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Local Ecological Knowledge and Conservation Attitudes of Fishers Regarding Shrimps and Crabs in Panguil Bay, Northwestern Mindanao, Philippines

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Panguil Bay, known for its rich crab and shrimp populations, faces a pressing challenge from unsustainable fishing practices that threaten these essential resources. To aid in their management, an assessment employing a 26-item questionnaire was used to explore the local ecological knowledge (LEK) and conservation attitudes of 181 fishers from five coastal communities along the bay. In general, the findings corroborated the perspectives of fishers with the established literature. However, some disagreements, particularly in relation to shrimp reproduction, were observed. Approximately 80% of fishers reported no strict regulations against capturing berried females or undersized crustaceans in the bay. Fishers displayed openness to sharing knowledge with researchers, evident in the positive conservation attitude index average of 0.80 ± 0.041 Standard Error of the Mean. Utilizing LEK surveys emerged as a practical strategy, tapping into the experiential knowledge of locals for profound insights into Panguil Bay's crab and shrimp fisheries. These outcomes underscore the vital need for nurturing dialogues and information dissemination among stakeholders—fishers, scientists, and managers—to formulate effective management strategies.

Keywords; Local ecological knowledge (LEK), conservation, Panguil Bay, crabs, shrimps, juveniles

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Introduction

Panguil Bay is recognized as an important fishing ground for commercially important crab and shrimp species (Gonzaga, 2020). However, the cumulative impact of unsustainable fishing practices and threats has inflicted a toll on these valuable resources, leading to a significant decline in their harvest over the years (Jimenez et al., 2009; Castrence-Gonzales et al., 2018). Overexploitation of these resources can be attributed to several factors, including the persistent use of highly efficient fishing gear and the harvesting of juvenile crabs for rearing and fattening projects (Jimenez et al., 2009). A report by Tumanda (2004) further highlighted that a considerable portion of the captured crabs and shrimps in the area were small or juveniles, indicating a worrisome case of growth overfishing, where fishing mainly targets young populations. An additional unsustainable fishing practice in Panguil Bay involves the capture of egg-bearing (berried) females using gill nets and crab pots, exacerbating the issue of recruitment overfishing (Ingles, 2004). Despite regulations prohibiting certain gear types, such as “sudsod” or scissor nets under FAO No. 170-s. 1990, and “sanggab” or filter nets in Panguil Bay (Christy, 1993), the continued utilization of these gears persists, as indicated by recent research conducted by Jumawan et al. (2020). Moreover, certain fishers persist in evading regulations by modifying gear that might not strictly fall under the banned filter net category, yet operates in the same manner (Christy, 1993). Further decline of the bay’s production results from the practice of dynamite fishing, conversion of mangrove areas (which are nursery ground of crabs, shrimps, and other organisms) to fishponds, and draining of polluted waters (from fishponds surrounding the bay) to the estuaries (Dunaway and Macabuac, 2022; Tabugo and Claver, 2022). These trends emphasize the pressing necessity for the implementation of sustainable management and conservation measures to preserve the delicate equilibrium of marine ecosystems in Panguil Bay.

One valuable tool that can be incorporated in the management and conservation strategies is the use of local ecological knowledge (LEK) to assess potential biodiversity loss and damage related to populations of species that are somewhat threatened (Olsson & Folke, 2001; Begossi, 2008). LEK encompasses the knowledge held by a specific group of individuals concerning their local ecosystems, emphasizing the interplay among and between organisms and their environment, and often incorporating elements of belief (Olsson &

Folke, 2001). LEK refers to a form of experiential knowledge concerning the natural environment that is acquired through regular interactions with it (Murray et al., 2006). LEK is primarily transmitted orally, evolves gradually, shows great adaptability, and is typically specific to a particular geographic area. It relies on the insights passed down through mentoring, storytelling, and collaborative endeavors of both past and present generations (Hamilton et al., 2011).

LEK holds key importance in fisheries management, encompassing resource utilization, marine space allocation, fisher behavior, and knowledge of fishers on the biology and ecology of species (Begossi, 2008). LEK enhances understanding about environmental data and encourages active involvement of local communities in resource management by providing invaluable insights for effectively managing coastal fishery resources (Berkström et al., 2019). According to Mellado et al. (2014), studying the LEK provided a clear representation of the factors essential for crafting a management plan. Some studies have reported that the use of LEK in management yielded more favorable outcomes compared to centralized, top-down management (Begossi, 2008). The advantages of having ecological information across various spatial scales for fisheries management were similarly demonstrated in previous studies (Nenadovic et al., 2012; Shepard et al., 2007). In the southern Philippines, specifically in General Santos City, South Cotabato and Mati City, Davao Oriental, the utilization of LEK has proven instrumental in crafting policy recommendations and management plans aimed at regulating fish aggregating devices (Macusi et al., 2017). Additionally, in Balete Bay, Davao Oriental, fishers’ knowledge combined with actual catch monitoring for three months were also conducted to gather information on the catch, composition, fishing practices as well as issues and challenges encountered in wild lobster (*Panulirus* sp.) fry fishery (Macusi et al., 2019).

While significant interest exists in integrating local and scientific knowledge to achieve effective management objectives, there remains a gap when it comes to assessing the essential role that local knowledge play in the management of resources. In this context, this study aims to evaluate fishers’ understanding on the ecology of crab and shrimp juveniles in Panguil Bay. This was achieved by conducting a LEK survey using a 26-item questionnaire, primarily focusing on the participants’ profiles, fisherfolk’s local ecological knowledge, and their conservation attitudes.

