines RB, Mecha NJMF and Dolorosa RG. 2020. Commonly gleaned macrobenthic invertebrates in a small offshore island of Cawili, Cayagancillo, Palawan, Philippines. The Palawan Scientist, 12: 102-125.

Bale R. 2016. Critical reefs destroyed in poachers' quest for world's biggest clams. National Geographic. https://www.nationalgeographic.com/animals/article/wildlife-giant-clam-poaching-south-china-sea-destruction. Accessed on 21 August 2022.

Balisco RAT and Dolorosa RG. 2019. The reef-associated fishes of West Sulu Sea, Palawan, Philippines: a checklist and trophic structure. AACL Bioflux, 12(4): 1260-1299.

Balisco RAT, Gonzales BJ and Dolorosa RG. 2020. Species composition, density, and conservation status of some economically important macrobenthic invertebrates in Pag-asa Island, Kalayaan, Palawan, Philippines. Asian Fisheries Science, 33: 357-365. https://doi.org/10.33997/j.afs.2020.33.4.007

Balisco RAT, Gonzales JG, Matillano JA and Gonzales BJ. 2017. Mapping and assessment of 1,700 ha coral reefs in Roxas, Palawan. Technical Report. Department of Environment and Natural Resources (DENR)–Provincial Environment and Natural Resources Office (PENRO). 30pp.

BBC News. 2021. Philippines: Giant clam shells worth $25m seized in raid. https://www.bbc.com/news/world-asia-56784215. Accessed on 21 August 2022.

Berumen ML, Pratchett MS and McCormick MI. 2005. Within-reef differences in diet and body condition of coral-feeding

butterflyfishes (Chaetodontidae). Marine Ecology Progress Series, 287: 217-227. http://dx.doi.org/10.3354/meps287217

Brooker RM, Munday PL, Mcleod IM and Jones GP. 2013. Habitat preferences of a corallivorous reef fish: predation risk versus food quality. Coral Reefs, 32(3): 613-622. https://doi.org/10.1007/s00338-013-1057-6

Burke L, Selig E and Spalding M. 2002. Reefs at Risk in Southeast Asia. World Resources Institute (WRI), Washington, DC. 72pp.

Burke L, Reytar K, Spalding M and Perry A. 2011. Reefs at Risk Revisited. World Resources Institute. Washington. 86pp.

Cabaitan PC, Gomez ED and Aliño PM. 2008. Effects of coral transplantation and giant clam restocking on the structure of fish communities on degraded patch reefs. Journal of Experimental Marine Biology and Ecology 357: 85-98. https://doi.org/10.1016/j.jembe.2008.01.001

Crosby MP and Reese ES. 1996. A Manual for Monitoring Coral Reefs with Indicator Species: Butterflyfishes as Indicators of Change on Indo-Pacific Reefs. Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, Silver Spring, MD. 45pp.

DA (Department of Agriculture). 2001. Conservation of rare, threatened and endangered fishery species. Philippines. Fisheries Administrative Order NO. 208, Series of 2001. http://www.bfar.da.gov.ph/LAW?fi=353#post. Accessed on 21 August 2022.

Dolorosa RG. 2016. Coral cover and density of reef associated macroinvertebrates and fishes in Rasa Island Wildlife Sanctuary, Narra, Palawan, Philippines. Technical report. 30pp.

Dolorosa RG, Balisco RAT, Bundal NA and Magbanua RM. 2015a. Reef assessment of Cagayancillo, Palawan, Philippines. World Wildlife Fund for Nature Philippines. 25pp.

Fabro KA. 2021. Surge in seizures of giant clam shells has Philippine conservationists wary. Mongabay News and Inspiration from Nature 's Frontline. https://news.mongabay.com/2021/03/surge-in-seizures-of-giant-clam-shells-has-philippine-conservationists-wary/. Accessed on 21 August 2022.

Flynn RL and Forrester GE. 2019. Boat anchoring contributes substantially to coral reef degradation in the British Virgin Islands. PeerJ, 7: e7010 https://doi.org/10.7717/peerj.7010

Gardner TA, Côté IM, Gill JA, Grant A and Watkinson AR. 2003. Long-term region-wide declines in Caribbean corals. Science, 301(5635): 958-960. https://doi.org/10.1126/science.1086050

Goatley CHR and Bellwood DR. 2013. Ecological consequences of sediment on high-energy coral reefs. Plos One, 8(10): e77737. https://doi.org/10.1371/journal.pone.0077737

Gomez ED and Mingoa-Licuanan SS. 2006. Achievements and lessons learned in restocking giant clams in the Philippines. Fisheries Research, 80:46-52. https://doi.org/10.1016/j.fishres.2006.03.017

Gonzales BJ. 2013 Field Guide to Coastal Fishes of Palawan. Coral Triangle Initiatives on Corals, Fisheries, and Food Security. USAID-WWF. 208pp.

Gonzales BJ, Pagliawan HB, Becira JG and Gonzales MMG. 2014a. Marine resource assessment for sustainable utilization of Snake Island, Palawan, Philippines. AACL Bioflux, 7(5): 372-385.

Gonzales BJ, Dolorosa RG, Pagliawan HB and Gonzales MMG. 2014b. Marine resource assessment for sustainable management of Apulit Island, West Sulu Sea, Palawan, Philippines. International Journal of Fisheries and Aquatic Science, 2(2): 130-136.

Graham NAJ, Wilson SK, Pratchett MS, Polunin NVC and Spalding MD. 2009. Coral mortality versus structural collapse as drivers of corallivorous butterflyfish decline. Biodiversity Conservation, 18: 3325-3336. https://doi.org/10.1007/s10531-009-9633-3

Jones GP, McCormick MI, Srinivasan M and Eagle JV. 2004. Coral decline threatens fish biodiversity in marine reserves. Proceedings of the National Academy of Sciences, 101(21): 8251-8253. https://doi.org/10.1073/pnas.0401277101

Juinio MAR, Meñez LAB and Villanoy CL. 1987. Use of giant clams resources in the Philippines. Naga, The ICLARM Quarterly 10(1): 7-8.

Larson C. 2016. Shell trade pushes giant clams to the brink. Science, 351(6271): 323-324. https://doi.org/10.1126/science.351.6271.323

Leahy SM. 2016. Habitat determinants of *Chaetodon* butterflyfish and fishery-targeted coral reef fish assemblages in the central Philippines. PhD Thesis, James Cook University. 184pp.

Licuanan WY. 2020. New scales to guide the assessment of hard coral cover and diversity in the Philippines. The Philippine Journal of Fisheries, 27(2): 121-126. https://10.31398/tpjf/27.2.2020-0008

Licuanan WY, Mordeno PZB and Go MV. 2021. C30—A simple, rapid, scientifically valid, and low-cost method for citizen-scientists to monitor coral reefs. Regional Studies in Marine Science, 47: 101961. https://doi.org/10.1016/j.rsma.2021.101961

Licuanan WY, Robles R and Reyes M. 2019. Status and recent trends in coral reefs of the Philippines. Marine Pollution Bulletin, 142: 544-540. https://doi.org/10.1016/j.marpolbul.2019.04.013

Lucas JS. 1994. The biology, exploitation, and mariculture of giant clams (Tridacnidae). Reviews in Fisheries Science, 2(3): 181-224. https://doi.org/10.1080/10641269409388557.

Madduppa HH, Zamani NP, Subhan B, Aktani U and Ferse SCA. 2014. Feeding behavior and diet of the eight-banded butterflyfish *Chaetodon octofasciatus* in the Thousand Islands, Indonesia. Environmental Biology of Fisheries, 97(2): 1353-1365. https://doi.org/10.1007/s10641-014-0225-z

Magdayao A. 2021. Endangered giant clams shells worth P57M confiscated in Palawan. Manila Bulletin. https://mb-com-ph.cdn.ampproject.org. Accessed on 21 August 2022.

Maulil RN, Mamauag SS, Cabral RB, Celeste-Dizon EO and Aliño PM. 2014. Status, trends and challenges in the sustainability of small-scale fisheries in the Philippines: Insight from FISHDA (Fishing Industries' Support in Handling Decision Application) model. Marine Policy, 44: 212-221. https://doi.org/10.1016/j.marpol.2013.08.026

McCook LJ. 1996. Effects of herbivores and water quality on Sargassum distribution on the central Great Barrier Reef: cross-shelf transplants. Marine Ecology Progress Series, 139: 179-192. https://doi.org/10.3354/meps139179

Mecha N and Dolorosa R. 2020. Searching the virtually extinct Tridacna gigas (Linnaeus 1758) in the reefs of Palawan. The Philippine Journal of Fisheries, 27(1): 1-18. https://doi.org/10.31398/tpjf/27.1.2019-0005

Neo ML, Eckman W, Vicentuan K, Teo SLM and Todd PA.2014. The ecological significance of giant clams in coral reef ecosystems. Biological Conservation, 181: 111-123. https://doi.org/10.1016/j.biocon.2014.11.004

Neo ML. 2017. The story of shells – Part 1. https://meilin5giantclam.wordpress.com/2017/11/26/the-story-of-shells-part-1/. Accessed on 03 January 2021.

Neo ML, Wabnitz CCC, Braley RD, Heslinga GA, Fauvelot C, Wynsberge SV, Andréfouët S, Waters C, Tan A.-H, Gomez ED, et al. 2017. Giant clams (Bivalvia: Cardiidae: Tridacninae): a comprehensive update of species and their distribution, current threats and conservation status. Oceanography and Marine Biology: An Annual Review, 55, pp. 87-388.

Newman WA, Gomez ED. 2000. On the status of giant clams, relics of Tethys (Mollusca : Bivalvia : Tridacninae). Proclamation of 9th International Coral Reef Symposium. Bali, Indonesia, 2: 927-936.

Noriega R. 2021. Authorities seize P250M worth of giant clams shells in Palawan. Manila Bulletin. https://mb.com.ph/2021/07/01/authorities-seize-p250m-worth-of-giant-clam-shells-in-palawan/. Accessed on 21 August 2022.

Palaganas VP. 1991. Anchor damage on the coral reef of Sombrero Island, Batangas, Philippines. 7th Symposium on Coastal and Ocean Management, Long Beach, CA.

Pratchett MS, Hoey AS, Feary DA, Bauman AG, Burt JA and Riegl BM. 2013. Functional composition of Chaetodon butterflyfishes at a peripheral and extreme coral reef location, the Persian Gulf. Marine Pollution Bulletin, 72(2): 333-341. https://doi.org/10.1016/j.marpolbul.2012.10.014

Pratchett MS, Wilson SK and Baird AH. 2006. Declines in the density of Chaetodon butterflyfishes following extensive coral depletion. Journal of Fish Biology, 69: 1269-1280. https://doi.org/10.1111/j.1095-8649.2006.01161.x

Reyes MZ, Raymundo DJC, Rizwan SJ and Licuanan WY. 2017. Coral gardening: Issues and challenges. Policy Brief, XI(1): 1-4.

Republic Act No. 10654. 2015. Amendment of the Philippine Fisheries Code of 1968. https://www.officialgazette.gov.ph/2015/02/27/republic-act-no-10654/. Accessed on 21 August 2022.

River GF and Edmunds PJ. 2001. Mechanisms of interaction between macroalgae and scleractinians on coral reef in Jamaica. Journal of Experimental Marine Biology and Ecology, 261(2): 159-172. https://doi.org/10.1016/S0022-0981(01)00266-0

Scheibling RE and Metaxas A. 2008. Abundance, spatial distribution, and size structure of the sea star *Protoreaster nodosus* in Palau, with notes on feeding and reproduction. Bulletin of Marine Science, 82(2): 221-235.

Shang YC, Tisdell C and Leung PS. 1991. Report on a Market Survey of Giant Clam Products in Selected Countries. Publication No. 107. Waimanshaalo, Hawaii: Center for Tropical and Subtropical Aquaculture. 1pp.

Tamayo NCA, Anticamara JA and Acosta-Michlik L. 2018. National Estimates of Values of Philippine Reefs' Ecosystem Services. Ecological Economics, 146: 633-644. https://doi.org/10.1016/j.ecolecon.2017.12.005

UN (United Nations). 2015. Do you know all 17 SDGs? https://sdgs.un.org/goals. Accessed on 21 August 2022.

Uychiaoco AJ, Green SJ, dela Cruz PA, Gaite HO, Aliño PM and White AT. 2010. Coral Reef Monitoring for Management, 2nd Edition. University of the Philippines Marine Science Institute. United Nations Development Programme Global Environment Facility-Small Grants Program, Guiuan Development Foundation, Inc., Voluntary Service Overseas, University of the Philippines Center for Integrative and Development Studies, Coastal Resource Management Project, and Fisheries Resource Management Project. 120pp.

van der Meer MH, Horne JB, Gardner MG, Hobbs J-PA, Pratchett MS and van Herwerden L. 2013. Limited contemporary gene flow and high self-replenishment drives peripheral isolation in an endemic coral reef fish. Ecology and Evolution, 3(6): 1653–1666. https://doi.org/10.1002/ece3.584

Verdadero FXD, Licuanan WY, Escudero KC, Narida EJG, Cristobal ACC and España NB. 2017. Status of coral communities and reef-associated fish and invertebrates in Batangas and Northern Palawan. Manila Journal of Science, 10: 101-114.

WWF-Philippines (World Wildlife Fund). 2010. Annual report: 2010. Summary of reports of all activities and studies apropos to Live Reef Food Fish. Sustainability project of the coral triangle (Province of Palawan, Philippines). Initiative submitted to the Palawan Council for Sustainable Development Staff. World Wildlife Fund for Nature-Philippines. 364pp.

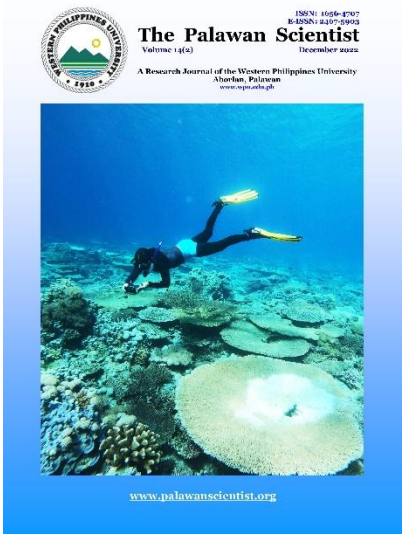
WWF-Philippines (World Wildlife Fund-Philippines). 2012. Hart reef marine protected area management plan. Unpublished report. World Wildlife Fund for Nature-Philippines. 13pp.

WWF-Philippines (World Wildlife Fund-Philippines). 2013. Dumaran marine protected area network management plan, Dumaran, Palawan. Unpublished report. World Wildlife Fund for Nature-Philippines. 15pp.

WWF-Philippines. 2017. Status of Coral Communities and Reef-Associated Fish and invertebrates in the Municipality of Araceli, Palawan. Technical Report. 13pp.

WWF-Philippines (World Wildlife Fund-Philippines). 2019. Reef monitoring system vital for reef conservation and management. Coral Reef Resilience and Fisheries Sustainability.

***ROLE OF AUTHORS**: RBC – gathered and analyzed the data and co-wrote the manuscript; GMA – gathered and analyzed the data; NJMFM – analyzed the data and co-wrote the paper; ARBC – gathered and analyzed the data; ANAMA – gathered and analyzed the data; JFR – gathered and analyzed the data; JAM – gathered and analyzed the data; IDM – gathered and analyzed the data; RGD – analyzed the data and co-wrote the paper.*



Gender awareness and perception on Marine Protected Areas (MPAs) in Taytay, Palawan, Philippines

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ABSTRACT

Marine Protected Area (MPA) is a recognized tool for conservation and fisheries management. In the Philippines, there are around 1,800 locally-managed MPAs and 155 are in Palawan. However, gender knowledge and perceptions on their impacts on communities and the environment are poorly documented. Thus, this study was conducted to determine the gender awareness and perception on MPAs' functions, benefits, and status of coastal communities in Taytay, Palawan, Philippines. The socio-demographics of the respondents and their effects on perceptions were also investigated. There were 401 respondents but only 108 were considered for analysis after data cleaning. About 60% are men and 40% are women. A total of 16 questions on MPA awareness and perceptions were asked during the interview that utilized KoboToolBox. The data were analyzed using General Linear Model, and Principal Component Analysis. Results showed that awareness varied between genders with men being more aware of the existence of MPAs (82%) and its programs (72%). However, both have almost the same level of perception on benefits from MPAs. Men and women perceived MPAs to have helped in conservation like improving biodiversity, but not on providing direct economic benefits such as an increase in catch and income. These indicate that their perceptions on MPAs were generally theoretical, rather than actual. Further, men's perceptions were significantly affected by age and ethnicity while women's perceptions were not affected by any of their socio-demographics.

Keywords: conservation, economic impacts, fish catch management, well-being

INTRODUCTION

Marine Protected Area (MPA) is recognized as an important tool for conservation and fisheries management across the globe (Claudet 2012; Bennett and Dearden 2014). MPAs are designed to manage human activities and protect the habitats, ecosystem structure, function and integrity of marine species (Lester et al. 2009; Sala and Giakoumi 2017) by protecting the critical spawning stock that ensures recruitment supply to fished areas (Roberts et al. 2001, Goñi et al. 2010, Muallil et al. 2014). Additionally, MPAs preserve natural and cultural heritages (Wahle et al. 2003; Clarke and Jupiter 2010). Some MPAs are traditional fishing grounds of coastal communities while there are sites too that are considered sacred by some indigenous groups.

The Republic Act (RA) 8550, as amended by RA 10654, encourages the local government units (LGU) to designate at least 15% of their municipal waters as fish sanctuaries. In 2014, there are 1,800 MPAs in the country (Cabral et al. 2014) with an area estimated at 3,861,25.5 ha (PMD 2022) and of these 155 are reported in Palawan covering 82,000 ha (PCSD 2015). However, only 115 are reflected in the Philippines Marine Protected Area Database (2022). Despite the number of MPAs in the country, the majority (80-90%) are "paper parks" or on papers only with policies but are weakly or not managed properly (Pollnac et al. 2001; Licuanan et al. 2006; PMD 2022).

In Taytay, Palawan, several small MPAs were established in 2007 like "Raket-Raket", Black Rock, "Pawikan", Dinot and Tecas Reef through Municipal Ordinance No. 037-2007, M.O No. 197-2014, and Resolution 115-2017. In 2017, the LGU declared its entire municipal waters as an MPA covering an area of 192,000 ha, with 15 core zones having a total area of 21,215.05 ha representing 11% of Taytay's municipal waters (Revised Fishery Code of Taytay, Palawan 2017). In addition to these LGU-managed MPAs, portions of Taytay have been declared under the National Protected Areas particularly the Malampaya Protected Landscape and Seascape and the El Nido-Taytay Managed Resource Protected Area, which were established in 2000 and 1998, respectively (WWF 2013).

As the establishment of MPAs directly impacts the community, particularly the fisherfolks due to fishing exclusions, community involvement in the planning and implementation of MPAs are therefore very important (White et al. 2002). MPAs are said to be effective if there is local participation in the planning, monitoring, and sound decision-making (White et al. 1994). Similarly, community perception is important for it serves as mental representations of the community's information that is a crucial factor in decision management and execution (Beyerl et al. 2016). However, the knowledge on the status of many MPAs including their impacts on communities and the environment is very limited (Leenhardt et al. 2015, Cayabo et al. 2020). In the case of Taytay, Palawan, the gender issues in fisheries management particularly an awareness and perception on MPAs have not been evaluated yet. According to WorldFish center (2022), gender equality in fisheries could increase fish production and reduce poverty. The FAO (2016) estimated that women comprise 15% of workforce in wild fisheries and 90% of fish processing but this important role and gender's role in fisheries sector (Siles et al. 2019; WorldFish 2022) and MPA management are often not accounted (Kleiber 2018). Considering the vital roles of gender in fisheries and MPA management (Kleiber 2018; Siles et al. 2019), this study was conducted to determine the gender's level of awareness and perception on MPAs in Taytay, Palawan, Philippines. The study investigated the gender's basic knowledge on MPAs existence, functions, and management. The study also determined their perceived benefits from MPAs and the latter's impacts on their economic status and well-being. Likewise, the socio-demographic profile of the respondents and their effects on their perception were investigated. These types of information are helpful in streamlining, monitoring, and evaluating of MPAs towards improving their management.

