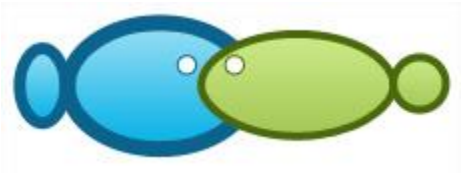

Macroinvertebrate gleaning in coastal ecosystems: utilization, pressures, and implications for conservation

[1,2]Kristian Q. Aldea

[1] Office of the Assistant Vice President for Research, Extension and Production Affairs, Catanduanes State University, Virac, Catanduanes, Philippines; [2] Natural Science Department, College of Science, Catanduanes State University, Virac, Catanduanes, Philippines. Corresponding author: K. Q. Aldea, k_aldea@catsu.edu.ph

Abstract. Coastal ecosystems are valuable for communities that are directly associated with their resources. In the Philippines, coastal resource utilization during low tide is usually practiced through gleaning, where people search for edible species, usually macroinvertebrates. To elucidate information on the gleaners' socio-economics, gleaning practices, and associated pressures on coastal ecosystems, this study was conducted using a descriptive design. Results suggest that gleaning provides additional food and income. The presence of invertebrate preference between gender as well as catch rates that are not discriminative at different ages suggests the availability of productive gleaning options between gender and age groups. All coastal ecosystems are utilized as gleaning sites, although there is a significant difference between seagrass and mangroves in the total catch rate. With traditional tools, this suggests that gleaning methods may have a minimal impact on the invertebrate population, at least considering the gleaning frequency rates in this study. Some pressures were, nonetheless, identified that deal with coral reef utilization (if activities extend to reefs), demands, coastal regulations, and social media. This study recommends coastal programs on livelihood development (including the culture of invertebrate species), the establishment of marine protected areas, policy regulations, and community information that may address responsible utilization of social media.
Key Words: intertidal habitats, marine dependence, resource sustainability.

Introduction. Coastal ecosystems are widely known for providing ecological and economic services to human societies. The natural resources present in them support the community by supplying food and other cultural requirements (Barbier 2007, 2017; Barbier et al 2008, 2011; Neumann et al 2015, 2017; Vierros 2017; Himes-Cornell et al 2018; Mehvar et al 2018; Blythe et al 2020; Carrasco de la Cruz 2021). Due to the biophysical features of the habitats, they also serve as communities' buffers against storms and other phenomena such as floods, wave actions, and rising sea levels (Costanza et al 2008; Arkema et al 2013; Duarte et al 2013; Barbier 2015; Spalding et al 2014; Chung et al 2015; Guannel et al 2016; Vuik et al 2016; Primavera et al 2019; Carlson et al 2021; Cunha et al 2021; Fernandez-Diaz et al 2022). Drawing from these given services, the importance of coastal ecosystems is largely reflected in species consumption and other forms of biodiversity utilization (Nagelkelkern et al 2000; Halpern and Warner 2002; Halpern et al 2009; Honda et al 2013; Madarcos et al 2021; Sagoe et al 2021; Gnansounou et al 2022).

Areas near the coasts attract more people due to the advantages derived from the ocean and all the interfaced regions between land and sea (Neumann et al 2015). The trend becomes complex when eventually, the flourishing communities utilize the place's natural resources. Utilization of coastal services is more intense among developing countries (Visbeck et al 2014; Neumann et al 2017), hence the pressure on their habitats to sustain resource production and minimize the impacts of demographic change. In the Philippines, utilization pressures in coastal ecosystems and their fisheries have been recorded since the 1980s (Gomez et al 1981, 1994), although the practice is probably much earlier. The initiatives of some organizations that started applying the approach of

coastal management programs in the mid-1970s (Alcala 1998) supported the idea of preserving the coastal resources due to current or predicted anthropogenic pressures at that time.

Macroinvertebrate gleaning (as gleaning hereafter) exists in the coastal areas of the Philippines. It has become the primary utilization type in the intertidal zones during low tide. However, compared to mainstream fishing, information is limited, with some data just known relatively recently (Del Norte-Campos et al 2005; Campos et al 2005; Vinson & Gamboa 2005; Nieves et al 2010; De Guzman et al 2019). This is also true at a global level, with data on macroinvertebrates (as invertebrates hereafter) being less known compared to fish catch (Andrew et al 2002; Anderson et al 2011). Furthermore, most gleaning information in the country is focused on coral reefs or their immediate adjacent areas, probably because coastal pressures and degradation on coral reefs were earlier recognized (Gomez et al 1981, 1994).

Gleaning on intertidal zones is conducted by gleaners for edible species during low tide. On Catanduanes Island, several coastal ecosystems serve as gleaning sites (Aldea et al 2014, 2015; Aldea 2022), where catches are usually invertebrates. The activity has been providing food for the coastal communities on the island, especially for economically challenged families (Aldea et al 2015; Aldea 2022). These trends reflect economic importance, although the continued collection in some areas may generate pressures on invertebrates and their habitats. Thus, a study on the socio-economics and activities of gleaners is necessary.