Methodology

Study Area

The research was carried among fishers in five coastal communities along Panguil Bay, namely: Municipalities of Kolambugan, Tubod and Lala in Lanao del Norte, and Bonifacio and Tangub City in Misamis Occidental (Figure 1).

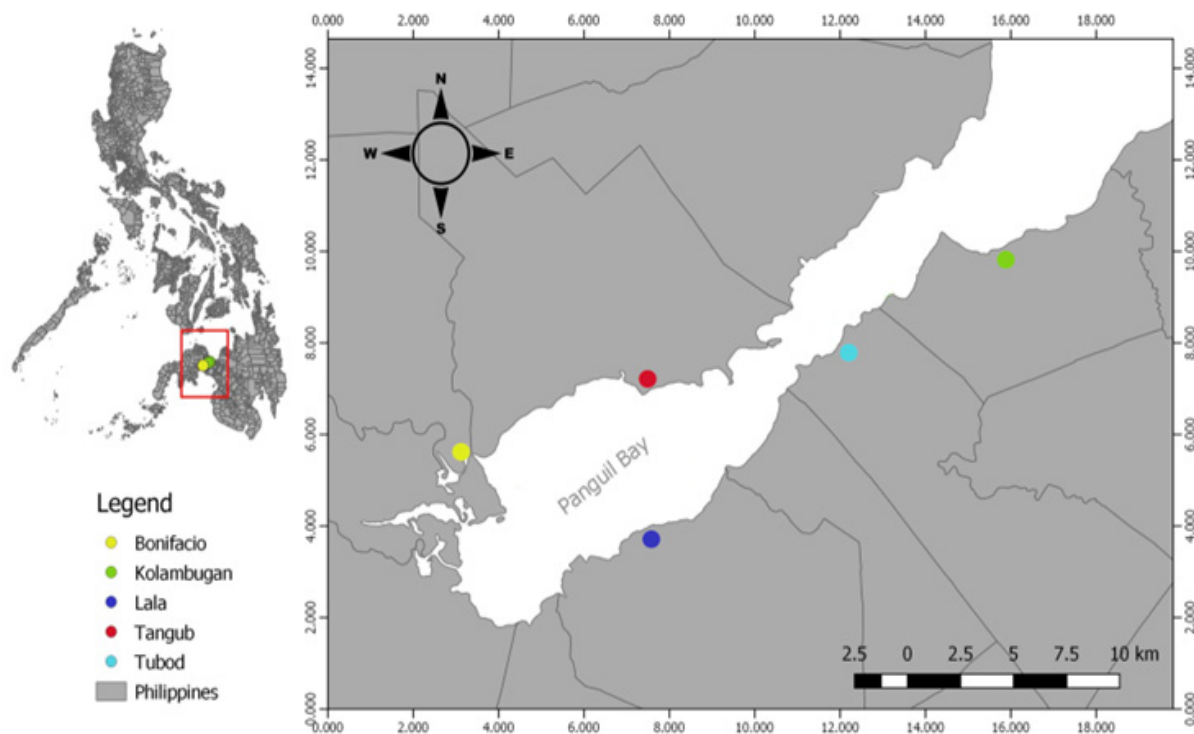


Figure 1. Five coastal areas around Panguil Bay where the interviews were conducted. Map was created using QGIS 3.10.

Research Ethics

This study involving humans was reviewed and approved by the Research Integrity and Research Office of Mindanao State University-Iligan Institute of Technology. Letters of consent were sent to the local offices of the Municipalities of Kolambugan, Tubod and Lala in Lanao del Norte, and Bonifacio and Tangub City in Misamis Occidental before the surveys were conducted. Upon approval from the local agencies, face-to-face interviews were done through door-to-door visits or in shared social spaces in the village, such as a covered court or near barangay halls. The participants' responses were anonymized and they were assured that raw data would be kept confidential.

Data collection

A total of 181 interviews using semi-structured questionnaires with open-ended (free-form survey questions) and closed-ended questions (those that can be answered by selecting from a number of options) were conducted between February and

March 2023 to gather information on fishers' LEK and attitudes toward conservation (Albuquerque et al., 2014) of shrimp and crab juveniles, with the questionnaire design referencing the work of Musiello-Fernandes et al. (2021).

The interview sessions were organized using a questionnaire written in the fishers' local language comprising of three main sections: Fishers' Profile, Fishers' Local Ecological Knowledge (LEK), and Fishers' Conservation Attitudes. The Fishers' Profile section collected information on the fishers' gender, age, education, and years in shrimp and crab fishing. The LEK section focused on the interviewees' knowledge of shrimp and crab resources in Panguil Bay, including local names, habitat, distribution, longevity, growth, food preferences, development, and reproduction. The Fishers' Conservation Attitudes section aimed to understand participants' views on shrimp and crab conservation, categorizing their attitudes as positive, neutral, or negative toward responsible management and preservation of these resources.

