Citizen Science in the Philippines: Coastal biodiversity engagements on a small island

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Abstract

The community's extreme perception of volunteerism (97%) for conservation on a small island relates to the limited resources and coastline vulnerability. This probably results in various types of citizen scientists associated with different coastal biodiversity projects. To elucidate these aspects, I explored the public's perception of participation in biodiversity conservation, the citizen science groups and their engagements (including profile by gender, age, and frequency of activity), as well as the potential ecological drawback of the engagement (primarily involving Independent Citizen Scientists). Results suggest that the public has a high perception of willingness to participate in citizen science (with three Types of Citizen Scientists). Gender prevalence in the participation is evident (suggesting viable options of participation for both genders) while the age and frequency of activities suggest that younger and more active individuals are significantly present in one type (Independent Citizen Scientists). Data gathering and public services demonstrate the contribution of citizen science to productive coastal biodiversity engagements on the island, although a potentially misguided activity, is also identified. It is emphasized, however, that this does not discourage any type of citizen scientists. This study recommends policy formulation and extended interventions in the island's coastal biodiversity programs.

Keywords

Citizen science | small island | Catanduanes | coastal biodiversity engagements

1. Introduction

Citizen Science (hereafter CS) is a system where the public is generally involved in projects that are coordinated with science professionals or research organizations (Shirk & Bonney, 2015; Ballard et al., 2017; Burgess et al., 2017; Pettibone et al., 2017; Lee et al., 2020; Peter et al., 2021). It has been popular in environmental studies that describe

traditional experiences and indigenous knowledge (Danielsen et al., 2021; Peter et al., 2021) as well as investigations that acquire information from activities such as leisure and eco-tourism (Schaffer & Tham, 2019). As other research methods are hard to conduct in the wild, public support is necessary to obtain data, which could be, in some ways, difficult to accomplish (Theobald et al., 2015; Krick, 2021; Tengo et al., 2021; Fraisl et al., 2022; Aldea & Azanza, 2024).

The work of citizen scientists (hereafter CSs) is often by group actions and based on projects that address socioeconomics or environmental issues (Shirk & Bonney, 2015; Hecker et al., 2018). Nevertheless, their involvement in projects, either working alone or with groups, has also been reported without direct connections with academic or research entities (Liebenberg, 2013; Cigliano & Ballard, 2018), as Independent Citizen Scientists in the context of this study. Regardless of their numbers or connections, CSs gather data while simultaneously participating in conservation programs. With the sense of volunteerism, their contribution is well-recognized in the success of community-driven activities (Vohland & Gobel, 2017; Moczek et al., 2021).

The value of CS in the coastal areas radiates in formulating policies (Bonney et al., 2016; McKinley et al., 2017; Warner et al., 2019), improving the local economy (Wehn et al., 2021), strengthening personal and public relationships (Kelly et al., 2019), stimulating awareness on marine ecosystems (Garcia-Soto et al., 2017; Zettler et al., 2017), and enabling the volunteers' minds towards collaborative behaviors on coastal conservation (Ballard et al., 2017; Richardson et al., 2020). Additionally, due to the technological revolution, CS is now producing information on digital and internet platforms, enabling accessible observations in remote areas (Earp & Liconti, 2020) and live interactions among different cultures through social media.

In the Philippines, direct CS topics on coastal biodiversity research are comparatively less known, with some studies just recently occurring. CS, however, can be widely observed in public (in contrast to the refereed literature), shown by the academic and government projects and social media groups that provide coastal biodiversity information. Some studies were, nevertheless, directly specified, such as the public collaborations on coral reef monitoring (Licuanan & Mordeno, 2021), photo-identification and observation of marine turtles (Madera & Habito, 2019), data collection-monitoring of an endangered whale shark (Araujo et al., 2020), addressing some of the limitations on marine litter research (Abreo & Kobayashi, 2021), and probing information of species occurrence (Aldea & Azanza, 2024). An additional notable project conducted a study in a semi-aquatic environment (rice ecosystem), although the site was in an inland province in the Philippines (Dem et al., 2018).

As a biodiversity hotspot, CS in the Philippines can be crucial because of the need for species monitoring. The relatively limited number of professional scientists, technology, and sources of funds among organizations additionally complicate the situation, hence the possibility of greater contribution of volunteers to data recording. For instance, monitoring by CSs described the extent of current environmental degradation in coral reef ecosystems (Licuanan & Mordeno, 2021), which information dissemination could have taken a long time due to limitations on scientific accessibility in the area. This trend of public participation in science, however, may vary across the country considering the socio-geographic status of other places, such as small islands.

CS engagement in the Philippines, arguably, can be very high in small islands, especially in a place where weather disasters are common. Due to limited spaces and resources, small islands are generally more vulnerable to environmental change (Mycoo et al., 2022), which may drive inhabitants to make dire predictions. I argue that the extreme perceptions of coastal biodiversity participation may provide both positive outcomes and drawbacks, especially considering the presence or absence of professional coordination when engaging in a project. With these concerns, I aimed to describe the current status of CS on coastal biodiversity engagements using the case of Catanduanes Island, a

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small island off the eastern coast of the Philippines. Specifically, I explored the public's perception of participation in coastal biodiversity conservation (preliminary interview), the CSs groups and their engagements (including profiles on gender, age, and frequency of activity), as well as the potential ecological drawback of the engagement (primarily with the Independent Citizen Scientists).