Previous studies on invertebrate gleaning have shown information on species compositions, yet comparative analyses on socio-demographic profiles are less known. Likewise, information on utilization between sites is not yet clear. In this study, I included descriptive and inferential analyses to elucidate the gleaning activities and the associated pressures of gleaning communities on coastal ecosystems.

Material and Method

Description of the study site. Catanduanes Island (Figure 1) is located on the eastern seaboard of the Philippines at 13.50 to 14.10 North Latitude and from 124.00 to 124.50 East Longitude (DENR-Catanduanes 2009). It has an area of 1511.5 km^2 (PSA 2020), with a population of 271279 in the 2020 census (PSA 2021). The island has many small bays and islets on its coastlines. Several ecosystems that serve as gleaning destinations are located on its coasts (Aldea et al 2015; Aldea 2022). The study areas were several villages (barangays) in Catanduanes Island adjacent to gleaning sites: Biong and District III in Gigmoto, Balite and Magnesia Del Sur in Virac, and Santa Ana in Panganiban. In 2021, the total population of these villages was 4334, with the highest population in Biong (1055) and the lowest population in Santa Ana (412) (NNC-Phil 2021). The households in these villages totalled 903 in 2015, with the highest number also in Biong (186) and the lowest number in Santa Ana (82) (PSA 2020). Based on preliminary data, the active gleaners comprise 1-10% of the population of coastal villages aged ten years and above. Gleaning is not necessarily inclusive to territorial jurisdictions of gleaners' villages, as the practice may overlap with other sites depending on gleaning preferences.

The gleaning sites have a distance that usually ranges from 20 m to 1000 m but may sometimes extend to 2000 m from the gleaners' households. The study referred to the following gleaning sites: seagrass, mangrove swamps, unvegetated tidal flats (hereafter tidal flats), coral reefs (crests), and combinations (two or more of the sites). Each gleaning site is continuous, where gleaners can reach all parts of the site by walking during low tide. Patches of natural small "blank" spaces, such as creeks in the mangroves and pools in the tidal flats, seagrass, and coral reefs, are nevertheless present. The mangrove creeks measured ≤5 m distance on opposite banks, pools in the tidal flats measured ≤3 m^2, while tidal pools in seagrass and coral reefs measured ≤1 m^2. Except in some natural pools, most substrates (including coral reef surfaces) are above sea level during low tide (spring tide) or at least submerged in water by ≤30 cm only. In most cases, gleaners can directly transfer to several sites. Some sites, however, are naturally

separated from each other (5-100 m) by rocks, sandy beaches, or shallow subtidal places that gleaners may pass through if they transfer to these zones.