Data analysis

All interviews were transcribed verbatim into a spreadsheet and analyzed by qualitative content analysis (Hsieh and Shannon, 2005). In the case of the fishers' attitudes towards the conservation and management of crab and shrimp resources in Panguil Bay, quantitative comparisons were made by converting the data into a 3-point Likert scale for the attitudes: positive attitudes = 1; moderate attitudes = 0.5; and negative attitudes = 0 (Musiello-Fernandes et al., 2021). Additionally, conservationist attitudes were classified into three categories based on Braga & Schiavetti (2013): negative (0 to 0.33), moderate (0.34 to 0.66), and positive (0.67 to 1.0). To investigate whether the level of education of respondents affects their conservationist attitude, the following classification was used, modified from Braga et al., 2018: Low (no formal education to elementary level), Basic (elementary graduate to high school level), and Intermediate (high school

graduate to college graduate). Normality tests, One-Way Analysis of Variance (ANOVA) with post hoc analysis were performed in GraphPad Prism 9.5.0. for MacOS, GraphPad Software, San Diego, California USA. Graphs were constructed using Number v13.1 (Apple Inc).

The mean conservationist attitude indices were also classified based on educational levels as described in Braga et al., (2018).

Results

Profile of fishers

A total of 181 fishers from five coastal communities in Panguil Bay were interviewed: Kolambugan (n=36), Tubod (n=36), Lala (n=47), Bonifacio (n=31), and Tangub City (n=31) (Table 1), with 154 (85%) males and 27 (15%) females.

Table 1. Fishers' profile in five coastal areas in Panguil Bay in Lanao del Norte and Misamis Occidental. The average values are expressed as mean + standard error of the mean (SEM).

	Kolambugan	Lala	Tubod	Bonifacio	Tangub
No. of Participants	n=36	n=47	n=36	n=31	n=31
Age					
Average	48±1.87	43±1.52	54±1.7	48± 2.176	45±2.17
Min	22	28	31	15	24
Max	70	68	76	70	63
Sex					
Male	34	34	31	28	27
Female	2	13	5	3	4
Educational Level					
No formal education	2	0	0	0	0
Elementary Level	14	16	15	18	12
Elementary Graduate	1	13	5	3	1
High School Level	10	10	6	3	12
High School Graduate	7	5	6	4	2
College Level	2	3	4	3	2
College Graduate	0	0	0	0	2
Years of fishing experience					
Average	25±2.12	26±1.33	31±2.16	26±2.60	23±2.38
Min	5	4	5	3	2
Max	50	50	50	60	47
Intentionally catching shrimp/crabs					
Yes	22	47	24	26	21
No	14	0	12	5	10

The age of the fishers ranged between 15 to 76 years, with an average age of 47 years (Figure 2). In terms of educational level, two individuals (1%) had no formal education, 75 individuals (41%) did not finish elementary school, 23 individuals (13%) completed elementary education, 41 individuals (23%) did not complete high school, 24 individuals (13%) graduated high school, 14 individuals (8%) attended college without graduating, and two individuals (1%) graduated from college.

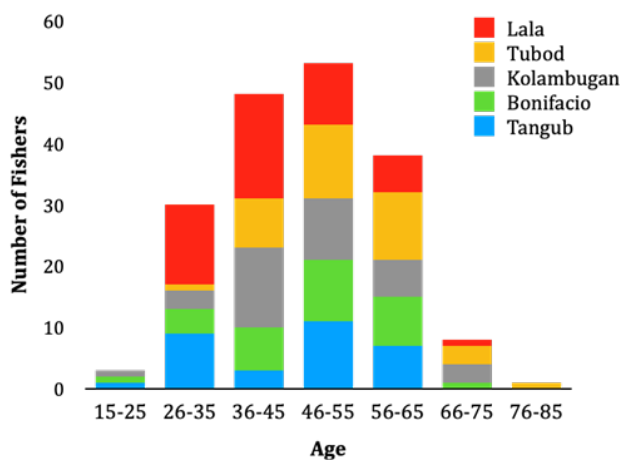


Figure 2. The age ranges of fishers interviewed across different areas in Panguil Bay.

The years of fishing experience varied considerably from two to 60 years, with an average of 26 years (Figure 3). Among the interviewed fishers, most of them (77%) intentionally catch crabs and shrimps, while some mentioned obtaining these resources incidentally when they get entangled in their nets as bycatch (e.g., “bunsod”, “pukot”).

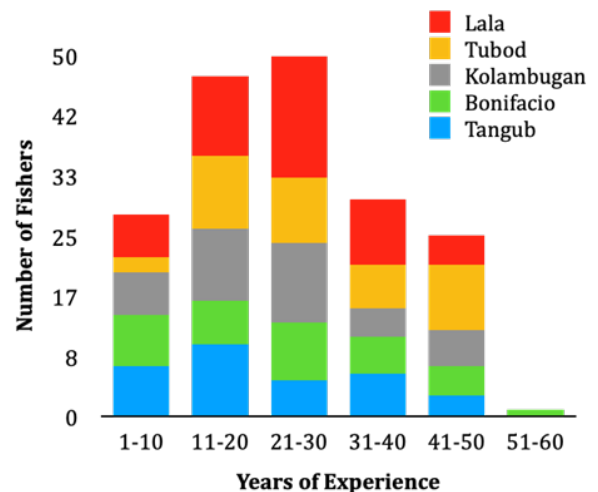


Figure 3. The years of fishing experience reported by fishers interviewed across different areas in Panguil Bay.

