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Integrating marine biodiversity through Philippine local development plans

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Abstract

Purpose – The purpose of this paper is to highlight how data from marine protected area (MPA) surveys can be used to facilitate the development of systematic approaches to monitoring biodiversity within local government development plans and across marine bioregions.

Design/methodology/approach – The study focussed on coastal Barangays of the Municipality of San Luis, Aurora Philippines. A Participatory Coastal Resource Assessment (PCRA) was conducted to gather information on corals and reef fishery resources. Resultant Simpson's biodiversity indices were calculated and compared to other MPA sites. Linkages to enhanced marine curriculum in a San Luis high school were evaluated by utilizing cultural consensus theory (CCT) on previously reported local student perception surveys as a further effort on defining pathways for localized transformation.

Findings – San Luis MPA biodiversity indices ranged from 0.56-0.8 on a scale of 0-1. This initial analysis demonstrates how local monitoring can be connected to resource assessment through biodiversity considerations and in developing local plans for site improvement linked to local economies. Results are used to demonstrate the potential for further development of an integrated approach to biodiversity monitoring across and between bioregions as a step forward in strengthening science for MPAs and biodiversity conservation for the Philippines.

Practical implications – The study could be used to pilot study strengthening of coastal resource management (CRM) at Municipal and Barangay levels and as well through application of CCT to the topics. The results will be used to reinforce the formulation of San Luis local development plans to better consider marine resource assessment.

Originality/value – This paper provides a new perspective on the use of quantitative measures of biodiversity to assist with local development plans. Projecting integrated biodiversity monitoring across and between bioregions is considered as a potential tool for facilitating climate change mitigation.

Keywords Local development plans, Marine biodiversity, Marine bioregion, Simpson's biodiversity index, The Philippines, Marine protected area surveys

Paper type Research Paper

1. Introduction

The Philippines is globally recognized as a marine biodiversity hotspot and priority jurisdiction for related conservation. Considering the impending challenges of climate change, fishery management in general needs to become more responsive, flexible and reflexive (Brander, 2010). The Philippines has a challenge associated with the local governance structure that makes it difficult to scale-up ecologically (Christie *et al.*, 2007). In part that is a result of the weak institutional mandates (Hutchcroft and

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Rocamora, 2003) and a lack of bioregional marine ecosystem consortiums. There are currently no programs systematically integrating marine biodiversity assessment and monitoring across complete bioregions, and measures of biodiversity are often biased by a failure to account for varying detectability among species and across time (Buckland *et al.*, 2012). This bioregional research need is presently being addressed through the application of the Philippine academic discipline of Development Communication (Pajaro *et al.*, 2013a).

The current work examines how marine protected area (MPA) survey data can be used as a means of developing systematic approaches to monitoring biodiversity. A monitoring approach could then be used to address development and/or refinement to establish one or more standard biodiversity indices across gradients and marine bioregions. Further consideration is given herein to the integration of biodiversity information and their relevance to local government development plans of local government units (LGUs) at the Provincial, Municipal and Barangay (smallest governance unit) levels. The current work considers the perspective that the development of responsive management systems for both social and environmental challenges must be connected to local culture, history and socio-economics (Cinner and Aswani, 2007; Cinner *et al.*, 2009). The Province of Aurora consists of eight municipalities, seven of which are located on the coast of the North Philippine Sea (NPS) marine bioregion, one of six in the Philippines (Ong *et al.*, 2002). The NPS shoreline consists of ten provinces that extend from Batanes in the north to Sorsogon in the south. The NPS and the South Philippine Sea form the Philippine Pacific Seaboard, which are areas most affected by typhoons and vulnerable to climate change. The Municipality of San Luis has four coastal Barangays (Brgy) which are accessible only by water, and are also isolated from cell phone and the electricity grid. In many ways, these communities are characteristic of isolated fisherfolk villages across the country. These barangays; Dibut, Dibayabay, Dikapinisan and Damanayat, are also characterized by significant challenges for development and management of fishery's harvest and resources. The fisherfolks of the Pacific Seaboard are generally thought to be more dependent upon fishing than in other areas of the Philippines (Samson and Licuanan, 2002). The two main forms of livelihood are fishing and farming, with many residents involved in both. Previously, there was a saw-mill in Dikapinisan, but it has been closed down under a total log ban for the area. The primary jurisdictional approach to development for these communities is focussed on the possibilities associated with tourism. Challenges for marine biodiversity conservation include human activities in both the agricultural and forest ecosystems. These three systems are not yet linked within local Philippine management strategies, in part due to a lack of quantitative assessment regimens.

Prior to the current work, a MPA had been established in Dibut where residents are now in the early stages of implementing an Ancestral Domain Sustainable Development and Protection Plan (Anabieza and Watts, 2010). Early fishery studies in the Province of Aurora through the Aurora Integrated Area Development Project focussed largely on economic aspects of development with limited ecological considerations. Conversely, the current initiatives are focussed on the development of expertise-based action at the Barangay, Municipal and Provincial government levels. Clearly the Philippine Local Government Code (1993) places a strong emphasis on the role of these local jurisdictions in particular municipalities. The current project was partly funded by the Canadian Fund for Local Initiatives and through an earlier work sponsored by Volunteer Services Overseas International.

PCRA

Within the Canada Fund for Local Initiative project, engagement of the local population was a primary consideration of the action. The study was intended as a Municipality-wide coastal initiation of strategic Action Research, a concept reviewed elsewhere (Reason and Bradbury, ,2008). Thus the activity is focussed on the researchers as facilitators and an overall goal of bringing positive changes in the communities. Initial focal group discussions indicated that some of the challenges in these fishing communities are illegal fishing and habitat destruction.