2. Methodology

2.1 Locale of the Study

Catanduanes Island is a province on the Pacific coast of the Philippines, separated from Mainland Luzon by the Maqueda Channel. It is a small island with an area of 1,511.5 km^2 and a 271,879 population as of the 2020 census (PSA, 2022). Ozuem and Thomas (2015) defined a small island with an area of < 10,000 km^2 inhabited by < 500,000 people (hence categorizing Catanduanes as a small island), although this definition may vary across different cultures. The island has an 8.6% share of the Bicol Region's land area or only 0.5% share of the land area of the Philippines (PSA, 2022). It is one of the disaster-prone provinces of the country, especially typhoons (WFP, 2015), such as Super Typhoon Goni (Rolly) in 2020, the strongest tropical cyclone at landfall based on a 1-minute average wind speed (Masters, 2020; Dela Cruz Santos, 2021). Aside from being a typhoon-prone, the island has notable biodiversity (Vargas & Asetre, 2011; Aldea et al., 2014, 2015; Aldea, 2022; BirdLife International, 2023) as well as issues on biodiversity utilization (Aldea et al., 2014, 2015; Aldea & Masagca, 2016; Aldea, 2022, 2023).

Fig 1. Map of Catanduanes Island, Philippines; zoom-out location in the box of the inset photo. Map generated with ARC-GIS (2023).

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2.2 Study Design, sampling, data collection, and treatment of data

This study utilized a descriptive design that collected data through preliminary and major interviews. The interviews were guided by structured questionnaires (with follow-up questions during the administration, thus obtaining some narratives). During the preliminary interview, the respondents were randomly selected from the public regardless of their involvement in coastal projects (with or without CS engagement). This is to obtain the general public perceptions of participation in coastal biodiversity conservation. The preliminary interview was conducted in February-March 2022. During the major interviews, respondents were identified based on their CS engagements with coastal biodiversity-related activities, either collaborating with science professionals and research organizations or operating as individuals. Research organizations include non-governmental organizations (NGOs) related to or working with coastal biodiversity conservation. This study included respondents not working in a group or organizations if their activities were within the scheme of biodiversity conservation, such as biodiversity bloggers, amateur photographers who conduct species monitoring, and private "environmentalist" individuals. Only active members were included in the major interviews, which means that CSs must have participated in the group (or actively performed personal activities if they have no group) at least once in the last three months or unanimously judged by other members as active members.

CS engagements include any of the following: working with science professionals or research organizations (e.g., providing data/reports of a species or their environment, facilitating research activities, volunteering in conservation projects), participating in biodiversity-related activities near or within the coastal areas (e.g., species surveying, mountain hiking, patrolling, tree-planting, coastal clean-up, etc.), and conducting social media information dissemination (e.g., posting/blogging about coastal species and their conservation, sharing of biodiversity information with science professionals or research organizations). When CSs are not associated with science professionals or research organizations (in the case of Independent Citizen Scientists), they must be part of the planning or facilitation of a completed biodiversity-related activity (in contrast to being just a recruit in a short event), or in posting/blogging of biodiversity-related topics and activities in social media. Engagements referred to in this study were drawn from voluntary work (not salary-based).

This study conducted Stratified Random Sampling (for the major interview phase) to represent other groups that might be under-represented in pure random sampling due to localized similarities of work in some areas (e.g., more private or personal projects in urbanized places). Field guides who were village seniors facilitated in identifying local areas of CSs. The major interviews were conducted in April-May 2022, June-July 2022, December 2022, and March-April 2023. For additional clarifications, some respondents were given an online address, which they may utilize to pose other questions anonymously and voluntarily. Social media pages (and posts) of organizations were also shown with their links. All interviews and social media presentations were agreed upon by both parties, together with the consent forms. Questionnaires were subjected to a reliability test (Cohen's Kappa, $\kappa = 0.81$ [Test-Retest]). Statistical analyses and graphical illustrations were done using SAS JMP software and Microsoft Excel.

3. Results and Discussion

3.1 Public perception of participation in coastal biodiversity conservation

The preliminary interview with the general public (regardless of involvement in biodiversity monitoring projects) was participated by 179 adults. Ninety-seven percent of the respondents perceived their willingness to participate in coastal biodiversity conservation either directly (e.g., environmental projects) or indirectly (coordination with professionals through photography or social media) (Figure 2A). The remaining three percent are not sure if they want to participate.

While there is no comparative data on the perception of participation on big islands (e.g., Luzon Island), this can be regarded as an extreme perception (97%) of willingness to participate in conservation activities, as also indicated by Aldea and Masagca (2016) about the perception of the island's people towards coastal vulnerability from environmental disturbances. Correspondingly, 93% described their willingness to report activities that they perceive crucial or needing immediate actions (e.g., poaching, sightings of a rare species, animal strandings, etc.); the only other option is to look for someone else to report for them (7%) (Figure 2B). These high perceptions (97%, 93%) may be related to a strong tendency for public cooperation with CS toward conservation. The primary reason for their willingness to participate is due to their belief in the place's vulnerability (being a small island regularly impacted by typhoons), wherein the sustainability of coastal species (food resources) and protection from storms (coastal forest shielding) are the most expected rewards from their engagements.