Fishers' LEK about shrimp and crab juveniles in Panguil Bay

Local names of shrimp and crab juveniles

The fishers mentioned different local terms they use to refer to the juveniles of crab and shrimp in Panguil Bay. In the case of crab juveniles, fishers call them “maniit”, “laras”, “ismol”, “alimango”, “kasag”, “bayot”, and “semilya”. The terms “maniit” and “alimango” were mentioned by fishers in all five coastal municipalities in this study. Among these terms, only the “kasag” and “alimango” pertain to specific crabs whereas the other terms are used to categorize the size classes of crabs sold in the market. The terms “B1/B2/B3/BG/L3/L4/L5” were commonly encountered in Lala, Lanao del Norte, referring to specific sizes of fish sold in the area.

In the case of shrimp juveniles, fishers use the terms “SB”, “ulang”, “bagal”, “uyap”, “uyabang”, “pansat”, “pasayan” and “lunhan”. The term “SB” was mentioned in all five coastal areas, while the term “bagal” was mentioned in four coastal areas, excluding Bonifacio. Among the terms used by the fishers, the “SB” refers to a category used for medium-sized shrimp sold in the market (Table 2).

Table 2. Comparative insights on the LEK of fishers and the scientific literature regarding the local names, habitat and migration, predator and food sources of crab and crustacean juveniles.

Items	Information provided by fishers	Information provided by the scientific literature
Local name	Crab: "maniit", "laras", "ismol", "alimango", "kasag", "bayot" and "semilya"	Crab: <i>Scylla</i> sp. ("alimango"), <i>Thallamita crenata</i> ("kasag") (Jimenez et al., 2009); <i>Portunus pelagicus</i> ("kasag") (Clemente et al., 2018)
	Shrimp: "SB", "ulang", "bagal", "uyap", "uyabang", "pansat", "pasayan"	Shrimp: <i>Acetes</i> sp. ("uyap/uyabang"), <i>Metapenaeus merguensis</i> ("lunhan"), <i>Metapenaeus ensis</i> ("bagal/bagalan"), <i>Penaeus monodon</i> ("pansat"), <i>Penaeus indicus</i> ("pasayan"), <i>Macrobrachium</i> sp. ("ulang") (Jimenez et al., 2009; Tumanda, 2004)
Habitat and migration	"The natural habitat of crab and shrimp juveniles are mangrove areas, seagrass beds or rivers."	Juvenile crabs are mainly found in the intertidal mangrove zone (Rouf et al., 2021). Nursery grounds for juvenile penaeid shrimps are characterized by the presence of vegetation such as mangrove areas and seagrass beds (Rönnbäck et al., 2002). "Ulang" can be found in rivers and tributaries (Benzon and Francisco, 1993).
	"Juvenile crustaceans are mostly found in shallow waters."	Juvenile crabs (mud crabs) were captured in shallow waters among macrophytes (Alberts-Hubatsch et al., 2016). Penaeid shrimps inhabit in shallow waters (Malauene et al., 2021).
	"Crab and shrimp juveniles migrate in groups or populations."	Juvenile crabs exhibit massive migrations during the wet season (Shelley and Lovatelli, 2011). Shrimp migrate in large numbers (Staples and Vance, 1986).
	"The development from the egg to adult is slow."	Penaeid shrimps have a lifespan of about 1–2 years (Gowri and Nammalwar, 2015).
Predator	"Crabs and shrimp juveniles are eaten by bigger fish."	The fish's stomach contents primarily consisted of shrimp, plant debris, fish, crab, and detritus (Paglinawan et al., 2022).
	"Some shrimp and crab juveniles eat their own kind (cannibals)."	Cannibalism is common among juvenile decapod crustaceans, especially during molting (Romano and Zeng, 2017).
Food sources	"Crab and shrimp juveniles eat algae/moss, small fishes, and small invertebrates."	Juvenile mud crabs eat plant, algae and seagrasses, fish meat, mollusk, wood, and other crustaceans (Shelley and Lovatelli, 2011). Juvenile penaeids mainly feed on algal material (El Hag, 1984).

Predators of shrimp and crab juveniles

The primary predators of shrimp and crab juveniles were various fish species including "pugapo/lapu-lapu" (grouper), "ugdok" (swamp eel), "butete" (pufferfish), "bangus" (milkfish), "buga-ong" (tiger perch), "aso-os" (silver silago), "tambangongo" (catfish), "bidbid" (tenpounder), "pagi" (ray), "ibis" (glassfish), "ubod" (conger eel), "bunog" (goby) and "balo" (needlefish). In addition to fish, fishers also identified birds as predators as well as humans, sea snake, pig, duck grouped together as "others" (Figure 4a). Some even noted instances of cannibalism among these crustaceans, where they consume their own kind (Figure 4b).

Food sources of shrimp and crab juveniles

Out of the surveyed fishers, 67 individuals (37%) reported that juvenile crabs and shrimps consume small fish, while 53 fishers (29%) indicated that these young crustaceans feed on "lumot" or moss. Apart from these findings, certain participants also noted that these juveniles consume shells, specifically "agihis" (wedge clam) or "suso" (snail).

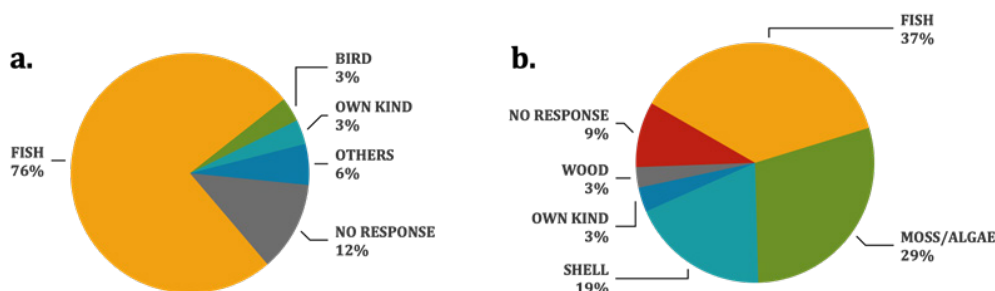


Figure 4. Fishers' responses concerning the (a) predators and (b) food sources of shrimp and crab juveniles within Panguil Bay, based on their observations.