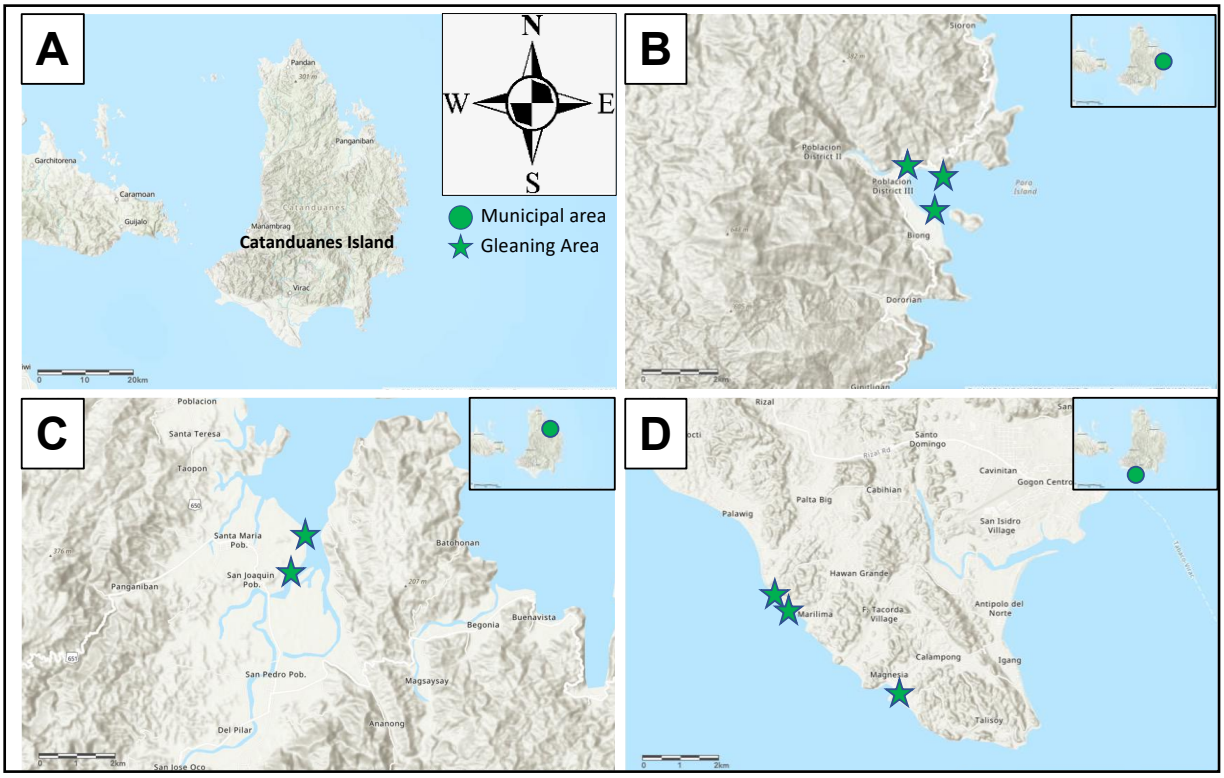

Figure 1. Map of Catanduanes Island, Philippines (1A); specific sites per municipality are presented in 1B (Gigmoto), 1C (Panganiban) and 1D (Virac) (Map generated with ArcGIS, 2023).

Research design, sampling, and interviews. This study utilized a Descriptive Design and conducted multi-stage sampling to represent the groups by gleaning site destinations, gender, and age (adults and children). Identification of the number of respondents and other subgroupings used the preliminary data of the total identified population of gleaners in stratified random sampling, with probability proportional to size. Due to some reasons, however, some individuals were not able to participate. Respondents were identified with the help of key informants (village chieftains or seniors) and during field visits to gleaning sites.

Most gleaners live on a narrow strip of land in each village, primarily on the "gleaning zone" or the beach zone starting just after the spring high tide mark (splash zone) up to 100 m inward to communities. The sampling was conducted mainly on the gleaning zone and included individuals with active gleaning experience. Active gleaning means multiple gleaning trips in a month or at least one gleaning trip in the last three months.

The interviews were conducted in January-February 2022, May-July 2022, and October 2022. The information on socio-economic profiles, gleaning practices, invertebrate catch, and associated pressures related to gleaning was solicited during the interviews using an interview-questionnaire tool. Interviews were personal (including ambush interviews) and Focused-Group Discussions (FGD). When some respondents requested free conversation, interviewing had flexible discussions (guided by questionnaires). There was supervision from parents or guardians during the interviews with children. Questionnaires were subjected to the Reliability Test using Test-Retest during survey preliminaries ($R^2 \geq 0.9$).

The following were the major taxonomic groups of invertebrates referred to in this study: gastropods, crustaceans, bivalves, and cephalopods. Fish are incidentally or

sometimes intentionally caught by gleaners, but this aspect is beyond the scope of the study.

Statistical analyses. The study used the following inferential statistics: Pearson chi-square (test of probability and association), Wilcoxon each pair test, T-test, ANOVA-Tukey's HSD test, and linear regression. The descriptive statistics (e.g., means) and data distributions were calculated before or simultaneously with the inferential statistics. All data were analyzed using the SAS-JMP statistical software (11.2.0, Serial No. NHRJ4HJJJZ).

Results

Utilization

Demographic profiles and socioeconomics. 152 gleaners participated in the study. They were composed of 93 (61%) adult females (as women hereafter), 38 (25%) adult males (as men hereafter), and 21 (14%) children (regardless of gender) (Figure 2). Gleaning is significantly practiced by women (Pearson chi-square, X^2=23.09; $p<0.01$). Most men primarily glean at night (Pearson chi-square, X^2=8.53; $p<0.01$), in contrast to most women and children that prefer to glean during the day (Pearson chi-square, X^2=77.69 [women], X^2=17.19 [children]; both $p<0.01$). The age range was 18-72 in women, 23-62 in men, and 9-17 in children. The average age was significantly different between groups, with the highest average for women at 51.4 years old (men, 43.1; children, 12.57; ANOVA-Tukey's HSD test, $p<0.01$). Most women were housewives (73%), while many men were fishers-farmers (47%) or just farmers (32%). There is a negative correlation between gleaners' primary work income (non-gleaning) against their spouses' (linear regression; R^2=0.76). There was a significant difference (T-test, $p<0.01$) between the average incomes (non-gleaning) of men and women.