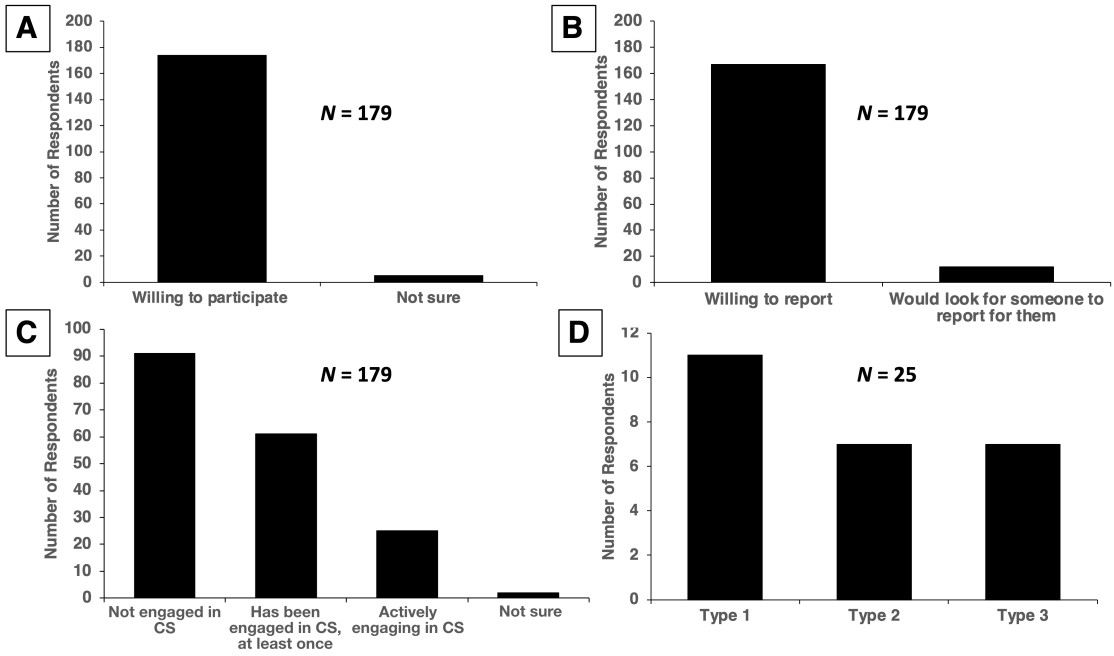

Fig 2. Public perceptions on participation in the coastal biodiversity conservation and types of CSs; willingness to participate in the coastal biodiversity-related activities (2A), willingness to report activities that are perceived crucial or needing immediate actions (2B), engagement of the public in CSs (2C), and types of CSs who are actively involved in coastal biodiversity activities in the island (2D).

Fourteen percent (25) of the public are actively engaged with CS while 34% (61) have been engaged with CS at least once (non-active) (Figure 2C). Among the actively engaging CSs, 44% (11) are Type 1, and 28% (7) both for the Type 2, and Type 3 CSs (Figure 2D). For those who have not been engaged in CS, willingness to engage is also the main response, although due to socio-economic limitations, several are restrained from doing so. A respondent stated:

> *"I do not engage because I think it needs spending, such as the expenses on cell phones, cellphone loads, and transportation. I have a big family and am working with daily wages, so my income is just enough, sometimes even insufficient. However, "I am willing to engage, if individuals or organizations approach me, and if my time for generating income will not be affected".*

There is limited information on the percentage of CSs engagement in the country, thus comparison between areas or regions becomes less straightforward. In the USA, however, the Pew Research Center in 2020 found that CS has been

engaged by 10% in the past year, and 26% by those who have ever done so (more than a year ago) (Thigpen & Funk, 2020). This demonstrates the higher CS engagements in Catanduanes Island (compared to the US data), although this should be taken with caution due to differences in the CS activities referred to, as well as differences in the year and the number of sampled participants.

The degree of willingness to participate in coastal biodiversity conservation on the island is arguably intense, likely due to their belief in volunteerism driven by island-based experiences related to disasters. This strongly implies that many of them may engage with various projects, including private or personal engagements that can be initiated without interventions from science professionals or research organizations.

3.2 CSs groups and their engagements

3.2.1 CSs Groups

A total of 128 CSs participated in the major interviews. CSs groups were identified as the following: Community-Based Group (Type 1 CSs) (e.g., members of a fisherfolk association, field volunteers); Extended Network Group (Type 2 CSs) (e.g., members of a biodiversity or environmental groups that are largely active in social media but also with physical community engagements); and Independent Citizen Scientists (Type 3 CSs) (e.g., individuals engaged in environmental awareness dissemination, freelance ecological photographers, and bloggers) (Figure 3A). The Community-Based Group and Extended Network Group both collaborate with science professionals or research organizations at all stages of engagements. On the other hand, Independent Citizen Scientists generally operate freely, wherein they can start a project even without collaborations with science professionals or research organizations, although they may share their results with the public using social media, especially at a later stage (through posting or blogging).

Community-Based Group and Extended Network Group are both engaged in a project; the former generally includes members who are associated with livelihood and community organizations while the latter includes members who are more active in social media activities. Extended Network Group includes individuals reporting or collaborating with biodiversity-related organizations (local and international biodiversity organizations). Many of the Community-Based Group and Extended Network Group are also NGOs themselves, whereas Independent Citizen Scientists are usually composed of one (freelance) person, although they may join together for short-term grouped activities. Community-Based Group was represented by 56 individuals (44%), while the Extended Network Group and Independent Citizen Scientists were represented by 37 (29%) and 35 individuals (27%) respectively. Community-Based Group is primarily categorized in Contributory CS, and Extended Network Group in Co-created CS based on the descriptions by Gunnell et al. (2021) and Senabre Hidalgo et al. (2021) while Independent Citizen Scientists are largely individually operational.

Many of the CSs provide data to biodiversity-related groups in social media (usually through online messaging systems), although direct social media activities (campaigns and posting on social media pages) are also conducted by members of the Extended Network Group and other Independent Citizen Scientists. To facilitate CSs activities (information dissemination, browsing, advertisements, etc.), social media is utilized primarily by most CSs (main type of utilization) (Figure 3B). The use of social media is an effective tool for disseminating ecological information, facilitating recruitment for environmental activities (Liberatore et al., 2018; Skelton et al., 2018; Oliveira et al., 2021), and maintaining communications among CSs (Skelton et al., 2018; Phillips et al., 2019). In addition, using photos (exclusive and mixed methods) is a popular method for many of the CSs (Figure 3C), whose usage (posting/blogging) is also mainly conducted with social media.