Fishers' LEK on reproduction and longevity of crabs and shrimps in Panguil Bay

In interviews with the fishers, 171 individuals (94%) reported encountering crabs and/or shrimps carrying eggs, either through capture or observation while the remaining 6% of the fishers did not provide a response on this matter (Figure 5a). Among the fishers who captured crabs with eggs (berried crabs), they consistently expressed a practice of releasing them back into the sea. In the case of shrimps, some fishers expressed that it is harder to distinguish berried shrimps compared to crabs.

Approximately 41% of participants observed slow development of crustaceans from egg to adult, while 38% perceived it as fast; around 14% abstained from offering a response, and the remaining 6% mentioned that the development depended on

various factors (Figure 5b). Regarding the lifespan of crabs and shrimps, approximately 36% of fishers refrained from responding or expressed uncertainty. Among those specifying durations, 30% noted a range of 1 to 3 months, while 14% reported lifespans of 4 to 6 months, and 10% reported 7 to 12 months, with the remaining 9% of the respondents said it was 'slow' (Figure 5c). Responses to inquiries about the reproduction periods of crabs and shrimps exhibited significant variability due to the diverse array of crab and shrimp species present in Panguil Bay. Notably, certain participants provided distinct months as reproductive periods for the following species: "alimango" – September, November to January; "pansat" – May; and, "ulang" – September. This This information underscores the importance of considering seasonality in the reproduction cycles of these species.

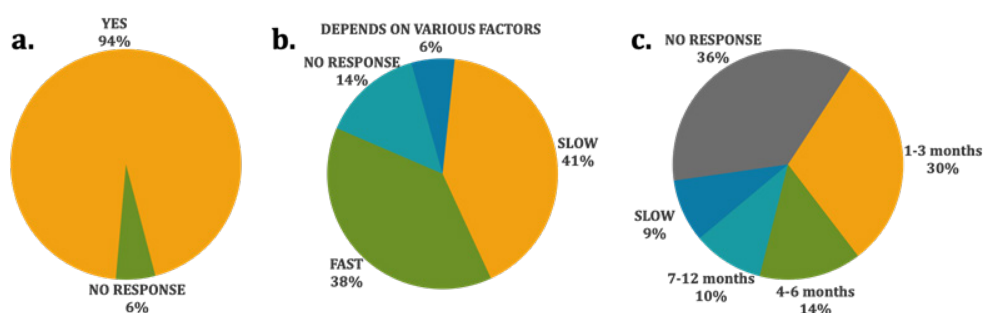


Figure 5. Fishers' responses on (a) observing crabs and shrimps carrying eggs upon capture; (b) the developmental duration from egg to adult in crustaceans; and (c) their lifespan.

Fishers' attitudes towards conservation

Applying the category classification established by Braga & Schiavetti (2013), the mean conservationist attitude (\pm SEM) indices among the fishers are as follows: 0.74 ± 0.051 for Tangub, 0.61 ± 0.050 for Bonifacio, 0.94 ± 0.027 for Kolambugan, 0.85 ± 0.044 for Tubod and 0.87 ± 0.033 for Lala. For the five areas in Panguil Bay combined, the mean conservationist

attitude (\pm SEM) indices among the fishers is 0.80 ± 0.041 . Notably, of these areas, only the mean conservationist attitude of fishers in Bonifacio falls within the moderate category, while the remaining four areas are classified within the positive category (Figure 6). The mean conservationist attitude index in Bonifacio is statistically different compared to that in Lala, Tubod and Kolambugan.

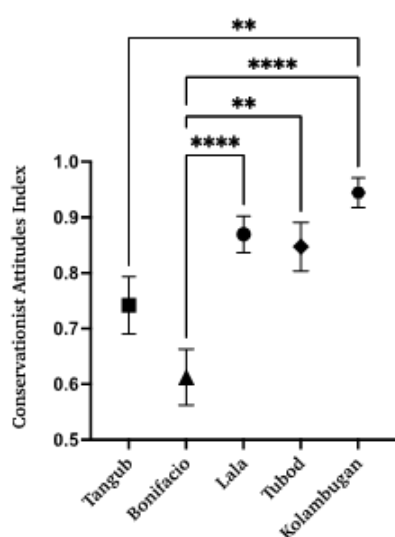


Figure 6. The conservationist attitudes index of fishers from Lanao del Norte: Kolambugan (n= 36), Tubod (n=36) and Lala (n= 47) and Misamis Oriental: Bonifacio (n= 31) and Tangub City (n=31). The values shown are the means standard error of the mean (SEM). Values with asterisks indicate statistical significance (** $P < 0.01$, **** $P < 0.00001$).

The mean conservationist attitude indices were also classified based on educational levels as described in Braga et al., (2018). While no statistically significant differences were found among these groups, a noticeable upward trend in values is evident (0.78 for Low, 0.83 for Basic, and 0.86 for Intermediate) as the level of education increases (Figure 7a). Notably, no participant under the Intermediate category showed a negative attitude (with mean conservationist attitude ranging from 0 to 0.33) (Figure 7b).