METHODS

Study Site

This study was conducted in Taytay, Palawan, Philippines covering the Barangays of Biton, Liminangcong, New Guinlo, and Pamantolon (Figure 1). The municipality of Taytay is a first class and the largest municipality in Palawan having a total area of 223, 319 ha. Its entire municipal waters (92,000 ha.) were declared as an MPA with 16 core zones or no-take zones that total to 21,215.50 ha (Municipal Ordinance No. 270). Taytay also harbors the Malampaya Sound Protected Landscape and Seascape and portions of it are also under the El Nido-Taytay Managed Resource Protected Area, both under the management of the National Integrated Protected Areas System (NIPAS). Taytay has a total population of 83,357 and the major sources of livelihood are fishing and farming (PSA 2020). The four barangays covered by this study had a total population of 14,490 and total household of 3, 171 (GCRF Blue Communities-Philippines 2020).

Data Gathering

Respondents. The survey was done in areas near the coasts of each barangay where most of the people with frequent interactions with the marine environment are residing. The respondents were chosen randomly and were limited to one respondent per household to cover more respondents who are not from the same household. This was done to avoid biases in answers because in a separate survey conducted by the team, the members of the same household gave almost the same answers to one question, which could have been different if they did not hear the answer of the other household member/s. Also, only those that were 18 years old and above were chosen as respondents due to ethical and legal considerations.

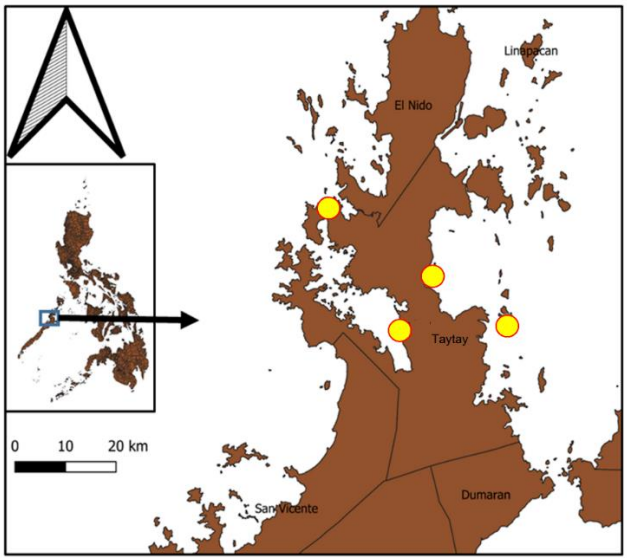

Figure 1. Map of Taytay, Palawan, Philippines indicating the sampling sites ( ).

In total, there were 401 respondents who participated in the survey, which represents 13% of the total households (3,171) of four barangays covered by this study (GCRF Blue Communities-Philippines 2020). Of these, only 108 responses were considered after the data cleaning that involved the elimination of respondents that have lower than 10 responses and disregarded supplemental questions that were answered by lower than 30 respondents. Many respondents refused to answer a lot of questions because they were not confident while others hesitated due to political issues thus, only few responses were considered for analysis. About 60% of the respondents are men and 40% are women, with age ranging from 19 to 77 years old with an average of 44 ± 13 years.

Questionnaire. A structured questionnaire translated to the local language and uploaded in KoBoToolbox, a free android application that was used during the survey. Questions include basic knowledge on MPAs and their benefits from it. Information on socio-demographics (age, gender, education and ethnicity) of respondents was also taken. The following questions on MPA awareness answerable by yes or no were asked:

1. Are you aware that there are MPAs in your area or in Taytay?
2. Are there securities or "Bantay Dagat" protecting the MPAs?
3. Were there any consultations done prior to establishment of MPAs?
4. Do you know the area covered or location of MPAs?
5. Are there signages about MPAs in your area?
6. Do you know who governs the MPAs?
7. Are you aware of the programs related to MPAs?

The following statements on benefits from MPAs were scaled by the respondents were from 1-7 with 1-extremely low/disagree; 2-moderately low/disagree; 3-low/disagree; 4-neutral/no change; 5 high/agree; 6-moderately high/agree; 7-extremely high/agree.

1. MPAs protect marine biodiversity.
2. MPAs increase the population of Key or Indicator species (e.g. sharks, turtles, large fish, and endangered species).
3. MPAs increase fish population/catch.
4. MPAs help you improve your well-being.
5. MPAs help you increase your income.
6. MPAs help you afford better health services.
7. MPAs help you send your children to school.
8. MPAs help you improve your houses.
9. MPAs help you acquire more assets.

Prior to the survey, the purpose and scope of the study were explained to the respondents, who were then asked if they were willing to participate. It was also explained that they can withdraw their responses at any period of the survey should they decide not to continue. They were further assured that their identity and answers will be kept confidential. Upon their consent, they were asked to answer the questionnaires on their own but some who asked for help were also assisted. This study has secured clearance from the National Ethics Committee of the Philippines.

Data Analysis

The data gathered were tabulated using Microsoft Excel 2016 Spreadsheet. This was followed by data cleaning that involved the elimination of respondents that have lower than 10 responses and disregarded supplemental questions that were answered by lower than 30 respondents. This was done to minimize data biases, skewness, and outliers. From 401 responses, only 108 were considered for analysis. A simple descriptive statistics and percentile analysis were used for the questions on awareness answerable by yes or no while the General Linear Models (GLM) was employed to determine the Mean Marginal Perception (MMP) of questions on the perception that were scaled by the respondents from 1-7. It was also used to determine if the 16 questions are significant factors affecting the respondents' perception. The 16 questions were further subjected to Principal Component Analysis (PCA) and Rotation Method (RM) using Varimax with Kaiser Normalization to reduce the complex individual analysis effects on the respondent's awareness and perceptions. The reduction method transformed the data into low-dimensional space, but retain their meaningful properties. The results were clusters of significant factors, which were further treated as dependent variables and tested against the socio-demographics of the respondents (gender, age, educational attainment, and ethnicity) using the Mutltivariate regression to determine which among the socio-demographics significantly affect the respondents' awareness and perception.

RESULTS

Awareness

The majority of men (82%) were aware of the existence of MPAs in their area and 74% have knowledge about MPA programs (Figure 2). However, only 38% of men were aware of the presence of MPA guards while only 35% had an idea about the public consultation done prior to the establishment of the MPAs. Men's awareness on the location or area covered by MPAs, presence of signages about MPAs, and its management body were apparently low (Figure 2).

Women also had high awareness on the existence of MPAs in the area (70%) despite the fact that only 2% were aware about public consultations prior to the establishment of MPAs. The majority of them were also not aware of the location or area of MPAs and whether they are guarded but more than 50% were aware of MPAs' signages, programs, and management body (Figure 3).

Perception

Both men and women highly perceived MPAs to have help improve the biodiversity, key marine species or indicator species such as sharks, turtles, and large fishes, including the volume of fish catch as shown by high MMP (6) (Figure 4). However, they were neutral in terms of MPAs contribution to their well-being and they do not perceive the MPAs to have helped them increase their income, acquire better health services, and education nor improve their houses. Perception of both men and women displayed consistent and similar patterns without apparent significant variations as indicated by error bars.

Clustering of Factors affecting the Perception of Men and Women

All 16 questions were treated as variables and were subjected to PCA reduction analysis for clustering of similar variables. Table 1 shows five clusters of variables for men: well-being, awareness, MPA goals, MPA program and management, and MPA area/location.

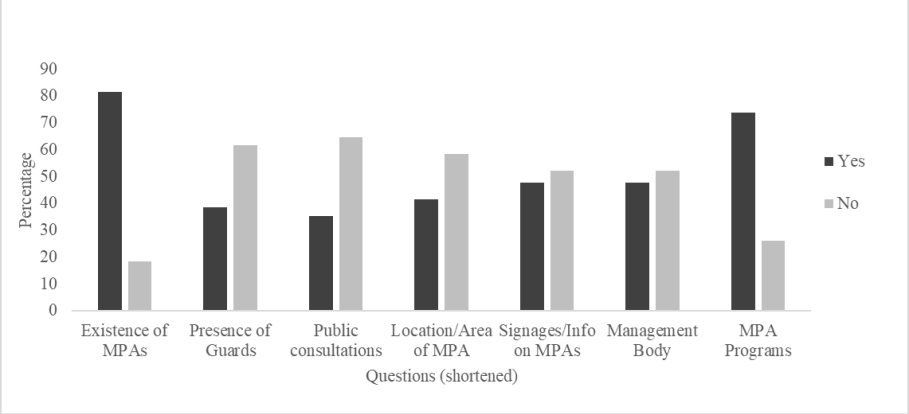

Figure 2. Awareness of men on Marine Protected Areas (n = 65).

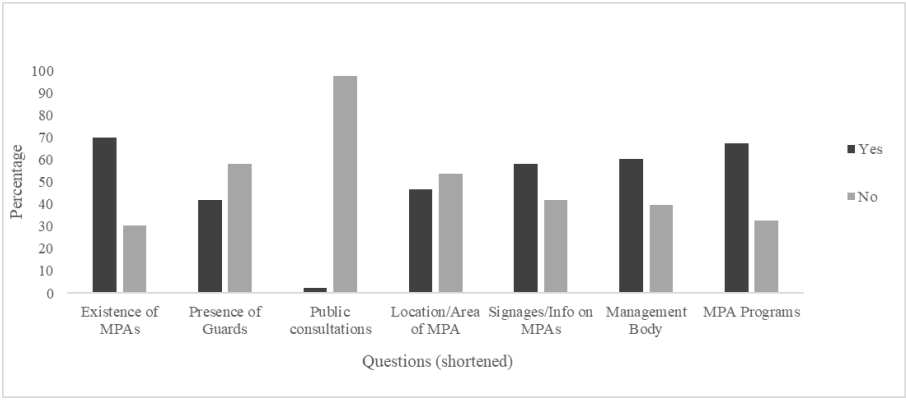

Figure 3. Awareness of women on Marine Protected Areas (n = 43).

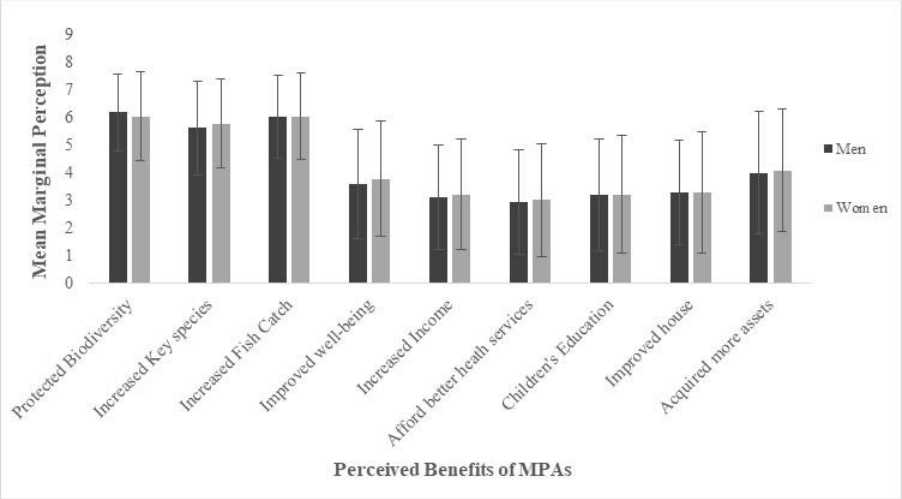

Figure 4. Mean Marginal Perception (MMP) of men and women on benefits from Marine Protected Areas. 1-extremely low/disagree; 2-moderately low/disagree; 3-low/disagree; 4-neutral/no change; 5-high/agree; 6-moderately high/agree; 7-extremely high/agree. Error bars represent Standard Deviation.

Table 1. Clustering of questions/variables on men's awareness and perceptions on Marine Protected Areas using General Varimax Dimension Reduction (Principal Component). Rotation Method: Varimax with Kaiser Normalization. Rotation converged in four iterations.

	Clusters (5)				
Questions /Variables	Well-being	Awareness	MPA goals	MPA Program and Management	MPA area/location
1. Help acquire more assets	0.966				
2. Help improve the house	0.958				
3. Help send children to school	0.941				
4. Help afford health services	0.913				
5. Increase income	0.806				
6. Improve well-being	0.703				
7. MPA consultations		-0.846			
8. MPA guards		0.775			
9. Awareness on presence of MPA		0.704			
10. Increase Biodiversity		0.550			
11. Improve key species			0.875		
12. Increase fish catch			0.827		
13. MPA programs				0.687	
14. MPA management body				0.683	
15. MPA signages				0.646	
16. MPA area/location					0.821

The variables that displayed high correlation coefficient were clustered together. High coefficient value means that there is a strong correlation between variables and factors while those with lower values (< 0.5) have weak correlation.

For women, only 13 variables were subjected to dimension reduction analysis due to exclusion of some variables with zero variances and/or showed no significant correlations across the other variables. The resulting clusters include well-being, MPA programs and management, and awareness (Table 2).

Socio-demographics on perception and awareness men and women

The socio-demographics such as age, education, and ethnicity of men and women were subjected to Multivariate Regression Analysis against the clustered perception to determine their effects. Results for men showed that age affects their perceptions on MPA awareness while ethnicity affects their perceptions on MPA programs and Information, Education, and Communication ($P < 0.05$, Table 3).

In the case of women, the socio-demographic profiles did not appear to have effects on their perceptions on MPAs ($P > 0.05$, Table 4).

Table 2. Clustering of questions/variables on women's awareness and perceptions on Marine Protected Areas using General Varimax Dimension Reduction (Principal Component). Rotation Method: Varimax with Kaiser Normalization. Rotation converged in four iterations.

Questions /Variables	**Clusters (3)**		
	Well-being and MPA goal	MPA Programs and Management	Awareness
1. Increase income	0.961		
2. Help improve the house	0.957		
3. Increase fish catch	0.953		
4. Improve key species	0.940		
5. Increase biodiversity	0.816		
6. Help acquire more assets	0.755		
7. MPA signages	-0.344		
8. MPA management body		0.980	
9. MPA guards		0.971	
10. MPA programs		0.955	
11. MPA area/location			0.784
12. MPA consultations			0.710
13. Awareness on presence of MPA			0.654

Table 3. Multivariate regression analysis across effects of demographic profiles on men's perceptions on Marine Protected Areas. *P* values in bold are socio-demographics with significant effect on perception of men on specific cluster of factors.

Cluster of factors		Regression coefficients and statistics				
		Coef.	SE	t	*P*	R^2
1. Improved well-being	Constant	3.67	1.33	2.76	0.01	
	Age	-0.02	0.02	-0.90	0.37	0.01
	Education	-0.01	0.33	-0.02	0.98	0.00
	Ethnicity	0.05	0.15	0.31	0.76	0.00
2. MPA Awareness	Constant	2.23	0.28	7.98	0.00	
	Age	0.01	0.00	2.11	**0.04**	0.04
	Education	0.12	0.07	1.65	0.11	0.01
	Ethnicity	-0.03	0.03	-0.98	0.33	0.00
3. MPA goal	Constant	5.09	0.96	5.31	0.00	
	Age	0.00	0.02	0.06	0.96	0.01
	Education	0.42	0.24	1.74	0.09	0.05
	Ethnicity	-0.04	0.11	-0.36	0.72	0.00
4. MPA Program & Management	Constant	1.32	0.25	5.24	0.00	
	Age	0.00	0.00	0.43	0.67	0.00
	Education	0.10	0.06	1.52	0.13	0.03
	Ethnicity	-0.06	0.03	-2.06	**0.04**	0.05
5. MPA area/location	Constant	1.43	0.30	4.73	0.00	
	Age	0.00	0.01	0.15	0.88	0.00
	Education	-0.05	0.08	-0.70	0.49	0.01
	Ethnicity	-0.01	0.03	-0.24	0.81	0.00

Table 4. Multivariate regression analysis across effects of demographic profiles on women's perceptions on Marine Protected Areas.

Cluster of factors		Regression coefficients and statistics				
		Coef.	SE	t	*P*	R^2
1. Well-being and MPA goal	Constant	3.95	0.98	4.05	0.00	
	Age	0.00	0.01	-0.34	0.73	0.01
	Education	0.05	0.23	0.21	0.84	0.00
	Ethnicity	0.14	0.09	1.51	0.14	0.06
2. MPA programs and Management	Constant	1.28	0.44	2.88	0.01	
	Age	0.00	0.01	0.60	0.56	0.01
	Education	0.08	0.10	0.78	0.44	0.02
	Ethnicity	-0.02	0.04	-0.53	0.60	0.02
3. MPA awareness and area	Constant	1.62	0.21	7.59	0.00	
	Age	0.00	0.00	-0.73	0.47	0.01
	Education	0.01	0.05	0.14	0.89	0.00
	Ethnicity	-0.01	0.02	-0.34	0.73	0.00

DISCUSSION

Awareness and Perception of Men and Women

The coastal communities of Taytay, Palawan, Philippines have high awareness despite the lack of knowledge of the majority on consultations prior to its establishment. In particular, men displayed higher awareness on the existence of MPAs and its program (82% and 74%) than women (70% and 67%). This could probably be attributed to the fact that more men (38%) were able to attend the consultations while only few women (2%) were aware about it. It is common in coastal communities that men attend to invitations concerning fishing and conservation because they are the ones who go out to the sea. This also showed that they have more interaction with the marine environment rather than women. In Danajon Bank, Central Philippines, it was also the men that participated mostly in MPA management while women were less likely to participate in such activities (Kleiber et al. 2018) because they were not comfortable to speak in a male-dominated event (Di Ciommo and Schiavetti 2012), or they do not have a role in management (Smith 2012).

Despite of not being able to attend the consultation, women appeared to be more aware of the MPAs signages (58%) and management body (60%) than men (< 50%). In rural areas, women being sociable in nature got more access to information. They are the ones who do most of the household errands thus they have higher chances of seeing signages about MPAs. The study of Madarcos (2021) in Palawan, Philippines noted that women are the ones who usually attend community consultations, meetings, seminars, and trainings but such finding could be purpose-specific because in this study, women have minimal participation in MPA consultations and they were not involved at all in management.

In terms of awareness on the location of MPAs and the presence of MPA guards, both men and women have limited knowledge. This is possible because MPAs are established far from shores and unmarked boundaries, making it hard for the people to identify their area or location. During the MPA management planning in 2019, it was found out that even the community leaders are not fully aware of the location of MPAs in their area, indicating that they are not actively involved in management. It is reported that in the Philippines, the choice of where to locate the MPA and which fisherfolk organization manages and guards it can sometimes be a political decision, and employment and income opportunities that emanate from its establishment are also influenced by politics (Rosales 2018). Political issues are also apparent during the survey in this study as many respondents refused to answer some questions out of hesitation or possibly fear despite the assurance that their identity would be kept confidential. For instance, the question on management of MPAs, if the respondents think it is well-managed or not, was removed during the data cleaning because very few answered this question.

On the aspects of benefits from MPAs, men and women displayed similar perceptions. Both agreed that MPAs help in protecting biodiversity and in increasing the key species including fish catch as supported by high MMP (6). This finding is similar to the study of Kleiber et al. (2018) in MPAs in Central Philippines where both men and women were positive about MPAs despite the fact that women were less certain about the impacts of MPAs in fishing. Additionally, results of this study showed that both genders did not consider the MPAs to have helped them improve their economic status. The MMP on direct economic benefits like increase in income and assets was below 4, which is close to disagree. This implies that their perception on the importance of

MPAs could be just theoretical, which they probably got from information campaigns on MPAs conducted by LGUs and other organizations working in the area, and not based on their actual experiences. Studies have shown that MPAs do increase the provisioning capacity of marine ecosystems particularly in no-take areas through their effects on diversity and fish population particularly the target species (Agardy 1993; Worm et al. 2006; Goñi et al. 2010; Bennett and Dearden 2014). Apparently, this impact was not felt yet by the respondents. Data of fish population within the core zones before and after the establishment of MPAs are not yet available to support this idea.