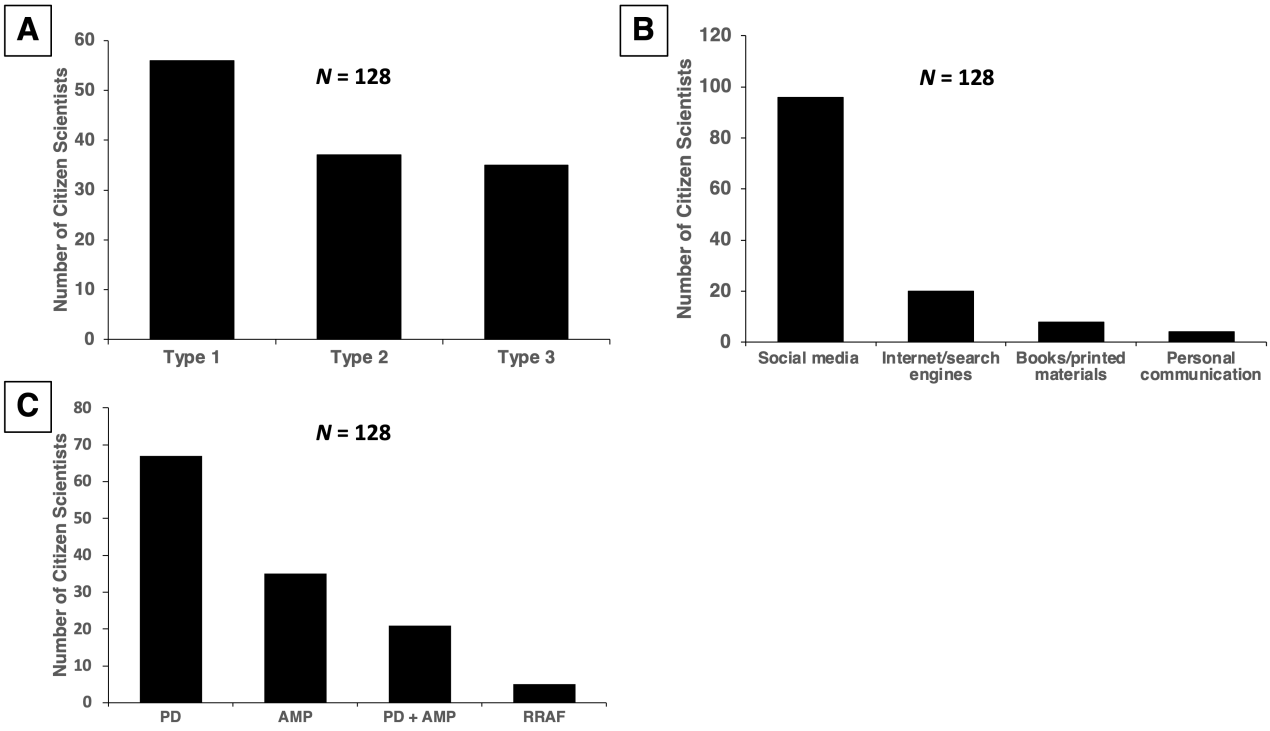

Fig 3. Number of CSs and their groups. The following types of CSs are shown (3A): Community-Based Group (Type 1), Extended Network Group (Type 2), and Independent Citizen Scientists (Type 3). Communication or information activities are conducted primarily through different media (3B). Data collection methods (3C) are as follows: PD (photo documentation); AMP (actual material presentation); PD + AMP (photo documentation + actual material presentation), and RRAF (recording and reporting of abiotic factors).

If all types are combined, CS on the island is predominantly represented by males (66%) (Pearson Chi-Square: X^2= 12.5, p < 0.01). However, if individual Type is considered, participating males are significantly prevalent only in the Community-Based Group (Pearson Chi-Square: X^2= 7.14, p < 0.01) (Extended Network Group: X^2= 2.19, p > 0.05; Independent Citizen Scientists: X^2= 3.46, p > 0.05). While communications with social media (messaging systems) are largely utilized by all types of CSs, it is noted that many individuals in Extended Network Group and Independent Citizen Scientists report or post their works through online schemes which may be generally accessible by both genders. Gender participation is reflected by engagements that are dependent on activities that may include physical attendance as well as online activities. In other studies, representations between genders also show a less clear trend (Pateman et al., 2021), wherein representations are sometimes biased towards females (Doemrose & Johnson, 2017), sometimes towards males (NASEM, 2018), and others found fairly similar results between genders (Mac Domhnaill et al., 2020).