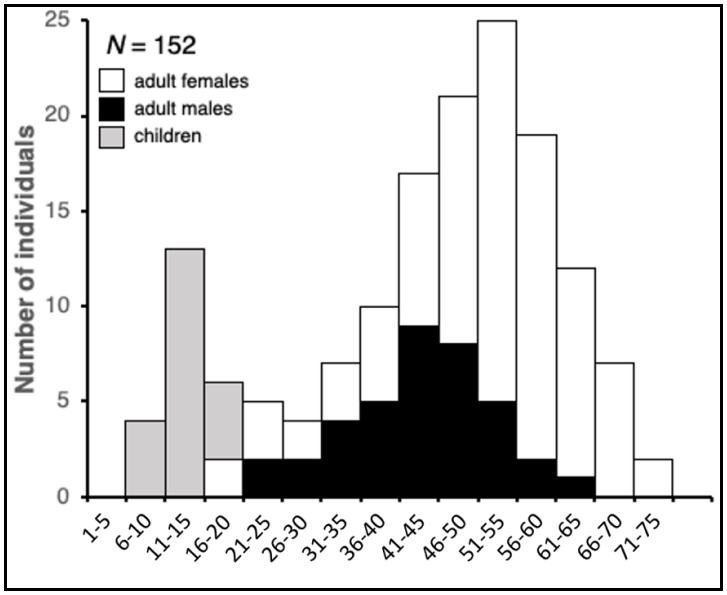

Figure 2. The age range of gleaners.

Gleaning provides a monthly income range of 1.86-76.26 USD with a monthly average of 21.07 USD. The average monthly gleaning income of exclusive intentional sellers was 64.23 USD. The daily catch average per gleaner was 4.28 kg, while the catch rate was 1.75 kg h^{-1}. Gleaning frequency ranged from 1 day in 3 months to 15 days per month (with a mean of 4.4 days per month). Gleaning income and catch are positively associated with the increase in gleaning frequency (linear regression, all groups, R^2>0.75, Figure 3A; linear regression, all groups, R^2>0.85, Figure 3B). The average

monthly incomes (non-gleaning) were 249.15 USD and 56.21 USD for men and women, respectively. Women with no sidelines (housewives) had higher gleaning incomes than women with other sidelines as storeowners and housekeepers (Wilcoxon each pair test, $p<0.01$). There was no significant difference among men's gleaning income (Wilcoxon each pair test, $p>0.05$). Children's gleaning income ranged between 1.86-55.80 USD, but most fall under 18.60 USD.

There is no relationship between age to gleaning income and catch (Figure 3C-D). There is a gender preference for invertebrate species. Men prefer cephalopods and crustaceans (ANOVA-Tukey's HSD test, $p<0.01$), while women and children prefer gastropods and bivalves (ANOVA-Tukey's HSD test, $p<0.01$).