Interestingly, cluster analysis showed that men's perception on MPAs was highly rooted on the impacts of MPAs on their well-being, which include their ability to acquire more assets, improve their houses, send their children to school, afford better health services, and increase their income. These variables were clustered because they were highly correlated with each other. The high correlation coefficients indicate that they are the most significant factors affecting men's perceptions. This is very likely because fishing is the major livelihood of men in the area. The negative correlation of MPA consultation was attributed to the fact that the majority were not able to attend or not aware of it. Other variables that significantly affect men's perception, but to a lesser degree, were their awareness on MPAs, their knowledge on importance of MPAs including its programs, management body, and area or location. Similarly, women's perception was also highly affected by their well-being but including their knowledge on MPA conservation goals because both were clustered together. This implies that women value equally the direct benefits from MPAs, or those that benefit their well-being (e.g. increase income, improve their houses, and acquire assets), and the conservation benefits of MPAs (e.g. improve key species and biodiversity), while men focused only on direct economic benefits. Other aspects that affect women's perception include their knowledge on MPA programs and management, location, consultations, and its existence.

Direct economic benefits such as the increase in fish catch and income take time to manifest and require thorough planning, management, and active support from the community. Micheli et al. (2004) reported that benefits from MPA are difficult to quantify and often slow to detect. Similarly, in Apo Island, Sumilon Island, and Tubataha Reefs Natural Park in the Philippines, the impacts on fish catch and coral cover took decades to manifest (Russ and Alcala 1999; Dygico et al. 2013). In addition, these MPAs have strong and well-defined management with sustained enforcement actions. Claudet (2012) noted that enforcement including the design and age of MPAs are crucial factors in the attainment of success, which are gauged against the goals and objectives through monitoring and evaluation (Dygico et al. 2013). In the case of Taytay Bay MPA, it was only established in 2017, and the majority of its core zones (10 out of 15) only covered 59 to 770 ha. The rest are pearl farms classified as core zones covering 1,000 has to around 8,000 ha (Municipal Ordinance No. 270). Additionally, the implementation of MPA programs and its management remained challenging as these are lodged under the Municipal Agriculture Office.

In coastal areas where fishing is a major livelihood, a reduction of fishing mortality due to fishing would be the most visible impact of MPAs (Goñi et al. 2010). Next is the increase in fish catch thru spill-over (Micheli et al. 2012), but such is highly reliant on the design, size, management and enforcement (Claudet 2012; Dygico et al. 2013). It is therefore important to monitor the Catch-Per-Unit Effort (Leenhardt et al 2015) along with other indicators stipulated in Taytay Bay MPA Management Plan. Results of monitoring should also be shared with the community and other stakeholders as it affects the public perception, awareness, and attitudes towards marine protection (Hawkins 2016). Moreover, the management must encourage the gender's participation in its programs and activities for the latter to have better understanding of the management or status of their MPAs as well as a sense of empowerment (Christie et al. 2005). Studies have shown that the community's engagement is the most important factor affecting the MPA's success or failure (Russ and Alcala 1999; White et al. 2002; Giakoumi et al. 2018) along with good governance (Dygico et al. 2013). It was noted that fishers' support to MPAs is determined by the benefits they could get from them (Fabinyi 2007).

Effects of Socio Demographics on Perception and Awareness of Men and Women

It is apparent that men's perception is affected by their age and ethnicity while women's perception is not influenced by their socio-demographics. Specifically, older men appeared to be more aware of the MPAs than the younger ones. It could be that older men have more interactions with the marine environment, just like fishing, making them more knowledgeable in terms of MPA existence, than the younger ones. Also, men who belong to indigenous groups showed higher awareness on MPA programs and IEC than the migrants or those coming from places outside Palawan. This is very likely since indigenous groups have been residing in the area since birth. Whereas women's perceptions appeared not to be affected by any socio-demographics. Even education do not influence the perceptions of both genders, indicating that information campaigns and

access to information as the major factors influencing the community's perceptions.

Overall, it appeared that there is a gender bias in terms of awareness with men being more aware than women in terms of MPA existence and its programs, although a higher percentage of the latter is aware of the other aspects of MPAs such as its management body and signages. In terms of benefits from MPAs, both genders almost have the same level of perception. They both agree that MPAs helped in conservation but not on giving direct economic benefits such as the increase in fish catch and income. Consequently, they do not perceive the MPAs to have helped their overall well-being. These findings indicate a strong information campaign on the importance of MPAs but their tangible impacts where people could directly benefit were not apparent yet. Further, men's perception on MPAs is mainly anchored on benefits that affect their well-being while women's perception is influenced by both the well-being and conservation benefits of MPAs.

As noted, impacts of MPAs like increase in fish biomass and population that could yield to an increase in fish catch and income of fishers take time to manifest (Russ and Alcala 1999, Micheli et al. 2004). In the case of Taytay, its entire municipal waters are only declared as MPAs in 2017 – two years prior to the conduct of this study. Although the LGU has MPAs in earlier years, the majority are classified as small MPAs (10-20 ha) and the impact range of such is also limited, and these could be the reasons for low agreement of the community on the direct economic benefits from MPAs. In many cases, the links between the ecological effects of MPAs and services have rarely been considered (Leenhardt et al. 2015), especially in small and LGU-managed MPAs. At present, there is no available data on fish population and other indicators for Taytay Bay MPA. Although earlier MPAs have baseline assessments, there is a need on updating data and monitoring as well. In addition, beneficial outcomes for all stakeholders are often hard to attain so it is important to present a realistic purpose and cost-benefit analysis within specified timeframe (Fabinyi 2008)

It is therefore recommended to revisit and evaluate the MPAs' management goals and objectives to align its programs and implementation. With fishers and marine users being the ultimate beneficiaries, it is important to include studies on fish catch and income of fishers fishing near the core zones, for this is where the spill-over effect is immediately manifested. Corals and indicator species in core zones among other related parameters must also be monitored to determine their exposure to impacts of climate change to ensure that conservation efforts would not be wasted. It is important that cores zones must also be resilient to impacts of climate change particularly the sea surface temperature, which cause corals to bleach and die-off if unable to recover (Arceo et al. 2001; Mcfield 2017). The social, economic, and political interests of stakeholders must also be considered in order to identify a set of specific, measurable, attainable, realistic, and time-bound goals with a defined set of indicators. More importantly, the management should consider the gender's participation particularly the representation of women in management especially that their perception was influenced by both the well-being or direct economic benefits and conservation benefits of MPAs while men's perception on MPAs was only driven by the direct economic benefits they could get from it. These information and considerations would be helpful in refining and improving the management of Taytay Bay MPA to ensure that it meets its purpose.

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REFERENCES

Agardy MT. 1993. Accommodating ecotourism in multiple use planning of coastal and marine protected areas. Ocean & Coastal Management, 20(3): 219-239. https://doi.org/10.1016/0964-5691(93)90068-A

Arceo HO, Quibilan MC, Aliño PM, Lim G and Licuanan WL. 2001. Coral bleaching in Philippine reefs: coincident evidences with mesoscale thermal anomalies. Bulletin of Marine Science, 69(2): 579-593.

Bennett NJ and Dearden P. 2014. Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. Marine Policy, 44: 107-116. http://dx.doi.org/10.1016/j.marpol.2013.08.01

Beyerl K, Mieg HA and Weber E. 2016. Comparing perceived effects of climate-related environmental change and adaptation strategies for the Pacific small island states of Tuvalu, Samoa, and Tonga. Island Studies Journal, 13(1): 25-44. https://doi.org/10.24043/isj.53

Cayabo GDB, Maquiso C and Aspe N. 2020. Status of six marine protected areas in Palawan, Philippines based on the perception of the MPA managers and the local communities. Journal of Environment and Aquatic Resources, 5: 10-27. https://doi.org/10.48031/msunjear.2020.05.02

Cabral RB, Aliño PM, Balingit ACM, Alis CM, Arceo HO, Nañola CL Jr., Geronimo RC and Partners MSN. 2014. The Philippine Marine Protected Area (MPA) Database. Philippine Science Letters, 7: 300-308.

Christie P. 2005. Observed and perceived environmental impacts of marine protected areas in two Southeast Asia sites. Ocean & Coastal Management 48(3-6): 252-270. https://doi.org/10.1016/j.ocecoaman.2005.04.012

Clarke P and Jupiter S. 2010. Law, custom and community-based natural resource management in Kubulau District (Fiji). Environmental Conservation, 37(1): 98-106. http://dx.doi.org/10.1017/S0376892910000354

Claudet J. 2012. Marine protected areas. In eLS, (Ed). John Wiley & Sons, Ltd: Chichester. https://doi.org/10.1002/9780470015902.a0023605

Di Ciommo RC and Schiavetti A. 2012. Women participation in the management of a marine protected area in Brazil. Ocean and Coastal Management 62: 15-23. https://doi.org/10.1016/j.ocecoaman.2012.02.010

Dygico M, Songco A, White AT and Green SJ. 2013. Achieving MPA effectiveness through application of responsive governance incentives in the Tubbataha Reefs. Marine Policy, 41: 87-94. https://doi.org/10.1016/j.marpol.2012.12.031

Fabinyi M. 2007. Illegal fishing and masculinity in the Philippines: a look at the Calamianes Islands in Palawan. Philippine Studies, 55(4): 509-529.

Fabinyi M. 2008. Dive tourism, fishing and marine protected areas in the Calamianes Islands, Philippines. Marine Policy, 32(6): 898-904. https://doi.org/10.1016/j.marpol.2008.01.004

FAO (Food and Agriculture Organization of the United Nations). 2016. The State of the World's Fisheries and Aquaculture 2016: Contributing to food security and nutrition for all. Rome. 200pp.

Giakoumi S, McGowan J, Mills M, Beger M, Bustamante RH, Charles A, Christie P, Fox M, Garcia-Borboroglu P and Gelcich S. 2018. Frontiers in Marine Science, 5: 223. https://doi.org/10.3389/fmars.2018.00223

GCRF-Blue Communities Philippines. 2020. Baseline Data of Taytay, Palawan, Philippines. 176pp.

Goñi R, Hilborn R, Dı´az D, Mallol S and Adlerstein S. 2010. Net contribution of spillover from a marine reserve to fishery catches. Marine Ecology Progress Series, 400: 233-243. http://dx.doi.org/10.3354/meps08419

Hawkins JP, O'Leary BC, Bassett N, Peters H, Rakowski S, Reeve G and Roberts CM. 2016. Public awareness and attitudes towards marine protection in the United Kingdom, 111(1-2): 231-236. https://doi.org/10.1016/j.marpolbul.2016.07.003

Kleiber D, Harris L and Vincent ACJ. 2018. Gender and marine protected areas: a case study of Danajon Bank, Philippines. Maritime Studies, 17: 163-175. https://doi.org/10.1007/s40152-018-0107-7

KobotoolBox. 2022. Data collection tools for challenging. https://www.kobotoolbox.org/kobo/. Accessed on 03 March 2019.

Leenhardt P, Low N, Pascal N, Micheli F and Claudet J. 2015. The Role of Marine Protected Areas in Providing Ecosystem Services. In: Belgrano A, Woodward G and Jacob U (eds). Aquatic Functional Biodiversity Academic Press, San Diego, pp. 211-231. https://doi.org/10.1016/B978-0-12-417015-5.00009-8

Lester SE, Halpern BS, Grorud-Coveret L, Lubchenco J, Ruttenberg BI and Gaines SD. 2009. Biological effects within no-take marine reserves: a global synthesis. Marine Ecology Progress Series, 384: 33-46. https://doi.org/10.3354/meps08029

Licuanan WY, Aliño PM, Campos WL, Castillo GB and Juinio-Meñez A. 2006. A decision support model for determining sizes of marine protected areas: biophysical considerations. The Philippine Agricultural Scientist, 89(1): 507-520.

Madarcos JRV, Creencia LA, Roberts BR, White MP, Nayoan J, Morrissey K and Fleming LE. 2021. Understanding local perceptions of the drivers/pressures on the coastal marine environment in Palawan, Philippines. Frontiers in Marines Science. 8: 659699. https://doi.org/10.3389/fmars.2021.659699

McField M. 2017. Impacts of Climate Change on Coral in the Coastal and Marine Environments of Caribbean Small Island Developing States (SIDS). Caribbean Marine Climate Change Report Card: Science Review 2017, pp. 52-59.

Micheli F, Halpern BS, Botsford LW and Warner RR. 2004. Trajectories and correlates of community change in no-take marine reserves. Ecological Applications, 14: 1709-1723. http://dx.doi.org/10.1890/03-526

Micheli F, Saenz-Arroyo A, Greenley A, Vazquez L, Espinoza Montes JA, Rossetto M, De Leo, GA. 2012. Evidence that marine reserves enhance resilience to climatic impacts. PLoS ONE 7 (7), e40832. http://dx.doi.org/10.1371/journal.pone.0040832

Muallil RN, Deocadez MR, Martineza RJS, Mamauag SS, Nañola C and Aliño PM. 2014. The Role of Small Marine Protected Areas in Heavily Fished Philippine Coral Reef Ecosystems. For publication in the proceedings of the 2nd World Small-Scale Fisheries Congress in Merida, Mexico on September 21-26, 2014. http://dx.doi.org/10.13140/2.1.1880.5447

Municipal Ordinance No. 270. 2017. Revised Fishery Code of Taytay, Palawan 2017. 40pp.

PCSD (Palawan Council for Sustainable Development). 2015. Demography. 14pp. https://pkp.pcsd.gov.ph/images/ppcprofile/Demography.pdf. Accessed on 08 July 2021.

PMD (Philippines MPA Database). http://www.database.mpasupportnetwork.com/. Accessed on 26 August 2022.

Pollnac RB, Crawford B and Gorospe MLG. 2001. Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. Ocean & Coastal Management, 44(11-12): 683-710. https://doi.org/10.1016/S0964-5691(01)00075-8

PSA (Philippine Statistics Authority). 2020. MIMAROPA Total Population by Province, City, Municipality and Barangay. PSA. http://rssomimaropa.psa.gov.ph/palawan. Accessed on 08 July 2021.

Republic Act (RA) 10654. An act to prevent, deter and eliminate illegal, unreported and unregulated fishing, amending republic act no. 8550, otherwise known as "The Philippine Fisheries Code of 1998," and for other purposes. https://lawphil.net/statutes/repacts/ra2015/ra_10654_2015.html#:~:text=Unauthorized%20Fishing.,from%20the%20Department%20or%20LGU. Accessed on 12 October 2022.

Roberts CM, Bohnsack JA, Gell F, Hawkins JP and Goodridge R. 2001. Effects of marine reserves on adjacent fisheries. Science, 294(5548): 1920-1923. https://doi.org/10.1126/science.294.5548.1920

Rosales RMP. 2018. SEAT: Measuring Socio-Economic Benefits of Marine Protected Areas, 92: 120-130. https://doi.org/10.1016/j.marpol.2018.02.026

Russ GR and Alcala AC. 1999. Management histories of Sumilon and Apo Marine Reserves, Philippines, and their influence on national marine resource policy. Coral Reefs, 18: 307-319. https://doi.org/10.1007/s003380050203

Sala E and Giakoumi S. 2017. No-take marine reserves are the most effective protected areas in the ocean. ICES Journal of Marine Science, 75(3): 1166-1168. https://doi.org/10.1093/icesjms/fsx059

Siles J, Prebble M, Wen J, Hart C and Schuttenberg H. 2019. Advancing Gender in the Environment: Gender in Fisheries - A Sea of Opportunities. IUCN and USAID. Washington, USA: USAID. 68pp.

Smith SL. 2012. Toward inclusive co-management: Factors influencing stakeholder participation. Coastal Management 40(3): 327-337. http://dx.doi.org/10.1080/08920753.2012.677642

Wahle C, Lyons S, Barba K, Bunce L, Fricke P, Nicholson E, Orbach M, Pomeroy C, Recksiek H and Uravitch J. 2003. Social Science Research Strategy for Marine Protected Areas. National Marine Protected Areas Center - MPA Science Institute. Santa Cruz, California, 36pp.

White AT, Hale LZ, Renard Y and Cortesi L. 1994. Collaborative and Community-Based Management of Coral Reefs: Lessons from Experience, West Hartford, Connecticut, USA. 10pp.

White AT, Courtney CA and Salamanca A. 2002. Experience with marine protected area planning and management in the Philippines. Coastal Management, 30(1): 1-26. http://dx.doi.org/10.1080/08920750252692599

WWF (World Wildlife Fund-Philippines). 2013. TAYTAY: Taking Charge of a Critical Resource A case study on the Philippine. 29pp.

WorldFish Center. 2022. https://www.worldfishcenter.org/pages/why-gender-equality-matters-fisheries-aquaculture/. Accessed on 20 September 2022.

Worm B, Barbier EB, Beaumont N, Duffy JE, Folke C, Halpern BS, Jackson JBC, Lotze HK, Micheli, F, Palumbi SR, et al. 2006. Impacts of biodiversity loss on ocean ecosystem services. Science, 314(5800), 787e790. http://dx.doi.org/10.1126/science.1132294

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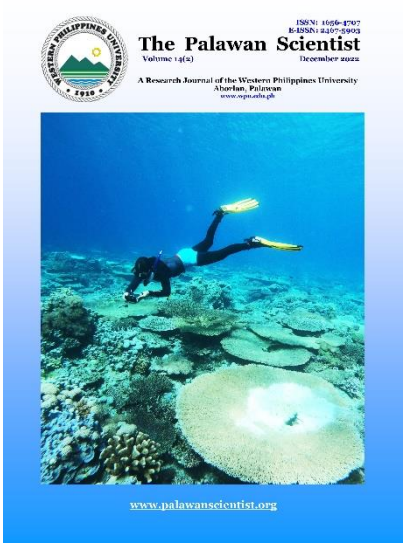

Predictors of students' conceptual understanding on finding volume of solids of revolutions in Integral Calculus

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ABSTRACT

Learning calculus concepts frustrates a lot of learners. This study assessed self-efficacy and previous mathematics performance (PMP) of Integral Calculus students and described the impact of these variables on their conceptual understanding on finding volume of solids of revolution (VSOR). This study utilized a quantitative non-experimental predictive research design for 86 students enrolled in Integral Calculus at the University of Science and Technology of Southern Philippines. A 6-item teacher-made open-ended test was used to quantify students' conceptual understanding on finding VSOR. Frequency, percentage, mean and standard deviation, were used to determine students' level of self-efficacy, previous mathematics performance, and their score in conceptual understanding test. Multiple regression analysis was used to determine if self-efficacy and previous mathematics performance are predictors of students' conceptual understanding. Results showed that self-efficacy was a predictor of students' conceptual understanding on finding VSOR and an important factor in the development of the profound understanding of the concepts of VSOR in Integral Calculus among students. Hence, it is recommended that calculus teachers should give emphasis on the development of the conceptual understanding moving away from teaching anchored merely on procedures. Moreover, calculus teachers need to explore on strategies that can effectively enhance students' self-efficacy which is instrumental for students' profound conceptual understanding of calculus concepts. Future research may be conducted in the face to face classes to establish generalizability of the results obtained because this study was conducted during the pandemic where the mode of instruction was online.

Keywords: conceptual understanding, Integral Calculus, previous mathematics performance, self-efficacy, volume of solids of revolution

INTRODUCTION

Calculus is considered to be a fundamental branch of mathematics (Zakaria and Salleh 2015), and learning this course supports components of students' intellectual development (Rajagukguk 2016). As a matter of fact, Calculus concepts are considered the foundation for many theories in our life. Yet, calculus classes internationally face high drop-out rates, failure and negative attitude (Khoshaim and Aiadi 2018). Hence, Calculus learning seems frustrating to most learners, leading to researchers spending time analyzing students' difficulties in the subject.

Volume of solids of revolution (VSOR) is one of the most important concepts in Integral Calculus. The topic of finding the volume of solids of revolutions is one of the applications of definite integral. This involves solving for the volume of three-dimensional solids through disk, washer, or shell method. These solids of revolution are very common in manufacturing and engineering (Larson and Edwards 2012). Difficulties in this topic among the students are also undeniable. Mofolo-Mbokane et al. (2013) found that students have difficulty in the selection of representative strips used in the approximation of the bounded region and even if the students correctly gave the formula, they found it hard to draw the representation of the solid generated.