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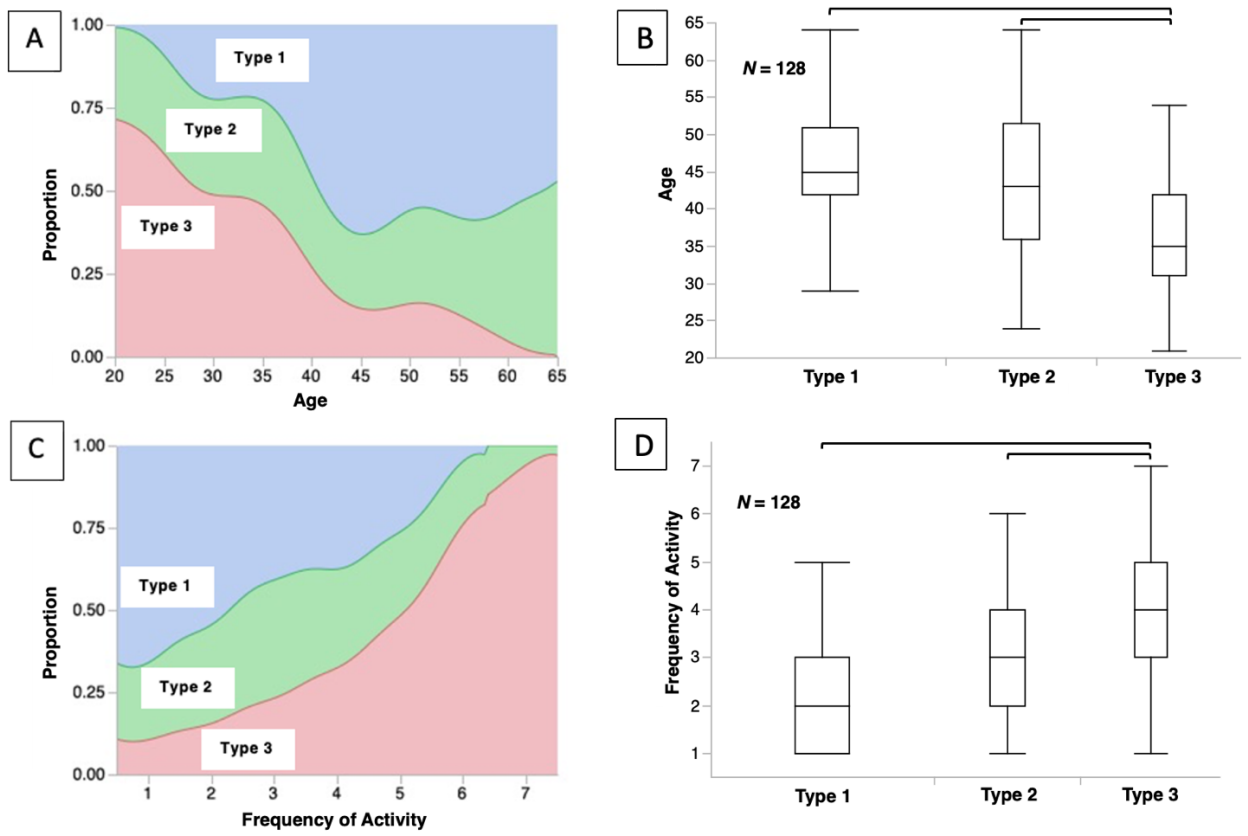

Fig 4. The proportion of CSs' and their differences per group. 4A-B on age; 4C-D on the frequency of CS activity per 3 months. Bracketed groups are significantly different ($p < 0.01$). Tukey's- HSD Test on 4B = Type 1 VS Type 2, $p = 0.36$; on Type 1 and Type 2 VS Type 3, $p < 0.01$ (Box plot). Tukey's HSD Test on 4D = Type 1 VS Type 2, $p = 0.22$; on Type 1 and Type 2, VS Type 3, $p < 0.01$ (Box plot).
Legend: Type 1= Community-Based Group; Type 2= Extended Network Group; Type 3= Independent Citizen Scientists

The age range was 23-64 (Average, 41) and 21-64 (Average, 45) for males and females respectively. There is a significant difference in the groups associated with the age of CSs (F value= 12.80, $p < 0.01$; Tukey's HSD Test on Independent Citizen Scientists against other groups, $p < 0.01$; Tukey's HSD Test on Community-Based Group and Extended Network Group, $p > 0.05$) (Figure 4A-B), suggesting that the group of Independent Citizen Scientists caters more to younger members. The frequency of CS activities engaged in the groups also differs significantly, where Independent Citizen Scientists had significant differences against the other two groups (F value= 14.58, $p < 0.01$; Tukey's HSD Test on Independent Citizen Scientists against other groups, $p < 0.01$; Tukey's HSD Test on Community-Based Group and Extended Network Group, $p > 0.05$) (Figure 4C-D). Some studies show that younger individuals have lower participation in CS (e.g., 25-34 years old) (Mac Domhnaill et al., 2020; Pateman et al., 2021). On the other hand, the data from Pew Research reveals higher participation among younger individuals in the United States (millennials and younger) (Thigpen & Funk, 2020). These signify that participation is not always dominated by a specific age group, especially considering activities in which types of CSs are engaging. A possible explanation of the significant engagement of Independent Citizen Scientists (frequency of activity compared to other groups), for example, is the physical and social media-related activities that are relatively more accessible for younger individuals (e.g., use of information technology, tree-planting activities, etc.). This is likely enhanced as most of the Independent Citizen Scientists may start activities generally spontaneously (without coordination with science professionals or research organizations).

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3.2.2 Engagements

Recording and Observation by CSs

Photo documentation (PD)

When providing data, most CSs practiced submission of photos (PD of Figure 3C) without presenting actual material or physicochemical information. Photo documentation of organisms has been used as a tool for documenting organisms which generated reliable results in species monitoring (Carpentier et al., 2016, Newcomer et al., 2019). CSs conduct photo documentation to provide information on any of the following: immediate reports on the appearance and location of species, b.) coastal projects, or c.) perceived irregular activities. Additionally, some CSs engage in this activity when encountering rare species and disseminate the photos on social media. Photos of plant and animal species, for example, are presented on social media pages, such as the Catanduanes Biodiversity (2018) (see the profile page), where it may serve as an "online library" of the island species. Many CSs who engage with coastal biodiversity information dissemination (photo sharing and other social media activities) connect with the Catanduanes Biodiversity (see the individual post) (Catanduanes Biodiversity, 2022), although the Page also caters to activities on the island's biodiversity as a whole. Some associated CS works have contributed to the publication of the butterfly species on the island (Mape et al., 2021).