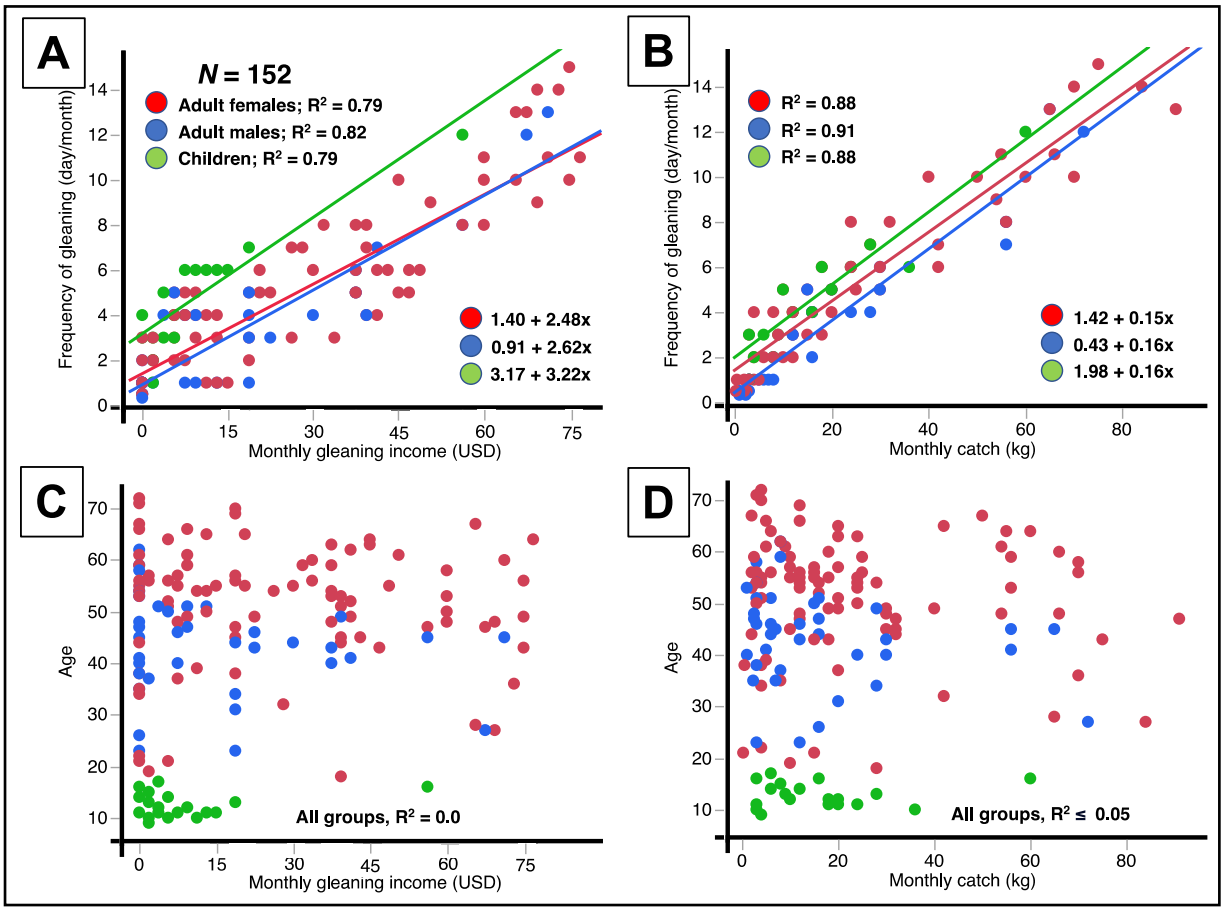

Figure 3. Gleaning income and catch in relation to gleaning frequency and gleaners' age (0 USD is represented by non-selling gleaners); strong positive relationships are shown in 3A and 3B, ≤ 0.05 relationship (R^2) in 3C and 3D.

Gleaning practices and invertebrate catch. There are four identified gleaning sites as exclusive gleaning destinations: seagrass (27%), mangroves (13%), tidal flats (10%), and coral reefs (7%). Several gleaners choose to glean in two or more of the sites (combinations, 43%).

All women and children use a traditional dull bolo (or an oldened metal used as a bolo) to facilitate the collection, although many species can also be hand-picked. Only some women use a sharpened or barbed rod, in contrast to all men that use it.

The invertebrates gleaned are gastropods (43%), crustaceans (25%), bivalves (20%), and cephalopods (12%) (Figures 4A-L, 5A). Among the exclusive gleaning sites, seagrass had the highest catch rate with 1.99 kg h^{-1}, followed by coral reefs (1.68 kg h^{-1}), tidal flats (1.65 kg h^{-1}), and mangroves (1.49 kg h^{-1}) (Figure 5B). Gleaning on mixed sites (combinations) had a catch rate of 1.71 kg h^{-1}. Only the catch rates between seagrass and mangroves had a significant difference (Wilcoxon each pair test; $p<0.05$).

Figure 4. Examples of invertebrates gleaned; gastropods (4A-D; 4A - usually caught in coral reefs; 4B-C - seagrass capture; 4D - mangroves capture), bivalves (4E-G; 4E-F - usually caught in muddy tidal flats; 4G - captured in stony tidal flats), crustaceans (4H), and cephalopods (4I); mixed invertebrates sold in the neighborhood (4J) and actual catch of a gleaner on site (4K); a gleaner showing his mostly bivalve catch (4L).