All fishers of the surveyed population demonstrate a clear understanding of the critical significance of maintaining a clean marine environment. This awareness stems from the acknowledgment that a pristine environment directly correlates with the quality and safety of the resources harvested from the sea. By ensuring a clean environment, fishers not only prioritize the well-being of the marine ecosystem but also guarantee that the resources (i.e., crabs and shrimps in this study) remain uncontaminated and safe for consumption.

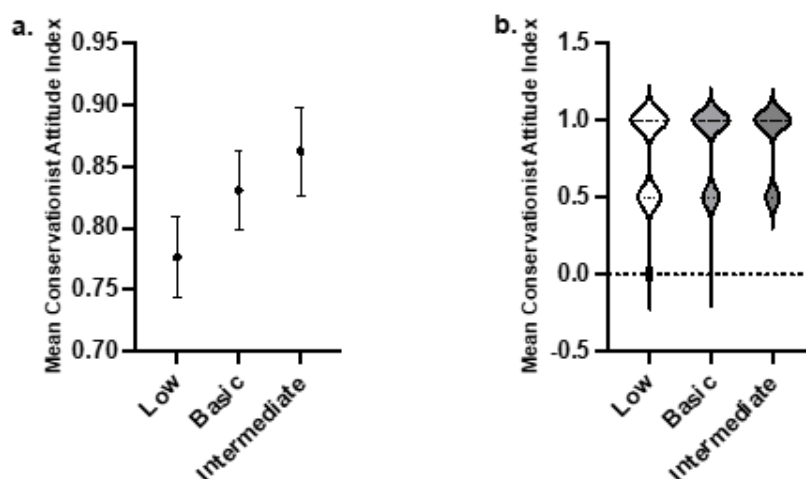


Figure 7. The (a) mean (with SEM) conservationist attitude index of fishers based on levels of education and (b) violin plot to visualize the distribution of numerical data.

Regarding fishers' opinions on implementing fishing bans during specific periods, like spawning seasons, 71% expressed agreement, 21% disagreed, and the remaining 8% either chose not to respond or expressed uncertainty. The negative attitudes of certain fishers towards conservation may be attributed to the absence of alternative employment opportunities during fishing ban periods. As a result, the implementation of fishing bans could potentially leave them without the means to secure food for themselves and their families. Some fishers emphasized that the varying spawning seasons among different types of crabs and shrimps

warrant specific species-focused implementation if a fishing ban is considered. Nevertheless, there is a consensus among these fishers that if they encounter berried shrimps or crabs, they will adhere to the practice of releasing them back into the sea.

Regarding intentional catch of crab and shrimp juveniles in Panguil Bay, 71% responded "No," 28% answered "Yes," and the remaining 2% did not provide a response (Figure 8a). Fishers were also asked regarding the existence of a closed season or a fishing ban for crustaceans in their respective areas (Figure 8b). On average, 80% indicated the

absence of existing ordinances banning the capture of crustaceans, while 19% reported the presence of a fishing ban, and the remaining 1% did not respond. However, these regulations occurred in the past, and some respondents noted that fishing bans in their area only apply to fish, excluding other aquatic organisms. Among the respondents, 79% said that their community respected fishing bans, 14% indicated “No,” and the remaining 7% reported occasional compliance. While there are no explicit fishing bans for crustaceans, certain fishers emphasized that representatives from the fisheries sector had previously educated them

about the importance of avoiding the capture of berried crabs and shrimps. Generally, they abide by this guideline, but in situations where food scarcity arises, they find themselves compelled to consume them. When asked about the gear employed for capturing small-sized crabs and shrimps, it's worth noting that “sudsod” (mesh #20-26) was mentioned in four areas, except for Kolambugan. In addition to “sudsod”, most fishers indicated that they capture small-sized crabs and shrimps using methods such as “pukot”, “bintol”, “laya”, and “bunsod” with varying mesh size numbers.

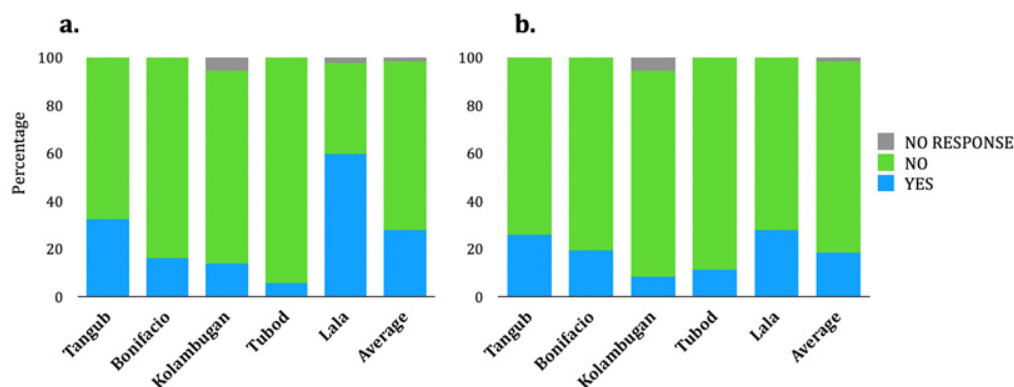


Figure 8. Fishers' responses regarding (a) intentional catching of crab and shrimp juveniles and (b) the existence of a closed season for crustaceans in their area.