The difficulties in learning Calculus, and Mathematics in general, may be attributed to a lack of conceptual and superficial understanding of the mathematical concepts. Conceptual understanding, also referred to as conceptual knowledge, is pointed by the National Research Council (NRC) as one of the five strands in building mathematical proficiency. This strand becomes the main concern of educators since it allows students to become flexible in analyzing and solving real-life problems (Maglipong et al. 2015). Several researchers emphasized the importance of conceptual understanding in learning Calculus (Carlson et al. 2015; Drlik 2015). This is parallel with the study of Hamid et al. (2019) who stipulated that students' difficulties in learning Calculus topics, especially derivatives, were due to their lack of conceptual understanding; and that this lack of conceptual understanding was due to their weak foundation in Mathematics and their problems in determining the type of functions to be derived. Pointing out the necessity of conceptual understanding in learning topics in Calculus, misconceptions, and difficulties in most of the Calculus topics can be attributed to other factors (Maglipong et al. 2015). One of these factors considered to be affecting students' conceptual understanding, based on literature, is self-efficacy.

Self-efficacy is a person's belief and confidence in his/her ability to accomplish a task (Liu and Koirala 2009). Self-efficacy is considered to be an important concept in social cognitive theory and is demonstrated to affect a person's persistence, efforts, motivation, perseverance, behavior, and achievement (Ayotola and Adedeji 2009; Liu and Koirala 2009; Marchis 2011; Marchis 2012; Cheema 2018). Self-efficacy in mathematics shows the self-belief of the learners in their ability in surpassing challenges in solving math problems (Ministry of Education 2009). Marchis (2011, 2012) further emphasized the significance of students' self-efficacy in problem solving. Another factor considered to affect students' conceptual understanding is students' previous mathematics performance.

Previous mathematics performance (PMP), in the context of the present study refers to students' performance in topics from Arithmetic, Algebra, Analytic Geometry, Limits and Derivatives, and Antiderivatives. These courses are pre-requisites to the course Integral Calculus. The study of Maglipong et al. (2015) found previous mathematics performance to be a predictor to students' conceptual understanding in determining area of plane regions in Calculus, making PMP to be a viable predictor of students' conceptual understanding on finding volume of solids of revolution.

Noting the importance of conceptual understanding and the studies showing relationship of self-efficacy and previous mathematics performance (PMP) to mathematics achievement, the present study sought to 1) assess the self-efficacy and previous mathematics performance of Integral Calculus students; 2) determine the students' level of conceptual understanding on finding the volume of solids of revolution (VSOR); and, 3) determine the impact of self-efficacy and previous mathematics performance to students' conceptual understanding on finding VSOR.

This study was mainly anchored to Bernstein (1996) framework and Kilpatrick et al. (2001) five strands of Mathematical Proficiency. Bernstein (1996) framework involves knowledge transmission and acquisition where knowledge transmission refers to the teaching process while the acquisition refers to the learning process. Recognition and realization rules are accordingly involved in the latter process. On the other hand, Kilpatrick et al. (2001) framework talks about the five strands of mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. The five strands of mathematical proficiency are believed to be necessary to successfully learn mathematics (Mofolo-Mbokane 2011). In the present study, students' conceptual understanding on finding volume of solids of revolution was given emphasis and how this strand is predicted by other factors in the learning process. These factors considered were self-efficacy and previous mathematics performance. Recognition and realization rules were evident as the students aimed to explain each question in the conceptual understanding test, and thus, the way the students' recognition and realization were interpreted was according to Bernstein's framework.

METHODS

Research Design

This study utilized a quantitative non-experimental predictive research design. Predictive research is chiefly concerned with forecasting

(predicting) outcomes, consequences, costs, or effects. This type of research tries to extrapolate from the analysis of existing phenomena, policies, or other entities in order to predict something that has not been tried, tested, or proposed before. In this, the students' self-efficacy, previous mathematics performance and conceptual understanding on VSOR were quantitatively described.

Research Instruments

Data were gathered through survey questionnaires. The mathematics self-efficacy scale was adapted from Liu and Koirala (2009). The Mathematics Self-Efficacy Scale was used to measure students' confidence level in completing mathematics courses, solving mathematics problems, and dealing with everyday mathematics-related tasks. The five-item questionnaire was found to have a reliability coefficient (Cronbach's alpha) of 0.933, inter-item correlation of 0.736 and standard deviation of inter-item correlations of 0.141. The Cronbach alpha indicates high internal consistency, while the inter-item correlation and its standard deviation shows acceptability of the questionnaire.

The PMP test composed of the 25-item questionnaire from Arithmetic, Algebra, Analytic Geometry, Limits and Derivatives, and Antiderivatives. It was a teacher-made test that was constructed using a Table of Specifications (TOS) and passed reliability and validity tests. This test obtained a reliability coefficient of 0.71. This same process was employed to the conceptual understanding test questionnaire which was composed of 6-item questions.

Data Gathering Procedure

The researchers sought permission from the Vice-Chancellor for Academic Affairs (VCAA) of the University upon the recommendation of the College of Science and Technology Education (CSTE) Dean to conduct this study. When the permission was secured, the researchers administered the self-efficacy and previous mathematics performance questionnaires to the participants. After the discussion on VSOR, the researchers administered the conceptual understanding test. Furthermore, in order to ensure the anonymity of the respondents of this study, informed consent was carried out and data coding of the respondents was applied.

The participants of the study were the third year Secondary Education major in Mathematics students and second year engineering students of University of Science and Technology of Southern Philippines (USTP). These students were enrolled in Integral Calculus in the second semester of school year 2020-2021. There were a total of 86 participants involved in the study selected purposively as these students are taking board exams with Calculus items after graduation and handled by the researcher.

Data Analysis

Descriptive statistics, specifically frequency, percentage, mean and standard deviation, were used to present the students' level of self-efficacy, previous mathematics performance, and their score in conceptual understanding test. Moreover, to determine the impact of self-efficacy and previous mathematics performance to students' conceptual understanding, multiple regression analysis was utilized.

RESULTS

Self-Efficacy

As portrayed by Table 1, the overall mean of the participants' self-efficacy is below 3. This showed a fair level of self-efficacy among the participants. Each item also showed a fair level. The items with the lowest mean score were numbers 2, "I'm certain I can understand the most difficult material presented in math texts" and 3, "I'm confident I can understand the most difficult material presented by my math teacher." This showed that participants had low confidence in their understanding in the materials and resources presented to them by their math instructor.

Previous Mathematics Performance (PMP)

In terms of participants' PMP, the majority of them scored average (Table 2). It was noteworthy that 27.91% scored above average; however, 2.32% were below average. The mean score and standard deviation of 17.26 ± 3.60 favored to average showed a homogeneity of the participants' scores. PMP questionnaire involved questions coming from Algebra, Analytic Geometry and Differential Calculus, all of which were pre-requisites of Integral Calculus. Participants could have forgotten some concepts from these courses.

Conceptual Understanding

It can be observed in the next table that the majority of the participants (68.60%) portrayed partial understanding of facts and ideas. Fourteen (14) participants had high level of facts and understanding while the remaining thirteen (13) participants had superficial understanding of facts and ideas. No one was categorized to have poor understanding and profound understanding of facts and ideas. The mean score of 42.74 and a standard deviation of 5.76 showed the spread of participants' scores.

It can be observed in Table 4 that students had satisfactorily scored in almost all of the problems in the conceptual understanding test, except for Problems 2 and 6. Participants only scored fairly for Problem 2 and scored very satisfactorily for Problem 6.

Table 1. Mean distribution of students' self-efficacy. Note: 1.00 - 2.33 = Low Self-efficacy; 2.34 - 3.66 = Fair; 3.67 - 5.00 = High Self-efficacy.

	Items	Mean	Standard deviation	Verbal Description
1.	I'm confident that I can do an excellent job on my math tests.	2.94	0.84	Fair
2.	I'm certain I can understand the most difficult material presented in math texts.	2.79	0.79	Fair
3.	I'm confident I can understand the most difficult material presented by my math teacher.	2.79	0.82	Fair
4.	I'm confident I can do an excellent job on my math assignments.	3.02	0.81	Fair
5.	I am certain I can master the skills being taught in my math class.	3.05	0.66	Fair
	Overall Mean	**2.92**	**0.66**	**FAIR**

Table 2. Participants' scores in previous mathematics performance test.

Description	Score Ranges	Frequency	Percentage	Mean and Standard Deviation (±) Score
Below Average	1-9	2	2.32%	17.26 ± 3.60
Average	10-19	60	69.77%	
Above Average	20-25	24	27.91%	

Table 3. Participants' scores in conceptual understanding test.

General Description of Conceptual Understanding	Overall Score	Frequency	Percentage	Mean and Standard Deviation (±) Score
Profound understanding of facts and ideas	63-70	0	0	42.74 ± 5.76
High level understanding of facts and ideas	49-62	14	16.28	
Partial understanding of facts/ideas	35-48	59	68.60	
Superficial understanding of facts/ideas	21-34	13	15.12	
Poor understanding of facts/ideas	Below 21	0	0	

Table 4. Participants' performance in the conceptual understanding test. Note: 4.5-5 = Excellent; 3.5-4.49 = Very Satisfactory; 2.5-3.49 = Satisfactory; 1.5-2.49 = Fair; 1-1.49 = Poor. Grand Mean Performance: 3.08

Problem	Performance Mean	Standard Deviation	Descriptive Level
1a	2.81	0.86	Satisfactory
1b	2.94	0.76	Satisfactory
1c	3.23	0.81	Satisfactory
2a	2.34	0.68	Fair
2b	2.30	0.81	Fair
2c	3.24	0.94	Satisfactory
3a	3.83	0.91	Satisfactory
3b	3.22	1.04	Satisfactory
4a	3.38	0.91	Satisfactory
4b	2.91	0.83	Satisfactory
5a	2.90	0.74	Satisfactory
5b	2.87	0.82	Satisfactory
6a	3.62	0.78	Very Satisfactory
6b	3.59	1.06	Very Satisfactory

To provide a glimpse of these problems, Figure 1 below displays Problem 2. The problem presented two (2) solutions and two (2) figures in solving one (1) problem. One of the figures used horizontal strip, while the other used vertical strip. Both solutions (and figures) arrived to the same answer. Participants had a hard time differentiating which of the figures properly represented the given problem. Both figures and solutions were correct; however, the participants preferred a solution, saying that the other one was wrong and complicated.

Problem 2.

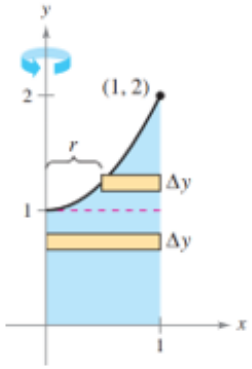
Mary and Anna are having an argument on how to answer the following questions.

Exercise: *Solve for the volume of the solid formed upon revolving the bounded region of* $y = x^2 + 1$, $y = 0$, $x = 0$, *and* $x = 1$.

Mary believes that to answer it, she should use washer method, choose a horizontal representative strip, and perform two integrals. Anna, on the other hand, believes that she should use vertical representative strip and use shell method. Their solutions and figures are shown below.

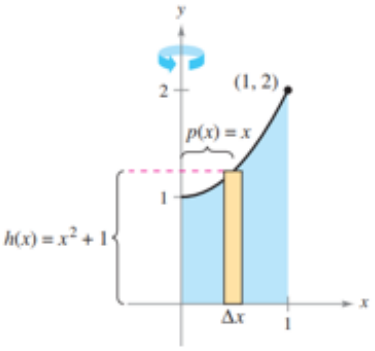
Mary's Answer and Figure

$$V = \pi \int_0^1 (1^2 - 0^2)\,dy + \pi \int_1^2 \left[1^2 - \left(\sqrt{y-1}\right)^2\right] dy$$
$$= \pi \int_0^1 1\,dy + \pi \int_1^2 (2 - y)\,dy$$
$$= \pi \left[y\right]_0^1 + \pi \left[2y - \frac{y^2}{2}\right]_1^2$$
$$= \pi + \pi\left(4 - 2 - 2 + \frac{1}{2}\right)$$
$$= \frac{3\pi}{2}$$



Anna's Answer and Figure

$$V = 2\pi \int_a^b p(x)h(x)\,dx$$
$$= 2\pi \int_0^1 x(x^2 + 1)\,dx$$
$$= 2\pi \left[\frac{x^4}{4} + \frac{x^2}{2}\right]_0^1$$
$$= 2\pi \left(\frac{3}{4}\right)$$
$$= \frac{3\pi}{2}$$



Interestingly, both Mary and Anna arrive with a volume of $\frac{3\pi}{2}$ cubic units. Based on this situation:

a. Explain why both solutions give the same answer.
b. Whose figure do you think properly represented the volume to be solved? Why?

Figure 1. Problem 2 of the conceptual understanding test.

Figure 2 presents sample answers of the students for Problem 2a. As shown on this figure, students interpreted that the usage of horizontal strips and washer method were not appropriate for the problem. The same outcome was manifested for Problem 2b, as shown on Figure 3.

Student A	2.) (a.) MARY, USES WASHER METHOD, WHICH I BELIEVE IT WAS NOT THE APPROPRIATE ONE BUT SINCE, MARY FIND TWO AREAS BY PUTTING TWO HORIZONTAL STRIPS FROM THE BOUNDED REGION THIS MADE MARY'S SOLUTION TO BE CORRECT, HOWEVER ANA USED THE MOST APPROPPIATE METHOD WHICH IS THE SHELL METHOD, CUTTING ONE VERTICAL STRIP TO CUT MAXIMIZE THE BOUNDED REGION.
Student B	2.) a.) Mary uses washer method, which I believe it was not the appropriate one but since Mary find two areas or she cut two horizontal strips from the bounded region this made Mary's solution to be exact. However Anna uses the most appropriate method which is the shell method, cutting one vertical strips to maximize the bounded region.
Student D	2. a) The method that Mary uses in answering the problem is washer method, which is for me not the appropriate method since, Mary finds two areas from the bounded region this comes up to a correct answer. While, Anna uses shell method where she cuts one vertical strips to maximize the bounded region this makes her method appropriate.

Figure 2. Sample answers of student-participants for problem 2a.

Student K	(b) The figure that I think properly presented the volume to be solve is Anna's figure, because Anna's presentation is properly labelled and it is much easier to use rather than Mary's figure, wherein she choose the complicated way.
Student L	b. Anna's solution and figure properly represented the volume to be solved, because she only used what was given in the problem, Her solution was also easier to understand.
Student M	b. For me, Anna's figure is properly represented the volume to be solved. On the given curved or the bounded region, Mary's figure is complicated where she cuts two horizontal strips from the bounded region whereas Anna's figure only got a strip that is parallel to the axis of rotation.
Student N	b.) I think the figure is properly represented the volume to be solved was Anna's answers As we look in the figure of Mary, the solution is complicated because she did not use the correct method on finding volume based on the given curves or the bounded region. Sence that Anna's way of answering given method she used are/is far from the proper method and correct answer.

Figure 3. Sample answers of students for problem 2b.

On the other hand, Problem 6 as shown on Figure 4 seemed to be easy for the participants. As shown, this problem provides the figure and students are tasked to choose which between two given equations best represent the figure. Almost all of the participants answered this question correctly. Samples of students' answer on this problem are shown on Figure 5.

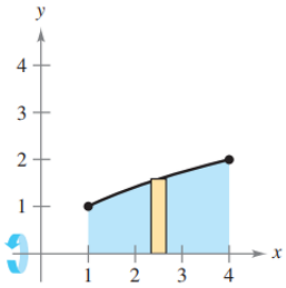
Impact of Self-efficacy and Previous Mathematics Performance on Students' Conceptual Understanding

Regression analysis was used to determine the impact of self-efficacy and previous mathematics performance to the conceptual understanding of students on finding volume of solids of revolution. R-square of 0.0645 showed that the predictors indicated the variance of students' conceptual understanding. The coefficient multiple correlation R of 0.2540 showed weak direct relationship between the predicted and observed data.

It can be inferred that self-efficacy has significantly influenced the conceptual understanding of the students. With a probability of 0.0201, self-efficacy could be considered as a predictor of students' conceptual understanding. On the other hand, previous mathematics performance showed weak impact to the conceptual understanding of students which is indicated by its probability value that is greater than 0.05. This implies that previous mathematics performance does not hinder students' conceptual understanding.

Teacher Joy asked her student to solve for the volume of a solid formed by revolving the shown region about the x-axis.

$y = \sqrt{x}$



To start answering, Bart represented the indefinite integral as $V = \pi \int_1^4 (\sqrt{x})^2 \, dx$. Ben on the other hand, represented it as $V = \pi \int_0^2 (\sqrt{x})^2 \, dx$.

a. Between Bart and Ben, who provided the correct representation of the volume?
b. What would be the volume of the solid formed?

Figure 4. Problem 6 of the conceptual understanding test.

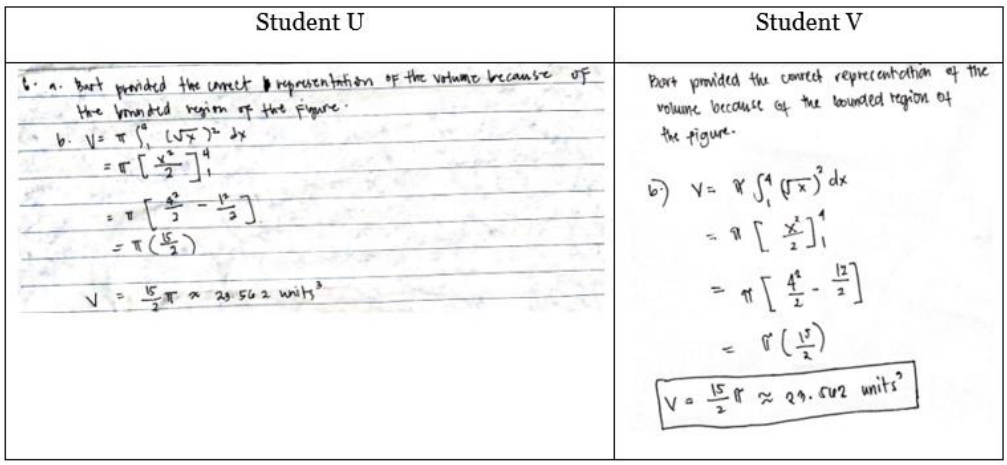


Figure 5. Sample answers of students for problem 6.

Table 5. Multiple regression analysis of predictors of students' conceptual understanding. *Test is significant at the 0.05 level (2-tailed).

Variables	Coefficient	Standard Error	*t*-value	*p*-value
Self-Efficacy	0.4393	0.1854	2.3692	0.0201*
PMP Test	-0.0964	0.1708	-0.5647	0.5739
Constant	37.9965	3.8478	9.8748	<0.001*
Standard Error of Estimate = 5.64209 R-square = 0.0645 Multiple R = 0.2540				

DISCUSSION

Students' Self-efficacy and Conceptual Understanding

While self-efficacy refers to students' belief and confidence in their ability to accomplish a task (Liu and Koirala 2009), it is important to note that self-efficacy is content-specific. One may have high self-efficacy in one task but low in the other asks. Moreover, as much as self-efficacy and self-concept are sometimes mistakenly used interchangeably, the former includes "organize and execute" and is used in reference to a particular goal, while the latter referes to individual's evaluation and belief on themselves. A student may have a negative self-concept for mathematics class but can have high self-efficacy for a certain class task (Schaal and Hurst 2022). This is true in the context of the present study where participants could have a fairly high self-concept, but a fair self-efficacy.

In terms of participants' performance in the conceptual understanding test, Mofolo-Mbokane et al. (2013) explained that students have difficulty in the selection of representative strips used in the approximation of the bounded region. They further expanded that even if the students correctly gave the formula, they found it hard to draw the representation of the solid generated.

Mofolo-Mbokane (2011) posited that students perform poorly in tasks that involve three-dimensional thinking. Accordingly, students were more competent when solving problems focusing on procedural skills, rather than those requiring conceptual skills. Volume of solids of revolution is recommended to be evaluated conceptually.

The study of Maglipong et al. (2015) which showed that students were able to correctly pair definite integral to the given figure for area of plane regions in Integral Calculus supports students' performance in Problem 6 of the present study. Further, since Problem 6 already gives the figure, the participants only had to correctly do the procedures. Students' competence in solving for procedural skill is more evident than their conceptual skills (Mofolo-Mbokane 2011).