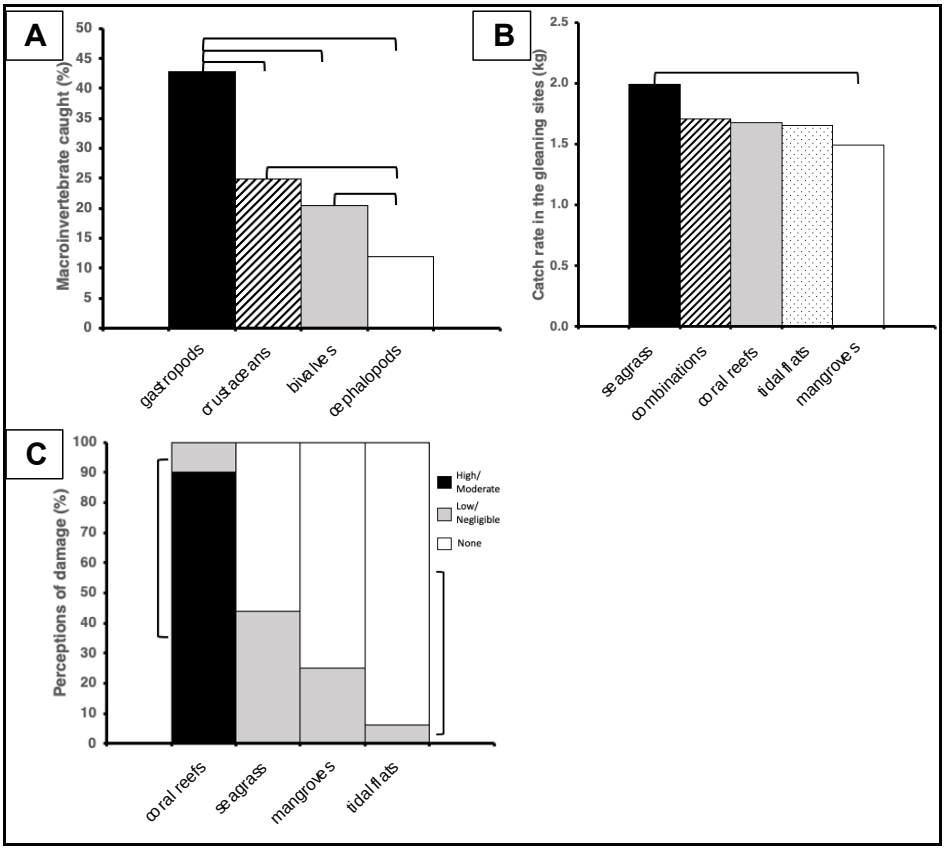

Figure 5. Gleaned invertebrates, catch rates, and perceptions of damage in coastal ecosystems. Gastropods are the most invertebrates caught (5A), while seagrass has the most catch rates among the coastal ecosystems (5B). Coral reefs are perceived to be negatively affected by gleaning activity (5C). Items with the bracket symbol show significant differences ($p<0.05$).

Pressures

Gleaning practices. On perceptions of physical damage to gleaning sites, exclusive gleaners (excluding mixed sites gleaners) generated responses of no or low damage in seagrass, tidal flats, and mangroves. However, they perceive that gleaning may cause moderate or high damage to coral reefs (Pearson chi-square: $X^2=6.4$; $p<0.05$) (Figure 5C). They observe that coral breakage happens when they step on the coral reef surfaces. The reef gleaners, nevertheless, perceive that the damage is usually unintentional. In connection, narrations on some dangers associated with gleaning on the coral reefs were told, such as wound injury and accidental falling on the reef crests.

Demand, local regulations, and social-media. Gleaners sell their catches with an estimated price increase of 30-60% from the last two years. Selling is usually carried out in the neighborhood or streets. Conches and octopuses had the most price increase at 50 to 60%, while common types (limpets, turbinid snails, and intertidal clams) had a price increase of 30-40%. When gleaners encounter rare invertebrates with high economic value, they also sell them with the highest range of price increase (50-60%). Prices vary greatly. Small or juveniles of common invertebrates (e.g., small gastropods) sell at 1.86-2.79 USD per kg, either sorted (one type) or assorted, while large sizes sell at 2.79-3.72 USD per kg. Highly economically important invertebrates sold at 3.72-7.44 USD per kg, generally sorted. The classification of size depends on the decision of the gleaners.

While there were establishments of MPA in some sites, gleaners perceive that limitations on several coastal regulations still exist. Gleaners thought establishing or managing MPAs is challenging considering community partnerships, funds, and local governance networks. The community is, nevertheless, willing to participate in conservation programs if initiated by local government units and academic institutions, especially considering the perceived positive impacts of the local conserved areas. They mentioned that interventions with the academia and non-government organizations (NGOs) are also necessary for sustaining active marine sanctuaries. Furthermore, 96% responded that social media influence invertebrate utilization, while 68% believe that the negative impacts of social media may already be observed in the gleaning activities on Catanduanes Island (Pearson chi-square: $X^2=19.2$; $p<0.01$). Most individual social media posts are perceived to be exploitative without or with less information on their ecological implications. A short, but intense gleaning (gleaning rush), especially in summer, is perceived in this trend. Nonetheless, 38% acknowledge that social media groups on the island possibly promote and engage with coastal conservation.

Discussion

Utilization

Demographic profiles and socioeconomics. Results suggest that gleaning is prevalent among women. Most women have no work or sideline (housewives). The income (non-gleaning) of men is primarily the source of income for the family, which can be reflected in the negative correlation between gleaners' income (non-gleaning) against their spouses'. While men's monthly average income (non-gleaning) is above the minimum wage (regional classification by DOLE 2022), it is still low compared with the salary grade system in the country (DBM 2022). Additionally, men spend most of their income on the regular maintenance and purchase of fishing and farming tools. Gleaning may provide additional income and food for their families to alleviate these financial constraints. These may have driven several women to glean.

Gleaning is done primarily for family consumption, but gleaners may also sell their catch unintentionally through neighborhood or street selling. They may only sell, however, if they believe they have collected more than enough for their families. Despite many gleaners selling their catch sparingly (many are gleaning several times per week), the gleaning income is still positively correlated to gleaning frequency. This case shows the potential economic benefits of gleaning. The monthly catch and the gleaning

frequency also had a similar positive relationship. As gleaning catch and gleaning frequency may not always have positive relationships (e.g., lower catches in other sites, despite more frequent gleaning), this case suggests productive gleaning activity, at least in the frequency rates provided here.

The higher gleaning income of women with no other sidelines (housewives) compared to that of women who were also storeowners and housekeepers suggests that women with no sidelines may use gleaning as an additional source of income due to the absence of a job. The insignificant difference in the gleaning income of men contrasts this. Financial support by men (most are fathers) prevails in the gleaning families. As a result, despite some gleaning income, men's gleaning activities are generally uniform and less intense than women's are. Most children are gleaning primarily for food, but may sell their catch if a buyer approaches. The low gleaning income of children may be associated with their general non-selling tendency. One child of the respondents, however, is known to intentionally glean and sell his catch at a relatively large scale.