In October 2020, a mass whale stranding occurred in San Andres, Catanduanes. In this regard, CSs participated in information dissemination and online discussions associated with the event (Figure 5A-B) (see the post). With collective efforts by CSs, the Catanduanes Biodiversity (2018) provided a series of social media communications about coastal responses (regarding whale stranding) and periodic updates on the incident. The role of CS has been recognized in the contribution of information in other instances of wildlife mortality such as roadkills (Heigl et al., 2017; Valerio et al., 2021), and electrocutions (Demeter et al., 2018; Dwyer et al., 2022) with implications on wildlife conservation strategies.

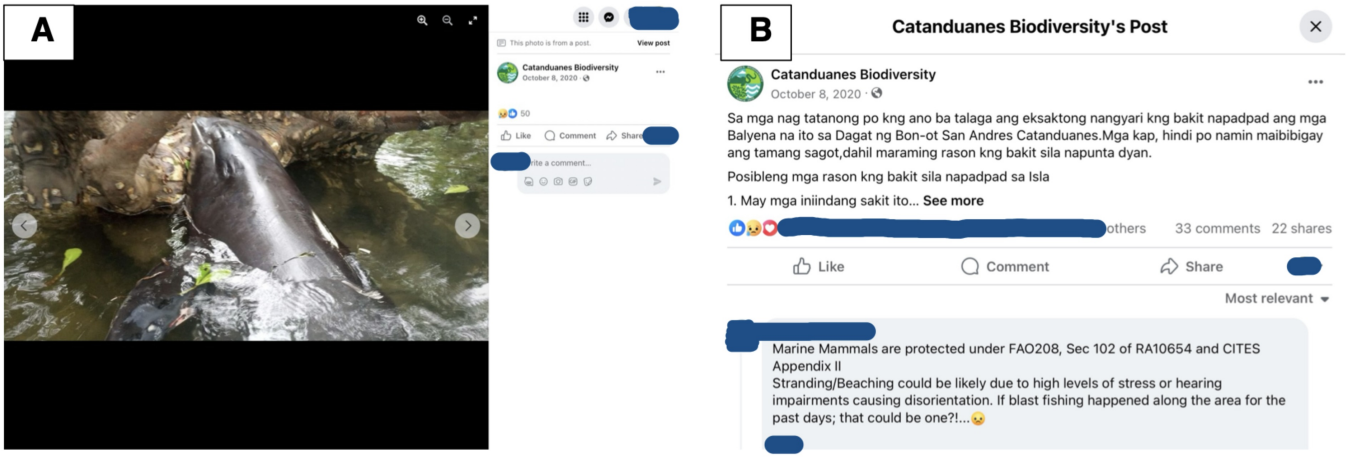

Fig 5. Social Media Engagements: A photo of a melon-headed whale (an update about the dead whales found) posted on Catanduanes Biodiversity Facebook Page on October 8, 2020 (5A). Related post on the same day by Catanduanes Biodiversity about possible causes of the whale mass stranding (5B). Discussions are further engaged in the comments section (lower portion of 5B).

Other CSs mentioned that they present and discuss their photos in social media groups (with national coverage), such as the Co's Digital Flora of the Philippines (CDFP) (2011) (see the profile page), by contacting the page's administrators through personal messaging systems. In some instances, communication of the CSs is through the Philippine Plants website (Pelser et al., 2011). Their presentation and discussions of plant photos with the CDFP cover parts of the island

environment (including lowland and coastal areas). Most respondents feel that photo documentation is a powerful tool that bridges non-professionals and professionals with scientific perspectives. CS has been documented to facilitate knowledge on biodiversity conservation (hence reducing the knowledge gap) through photographs shared with online communication platforms (Oliveira et al., 2021; Soltani et al., 2022; Krueger et al., 2023; Chowdhury et al., 2024).

Actual materials presentation (AMP)

Several CSs were involved in providing reports with actual materials only (AMP of Figure 3C), most of whom were either Community-Based Group or Extended Network Group. Materials can be a specimen, plant material (e.g., a leaf), an empty shell, or other things for scientific purposes. Under this method, CSs collect materials with basic techniques, such as labeling or initial preservation. Sample collections with the aid of CSs have contributed to obtaining data on microplastics (Paradinas et al., 2021) and surficial soil Blue Carbon stocks (Smeaton et al. 2022), and are viewed as one of the potential components in studying fungal biodiversity (training CSs on the collection and processing of fungal specimens) (Gryzenhout, 2015). In Catanduanes Island, related CSs works are during conservation seminars, such as in the presentation of a part of a plant in a meeting for coastal forest projects (activities on plant classification). From the collected materials, project leaders or organizers facilitate and streamboard scientific discussions as observed by CSs. The flow of information may be helpful in the two groups; the project leaders collect data as the CSs learn scientific concepts that may be important in biodiversity conservation. In other cases, communication with CSs starts with available materials presented to them, wherein they may provide additional samples in the process. For instance, information on the distribution of the red swimming crab *Portunus convexus* was initially communicated with the CSs, after the crab's empty shells (carapace) were shown by the researchers (Aldea & Azanza, 2024). Further, the actual material presentation is sometimes combined with photo documentation (PD + AMP of Figure 3C). In the study of Killen et al. (2022), combining actual materials (leaf samples) and digital information (including photos) indicates benefits in meeting or exceeding the traditional models of scientific inquiry.