Self-efficacy is a Predictor of Students' Conceptual Understanding on Finding Volume of Solids of Revolution while PMP is not

The results of this study have shown that student's self-efficacy influenced their level of conceptual understanding on finding volume of solids of revolution. Students' belief and confidence in their ability that they can accomplish a task allowed them to perform better in understanding the concepts in Integral Calculus, specifically, on finding volume of solids of revolution. This was supported by the findings of the study of Liu and Koirala (2009) that mathematics self-efficacy was a significantly positive predictor of mathematics achievement, in the case of this study was their conceptual understanding on finding volume of solids of revolution in Integral Calculus.

Self-efficacy has always been proven to affect students' performance in mathematics. It shows significance in mathematical problem solving (Marchis 2011, 2012); it significantly predicts mathematics achievement (Liu and Koirala 2009); it displays significant relationship to mathematics literary of students (Cheema 2018).

On the other hand, students' previous mathematics performance does not guarantee profound understanding on finding volume of solids of revolutions which is a contradiction of the study of Maglipong et al. (2015) where students' previous mathematics performance can significantly predict students' conceptual understanding on finding areas of plane regions. As much as previous mathematics performance may affect conceptual understanding of students, if there are times gap, students tend to forget concepts.

From the results of the study, the following conclusions were derived: Students' self-efficacy is a relevant predictor to students' conceptual understanding on finding VSOR in Integral Calculus, and previous mathematics performance is not a predictor for students to have profound understanding on finding VSOR.

Implications to Practice and Future Directions

Moreover, the following recommendations are generated: Calculus teachers should give emphasis on the development of the conceptual understanding moving away from teaching anchored merely on

procedures; they also need to explore on strategies that can effectively enhance students' self-efficacy which is instrumental for their profound conceptual understanding of Calculus concepts; this study may be replicated to a bigger population and with consideration to other factors that may affect students' conceptual understanding on finding VSOR; and, to establish generalizability of the results obtained, future research may be conducted in the face to face classes because this study was conducted during the pandemic where the mode of instruction was online as well as alignment of the number of items of the questionnaires.

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REFERENCES

Ayotola A and Adedeji T. 2009. The relationship between mathematics self-efficacy and achievement in mathematics. Procedia-Social and Behavioral Sciences, 1(1): 953-957. https://doi.org/10.1016/j.sbspro.2009.01.169

Bernstein B. 1996. Pedagogy, Symbolic Control and Identity: Theory, Research, Critique. London: Taylor & Francis. 229pp.

Carlson MP, Madison B and West RD. 2015. A study of students' readiness to learn calculus. International Journal of Research in Undergraduate Mathematics Education, 1(2): 209-33. https://doi.org/10.1007/s40753-015-0013-y

Cheema JR. 2018. Effect of math-specific self-efficacy on math literacy: Evidence from a Greek survey. Research in Education, 102(1):13-36. https://doi.org/10.1177/0034523717741914

Creswell JW. 2009. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (3rd ed.). Thousand Oaks, CA: Sage Publications.

Drlik DI. 2015. Student Understanding of Function and Success in Calculus. Boise State University, Boise, Idaho, USA. 893pp.

Hamid AS, Saari IS, Razak SA and Omar A. 2019. A proposed conceptual derivative technique by using interactive application games. Malaysian Journal of Industrial Technology, 3(1): 59-62.

Kilpatrick J, Swafford J and Findell B (eds). 2001. Adding it up: Helping Children Learn Mathematics. Washington DC: National Academy Press.

Khoshaim HB and Aiadi SS. 2018. Learning calculus concepts through interactive real-life examples. African Journal of Educational Studies in Mathematics and Sciences, 14: 115-124.

Larson R and Edwards B. 2012. Calculus of a Single Variable Tenth Edition. Cengage Learning.

Liu X and Koirala H. 2009. The effect of mathematics self-efficacy on mathematics achievement of high school students. NERA Conference Proceedings 2009. https://opencommons.uconn.edu/nera_2009/30

Maglipong CV, Roble DB and Luna CA. 2015. Students' Mathematics Comprehension and Previous Mathematics Performance (PMP): Its Impact on Students' Conceptual Understanding in Determining Area of Plane Regions in Integral Calculus. Liceo Journal of Higher Education Research, 11(1). http://dx.doi.org/10.7828/ljher.v11i1.891

Marchis I. 2011. How mathematics teachers develop their pupils' self-regulated learning skills? Acta Didactica Napocensia, 4: 9-14.

Marchis I. 2012. Self-regulated learning and mathematical problem solving. New Educational Review, 27(1): 195-208.

Ministry of Education. 2009. PISA 2003: Student learning approaches for tomorrow's world. Ministry of Education, New Zealand. https://www.educationcounts.govt.nz/publications/schooling2/large-scale-international-assessments/pisa-2003-student-learning-approaches. Accessed on 5 August 2021.

Mofolo-Mbokane BL. 2011. Learning difficulties involving volumes of solids of revolution: A comparative study of engineering students at two colleges of further education and training in South Africa. Doctoral Philosophy, University of Pretoria, South Africa. http://hdl.handle.net/2263/25167

Mofolo-Mbokane B, Engelbrecht J and Harding A. 2013. Learning difficulties with solids of revolution: classroom observations. International Journal of Mathematical Education in Science and Technology, 44(7): 1065-1080. https://doi.org/10.1080/0020739X.2013.823253

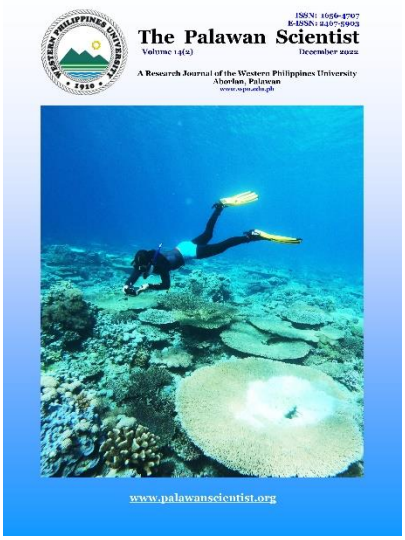
Radmehr F and Drake M.2020. Exploring students' metacognitive knowledge: The case of integral calculus. Education Sciences, 10(3): 55. https://doi.org/10.3390/educsci10030055

Rajagukguk W. 2016. Some factors effected student's calculus learning outcome. Journal of Education and Practice, 7(13): 96-105.

Schaal C and Hurst M. 2022. Self-Concept vs. Self-Efficacy vs. Self-Esteem. Study.com. https://study.com/learn/lesson/self-concept-vs-self-efficacy-differences-factors-examples.html#:~:text=Lesson%20Summary,-Self%2Dconcept%20and&text=Both%20self%2Dconcept%20and%20self,physiological%20factors%20and%20verbal%20encouragement. Accessed on 10 March 2022.

Zakaria E and Salleh TS. 2015. Using technology in learning integral calculus. Mediterranean Journal of Social Sciences, 6(5): 144. http://dx.doi.org/10.5901/mjss.2015.v6n5s1p144

ROLE OF THE AUTHORS: *AST – conceptualized, drafted the paper, consolidated the data, analyzed data, wrote the manuscript; DBR – conceptualized, conducted the data gathering, reviewed the data analysis, edited the manuscript*



On modelling student's resilience in learning statistics at a distance

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ABSTRACT

Learning statistics online during the COVID-19 pandemic became a challenging experience for most students in higher institutions. This study aimed to measure the students' level of resilience and determine its influencing factors in distance learning during the pandemic. Data from an availability sampling of 129 engineering students were gathered with the aid of a Google form survey. The study used some descriptive measures and employed a regression modeling approach to extract detailed information from the survey data. Results showed that, on average, students were considered "resilient" in learning statistics during the pandemic. Statistical models revealed that sex, number of family members, household assets, and level of how conducive learning at home are significant predictors of students' resilience. Additionally, the model showed that male students are more resilient compared to female students. Lastly, more family members and household assets can increase students' resilience level as well as a comfortable place (at home) for learning. Hence, the study suggests that teachers must strengthen the interest of students especially female students by showing them a good attitude that promotes well-being. Furthermore, teachers must regularly monitor their learning progress, and provide comfortable and reasonable learning activities suitable for distance learning.

Keywords: engineering students, level of resiliency, predictors, statistical modeling, state university

INTRODUCTION

Distance learning is a challenging and draining procedure for both teachers and students to continue the teaching-learning process during the COVID-19 pandemic. Learning at a distance (online learning) amidst the pandemic has existing problems that include a lack of technology and internet connectivity (Carius 2020; Casinillo et al. 2022), limitations in presenting the lessons (Schneider and Council 2021), costs for gadgets and acquiring internet load (Srivastava and Agarwal 2020), and misuse of online technology (Bakker and Wagner 2020), among others. On the face of it, technical courses in higher institutions may not be properly taught especially in the field of statistics which requires more attention and work monitoring from instructors/professors. Statistics is one of the toughest courses for degree programs with a high-paying career in the future like engineering and other sciences. In the study of Legaki et al. (2020), it is explained that in times of the pandemic as a hindrance to understanding science,

there is a need to improve the teaching strategies in statistics education to be more engaging and suited for remote learning. This accelerates the students' background, attitude, and interest in statistical analysis and mathematical skills (Ramirez et al. 2012; Miñoza and Casinillo 2022). In this regard, resilience is one of the important variables during unprecedented times in education. According to Karairmak (2010), resilience is essential because it regains positive reasoning that builds up intellectual well-being from adversity.

As engineering students, some statistical concepts must be familiarized and illustrated in practical application, specifically, in engineering projects (Zhan et al. 2010). It is worth noting that most of the students in higher education detected that statistics is a daunting course in the curriculum. Comprehending statistical methods and theories is quite challenging (Haines 2015) especially during the COVID-19 outbreak, teaching and learning statistics have become a very difficult process due to the negative attitudes and anxiety brought about by the pandemic. In the study of Repedro Jr. and Diego (2021), it is mentioned that attitudes toward learning statistics are correlated to students' statistical literacy. To have a positive attitude toward learning statistics, students must increase their resilience to cope with difficulties experienced during distance learning. According to Johnston-Wilder and Lee (2010), resilience in education means that students continue learning despite encountering setbacks and difficulties in their learning process. According to Keener et al. (2021), there are related factors that govern the fluctuating behavior of resilience during the COVID-19 pandemic. Additionally, Laird et al. (2019) found some psycho-biological factors that significantly influence the level of resilience in different stages of life and situation. In that case, this study assumed that the resilience level of students in learning statistics is affected by causal determinants during the pandemic. Hence, elucidating the students' resilience in learning statistics online is crucial in formulating policy inputs to improve statistics education and enhance teaching strategies suitable to distance learning.

Evaluation of engineering students' resilience in learning statistics during the COVID-19 pandemic is scarce in the body of statistics education literature. Statistical modeling of the level of resilience and its influencing predictors has never been realized in a State University in Leyte, Philippines where most students live in rural areas. Hence, the study was realized. In this current study, it accomplished its goals by elucidating the following specific objectives: (1) to summarize the profile of engineering students; (2) to measure the level of resilience of engineering students in learning statistics online; and (3) to model the level of resilience of engineering students and its predictors. The findings of the current study might help instructors/professors understand the resilience level in learning statistics under distance learning. Perhaps, the results might improve the teaching strategies in statistics, and serve as a benchmark for future researchers in the field of statistics education. Furthermore, this study might contribute momentous information to the literature on educational studies.

METHODS

The Research Design

A complex correlational research design was employed in this study to determine the evident predictors of students' resilience levels in learning statistics online amid the COVID-19 pandemic. To shed light on the research objectives, the study concentrated on primary and cross-sectional data from engineering students that dealt with the resiliency instruments of Kooken et al. (2013) and influencing factors based on the study by Casinillo et al. (2022). Moreover, to excerpt detailed ideas and policies, the study used some descriptive statistics and regression models.

The Respondents, Sampling Procedure, and Ethics

The population of interest in this study was the bonafide engineering students of Visayas State University who were currently enrolled in the course "Engineering Data Analysis" in the 1st semester of the academic year (A.Y.) 2021-2022. These students were chosen to be the respondents because they were considered the students with a rigorous approach to statistics in the University with a large population. Google form survey was employed in gathering the desired data for this study. Hence, the sampling procedure used in this study is a non-probabilistic approach where it applies a non-random technique, that is, availability sampling. Hence, by the complete enumeration method, all engineering students were sent the link of the survey, and those students who willingly participate automatically be part of the respondents. Students were given one week to respond to the Google form survey questionnaire which could be accomplished within 10-15 min. To motivate students in responding to the survey, they were given additional points for their course "Engineering Data Analysis" to get the desired data within the time constraint. Fortunately, a summation of 129 students which consists of 98% of the total population responded to the survey and the remaining 2% declined the participation of the said survey. According to Jenkins and Quintana-Ascencio (2020), the needed respondents in constructing multiple regression models is above 100 samples which can suffice its minimum requirement. In this case, 129 students are enough and considered large in dealing with a statistical model. Furthermore, this study considered ethics in dealing with the survey. First, a

letter of consent was sent to the Department Head of Statistics. After its approval, the two teachers handling the course "Engineering Data Analysis" were informed about the survey. Students were also oriented about their participation and the information to be collected that follows the Data Privacy Act (Republic Act 10173).

The Survey Instrument and Data Collection

A developed structured questionnaire was used in the study as a Google survey. It comprised three (3) parts that include a profile of students, learning experiences, and the Mathematics Resilience Scale (MRS). As for the profile of students, this covered data such as age (in years), sex (1=male, 0=female), residence (1=Urban, 0=Rural), Use of laptop(s) (1=Yes, 0=No), internet signal strength (Scale of 1 to 10), hours studying statistics per week, money spent on internet load per week (PHP), number of family members, household assets (PHP), monthly family income (PHP), monthly family expense (PHP), leisure time (Scale of 1 to 10), physical health (Scale of 1 to 10), and mental health (Scale of 1 to 10). In addition, students were asked about their learning experiences including how conducive learning at home (Scale of 1 to 10), statistical anxiety (Scale of 1 to 10), difficulty level in learning statistics (Scale of 1 to 10), logical level of statistics (Scale of 1 to 10), level of creativity in learning statistics (Scale of 1 to 10), how rewarding is learning statistics (Scale of 1 to 10). Furthermore, to capture the resilience level of engineering students in learning statistics online, this study adapted the questionnaire of Kooken et al. (2013), that is, the MRS. The questionnaire dealt with 23 worded questions on the negative and positive sides of students' resilience in learning. However, this study only considered the positive questions to capture the students' positivity and resilience behavior during the pandemic, hence, it dealt with 17 questions only. MRS follows a 5-point Likert scale such as 1-Strongly disagree, 2-Disagree, 3-Undecided, 4-Agree, and 5-Strongly agree. According to Kooken et al. (2013), the MRS instrument has undergone content validation with experts in which it is found that it is correlated to an individual's emotions and well-being as a student. Moreover, the negative questions captured the pessimistic overview of students, stress, and anxiety level in learning. To ensure the reliability of the adapted MRS questionnaire, it has undergone a reliability test. In this case, the result showed that it has a Cronbach's alpha coefficient of 0.86, which can be interpreted as reliable (Cronbach 1951). Table 1 represents the range of possible scores and their verbal description.

Table 1. Resilience perception scores and their corresponding description.

Perception Scores	Response	Description
1.00 – 1.80	Strongly disagree	Not resilient
1.81 – 2.60	Disagree	Slightly resilient
2.61 – 3.40	Undecided	Moderately resilient
3.41 – 4.20	Agree	Resilient
4.21 – 5.00	Strongly agree	Very resilient

The Data Management and Statistical Model

In summarizing the data collected, some descriptive analyses that include mean or average (M), a measure of dispersion called standard deviation (SD) and coefficient of variation (CV), minimum (min) observation, and maximum (max) observation were engaged. As for the modeling procedure, multiple regression analysis in the form of ordinary least squares (OLS) was used to shed light on the significant regressors of the students' level of resilience in learning statistics at a distance. Hence, the regression model takes the following form:

$$R_j = c_0 + c_1 V_{j1} + c_2 V_{j2} + \cdots + c_p V_{jp} + \varepsilon_j \qquad (1)$$

where R_j refers to the students' total resilience score, $j = 1, \ldots, n$ and n refer to the number of students, c_t ($\forall \mathrm{t} \in \{0, 1, \ldots, \mathrm{p}\}$) are the parametric quantity of the model (1) that is to be approximated and can be interpreted as incremental change in R_j for every 1 unit change in V_{jt} while holding other regressors constant, V_{jt} ($\forall \mathrm{t} \in \{1, \ldots, \mathrm{p}\}$) are the causal regressor variables in the model (1), and ε_j refer to the random error in the model (1). The parametric quantity c_t ($\forall \mathrm{t} \in \{0, 1, \ldots, \mathrm{p}\}$) are tested at 1%, 5%, and 10% level of significance since the respondents are human in which their response is somehow affected by their emotions or mood (Klasen 2002). Three regression models were constructed considering the number of independent variables is subject to the sample size (Jenkins and Quintana-Ascencio 2020). Also, the independent variables that were included in the model were based on the optimality of the coefficient of determination or the goodness of fit. To be accurate in the data analysis, STATA version 14.0 was used for the calculation. Moreover, for the post-estimation technique (diagnostic test), the heteroscedastic test, test for omitted variables, test for multicollinearity, and non-normality test for residuals were employed to validate the results of the statistical model and tested at a 5% level of significance.

RESULTS

Students' Profile

The mean age of engineering students was close to 20.12 (± 1.47) with the youngest at 18 years old and 30 years old as the oldest (Table 2). Thirty-nine percent of them are male and 61% are female. Most of them are living in rural areas (74%) and while 26% of them live in urban places. Eighty-two percent of these students were using laptop/s in their online classes and 18% were just using cellular phones. On average, students were studying their statistics lessons for 6.90 (± 9.68) h and spent PHP234.49 (± 205.09) on internet load per week. Approximately, the household size of each student was close to 6 (± 1.90) members and their household assets were close to PHP190,722.1 (± 364,422.4). Regarding their family income, it was more or less PHP24,871.51 (± 32,455.24) and their household expense was approximately PHP14011.05 (± 11983.83).

Meanwhile, students' perception of their leisure time during the COVID-19 pandemic was 6.60 (± 2.53) and their rating for their physical health was close to 6.09 (± 2.24). However, these students have rated their mental health low at about 4.81 (± 2.34) out of 10. They also rated their internet signal relatively low for more or less 5.49 (± 1.95) as well as their learning environment at their respective home (5.63 ± 2.29). On a scale of 1 to 10, students' statistical anxiety was about 7.16 (± 1.88) and they have difficulty learning the statistical concepts online (7.85 ± 2.26). Students found that learning statistics is somewhat logical (7.27 ± 2.22) and moderately creative (6.07 ± 1.86). Furthermore, they found that their learning in statistics is rewarding (6.93 ± 2.08) and fulfilling in nature.

Students' Resilience Level

Table 3 shows students' level of resiliency. Data disclosed that no engineering students were not resilient and slightly resilient during their statistics classes amid the pandemic. Of these students, 60.47% were resilient in learning statistics online and 35.66% were a very resilient attitude during the online class. This student can easily adopt the new type of learning and could manage the difficulties behind it. However, only 3.88% of the students were moderately resilient. On average, engineering students during the pandemic were resilient (4.13 ± 0.43) in remote learning during the COVID-19 pandemic. This result is considered consistent based on the coefficient of variation (CV = 10.41%), which implies that students are persistent in their resilient behavior in the cognitive process despite the challenges brought by distance learning and limited interaction with their instructors/professors. Hence, this suggests that students have developed a coping mechanism to level up their resilience and adapt to the new normal activities in online learning consistently.

Table 2. Descriptive statistics for profile and learning experiences of engineering students. a-dummy (indicator) variable; b-count; c-Philippine Peso (PHP); d-Scale 1 to 10.