Several coastal ecosystems in Catanduanes Island are gleaning sites, each perceived as a productive gleaning resource. Gleaners have unspoken rules (e.g., systematic dispersion) when many fellow gleaners are already gleaning on the site. The gleaning income and catch are not discriminative with age, which suggests the availability and richness of the ecosystems when it comes to providing economic significance for different age cohorts. In addition, many gleaners can generally choose the time and specific areas in the gleaning sites, which may satisfy physical limitations between age and gender.

Gleaning sites and gleaning practices. All gleaning sites are a valuable resource for invertebrate biodiversity on the island (Aldea et al 2014, 2015; Aldea 2022). These reflect on the various types of gleaned invertebrates such as gastropods, crustaceans, bivalves, and cephalopods. Due to the species richness of the sites, gleaners, especially men, may also catch fish. Many women and children may sometimes gather tidal valuables such as seagrass fruits and *Caulerpa* algae as additional resources.

Gleaning on seagrass recorded the highest catch rates among the ecosystems, with a significant difference against the catch rate in the mangroves. The difference in the catch rates between seagrass and mangroves may be associated with the mangroves' substrates (depth) and distance, as well as less preference during night gleaning. In connection, some responded that several highly economically important mollusks (e.g., conches, octopuses) are usually absent in the mangroves. Nevertheless, gleaners acknowledge that mangroves are still comparatively valuable and suggest that they can be utilized with other sites (mixed sites) during gleaning or can be a source of other important species (e.g., fish) when gleaning is not possible.

The use of a dull bolo (or oldened metal used as a bolo) by most women and children and a sharpened or barbed rod by most men indicates a species preference between gender and age. This suggests habitat richness where genders can prefer target species. Collection of bivalves and several gastropods is usually made by bolo. Highly motile invertebrates such as crustaceans and cephalopods (located in the vegetations, crevices, burrows, or tidal pools) are usually collected using a sharpened or barbed rod. In some instances, gleaners may bring small sweep nets for some crustaceans and incidentally catch fish. These practices show a generally sustainable method due to the use of traditional tools.

Pressures

Gleaning practices. The gleaning practices are generally acceptable concerning their impact on the gleaning sites. The perceptions of "no or low damage" in seagrass, tidal flats, and mangroves are probably in conjunction with the beliefs that the methods are simple and traditional, hence can be sustainable. The observations become different, however, when it comes to coral reef utilization. Corals are exposed during low tide (coral gleaning), thus prone to breakage when people frequent a coral area (Woodland & Hooper 1997; De Guzman et al 2016). Coral breakage is the most observed impact of

gleaning in coral reef sites, which respondents believe happens when they step on the top of the coral heads. Gleaners recognize that corals are primarily fragile substrates that easily break when they step on them. In some cases, gleaners may chase an invertebrate into the farther parts of reef crests, thus providing more opportunities to increase the damaged areas among the corals.

Demand, local regulations, and social-media. The rapidly increasing price of the gleaned species is another concern, especially for several economically important species such as conches, crabs, lobsters, and octopuses. The rise in the establishment of infrastructures and businesses (Aldea et al 2015; Aldea & Masagca 2016; Aldea 2022), and the growth of island tourism may also be related to the current high demand for aquatic products. This situation may intensify the gleaning frequencies, especially for the highly-priced invertebrates.

Local regulations and policies in coastal communities may play a vital role in invertebrate diversity, but respondents strongly confirm the need for socio-politics intervention. People believe in marine protected areas (MPAs), which may provide political control. However, very few coastal regulations related to MPA were established in the past (Aldea et al 2015; Aldea & Masagca 2016; Aldea 2022). Possibly, the most successful coastal ecosystem initiative on the island is the establishment of the Agojo Point Fish Sanctuary and Marine Reserve (APFSMS) (Aldea 2022). One of the purposes of the APFSMS is to provide ecosystem services for generations (Vargas & Asetre 2011), which needs support from the government, NGOs, and the public to continue its operation.

The role of social media (usually individual posts) has created exploiting effects on invertebrate utilization and may drive unregulated collection, as observed in a gleaning rush. Social media have been associated with some wildlife trade (King et al 2014; Sung et al 2021), although this scheme can be hard to determine on Catanduanes Island, at least for now. Gleaners observed that, aside from food consumption, social media-related exploitation (e.g., attempts to make pets) is mainly seasonal. Nonetheless, they believe there must be a responsible use of social media as tidal invertebrates are generally less motile and usually found in open spaces, thus, vulnerable to exploitation.

Implications for conservation. Gleaners are immediate resource users that may influence the conservation of intertidal habitats. They may serve as stewards of the tidal ecosystems for sustainable actions. While natural stewards and players may have productive activities over the coasts, they may also link to exploitation. The importance of identifying their status and concerns is therefore necessary.