Discussion

Profile of fishers

Majority of the fishers in Panguil Bay are middle-aged (Figure 2). This results closely resemble that of the fisherfolks in the coastal municipalities of Zambales with around 76% of the respondents are from the ages 31 to 60 (Paz-Alberto et al., 2020). From a young age, the locals of Panguil Bay participate in fishing to financially support their families or secure food. Women interviewed in this study actively engage in fishing with their husbands, and some also work in fishponds—a common practice in Panguil Bay (Dunaway and Macabuac, 2022). The longest recorded experience in our surveys was 60 years, with most participants having around 21-30 years of experience (Table 1, Figure 3). According to Anadón et al. (2009), the individuals' level of experience with the environment is likely to impact the quality and depth of their knowledge.

Fishers' LEK about shrimp and crab juveniles in Panguil Bay

The fishers provided several names they use to refer to the juveniles of crab and shrimps in Panguil

Bay. Even for young crabs, some fishers still call them “alimango”, which is a local name of crabs belonging to *Scylla* sp. (Tumanda, 2004). Three mud crab species dominate the landed catch (i.e. that which is brought ashore) of crustaceans in Panguil Bay (Jumawan et al., 2020): the giant mud crab (*Scylla serrata*), purple mud crab (*S. tranquebarica*), and orange mud crab (*S. olivacea*). Another local name, “kasag”, was mentioned by some fishers and according to published papers, “kasag” pertains to the crab species *Thallamita crenata* which was also reported in Panguil Bay (Jimenez et al., 2009). The blue swimming crab, *Portunus pelagicus*, is also called “kasag” by some authors (Clemente et al., 2018; Ingles, 2004). The other terms the fishers use for young crabs are “maniit”, “laras”, “ismol”, “semilya” and “bayot”. According to Poonon and Soliven (2022), immature crabs or “bayot” are lean crabs purchased for crab fattening. The other terms (“maniit”, “laras”, “ismol”, “semilya”) on the other hand, pertain to size of crabs in the market.

Regarding shrimps, fishers mentioned various names such as “SB”, “ulang”, “bagal”, “uyap”, “uyabang”, “pansat”, “pasayan”, and “lunhan”. Notably, “SB” is a term used for a shrimp size category

in the market. Even at small sizes, fishers were still able to identify shrimps belonging to certain taxonomic groups, including *Acetes* sp. ("uyap/uyabang"), *Metapenaeus merguensis* ("lunhan"), *Metapenaeus ensis* ("bagal/bagalan"), *Penaeus monodon* ("pansat"), *Penaeus indicus* ("pasayan"), and *Macrobrachium* sp. ("ulang"), all documented in previous reports to inhabit Panguil Bay (Tumanda, 2004; Jimenez et al., 2009).

Fishers answered that juvenile crustaceans inhabit mangrove areas, seagrass beds, and shallow coastal waters. This LEK agrees with the scientific literature, wherein crabs and shrimps are reported to inhabit these habitats (Rouf et al., 2021; Rönnbäck et al., 2002) to provide them with suitable shelter, protection, and access to food, contributing to their growth and development (Arceo-Carranza et al., 2021). Furthermore, fishers reported that juvenile crabs and shrimps are commonly found in shallow waters (Alberts-Hubatsch et al., 2016; Malauene et al., 2021). When it comes to migration, majority of the fishers mentioned that crabs and shrimps migrate in large numbers. This observation has been documented in juvenile crabs, particularly their movement towards brackish water habitats. These migrations often lead them to gather in substantial numbers around river mouths and along the shoreline. At times, these swarms of young crabs are even left stranded on the mud during ebb tides (Shelley and Lovatelli, 2011). On the other hand, it has also been reported that small shrimps migrate at large numbers during the wet season, as in the case of *M. merguensis* (Staples and Vance, 1986).

According to fishers in Panguil Bay, crabs and shrimp juveniles are eaten by bigger fish and sometimes, they eat their own kind. A study conducted by Romano and Zeng (2017) mentioned that juvenile decapod crustaceans often engage in cannibalism, particularly during molting. Additionally, certain fish species such as Striped snakehead *Channa striata* have been documented to consume shrimp, plant debris, fish, crab, and detritus (Paglinawan et al., 2022). In the research by Mwijage et al. (2018), juvenile shrimps were identified as a significant dietary component for the longnose trevally

Carangoides chrysophrys and the Malabar grouper *Epinephelus malabaricus*.

Local fishers in Panguil Bay also reported that juvenile crabs and shrimps predominantly feed on algae, small fishes, and invertebrates. These findings align with the findings of Shelley and Lovatelli (2011), who highlighted that the diet of juvenile mud crabs encompasses plants, algae, seagrasses, fish meat, mollusks, wood, and other crustaceans. Additionally, research by Viswanathan and Raffi (2015) indicated that the stomach contents of juveniles and sub-adult mudcrabs are largely composed of crustaceans and fishes. In contrast, juvenile penaeid shrimps are known to primarily feed on algal material (El Hag, 1984).

Fishers' LEK on reproduction and longevity of crabs and shrimps in Panguil Bay

A significant portion of the fishers acknowledged their ability to identify berried crabs and shrimps in Panguil Bay. Most respondents noted frequent sightings of berried crabs compared to berried shrimps. Female crabs are more obvious since these animals bear eggs on their abdominal pleopods (Rasheed and Mustaqim, 2010). Although there are no stringent regulations against capturing berried crabs in Panguil Bay, a practice has emerged where fishers routinely release these crabs back into the sea. Some participants emphasized that they have received guidance from fisheries experts on the importance of abstaining from capturing berried crabs to support their reproduction and population growth. However, in situations where catches are exceedingly limited, they find themselves compelled to consume these berried crabs.