Variables	M± SD	min	max
Students' profile			
Age in years	20.12 ± 1.47	18	30
Male[a]	0.39 ± 0.49	0	1
Urban[a]	0.26 ± 0.44	0	1
Use of laptops(s)[a]	0.82 ± 0.38	0	1
Hours (h) studying math lesson (per week)[b]	6.90 ± 9.68	1	70
Money spent on internet connection (per week)[c]	234.49 ± 205.09	20	1400
Family members[b]	5.64 ± 1.90	2	13
Household Assets[c]	190722.1 ± 364422.4	10000	2000000
Monthly Family Income[c]	24871.51 ± 32455.24	5000	250000
Monthly Household Expenses[c]	14011.05 ± 11983.83	3000	70000
Leisure Time[d]	6.60 ± 2.53	1	10
Physical Health[d]	6.09 ± 2.24	1	10
Mental Health[d]	4.81 ± 2.34	1	10
Internet Signal Strength[d]	5.49 ± 1.95	1	10
Students' learning experiences			
How conducive learning at home[d]	5.63 ± 2.29	1	10
Statistical anxiety level[d]	7.16 ± 1.88	1	10
Difficulty level in learning Statistics[d]	7.85 ± 2.26	1	10
Logical level of Statistics[d]	7.27 ± 2.22	1	10
Level of Creativity in Statistics[d]	6.07 ± 1.86	2	10
How rewarding is learning Statistics[d]	6.93 ± 2.08	2	10

Table 3. Students' level of resilience. a - See Table 1 for details; b - If the CV is less than 20%, then it is considered a consistent response (Reed et al. 2002).

Response to Resiliency	Frequency	Percentage (%)	Description
Strongly disagree	0	0.00	Not resilient
Disagree	0	0.00	Slightly Resilient
Undecided	5	3.88	Moderately resilient
Agree	78	60.47	Resilient
Strongly agree	46	35.66	Very resilient
M (± SD)	**4.13 (± 0.43)**		**Resilient[a]**
CV (%)	**10.41**		**Consistent[b]**

Statistical Models for Students' Resilience

Three regression models were constructed and estimated based on the sample size, number of independent variables, and optimality of the coefficient of determination (Table 4). All three regression models (*P*'s are greater than the 5% level) in Table 4 were found to be homoscedastic concerning the variances of residuals with the aid of the Breusch-Pagan test. Models 1 and 2 did not contain omitted variable bias ($P > 0.05$) while model 3 possessed omitted variable bias ($P = 0.012$) at a 5% level using the Ramsey RESET test. Additionally, the three models do not have problems in multicollinearity. Thus, there was no significant correlation between the predictor variables. This implies that the variance inflation factor (VIF) is lesser than 10.

Table 4. Statistical models for students' level of resilience in learning statistics online and its predictors. a-dummy (indicator) variable; b-count; c-Philippine Peso (PHP); d-Scale 1 to 10; Standard error is enclosed with parenthesis; $*P < 0.10$; $**P < 0.05$; $***P < 0.01$, ns-not significant.

Predictors	Statistical models		
	OLS Model I	**OLS Model II**	**OLS Model III**
Age in years	-0.4958[ns] (0.4478)		
Male[a]	3.3870** (1.3883)	2.8205* (1.4448)	2.5461* (1.3000)
Urban[a]	0.8454[ns] (1.5168)		
Use of laptops(s)[a]		0.2141[ns] (1.7812)	
Hours (h) studying math lesson (per week)[b]		0.0667[ns] (0.0692)	
log (Money spent on internet connection (per week)[c]+1)	0.3506[ns] (2.0628)		
Family members[b]	0.7011** (0.3441)	0.6333* (0.3606)	0.5566* (0.3353)
log (Household Assets[c]+1)	1.9701*** (0.7134)		0.9278[ns] (0.6417)
log (Monthly Family Income[c]+1)	-3.1495[ns] (2.7459)		
log (Monthly Household Expenses[c]+1)	0.2894[ns] (3.0790)		
Leisure Time[d]		-0.0046[ns] (0.2780)	
Physical Health[d]		0.3282[ns] (0.3910)	
Mental Health[d]		0.0976[ns] (0.4019)	
Internet Signal Strength[d]		-0.5077[ns] (0.3653)	
How conducive learning at home[d]		0.5667* (0.3102)	
Statistical anxiety level[d]		0.3473[ns] (0.3659)	

Predictors	Statistical models		
	OLS Model I	**OLS Model II**	**OLS Model III**
Difficulty level in learning Statistics[d]			-0.5761[ns] (0.4484)
Logical level of Statistics[d]			0.6212[ns] (0.4876)
Level of Creativity in Statistics[d]			0.1066[ns] (0.4541)
How rewarding is learning Statistics[d]			0.6015[ns] (0.5097)
Constant	76.9091*** (11.6581)	59.5671*** (4.7445)	55.8534*** (4.0792)
Number of students	129	129	129
F-computed	1.89*	1.34[ns]	2.47**
P-value (P)	0.0683	0.2148	0.0164
R-squared	0.1117	0.1023	0.1413

Moreover, the normality test for residuals using the Shapiro-Wilk test revealed that Model 1 (P = 0.047) was not normal. However, the density estimate graph showed that it was almost normal. In addition, Models 2 (P = 0.083) and 3 (P = 0.133) possess normal residuals revealed by the Shapiro-Wilk test. The first model (Model 1: $F_c = 1.89$; P = 0.068) is significant at a 10% level and had a goodness-of-fit (R^2) of 0.112. This implies that this model has few significant predictors of students' resilience that include gender (P=0.016), number of family members (P = 0.044), and household assets (P = 0.007).

As for the second model (Model 2: $F_c = 1.34$; P = 0.215), it was only significant at a 21.5% level and possessed a goodness-of-fit (R^2) of 0.102. However, it had revealed significant predictors of students' resilience such as gender (P = 0.053), the number of family members (P = 0.082), and how conducive learning at home (P = 0.070). Furthermore, the third model (Model 3: F_c = 2.47; P = 0.016) is significant at a 5% level with a goodness-of-fit (R^2) of 0.141. Specifically, predictors that include gender (P = 0.053) and the number of family members (P = 0.100) were significant in the model.

DISCUSSION

Students' Profile

The same finding was revealed from the study of Casinillo et al. (2022) that the average age of first-year students is more or less 20 years old. Additionally, results revealed that the dominant sex of engineering students is female. This finding is consistent with the findings of Balakrishnan and Low (2016) that the insufficiency of engineers will be resolved if female students intend to enroll in engineering as their career. Most of the engineering students live in rural areas where internet connectivity is relatively low as opposed to urban places. In that case, even if the dominant of students are using a laptop as their learning instrument, they still have an unconducive place to learn in their home. Carius (2020) justified that internet connection is one of the barriers in remote learning where the teaching-learning process is adversely affected. Although students can afford to load for the internet considering their parents/guardians can supply money, still, these students are having challenges due to fluctuating internet signals. Because of health protocols, students are limited to doing some physical activities outside their homes. On the face of it, they do not have the opportunity to relieve stress through leisure activities that's why they have poor mental health during the pandemic. Accordingly, Gao et al. (2021) portrayed that students during the pandemic are experiencing mental health trouble that includes depression, anxiety, and stress disorder. Moreover, although students found learning statistics online to be logical, creative, and rewarding, they still struggle with some barriers and limitations that produce anxiety. Dratva et al. (2020) found that during the pandemic, students are having a high level of anxiety due to abrupt changes and challenges that they confronted.

Students' Resilience Level

Results presented that there are only a few engineering students who are not resilient during their statistics classes online. Resilience is vital to adapt to abrupt changes and adverse impacts due to the COVID-19 pandemic. Through resilience, students can continue and cope with the difficulties and even learn despite the limited interaction with their instructors/professors. Moreover, the results have revealed that most of the students are resilient and some are very resilient. This implies that, in the actual situation, students have developed and implemented strategies that build and increase their resilience and well-being while learning at a distance. According to Schlesselman et al. (2020), to earn a good education amid the pandemic, students must improve and restore

their resilience level. Another reason is that students have a life purpose and that is to earn a degree, that's why students are actively doing their duties as a student and intent to persevere (increasing their level of resilience) despite the unfavorable issue of online learning to them (Ardhiani et al. 2021; Sharma and Yukhymenko-Lescroart 2022). Likewise, the study of Hamadeh Kerbage et al. (2021) found that students are developing some coping strategies that include staying connected via the internet, establishing a daily routine, and always processing self-help methods that promote well-being (good mental health) and enhancing their resilience level amid the difficult times of the pandemic.

Statistical Models for Students' Resilience

The three statistical models revealed that a male engineering student is more resilient in learning statistics at a distance. This implies that male students are more capable of handling difficulties and obstacles brought on by the pandemic. In addition, male students are more likely to have a strong ability to cope emotionally and even mentally amid challenges as opposed to female students. This result is aligned with the study by McGee and Pearman (2015) that depicted that male students are achievers in the different areas of mathematics. Likewise, the study by Pilotti et al. (2022), discovered that male students performed better in mathematics courses compared to female students during online classes amid the pandemic. On the face of it, male students can be more productive in the cognitive process despite barriers and limitations in remote learning. It is worth noting that resilience that it promotes positivity in the mental and behavioral processes that boost the learning ability of a student. Apparently, Cheung (2017) explained that the mathematical and statistical literacy of students is positively influenced by resilience.

Additionally, the three models have shown that family members influence the students' level of resilience in learning statistics online. This result suggests that students are inspired to do their duty as educatee if they have more family members in the household that encourage them despite the disruptive environment due to the COVID-19 pandemic. The more family members they have, the more they can develop resilient behavior and cope with stress in learning online because they are not bored and they have more time for family bonding. Adams (2021) found out that family bonding and therapy can nurture the resilience of family members as they face challenges amid the pandemic. In that case, a student who belongs to a resilient family can continue the learning process as creatively compared to non-resilient families. Orlowski et al. (2022) pictured that families who are working together with constant care and parents that meaningfully communicate with their children can creatively develop good resilience and well-being in a time of the COVID-19 pandemic. Note that, good communication with family members can encourage students to perform better in class even if they are facing obstacles and limitations in online learning.

Next, the result showed that household assets are a significant predictor of students' resilience in learning statistics online. It is worth noting that household assets provide benefits and even comfort that helps them increase their well-being. According to Valenzona et al. (2022), students with more resources and belongings tend to be more creative in the learning process despite the limitation of distance education. This indicates that students with more assets or possessions can work advantageously with difficulties due to the benefits of available resources they have. Qazi et al. (2020) expressed that students with more assets like gadgets, internet access, and the like can easily cope with the difficulties of online learning and progress their resilient behavior in-class activities. It is worth noting that statistics activities require advanced gadgets like laptops and good internet access. Hence, this implies that students with higher household assets value are more resilient and productive in learning statistics online.

Moreover, Model II revealed that a conducive place for learning is a significant determinant of students' level of resilience in learning statistics under distance education. The result implies that a student with a comfortable learning environment is more likely adaptive to the unprecedented situation amid the pandemic. In other words, learning in a conducive environment results in a more collaborative and active student (Pratama and Scarlatos 2020). In the study of Oducado and Soriano (2021), it is found that students with a conducive environment and stable internet connections tend to have a better learning attitude and well-being as they face the disrupted education brought by the pandemic. In addition to that, Dai and Xia (2020), a conducive learning environment can be more effective in progressing the students' academic performance since they can develop positive learning cognitive behavior and be resilient to difficulties.

On the face of it, statistics teachers must rectify the negative behavior of engineering students in online education by constantly monitoring and measuring their learning progress and always entertaining their concerns (Baharun et al. 2017). Teachers must provide realistic and lively statistics activities to boost their interest and to be collaborative in learning despite the adverse situation brought by the pandemic. This study recommended that it is vital for the policymakers in education to address the issues and concerns of teachers and students for their online classes especially for statistics so that effectiveness in learning will not be compromised amidst the health crisis. Additionally, it is suggested that for future

research, one may construct a statistical model that captures the determinants of statistical anxiety of students to supplement the information of the current study. A possible limitation of this study is the small sample size used, hence, it is recommended that a large population of students must be considered for future research to gather richer and statistically sound information. Another limitation is that the study does not gather information from the teachers' side, thus, it is suggested that to have a strong argument concerning resilience amid the pandemic, both teachers and students must be part of the respondents for further studies.

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REFERENCES

Adams GC. 2021. Resilience in the time of pandemic. The Canadian Journal of Psychiatry, 66(1): 62-63. https://doi.org/10.1177/0706743720946170

Ardhiani LN, Hyoscyamina DE and Al Karim CH. 2021. Online positive attitude training: Increasing resilience amidst pandemic. Journal of Nonformal Education, 7(2): 157-165. https://doi.org/10.15294/jne.v7i2.30278

Baharun S, Mohammad Yusof Y, Abdul Rahman R and Ismail Z. 2017. Invoking and supporting engineering student mathematical thinking in informal cooperative learning classroom. Sains Humanika, 9(1-2): 33-38. https://doi.org/10.11113/sh.v9n1-2.1094

Bakker A and Wagner D. 2020. Pandemic: lessons for today and tomorrow? Educational Studies in Mathematics, 104(1): 1-4. https://doi.org/10.1007/s10649-020-09946-3

Balakrishnan B and Low FS. 2016. Learning experience and socio-cultural influences on female engineering students' perspectives on engineering courses and careers. Minerva, 54(2): 219-239. https://doi.org/10.1007/s11024-016-9295-8

Carius AC. 2020. Teaching practices in Mathematics during COVID-19 pandemic: Challenges for technological inclusion in a rural Brazilian school. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 72(1): 35-43.

Casinillo LF, Casinillo EL, Valenzona JV, Almonite MRC and Valenzona DL. 2022. How challenging it is to learn Mathematics Online. Philippine Social Science Journal, 5(1): 80-89. https://doi.org/10.52006/main.v5i1.447

Cheung KC. 2017. The effects of resilience in learning variables on mathematical literacy performance: A study of learning characteristics of the academic resilient and advantaged low achievers in Shanghai, Singapore, Hong Kong, Taiwan and Korea. Educational Psychology, 37(8): 965-982. https://doi.org/10.1080/01443410.2016.1194372

Cronbach LJ. 1951. Coefficient alpha and the internal structure of tests. Psychometrika, 16: 297-334. https://doi.org/10.1007/BF02310555

Dai D and Xia X. 2020. Whether the school self-developed e-Learning platform is more conducive to learning during the COVID-19 pandemic? Best Evidence in Chinese Education, 5(1): 569-580. https://doi.org/10.15354/bece.20.ar030

Dratva J, Zysset A, Schlatter N, von Wyl A, Huber M and Volken T. 2020. Swiss university students' risk perception and general anxiety during the COVID-19 pandemic. International Journal of Environmental Research and Public Health, 17(20): 7433. https://doi.org/10.3390/ijerph17207433

Gao J, Wang F, Guo S and Hu F. 2021. Mental health of nursing students amid coronavirus disease 2019 pandemic. Frontiers in Psychology, 12: 1-12. https://doi.org/10.3389/fpsyg.2021.699558

Haines B. 2015. Conceptualizing a framework for advanced placement statistics teaching knowledge. Journal of Statistics Education, 23(3): 1-16. https://doi.org/10.1080/10691898.2015.11889747

Hamadeh Kerbage S, Garvey L, Willetts G and Olasoji M. 2021. Undergraduate nursing students' resilience, challenges, and supports during corona virus pandemic. International Journal of Mental Health Nursing, 30: 1407-1416. https://doi.org/10.1111/inm.12896

Karairmak O. 2010. Establishing the psychometric qualities of the Connor-Davidson Resilience scale (CD_RISC) using exploratory and confirmatory factor analysis in a trauma survivor sample. Psychiatry Research, 179: 350-356. https://doi.org/10.1016/j.psychres.2009.09.012

Jenkins DG and Quintana-Ascencio PF. 2020. A solution to minimum sample size for regressions. PloS ONE, 15(2): e0229345. https://doi.org/10.1371/journal.pone.0229345

Johnston-Wilder S and Lee C. 2010. Mathematical resilience. Mathematics Teaching, 218: 38-41.

Keener TA, Hall K, Wang K, Hulsey T and Piamjariyakul U. 2021. Quality of life, resilience, and related factors of nursing students during the COVID-19 pandemic. Nurse Educator, 46(3): 143-148. https://doi.org/10.1097/NNE.0000000000000969

Klasen S. 2002. Low schooling for girls, slower growth for all? Cross-country evidence on the effect of gender inequality in education on economic development. The World Bank Economic Review, 16(3): 345-373. https://doi.org/10.1093/wber/lhf004

Kooken J, Welsh M, McCoach D, Johnston-Wilder S and Lee C. 2013. Measuring Mathematical Resilience: An application of the construct of resilience to the study of mathematics. Paper presented at national conference of the American Educational Research Association, San Francisco, CA. http://oro.open.ac.uk/38987/3/Mathematical%20resilience%202013.pdf. Accessed on 08 June 2022.

Laird KT, Krause B, Funes C and Lavretsky H. 2019. Psychobiological factors of resilience and depression in late life. Translational Psychiatry, 9(1): 1-18. https://doi.org/10.1038/s41398-019-0424-7

Legaki NZ, Xi N, Hamari J, Karpouzis K and Assimakopoulos V. 2020. The effect of challenge-based gamification on learning: An experiment in the context of statistics education. International journal of human-computer studies, 144: 102496. https://doi.org/10.1016/j.ijhcs.2020.102496

McGee EO and Pearman FA. 2015. Understanding Black male mathematics high achievers from the inside out:

Internal risk and protective factors in high school. The Urban Review, 47(3): 513-540. https://doi.org/10.1007/s11256-014-0317-2

Miñoza SB and Casinillo LF. 2022. Profiling bachelor of science in statistics (BSS) students under the open enrolment policy. International Journal of Indonesian Education and Teaching, 6(1): 1-24. https://doi.org/10.24071/ijiet.v6i2.3723

Oducado RMF and Soriano GP. 2021. Shifting the education paradigm amid the COVID 19 pandemic: Nursing students' attitude to E-learning. Africa Journal of Nursing and Midwifery, 23(1): 1-14.

Orlowski EW, Friedlander ML, Megale A, Peterson EK and Anderson SR. 2022. Couple and family therapists' experiences with Telehealth during the COVID-19 pandemic: a phenomenological analysis. Contemporary Family Therapy, 44(2): 101-114. https://doi.org/10.1007/s10591-022-09640-x

Pilotti MA, El-Moussa OJ and Abdelsalam HM. 2022. Measuring the impact of the pandemic on female and male students' learning in a society in transition: A must for sustainable education. Sustainability, 14(6): 3148. https://doi.org/10.3390/su14063148

Pratama AR and Scarlatos LL. 2020. The roles of device ownership and infrastructure in promoting E-learning and M-learning in Indonesia. International Journal of Mobile and Blended Learning (IJMBL), 12(4): 1-16. https/doi.org/10.4018/IJMBL.2020100101

Qazi A, Naseer K, Qazi J, AlSalman H, Naseem U, Yang S, Hardaker G and Gumaei A. 2020. Conventional to online education during COVID-19 pandemic: Do develop and underdeveloped nations cope alike. Children and Youth Services Review, 119: 105582. https://doi.org/10.1016/j.childyouth.2020.105582

Ramirez C, Schau C and Emmioglu E. 2012. The importance of attitudes in statistics education. Statistics Education Research Journal, 11(2): 57-71. https://doi.org/10.52041/serj.v11i2.329

Reed GF, Lynn F and Meade BD. 2002. Use of coefficient of variation in assessing variability of quantitative assays. Clinical and Vaccine Immunology, 9(6): 1235-1239. https://doi.org/10.1128/CDLI.9.6.1235-1239.2002

Repedro Jr RE and Diego CV. 2021. Attitudes toward Statistics and Statistical Literacy of public senior high school students. Philippine Social Science Journal, 4(3): 48-56. https://doi.org/10.52006/main.v4i3.399

Schneider SL and Council ML. 2021. Distance learning in the era of COVID-19. Archives of Dermatological Research, 313(5): 389-390. https://doi.org/10.1007/s00403-020-02088-9

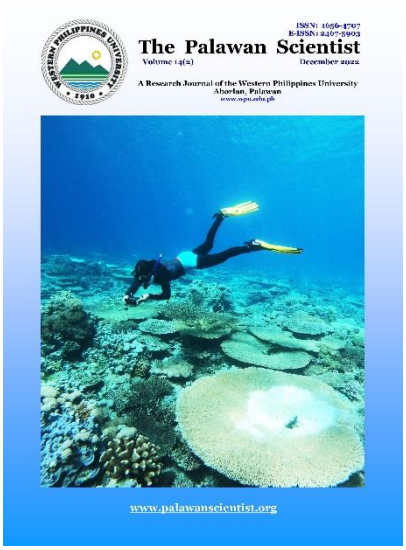
Schlesselman LS, Cain J and DiVall M. 2020. Improving and restoring the well-being and resilience of pharmacy students during a pandemic. American Journal of Pharmaceutical Education, 84(6): 677-682. https://doi.org/10.5688/ajpe8144

Sharma G and Yukhymenko-Lescroart MA. 2022. Life purpose as a predictor of resilience and persistence in college students during the COVID-19 pandemic. Journal of College Student Retention: Research, Theory & Practice, 1-21. https://doi.org/10.1177/15210251221076828

Srivastava S and Agarwal N. 2020. Psychological & social effects of pandemic Covid-19 on education system, business growth, economic crisis and health issues globally. An International Journal of Management & IT A Refereed Research Journal, 11 (2): 40-45. https://doi.org/10.46360/globus.mgt.120201007

Valenzona JV, Casinillo LF and Casinillo EL. 2022. Modeling students' innovativeness and its factors in learning mathematics amidst COVID-19 pandemic. The Palawan Scientist, 14(1): 43-50.