The socioeconomics of gleaners and their associated pressures must be addressed, especially in growing communities and developing human systems. For instance, Clua et al (2005) have identified utilization and fishing pressures in a coral reef fishery, including sociocultural patterns, economic environment, politico-institutional patterns, and technology. The influence of human intervention in coastal management, such as the impact of population on fish stock depletion (in this case, invertebrates), can play a critical role in an island's demography (McManus et al 2000; Iversen et al 2020). With these connections, the following are the identified pressures associated with gleaning activities in Catanduanes Island: coral reef intrusion, rising demand, limited regulations and establishments of MPA, and social media (information technology) (Table 1).

Table 1

Pressures associated with gleaning activities on coastal ecosystem

Socioeconomic factors that contribute to the gleaning pressures	*Example*
Sociocultural patterns	Coral reef intrusion (part of marine dependency)
Economic environment	Rising demand
Politico-institutional	Limited regulations and establishments of MPA
Information technology (a new socioeconomic factor)	Social media

Cooperative management may alleviate the issues which had shown various benefits in coastal governance due to working relationships between players and stakeholders for joint management and decision-making (Jentoft 2005; Abernethy et al 2014; Lynch et al 2016; Maestro et al 2022). The pressures can be abated and guided by the human framework (exploitation and ecology) on studying the socio-economics and cultural dependence on marine ecosystems, the ecological and cultural importance of coastal areas, and the effectiveness of resource management (Caddy & Griffiths 1995; Furkon et al 2019). Cooperative management towards preserving vulnerable gleaning sites (coral reefs) and possibly enhancing MPA are opportunities for these ventures.

Some locals on the island serve as volunteers in monitoring coastal activities, guided by local regulations. The regulations in some areas are generally perceived to be acceptable by the locals. Under this scheme, gleaners are allowed to glean only on selected sites (not in regulated areas, locals call them sanctuary), which happens when there is a fish sanctuary in the village. Despite the general belief that gleaning has no or only minimal damaging effect (except on coral reefs), they are supportive of local governance through site-selective gleaning.

Gleaners indicate that livelihood programs should be strengthened in the area to lessen the impacts of gleaning reliance on marine ecosystems. Aquaculture development (e.g., crab nursery) may also be enhanced, as it is one of the fundamentals of global food sovereignty (Welcomme et al 2010; Pradeepkiran 2019). The availability of multi-species cultures may help lessen the pressure on rising demands. These developments may further link to eco-tourism, where tourists can actively participate in eco-recreational activities (e.g., a trip to a crab hatchery, gleaning in an aquaculture pond, etc.), thus contributing to the local economy (Tsafoutis & Metaxas 2021). Moreover, while social media are associated with some risks, their uses can increase pro-conservation behaviors, project funds, and incite policy changes (Bergman et al 2022), with collaborative efforts between conservation managers and the public. For instance, a local social media page has been active in promoting conservation-related activities for the island's biodiversity. Due to the capacity of social media to dispense information at a large scale, conservation partnerships with them may be productive if effectively used.

Conclusions. Gleaning can provide additional food and income for the family, especially when gleaners cannot go fishing or farming during harsh weather. Gleaning productivity is non-discriminative at different ages, which suggests economic benefits for all age groups. The preference for species and gleaning time between genders means resource productivity of the sites. These show that variations in ecosystem services are generally available for gleaning options.

The gleaning practices are generally acceptable (seagrass, mangroves, tidal flats), except when gleaners extend their grounds to coral reefs. While the gleaning sites have been providing economic benefits, at least coral reef intrusions may be regulated or restricted. Considering that differences in the catch rates of other ecosystems are not significant against the corals, this suggests that gleaners can still harvest productively

(relative to coral harvest) when coral areas become regulated. Nevertheless, there should be detailed discussions with the community regarding this concern.

Coastal programs on livelihood development (e.g., food processing), conservation, and breeding may help to alleviate the increasing demand for invertebrates. Reliance on the ecosystems may be lessened because of this, while at the same time, the gleaners may have a marketing opportunity. The local government may provide more fund assistance on the regulations or establishments of MPAs including initiation of programs with the academia and NGOs. The cooperative management of communities (e.g., roles in MPA, species monitoring, etc.) may also be extended, because most are willing to participate in community-based coastal conservation. The local government may conduct standardization and regulation of social media posts. Official local programs may be employed, such as eco-tourism pages that include impactful information on the importance of coastal biodiversity (including information on the regulations of threatened species), and if possible, coordinate with social media groups (including non-profit organizations) that are already engaged in information dissemination on coastal conservation.

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Conflict of Interest. The author declares that there is no conflict of interest.

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Authors:
Kristian Q. Aldea, Office of the Assistant Vice President for Research, Extension and Production Affairs, Catanduanes State University, Virac 4800, Catanduanes, Philippines, e-mail: k_aldea@catsu.edu.ph
Kristianaldeabiology@gmail.com
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