Fishers' attitudes towards conservation

Participants from Bonifacio demonstrated a moderate mean conservationist attitude index, whereas participants from the four other localities expressed overall positive attitudes towards conservation. This finding aligns with earlier studies (Musiello-Fernandes et al., 2021; Braga et al., 2018; Braga and Schiavetti), which also observed moderate conservation attitudes in certain communities. One influential factor

linked to environmental awareness is education, often serving as a key explanatory variable for both causality and pro-environmental behavior (Zsóka et al., 2013). Although no statistically significant differences in mean conservationist attitude indices were identified among the groups based on education levels in this study ($p > 0.05$), it is noteworthy that the Intermediate group exhibited the highest mean index value (Figure 7a). This outcome aligns with findings from Braga et al. (2018), where the most advanced schooling class also showed the highest values in the attitude index. Based on these findings, there appears to be a trend indicating that fishers with higher levels of education tend to have more positive conservationist attitudes. Nevertheless, it is crucial to emphasize the significance of implementing environmental education programs in Panguil Bay, particularly in Bonifacio, to enhance fishers' perspectives on the conservation of crabs and shrimps. As highlighted by Daoutopoulos and Pyrovetsi (1990), environmental education initiatives have the potential to positively influence attitudes toward the conservation of fishery resources. Fishers who possess a deeper understanding of the marine environment are more inclined to comply with fisheries legislation and understand the critical role the environment plays in sustaining fishery resources (Braga et al., 2018).

Section 98 of The Philippines Fisheries Code of 1998 (RA 8550) prohibits the capture of breeding fish species except for research purposes. Nevertheless, the same code grants local government units the authority to independently manage their coastal resources (Article I, Section 16 of RA8550). In the Philippines, certain regions have already enacted prohibitions on catching berried crabs and crablets. For instance, Bacolod City Ordinance No. 901 entitled "An ordinance regulating the catching, selling or buying of berried blue crabs and crablets in the city of Bacolod and providing penalties for violations thereof" was approved in 2019. Similarly, in Iloilo, Provincial Ordinance No. 2012-093 entitled "Prohibition on the catching of berried and undersized crabs" has also been implemented (Province of Iloilo, 2012).

In Panguil Bay, a wide implementation of fishing ban was introduced in 2016, as in the entire Province of Misamis Occidental. This measure aimed to curtail the unregulated capture of marine resources, with a particular focus on conserving the mud crab species *S. serrata* (Rivera et al., 2017). However, in the current study, when fishers were asked about the existence of a fishing ban for crustaceans in

Panguil Bay, majority (80%) responded "None," indicating that if any restrictions are in place, their effective enforcement is limited. The literature lacks information on explicit regulations in Panguil Bay prohibiting the capture of berried and undersized crustaceans, unlike the regulations in Bacolod City and Iloilo provinces for crabs. Interestingly, the previously prohibited fishing gear known as "sudsod," is still employed by a minority of fishers across four areas within this study. In Tangub Cuty, "sudsod" is utilized for capturing small crabs and shrimps. Moreover, certain fishing gears like "pukot", and occasionally "laya", "bintol", and "bunsod" – which was not prohibited in the region were also cited by several fishers as effective tools for capturing small-sized crabs and shrimps. In the Western Visayan Sea, the bottomset gillnet (locally known as "pukot", "palugdang" or "palubog") has also been reported to catch premature sizes of crabs by 57% (Mesa et al., 2018).

In addition to the limitations on capturing berried and undersized crustaceans, measures have also been taken to regulate the harvest of fishery resources during their spawning seasons. Notably, closed fishing seasons have been implemented in regions such as the Zamboanga Peninsula (Rola et al., 2018) and the Visayan Sea (Napata et al., 2020) with the aim of enhancing the productivity during spawning periods and countering the diminishing sardine yields. While closed seasons for crustaceans are yet to be implemented in the Philippines, noteworthy recommendations have emerged from several studies. For instance, Nieves et al. (2015) put forth a proposal for a closed season for Christmas crabs (*Charybdis feriatus*) in San Miguel Bay, while Mesa et al. (2018) advocate for a closed season for the blue swimming crab (*Portunus pelagicus*) in the Western Visayan Sea. Similarly, Jumawan et al. (2020) emphasized the importance of reducing mud crab harvesting from July to October, providing an opportunity for crabs to spawn in Panguil Bay. In the event of fishing bans introduced in the bay, majority (71%) of the fishers in this study expressed their support. However, they also harbor concerns that alternative livelihood opportunities should be provided during this period.

Conclusion

The utilization of LEK surveys proves valuable in gathering insights into the crab and shrimp fisheries of Panguil Bay, leveraging the experiential and accumulated knowledge of local communities. The incorporation of LEK and insights into

conservationist attitudes from this study holds significant implications for policy formulation and enforcement. This locally grounded knowledge augments scientific data, providing a comprehensive perspective that enriches decision-making, facilitates the identification of conservation strategies, and nurtures collaboration between local stakeholders and researchers. The research underscores the urgency of implementing efficient management measures to safeguard the bay's crab and shrimp resources, necessitating an exchange of knowledge among stakeholders, including fishers, scientists, and managers responsible for devising these measures.

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