Zhan W, Fink R and Fang A. 2010. Application of statistics in engineering technology programs. American Journal of Engineering Education, 1(1): 65-78. https://doi.org/10.19030/ajee.v1i1.793



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Fishing trials using banana and fish baits in pots for catching marine crabs: an attempt to tropical selective crustacean trapping

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ABSTRACT

Experimental fishing targeting marine crabs was conducted using crab pots baited with overripe banana locally known as "latundan", which is a hybrid of *Musa acuminata* (Colla 1820) and *Musa balbisiana* (Colla 1820), and cardinal fish *Apogon lineatus* (Temminck and Schlegel 1842). This was done to assess the catch composition and to investigate the effect of the baits on the selective catching of the desired crab species, size, and sex during trapping operations. Four bait treatments were used: no bait (NB), banana (BB), fish bait (FB), and banana-fish combination (FB+). Results showed that the FB+ caught comparable *P. pelagicus* with FB in terms of numbers, and the catch of *T. sima* was about the same. Pots having NB or BB alone caught the fewest crabs during the trapping operations. The combination of banana and fish baits showed no significant difference in the number of crabs caught when using fish baits. *Portunus pelagicus* (Linnaeus 1758) and *Thalamita sima* (Milne Edwards 1834) dominated the catches among crabs comprising a total of 44.21% and 18.95%, respectively. In terms of crab size (carapace width), catches in pots baited with FB alone had smaller crabs in comparison to the catches in pots with FB+, but in *P. pelagicus* no statistical difference was detected. Moreover, FB+ showed gender neutrality for *P. pelagicus*, but more *T. sima* females than males were caught. This shows that banana combined with fish baits has intraspecific selective properties towards some crab species. Furthermore, the addition of bananas to fish baits seemed to decrease the number of non-target species caught. The overall high percentage of crabs caught in the pots baited with FB+ and FB means that these baits may have extra-specific potential in crab trapping thus reducing undesired species trapped in the pots. Furthermore, the inclusion of banana to fish as bait can be beneficial for future studies in resource management and the reduction of fish utilization as bait.

Keywords: banana baits, crab pot, *Portunus pelagicus*, selective fishing, *Thalamita sima*

INTRODUCTION

Economically important crabs are amongst the most exploited marine resources throughout the world due to their commercial demand. The crab *Portunus pelagicus* (Linnaeus 1758) is considered one of the most targeted m arine crustaceans because of its good quality meat among marine crabs. The species

was reported to be one of the world's heavily-fished crab species (Permatahati et al. 2020). In the Philippines, this species is continuously harvested in the wild since hatchery for this commodity is not yet fully developed, although studies on the hatchery-related techniques on the species are being done elsewhere (Cabacaba and Salamida 2015). At present, *P. pelagicus* wild stocks are highly threatened and overexploited, yet few efforts have been done to control their extraction and this presents a challenge to the researchers collecting and trapping them since this is one of the sources of livelihood for fisherfolks. Hence intraspecies and extraspecific selective fishing on marine crabs must be done to conserve the resources.

However, selective fishing in tropical areas is very difficult to achieve. The tropical Philippine Sea has a magnitude of underwater organisms that may occupy the same space and time during foraging. This means that fishers and researchers cannot always get the desired species and size of the preferable target organisms during fishing. As a result, massive amounts of the by-catch were disposed of. Different designs of pots and other gears have been used to catch crabs and other crustaceans with high efficiency (Yamane and Fujiishi 1992; Zhou and Kruse 2000; Vazquez Archdale and Kuwahara 2005; Vazquez Archdale et al. 2006; Vazquez Archdale et al. 2007; Winger and Walsh 2007; de la Cruz et al. 2018; Glamuzina et al. 2021; Hanamseth et al. 2022). However, trapping gears may be generally unselective to some extent because they may catch non-target fishes and crustaceans with sizes that are not commercially viable and will result in high bycatch. Furthermore, entrances and exits of crab pots cannot always regulate the catching of smaller sizes. An alternate solution is to look in detail at the food habits of the target species and to study possible baits that might be used to increase catches of typical gears for crab trapping. Kawamura et al. (1995) discovered that fish baits combined with sugarcane can catch more crabs than using fish and or sugarcane separately.

This study was conducted to assess catch composition, and to investigate the selectivity of different baits, including an overripe banana which is locally known as “latundan”, which is a hybrid from the species *Musa acuminata* (Colla 1820) and *Musa balbisiana* (Colla 1820), and fish bait *Apogon lineatus* (Temminck and Schlegel 1842) in catching the desired species, size, and sex of marine crabs. Both baits are locally used by fishers in the area for catching marine species and are commonly cheap and available in large quantities.

METHODS

Field Study Site

Experimental trapping was conducted in Barangay Tanao, near the island of Magalumbe, in the Municipality of Batad Northern Iloilo (Figure 1). Batad is known as one of the major suppliers of portunid crabs and other marine products from the Visayan Sea. The area supports the crab meat industry in the nearby areas. Here, crabs are caught using various types of gears like trawls, gillnets, and crab pots/traps.

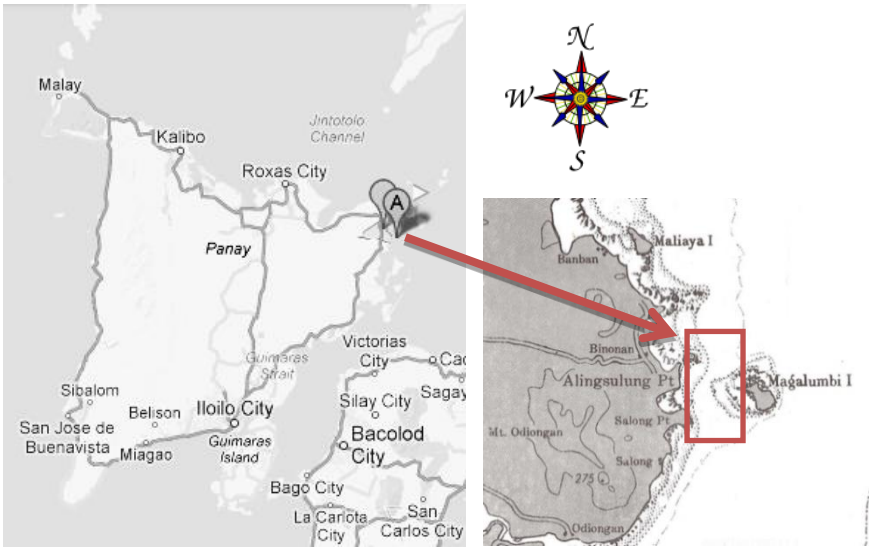

Figure 1. Map showing the location of the crab trapping activity area near the Island of Magalumbe in Barangay Tanao, Municipality of Batad, Iloilo, Philippines.

Day and night local fishers target *P. pelagicus* and other crab species to meet the demands of the local market. Sampling depth ranged from 4 to 12 m. Depths greater than 12 m were not used for trapping because these were usually areas for trawling operations.

Baits and Trapping Gear

Crab pots, locally known as "panggal" are used locally among crab fishers in Batad and they were utilized in this study. The pots measuring 31 x 31 x 10 (Figure 2a) were made of a bamboo frame wrapped with multifilament nylon mesh (6 cm mesh size). Each trap has a bait holder to hold the bait firmly inside the pots (Figure 2b). The gear entrance is located at the upper center portion of the pot and made of plastic materials from unserviceable gallons section with an average diameter of 9.04 ± 0.09 cm (n = 20), which acts as the opening for organisms to enter as they are attracted to the bait inside.

The fish *A. lineatus* and the overripe hybrid banana derived from *M. acuminata* and *M. balbisianna* were utilized as baits to investigate their potential in catching marine crabs (Figures 3a and b). Both baits were chopped into similar sizes and placed into the bait holder and mounted inside the crab pot. This fish bait was used because it was readily obtained as a bycatch from local trawling operations. Additionally, there was an abundant supply of overripe "latundan" bananas in the local markets around Iloilo.

Experimental Design

Four baiting treatments with four replications were used to complete the experimental field crab trapping operation. Baits were chopped into similar portions. The replicated treatments included: banana bait (BB), fish bait (FB), combined fish-banana bait (FB+), and no bait (NB) as control. Pre-weighted (40 g) baits were placed in each crab pot with a 1:1 ratio-wet weight. In the case of the fish-banana bait combination, 20 g fish and 20 g banana were pre-weighted to complete the 40 g bait amount.

Four replications of a series of 32 crab pots were used per trapping operations. In a 32 series of pots, 8 crab pots were randomly assigned for each bait treatment. Thus, in each experimental crab trapping trip, a total of 128 crab pot units were utilized (Table 1). These 128 pot units were arranged in a blocked random manner attached to a rope line with their assigned baits before setting to eliminate area effects. A total of six experimental trapping trips were conducted from November to December 2012. Crab pots were set about 13 m away in a line from each pot position. These pots were set at about 0700H and hauled after an 8-h soaking time.

Experimental crab trapping trips were tracked using a handheld Global Positioning System (GPS) from the starting point to the endpoint (Table 1). Sizing, species sorting, and sex determination was immediately done after each crab trapping operation. Data such as carapace width (CW) and carapace length (CL) of the samples were taken and recorded using a vernier caliper.

Statistical Analysis

The number of crabs caught using the traps did not satisfy the test for normality hence, Kruskal-Wallis H-test was used to compare the number of catch among treatments. Steel-Dwass-Critchlow-Fligner (SDCF) procedure was further used for multiple pairwise comparisons (Hollander and Wolfe 1999). Chi-square analysis ($\alpha = 0.05$) was done to determine the differences in the sex and size of crabs trapped in the pots. The IBM SPSS ver.20 and XLSTAT 2013 software were utilized for the different statistical analyses conducted.

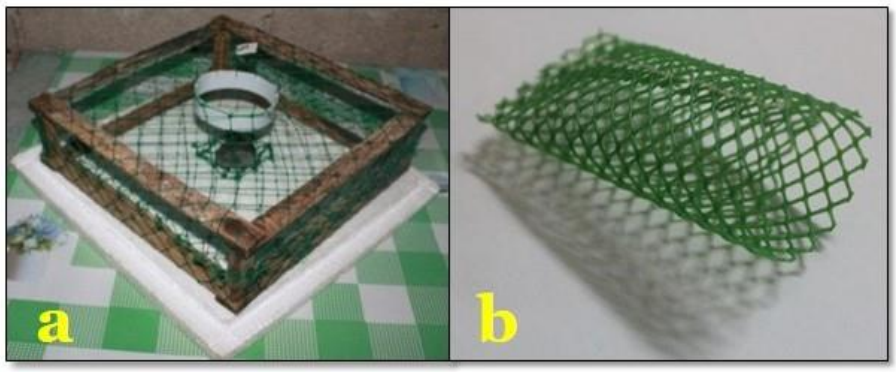

Figure 2. Locally manufactured crab pot "panggal" (a) used to catch marine crabs in the Municipality of Batad, Iloilo, Philippines, and bait holder (b) (height=10 cm with mouth diameter=3.9 cm) made of polyethylene material used in the field sampling (b).

Figure 3. Baits used in catching marine crabs. Fish bait (a) *Apogon lineatus* (and overripe hybrid banana (b) from *Musa acuminata*.

Table 1. Coordinates taken during crab trapping operations conducted at Barangay Tanao, Batad, Iloilo, Philippines. Letters A and B attached at the end of each track code (CRB) denotes the beginning point and ending point of crab pot line series, respectively, while numbers 1 to 6 represent the sampling trips.

Track Code	Sampling Trip #	Depth Range (m)	Tracked GPS positions From	Tracked GPS positions To	Date (dd-mm-yy)	Crab Pots Details
CRB1A	1	5.25	N 11^0 23.111'	N 11^0 23.678'	26-11-2012	8 pots NB 8 pots for BB 8 pots for FB 8 pots for FB+ 32 pots x 4 rep. = 128
CRB1B		6.50	E 123^0 09.065'	E 123^0 09.082'		
CRB2A	2	9.00	N 11^0 23.044'	N 11^0 22.311'	27-11-2012	8 pots NB 8 pots for BB 8 pots for FB 8 pots for FB+ 32 pots x 4 rep. = 128
CRB2B		10.00	E 123^0 09.334'	E 123^0 09.317'		
CRB3A	3	9.00	N 11^0 23.044'	N 11^0 22.311'	30-11-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB3B		10.00	E 123^0 09.334'	E 123^0 09.317'		
CRB4A	4	10.50	N 11^0 22.788'	N 11^0 22.174'	01-12-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB4B		11.00	E 123^0 09.545'	E 123^0 09.207'		
CRB5A	5	4.00	N 11^0 22.272'	N 11^0 22.842'	02-12-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB5B		5.25	E 123^0 09.013'	E 123^0 09.146'		
CRB6A	6	6.50	N 11^0 24.549'	N 11^0 23.985'	03-12-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB6B		5.75	E 123^0 08.855'	E 123^0 09.268'		

RESULTS

Species and Size Composition of Crabs Caught during the Trapping Operation

A total of 95 individuals of various crustacean species and non-target organisms were recorded for the six (6) crab trapping operations (Table 2). Among the crustacean species caught, the main ones were the blue swimming crab *P. pelagicus* with a total count of 42, the four-lobed swimming crab *Thalamita sima* (Milne Edwards 1834) (18), and other minor crustacean species (4) which included the red egg crab *Atergatis intergerrimus* (Lamarck 1818), mantis shrimp *Harpiosquilla harpax* (de Haan 1844), Saint Francis crab *Charybdis feriata* (Linnaeus 1758) and two-spine arm swimming crab *Charybdis*

anisodon (De Haan 1850). Blue swimming crabs dominated the catches (~ 44.21% of the total organisms caught) irrespective of baits.

Non-target organisms caught by pots during the trapping operation were mostly fishes, while others included four echinoderms, one marine worm, and one mollusk (Table 2). The highest numbers of non-target species were seen in pots baited with FB, whereas the FB+ combination caught fewer non-target species than FB.

Crabs captured by pots under various bait treatments significantly differed in numbers (Kruskal - Wallis H-test, $H_0 = 72.853$, df = 3, $P < 0.001$). Unbaited pots (NB) and pots baited with banana (BB) yielded significantly lesser catches than pots baited with fish (FB) and fish mixed with banana (FB+). Furthermore, pots baited with FB and FB+ showed no differences in catches (Figure 4).

In terms of size, large-sized *P. pelagicus* were recorded mostly in pots baited with combined fish and banana baits (FB+) with CWs that ranged from 90.2 to 160.2 mm. In contrast, pots baited with fish only (FB) caught crabs with CWs that ranged from 61.30 to 155.0 mm. However, no statistical differences were seen in the size range of both treatments (Kruskal-Wallis H-test, $P > 0.05$; Table 3). On the other hand, significant differences in the size range were observed for the species *T. sima* (Kruskal-Wallis H-test, $P < 0.05$; Table 3).

Pots baited with FB had the same numbers of female and male *P. pelagicus* in the catch, while pots with FB+ had slightly more male than female *P. pelagicus*; however, results were not significantly different (FB, $\chi^2 = 0.610$, df = 1, $P > 0.05$ and FB+, $\chi^2 = 0.692$, df = 1, $P > 0.05$) (Table 4). On the other hand, significant differences were found in *T. sima*, where female is more abundant than males in pots using FB+, while pots with FB did not have differences in terms of sex (FB+, $\chi^2 = 5.556$, df = 1, $P < 0.05$ and FB, $\chi^2 = 0.600$, df = 1, $P > 0.05$).

Table 2. Catch species composition of pots baited with fish (FB), banana (BB), combined banana-fish (FB+), and no bait (NB) during the six crab trapping operations conducted in Barangay Tanao, Batad, Iloilo, Philippines, using a total of 128 crab pots per trapping operation with 32 pots assigned per bait treatment ; n = 24

Pot catches	**Catch count per bait treatments (n = 24)**				**Total**	**%**
	Fish (FB)	Banana (BB)	Fish-banana (FB+)	No bait (NB)	**Count**	
Crustacean species						
1. Portunus pelagicus (Linnaeus 1758)	30	-	12	-	42	44.21
2. Thalamita sima (Milne Edwards 1834)	7	2	8	1	18	18.95
3. Atergatis intergerrimus (Lamarck 1818)	-	-	1	-	1	1.05
4. Harpiosquilla harpax (de Haan 1844)	-	-	1	-	1	1.05
5. Charybdis feriata (Linnaeus 1758)	1	-	-	-	1	1.05
*6. Charybdis anisodon (*De Haan 1850)	-	-	-	1	1	1.05
Subtotal	**38**	**2**	**21**	**2**	**64**	**67.37**
Non-target organism						
Fish	11	3	7	4	25	26.32
Echinoderms	-	2	1	1	4	4.21
Marine worm	1	-	-	-	1	1.05
Mollusc	-	-	1	-	1	1.05
Subtotal	**12**	**5**	**9**	**5**	**31**	**32.63**
Total	**50**	**7**	**30**	**7**	**95**	**100.00**

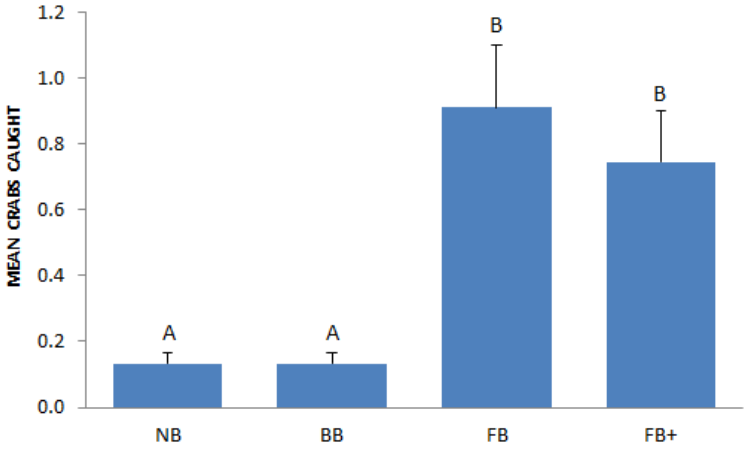

Figure 4. Number (mean ± SEM) of crabs caught per pot baited with no bait (NB), banana bait (BB), fish bait (FB), or fish-banana (FB+). Letter notations indicate a significant difference (Kruskal-Wallis H-Test and Steel-Dwass-Critchlow-Fligner Procedure, $P < 0.05$, n = 24).

Table 3. Differences in crab size composition using the *Kruskal-Wallis test* and *Steel-Dwass-Critchlow-Fligner procedure* (α = 0.05) caught in pots baited with fish (FB) and combined banana-fish (FB+) during trapping operations conducted in Barangay, Tanao, Batad, Iloilo, Philippines.