Recording and reporting of abiotic factors

Few CSs (all from Community-Based Groups) are engaged in this method (RRAF or "recording and reporting of abiotic factor" of Figure 3C), where they use recording notes and sampling equipment for physicochemical observation. CSs in this method are arguably skilled in measurement, enhanced through constant communication with their project leaders, science professionals, or even among themselves. CSs may also combine photo documentation that may be used for future purposes (although not necessarily, as they perceived). An example of this is collecting physicochemical parameters of estuarine waters in a river mouth (e.g., temperature, pH, and other technical information) conducted by one of the CSs. Related works that are collaborated by CSs have provided data on water quality (San Llorente Capdevila et al., 2020) and real-time estimation of soil moisture (Karamouz et al., 2021), suggesting the potential roles of CS in the recording of the physical environment. Further, a study by Babiso et al. (2023) has included training of the CSs on water quality data recording (and other related conditions), which results have shown good agreement for selected parameters, thus providing an accurate data set.

Public services

Participation in Marine Protected Areas (MPAs)/ Other Conservation Engagements

The establishment and implementation of an MPA (or sanctuary) on the island are community-based, where there is a direct connection and participation of several stakeholders, such as the local government unit (LGU), NGOs, and the

coastal community (Vargas & Asetre, 2011; Aldea & Masagca, 2016). CSs in the community are usually included in the Community-Based Groups. In this case, CSs contribute to planting, patrolling, information dissemination, and seminar facilitation. The coastal village may also allow educational interventions from academic institutions (usually with educational or research services with the MPA) (Vargas & Asetre, 2011, Aldea et al., 2015), wherein most activities are actively engaged by CSs.

Coastal projects with the active participation of the community have led to successful programs, such as the Agojo Point Fish Sanctuary and Marine Reserve (APFSMR) (Vargas & Asetre, 2011; Aldea et al., 2015). Other community-collaborated programs on the island are currently in progress, with positive feedback on increasing fish biodiversity and biomass (Aldea, 2023). The coastal benefits are perceived to be the effect of the implementation of the projects, probably due to the collaboration efforts between CSs, academic institutions, and policy implementers. In particular, this led to the recovery of the mangrove forests in the Agojo Point Fish Sanctuary and Marine Reserve (Aldea et al., 2015). Perhaps one of the notable steps towards marine biodiversity conservation on the island is volunteering for coastal activities which includes a site-selective gleaning scheme (Aldea, 2023) in areas within or near the fish sanctuaries.

Meanwhile, an initiative about turtle conservation is ongoing on the island, wherein the local community's participation is viewed as instrumental in the conservation efforts (Municipality of Virac, 2022). Several cases of voluntary turtle turnovers such as the cases in Bagamanoc (DENR-5, 2021) and Virac (Provincial Local Government of Catanduanes, 2024) were recorded, perhaps due to the intensive campaign of the government on turtle conservation, collaborated by the community. Some CSs participate by informing the community about the need for a turtle's rescue and release, through an information drive or online through posts on social media. CSs mentioned that in some cases, individuals who would like to turn over turtles, first approach them, where they facilitate communication leading to the rescue and release process. An experience by one of the CSs is shown below:

> *"One night, a person sent me a message about a sea turtle in his possession. I provided him with input about the importance of the release and its guidelines. I instructed him to contact me immediately if releasing or reporting to the authorities may be delayed. When I contacted him the next day, he said that the turtle was already rescued and released, which I confirmed later".*

Providing Information on Biodiversity and Environment

Several groups regularly report information physically (gatherings) or through online means. Social media may serve as an influential platform for this method due to its accessibility among all types of CSs. The topics are usually the role of a species in the ecosystem, consequences of species endangerment, natural and anthropogenic disturbances, and the vulnerability of the coasts. Many CSs do this personally through a personal narrative, chain messages, or a personal photo presentation on social media, with a portion of the interview (from one of the CSs) on the reason for engagements as follows:

> *"I disseminate information against the collection, eating, or poaching of the endangered species, including the legal consequences. Maybe, some people are unaware of their status, so providing them with information can be both beneficial to them and to the endangered species".*

The work of CSs may provide more data for the island's species through biodiversity monitoring. Specific examples (as mentioned by CSs) of these works are information on mangrove-wetland conservation, prohibition on catching endangered species, island eco-tourism, and conservation activities for species that are generally persecuted by the community (e.g., snakes). Whenever a photo of a species is disseminated, information is posted about its biology, ecology, and warnings on its exploitation. For instance, CSs groups conduct seminars on ecological information about snakes, and snake-bite knowledge, including strategies to drive them away during an encounter (Catanduanes Biodiversity Group, 2018). The snake education movement by the Catanduanes Biodiversity Group encompasses the diversity of snakes on the island, such as those in the mountainous and forested areas as well as in the lowlands, coastal, and aquatic environments. One of the related snake ecology-awareness engagements was conducted recently (Catanduanes Biodiversity, 2023a). Below is a statement from one of the CSs about the dissemination of information of snakes' ecology and associated human interactions:

> *"When we educate the public about snakes, we are giving them opportunities to learn about their ecological importance as we also lessen the stigma against them. These are crucial in the introduction of their conservation. During our outreach program, I am happy to see the participants conquering their fear (of handling snakes), and learning a science-based response in case of a snake bite or during a human-snake encounter".*

In addition, several CSs have extended networks (with other experts and groups in the country), in which participation may be collectively drawn for certain issues. In this regard, a group composed of CSs and other stakeholders has raised concerns about the recent mangrove planting activities on the island (Catanduanes Biodiversity, 2023b), and eventually gaining attention from a national media (Subingsubing, 2023).

Information Dissemination of Invasive Species

Reports of introduced species reveal their presence in the island's coastal areas and low-lying communities. For example, an introduced achatinid snail is widely reported for its invasive nature on the island (coastal/lowland areas but includes communities adjacent to the forest margins). In cooperation with CSs, Aldea and Azanza (2024), provided information on the spatiotemporal distribution of the introduced snail, including the status of its infestation (invasiveness). On the other hand, Dela Cruz and Gil (2019) have reported a new distribution record of a Chinese softshell turtle on the island (estuarine areas), wherein actual field observation was primarily obtained through CS.

Special Community-Driven Events (usually short-term activity)

On some occasions, the CSs may gather in groups during an environment-related event, either personally initiated (by them) or sponsored by other organizations. Coastal clean-up drives and tree planting are some of the examples. For instance, in 2023, the International Coastal Clean-up Day was participated by various organizations through clean-up activities on the southern portion of the island (Catanduanes State University, 2023; Provincial Local Government of Catanduanes, 2023), where some CSs served as volunteers of the participating organizations during the clean-up. On these special occasions, the event leaders contact the CSs (volunteers) for collaboration, perhaps due to the CSs' established connections in the community. Further, during summer, some biodiversity-related seminars and training are also sponsored by CSs such as an information drive on reptile diversity, and planting activities in the coastal areas.

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3.3 Potential ecological drawback of the engagement (primarily with the Independent Citizen Scientists)

Given that Independent Citizen Scientists are generally not associated with science professionals or research organizations, they may start a project, relatively more often. Many of the activities in the coastal areas are initiated by Independent Citizen Scientists themselves. Several of them claim that they have the advantage of undertaking a project (compared to other CSs) relatively anytime due to the absence/minimal research or scientific networks and logistics in their activities.

Due to the nature of the activity of the Independent Citizen Scientists that may be done more spontaneously, some of their activities may be prone to being potentially "misguided". In several cases, they may form a temporary group; thus, a project may be participated by many others, possibly creating an extensive impact. Over the last five years, several Independent Citizen Scientists have either initiated or joined tree planting activities that introduced exotic trees in forested coastal areas (wetland and non-wetland). Of the 32 CSs who admitted initiating or participating in potentially "misguided" planting activities, 23 were Independent Citizen Scientists (72%) (Pearson Chi-Square, X^2= 32.0, $p < 0.01$). Their primary reason is the immediate need for planting due to the belief that it may protect the island from storm surges, regardless of a detailed plan and professional coordination. Among Independent Citizen Scientists, those who admitted initiating/participating (in potentially "misguided" projects) or thinking to initiate/participate in similar schemes, are 74% ([Yes or No] excluding those who had no response) (Pearson Chi-Square, X^2= 7.26 $p < 0.01$), which shows that these engagements are significantly associated with them.

While a high perception of participation in tree planting may be helpful in some ways, it might have caused the indiscriminate mangrove planting activities in some seagrass beds (unpublished data) and tidal flats on the island (Aldea, 2022), likely due to abrupt engagements (without science and research professional coordination). Likewise, these activities generally may compromise factors described by Field (1999), such as soil characteristics and site classifications, as well as the site-specificity of mangrove species (Primavera et al., 2012). Due to site incompatibility, the activities are inefficient and costly as mangroves are usually unsuccessful (high seedling mortality) in their establishments to new sites (historically non-mangrove sites) (Erftemeijer & Lewis, 2000). On Catanduanes Island, high mangrove seedling mortality has been noted in the past, which is linked to a planting event with site incompatibility (Aldea, 2022), arguably participated by many Independent Citizen Scientists. In addition, seagrass beds and tidal flats are productive habitats that need conservation as well. Mangrove planting in these areas is often ecologically misguided (Primavera et al., 2011, 2012) and usually not recommended (Erftemeijer & Lewis, 2000; Aldea, 2022), as it may have a detrimental impact on coastal biodiversity.

This study, nevertheless, acknowledges the significance of planting activities on the island as suggested by Vargas and Asetre (2011), which revealed that mangrove projects with stakeholders coordination (including science professionals, research organizations, LGU, NGOs, and the community) and engagements were associated with the productive program. Specifically, planting efforts that consider species and site selections, biophysical conditions, and stakeholder engagements are usually linked to the successful establishment/restoration of mangroves (Ellison et al., 2020; Zimmer et al., 2022). These demonstrate the importance of mangrove conservation, anchored on guided activities to minimize or avoid unproductive outcomes (e.g., mass seedling mortality and intrusion into other important habitats). It should be emphasized, however, that this study does not discourage Independent Citizen Scientists from their engagements. As they are arguably more dynamic due to their higher frequency of engagement and relative enthusiasm for information

technology (considering information dissemination), it is reasonable that their coastal involvement is encouraged on the island.

4. Conclusions and Recommendations

Catanduanes Island people highly perceive the need for coastal protection, possibly due to limited resources and the coastal vulnerability of the island. This probably results in various projects in the community that are either associated with science or research professionals or personally initiated due to the perceived “immediate” need for coastal biodiversity conservation.

CSs participate in male-dominated to non-gender-dominated engagements, while their types are significantly different in age groups and frequency of activities. These suggest diverse opportunities available for both genders and age groups for community participation, although the difference in age groups and frequency of activities has implications for the engagements of Independent Citizen Scientists. Further, the activities of CSs generally provide scientific information and public services, which suggests that CS, in general, demonstrates a productive and relevant source of information for coastal biodiversity. Participation in coastal biodiversity conservation is either synergized if their participation is associated with science professionals or research organizations or constrained when individuals engage in potentially “misguided” projects. To address this issue, the enhancement of coastal policy communication and extended science-professional interventions on CS engagements is recommended.

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