Species	Bait	Size range (mm)		Mean size	Size differences
		Min.	Max.		
Portunus pelagicus (Linnaeus 1758)	FB	61.30	155.00	132.32	$P > 0.05$; $P = 0.132$
	FB+	90.20	160.20	129.87	
Thalamita sima (Milne Edwards 1834)	FB	54.60	73.40	63.53	$P < 0.05$; $P = 0.009$
	FB+	48.70	151.00	61.428	

Table 4. Statistical differences in sex composition of crabs using Chi-square analysis (α = 0.05) caught in pots baited with fish (FB) and combined banana-fish (FB+) during trapping operations conducted in Barangay, Tanao, Batad, Iloilo, Philippines.

Species	Bait	No. of catches		Total	Differences
		Male	Female		
Portunus pelagicus (Linnaeus 1758)	FB	15	15	30	$P > 0.05$; $P = 0.435$
	FB+	7	5	12	$P > 0.05$; $P = 0.405$
Thalamita sima (Milne Edwards 1834)	FB	4	3	7	$P > 0.05$; $P = 0.439$
	FB+	2	6	8	$P < 0.05$; $P = 0.018$

DISCUSSION

Effect of Banana on Catch Rates

The overripe *M. acuminata x M. balbisiana* hybrid banana lowered the catches of *P. pelagicus* however no statistical differences were observed. Catches for *T. sima* were not affected when the banana-fish bait combination was used. It is assumed that fish is the most effective bait in catching most marine organisms such as crabs since it is commonly used in various capture fisheries. The present result on crab catches with the addition of banana to fish bait can be attributed to the chemical properties of ripe bananas having soluble saccharides like glucose, sucrose, and fructose (Garcia and Lajolo 1988; Tapre and Jain 2012) which may add stimulatory properties toward crustaceans. Studies done in the laboratory have made several successful findings on the stimulatory potential of saccharides to crustaceans (Hartman and Hartman 1977; Trott and Robertson 1984; Zimmer-Faust et al. 1984; Sear et al. 1991; Vazquez Archdale and Nakamura 1992). However, if only bananas were utilized as baits this resulted in a very low catch. Present results showed that banana alone is an inefficient bait for marine crabs. This coincides with similar results obtained by Kawamura

et al. (1995), who also observed few catches with sugarcane (sweet agricultural crop) bait treatment only.

Adding banana to fish bait showed comparable results on the number of catches of *T. sima* in comparison with pots baited with fish bait only. Although crabs are highly sensitive to sugars or saccharides (Hartman and Hartman 1977; Vazquez Archdale and Nakamura 1992; Kawamura et al. 1995; Anraku et al. 2001), the amount of sugar present in bananas may not be enough to elicit the chemosensory responses of crabs in such a way as to affect their feeding habits. Synergisms of substances like amino acids from fish and sugars or saccharides from alternative sources like sugarcane are definite to be functional as shown in some studies by Kawamura et al (1995) and Vazquez Archdale and Anraku (2005), however, this is not clear from the results obtained in the present study using banana. Saccharides from banana alone are not enough to attract and influence crab catches; therefore, further studies are needed on the appropriate amount that should be combined with fish bait. However, the 50% addition of banana to fish bait in the present study does not differ statistically from the crab catches using 100% fish bait. This will help reduce the utilization of expensive fish bait and can consequently may reduce operational expenses in crab trapping but an in-depth future investigation on this matter should be done.

Effect of Banana and Fish Baits on Species Selectivity and Non-Target Catch Composition

A moderately low percentage of non-target species were caught in pots with FB+ than in FB. This shows that the addition of banana to fish bait can decrease the catching of non-target species and can use particularly in crab trapping. In addition, results on the use of banana bait alone also show infrequent or low non-target catches. Both results in using FB+ and BB imply that this banana bait can be selectively used to catch crustacean species and may regulate the catching of other marine organisms. As of these days, not many studies are concentrating on the selectivity of bait materials in catching marine crabs, instead, most studies are focusing on gear innovations and designs (Glamuzina et al. 2021; Zhang et al. 2021; Hanamseth et al. 2022).

The presence of non-target species on pots with NB is probably due to the tendency of fish to occupy the space offered by the gear as shelter although occurrence seems to be infrequent. The biology of animals may be attributed to factors influencing catches on baited pots. Furthermore, other organisms or crabs may possess aggressive behaviors which may influence the presence of a by-catch (Tanner 2007). Thus, for a more efficient trapping operation, studying hydrodynamics with timing, gear, and baits as well as the ecology of the target species is necessary.

Effect of Banana and Fish Baits on Crab Size and Sex Selectivity

Size and sex selectivity are often a concern for the effective management of the target species. The capture of legal-sized male and the conserving of female individuals are among the main concerns used by governing bodies in fisheries management. In the case of blue swimming crabs, *P. pelagicus,* males with CW measuring from 8.5 cm or above and females with CW more than 8.7 cm are considered mature and are legally sized and suitable for capture (Chande and Mgaya 2003).

In the present study, the "panggal" crab pot baited with FB and FB+ caught the most mature-sized *P. pelagicus* although, no clear patterns in the size selectivity among the bait treatments are seen. This result conforms to a study that using crab pots is biased in catching mature-sized female *P. pelagicus* than immature crabs (Smith et al. 2004). Biased for bigger sizes may be attributed to a more developed olfactory system in adult crustacean species than in immature ones (Schmidt 2007). In addition, adult swimming crabs have a greater ability to swim and resist strong waves (Chande and Mgaya 2003). This explains the higher number of larger crabs reaching the baited pots than smaller and immature crabs. Longer chelae also support them during competition against small crabs (Matheson and Gagnon 2004; Sneddon et al. 1997). Furthermore, bigger-sized crustaceans like shrimps scare away smaller conspecifics due to the competing potentials of larger conspecifics (Petetta et al 2021). Moreover, a clear result in the present study was seen on pots baited with fish alone (FB) which caught larger *T. sima* compared with pots baited with FB+ ($P < 0.05$).

Combining banana with fish as bait is gender-neutral for *P. pelagicus*. This result is different from the results of Kawamura et al. (1995), who observed that pots baited with a combination of sugarcane and fish were extremely biased for male of this species. In contrast, banana and fish combination bait revealed a biased for female of *T. sima.* This result is similar to the effect of the sugarcane and fish bait combination on *Charybdis japonica* (Milne-Edwards 1861) in the study of Kawamura et al. (1995). Therefore, using banana combined with fish can be useful for sex-selective trapping for *T. sima*, which is important in fisheries management.

Furthermore, the relationship between crab maturity stages on bait attraction can also be one of the focus of future studies because crab maturity plays a big role in the effective management of marine crab capture fisheries.

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REFERENCES

Anraku K, Vazquez Archdale M, Mendez BC and Espinosa RA. 2001. Crab trap fisheries: capture and an attempt on bait improvement. UPV Journal of Natural Science, 6: 121-129.

Cabacaba NS and Salamida JE. 2015. Seed production of the blue swimming crab (Portunus pelagicus). In: Romana-Eguia MRR, Parado-Estepa FD, Salayo ND and Lebata-Ramos MJH (eds). Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia: Challenges in Responsible Production of Aquatic Species: Proceedings of the International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia 2014 (RESA). Tigbauan, Iloilo, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center. pp. 313.

Chande AI and Mgaya YD. 2003. The fishery of *Portunus pelagicus* and species diversity of portunid crabs along the coast of Dar es Salaam, Tanzania. Western Indian Ocean Journal of Marine Science, 2(1): 75-84. http://dx.doi.org/10.4314/wiojms.v2i1.28431

Garcia E and Lajolo FM. 1988. Starch transformation during banana ripening: the amylase and glucosidase behavior. Journal of Food Science, 53: 1181-1188. https://doi.org/10.1111/j.1365-2621.1988.tb13557.x

de la Cruz MT, de la Cruz JO, Ruizo EKC and Tan IL. 2018. The blue swimming crab fishers and fishing practices in Leyte and Samar, Philippines. The Philippine Journal of Fisheries, 25(2): 1-15. https://doi.org/10.31398/tpjf/25.2.2018-0001

Glamuzina L, Conides A, Mancinelli G and Glamuzina B. 2021. A comparison of traditional and locally novel fishing gear for the exploitation of the invasive Atlantic Blue Crab in the Eastern Adriatic Sea. Journal of Marine Science and Engineering, 9(9): 1019. https://doi.org/10.3390/jmse9091019

Hanamseth R, Johnson DD, Schilling HT, Suthers IM and Taylor MD. 2022. Evaluation of a novel research trap for surveys of blue swimmer crab populations. Marine and Freshwater Research, 73(6): 812-822. https://doi.org/10.1071/MF21005

Hartman HB and Hartman MS. 1977. The stimulation of filter feeding in the porcelain crab *Petrolisthes cinctipes* Randal by amino acids and sugars. Comparative Biochemical Physiology Part A: Physiology, 56(1): 19-22. https://doi.org/10.1016/0300-9629(77)90435-2

Hollander M and Wolfe DA. 1999. Non statistical methods. 2nd Edition. John Wiley and Sons, Inc. 806pp.

Kawamura G, Matsuoka T, Tajiri T, Nishida M and Hayashi M. 1995. Effectiveness of a sugarcane-fish combination as bait in trapping swimming crabs. Fisheries Research, 22(1-2): 155-160. https://doi.org/10.1016/0165-7836(94)00314-M

Matheson K and Gagnon P. 2004. Effects of temperature, body size, and chela loss on competition for a limited food resource between indigenous rock crab (*Cancer irroratus* Say) and recently introduced green crab (*Carcinus maenas* L.). Journal of Experimental Marine Biology and Ecology, 428: 49-56. https://doi.org/10.1016/j.jembe.2012.06.003

Permatahati YI, Bugis NN, Sara L and Hasuba TF. 2020. Stock status of Blue Swimming Crab (*Portunus pelagicus* Linnaeus, 1758) in Tiworo Strait Waters, Southeast Sulawesi, Indonesia. ILMU KELAUTAN: Indonesian Journal of Marine Sciences, 25(2): 85-90. https://doi.org/10.1016/j.jembe.2012.06.003

Petetta A, Virgili M, Guicciardi S and Lucchetti A. 2021. Pots as alternative and sustainable fishing gears in the Mediterranean Sea: an overview. Reviews in Fish Biology and Fisheries, 31(2021): 773-795. https://doi.org/10.1007/s11160-021-09676-6

Sear MA, Rittschof D and O'Brien T. 1991. Eyestalk factor modulation of chemically stimulated feeding in sand fiddler crabs *Uca pugilator* (Bosc 1802). Journal of Experimental Marine Biology and Ecology, 152(1): 1-13. https://doi.org/10.1016/0022-0981(91)90131-F

Schmidt M. 2007. The olfactory pathway of decapod crustaceans – an invertebrate model for life-long neurogenesis. Chemical Senses, 32(4): 365-384. https://doi.org/10.1093/chemse/bjm008

Smith KD, Hall NG, de Lestang S and Potter IC. 2004. Potential bias in estimates of the size of maturity of crabs derived from trap samples. ICES Journal of Marine Science, 61(6): 906-912. https://doi.org/10.1016/j.icesjms.2004.07.019

Sneddon LU, Huntingford FA and Taylor AC. 1997. Weapon size versus body size as a predictor of winning fights between shore crabs, *Carcinus maenas* (L). Behavioral Ecology and Sociobiology, 41(4): 237-242.

Tanner JE. 2007. The influence of introduced European green crabs (*Carcinus maenas*) on habitat selection by juvenile native blue crabs (*Portunus pelagicus*). Estuaries and Coast, 30(4): 601-606.

Tapre AR and Jain RK. 2012. Study of advanced maturity stages of banana. International Journal of Advanced Engineering Research and Studies, 1(3): 272-274.

Trott TJ and Robertson JR. 1984. Chemical stimulants of cheliped flexion behavior by the western Atlantic ghost crab *Ocypode quadrata* (Fabricius). Journal of Experimental Marine Biology and Ecology, 78(3): 237-252. https://doi.org/10.1016/0022-0981(84)90161-8

Vazquez Archdale M and Anraku K. 2005. Feeding behavior in scyphozoa, crustacea and cephalopoda. Chemical Senses, 30 (suppl_1): i303-i304. https://doi.org/10.1093/chemse/bjh235

Vazquez Archdale M, Aňasco CP, Kawamura Y and Tamaki S. 2007. Effect of two collapsible pot designs on escape rate and behavior of the invasive swimming crabs *Charybdis japonica* and *Portunus pelagicus*. Fisheries Research, 85(1-2): 202-209. https://doi.org/10.1016/j.fishres.2007.02.008

Vazquez Archdale M, Kariyazono L and Aňasco CP. 2006. The effect of two pot types on entrance rate and entrance behaviour of the invasive Japanese swimming crab *Charybdis japonica*. Fisheries Research, 77: 271-274. https://doi.org/10.1016 /j.fishres.2005.11.012

Vazquez Archdale M and Kuwahara O. 2005. Comparative fishing trials for *Charybdis japonica* using collapsible box-shaped and dome-shaped pots. Fisheries Science, 71: 1227-1233. https://doi.org/10.1111/j.1444-2906.2005.01087.x

Vazquez Archdale M and Nakamura K. 1992. Responses to the swimming crab *Portunus pelagicus* to amino acids and mono- and disaccharides. Nippon Suisan Gakkaishi, 58(1): 165. http://dx.doi.org/10.2331/suisan.58.165

Winger PD and Walsh PJ. 2007. The feasibility of escape mechanisms in conical snow crab traps. ICES Journal of Marine Science, 64(8): 1587–1591. https://doi.org/10.1093/icesjms/fsm125

Yamane T and Fujiishi A. 1992. Catch performance of small prawn pots in terms of selectivity and escape. Fisheries Research, 15(3): 291-299. https://doi.org/10.1016/0165-7836(92)90020-T

Zhang J, Pei Z, He P and Shi J. 2021. Effect of escape vents on retention and size selectivity of crab pots for swimming crab *Portunus trituberculatus* in the East China Sea. Aquaculture and Fisheries 6: 340-347. https://doi.org/10.1016/j.aaf.2020.04.008

Zhou S and Kruse GH. 2000. Capture efficiency and size selectivity of two types of pots for red king crabs in the Bering Sea. Alaska Fisheries Bulletin, 6(2): 94-103.

Zimmer-Faust RK, Tyre JE, Michel WC and Case JF. 1984. Chemical mediation of appetitive feeding in a marine decapod crustacean: the importance of suppression and synergism. The Biological Bulletin, 167(2): 339-353. https://doi.org/10.2307/1541281

ROLE OF AUTHORS: *ACM – data collection and sampling procedures, gear designs, experimental designs, data analysis and manuscript writing; HMM – formulation of methods for field samplings and data analysis; advising, verification of results and interpretation, and editing and drafting of the manuscript; RPB – overall sampling and experimental designs, monitoring and sampling, fund support and does the critical revision of the manuscript.*

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   Ardines RB, Mecha NJMF and Dolorosa RG. 2020. Commonly gleaned macro-benthic invertebrates in a small offshore island of Cawili, Cagayancillo, Palawan, Philippines, The Palawan Scientist, 12: 102-125.
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   Guion SL. 2006. Captive breeding performance of *Crocodylus porosus* (Schneider 1901) breeders at the Palawan Wildlife Rescue and Conservation Center. BS in Fisheries. Western Philippines University-Puerto Princesa Campus, Palawan, Philippines. 28pp. (include weblink, if there's any, followed by accessed date).
   Lerom RR. 2008. Biosystematics study of Palawan landraces of rice (*Oryza sativa* L.). Doctor of Philosophy, Institute of Biological Sciences, University of the Philippines-Los Baños College, Laguna, Philippines. 197pp. (include weblink, if there's any, followed by accessed date).
m. Citing a Report
   Picardal RM and Dolorosa RG. 2014. Gastropods and bivalves of Tubbataha Reefs Natural Park, Cagayancillo, Palawan, Philippines. Tubbataha Management Office and Western Philippines University. 25pp. (include weblink, if there's any, followed by accessed date).
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   Alcantara LB and Noro T. In press. Growth of the abalone *Haliotis diversicolor* (Reeve) fed with macroalgae in floating net cage and plastic tank. Aquaculture Research.
o. Citing an article from an online newspaper.
   Fabro KA. 2021. Surge in seizures of giant clam shells has Philippine conservationists wary. Mongabay. https://news.mongabay.com/2021/03/surge-in-seizures-of-giant-clam-shells-has-philippine-conservationists-wary/. Accessed on 07 March 2022.

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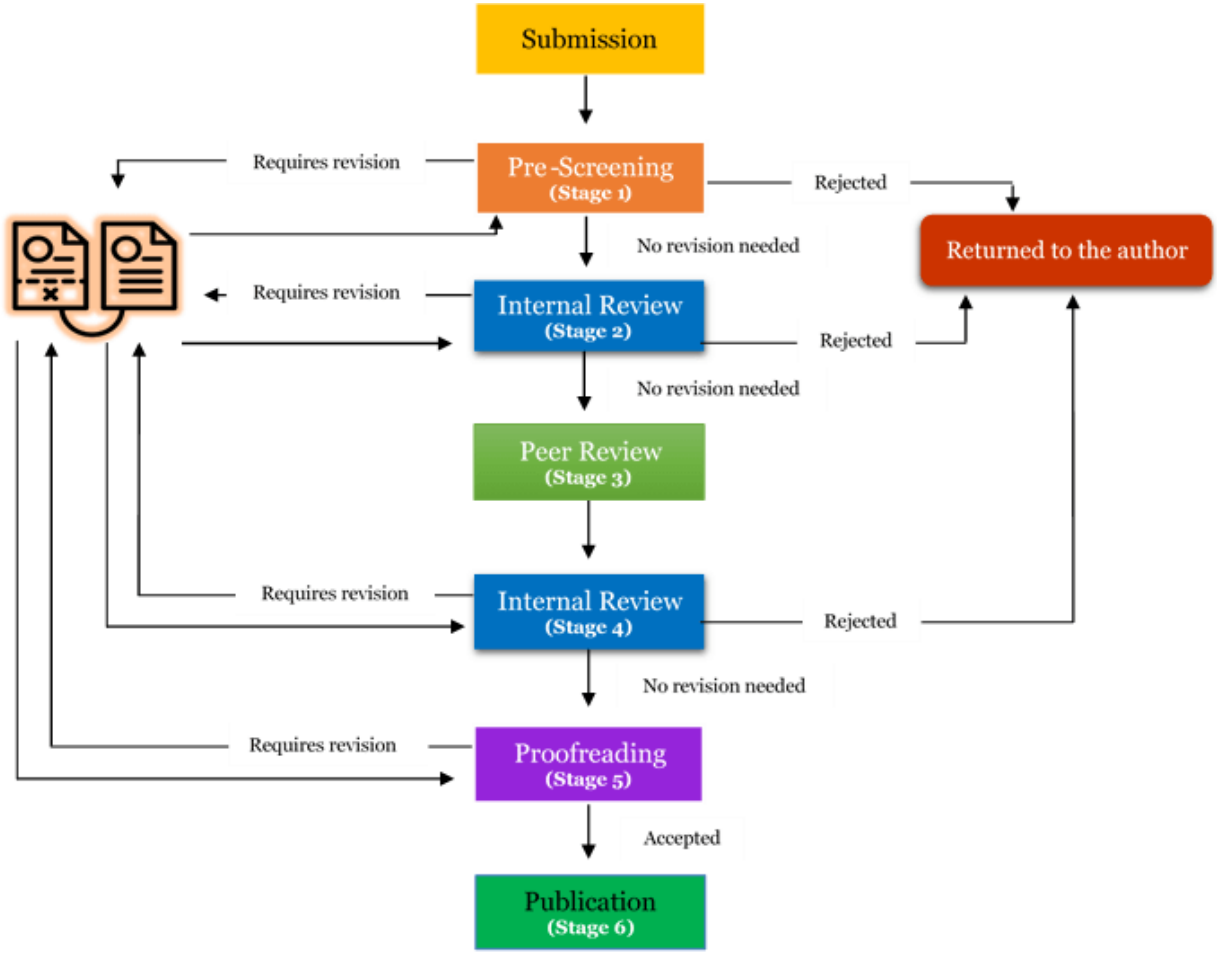

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