The status of marine resources in Dikapinisan, Dibayabay and Dimanayat were determined through PCRA. Coordinated by the non-government organization, DALUHAY, PCRA was conducted through the Aurora Marine Research and Development Institute with support from the Municipality of San Luis' Agricultural Office and the Province of Aurora's Environment and Natural Resources Office. Local residents were involved in all parts of the PCRA process except for the diving. Residents determined the areas that should be surveyed to initiate a database for barangay marine conditions and as well as baselines for possible MPA development. The PCRA process had previously been conducted in Dibut, which provided some data for comparison. PCRA is a rapid resource assessment for gathering baseline data on the status of the various major marine ecosystem components such that of corals, mangroves, and sea grasses (Deguit *et al.*, 2004). Data of corals and other benthic life form were gathered through manta tow and line-intercept method. This method of assessment measures coral cover percentages within the assessed area through observation and rational estimations with an aim to identify corals and fish to the species level. Fish abundance and fish size were also recorded through fish visual census. This census approach is used to estimate variety, numbers, and size of easily-seen and easily-identified fish in areas of good visibility. A 50-meter transect line was used in this method where observers were stationed on each side of each individual transect. The observers cover an area extending five-meter width from the transect when conducting their fish visual survey (Deguit *et al.*, 2004).

Biodiversity indices

Current global perspectives on biodiversity have outlined the need for regional monitoring guidelines (Buckland *et al.*, 2012). The Simpson Biodiversity Index (Simpson, 1949) has been applied in the present work to measure local fish diversity and also to other PAMANA ka sa Pilipinas MPA sites to establish initial comparisons between marine bioregions. The Simpson's Biodiversity Index is based upon the formula $D = \sum n(n\text{-}1)/N(N\text{-}1)$;where n is the total number of organisms of a particular species and N as the total number of organism of all species. The calculation determines the probability that two randomly drawn individuals from the ecological community belong to the same species. The lower the probability, the lower the diversity in the community. Since the general formula measures homogeneity rather than diversity, the transformation, 1-D is used as the index. The probability, 1-D that two individuals do not belong to the same species can be interpreted as within-species contribution to the total variation. The within-species variance may be interpreted as a probabilistic measure of species richness while the between-species component account for evenness (Maurer and McGill, 2011). Data sets were available to calculate indices for three of the four San Luis Barangay MPAs.

Applying cultural consensus theory (CCT) to knowledge transfer in high school

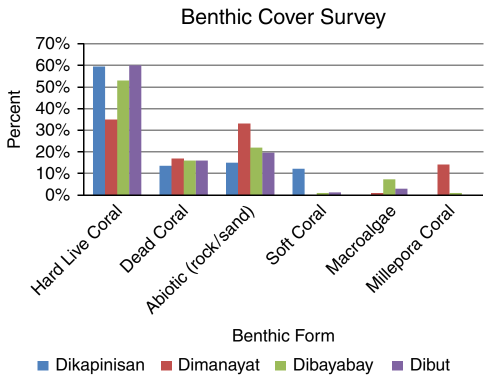
Recognizing that cultural transformation on environmental stewardship requires multi-generational and formal education approaches, the current work tested the use of

CCT in a controlled school setting. The approach was designed to determine if we could link learning perception to marine sustainability goals and cultural consensus. Students at San Luis National High School had previously been offered a grade-specific marine seminar. The raw results from that work implied strong student buy-in (Pajaro *et al.*, 2013b). However, advancement of the delivery of both formal and informal educational approaches would best be based upon a more quantitative analysis of local and regional school responses to program initiatives. One advancement through education psychology is a result of approaches that look at societal traits in terms of science cognition and cultural consensus (Bang and Medin, 2010; Medin *et al.*, 2006, 2007), based upon the earlier work of Romney *et al.* (1986). Previously, over 400 students were surveyed based upon individual symposiums presented for each of four grade levels. Each question could be answered by selection across a five-point likert scale of strongly disagree, disagree, neither agree nor disagree, agree, strongly agree. The current work considered early survey results involving over 400 students (Pajaro *et al.*, 2013b) as an initial application of the statistical cultural consensus approach for the purpose of developing marine curriculum in the Philippines. Students had been asked if their symposium enhanced existing curriculum and their knowledge base concerning the marine environment. Factor analysis was used to determine independent patterns of relationships (Rummel, 1970) among the observed values from the survey.

2. Results

Coral reef resources

Percent coral cover was surveyed in the Barangays of Dikapinisan, Dibayabay, Dimanayat and previously in Dibut (Figure 1). Dikapinisan and Dibut have the highest coral cover with 60 percent hard live coral recorded. Dimanayat has 35 percent of hard live coral recorded and Dibayabay has 53 percent of hard live coral. From the assessment, Dimanayat has the highest percent of dead coral with 17 percent, followed by Dibayabay and Dibut with 16 percent and Dikapinisan with 14 percent. Abiotic component (rock and sand) and soft corals were also recorded on the assessment. Rock and sand seen were highest in Dimanayat (33 percent) second in Dibayabay (22 percent) and third in Dibut (20 percent) and last in Dikapinisan (15 percent). Soft corals contributed in the survey with 12 percent from Brgy. Dikapinisan, 1 percent in



Source: Author’s own elaboration

Figure 1.
Percent cover of Benthic life form categories

Dibayabay and Dibut and none in Dimanayat. Macroalgae and millepora corals were also recorded on the survey. Dibayabay has 7 percent macroalgae while Dibut has 3 percent, Dimanayat with 1 percent and none in Dikapinisan. Millepora (fire) corals recorded were highest in Dimanayat with 14 percent, and 1 percent in Dibayabay and none in Dikapinisan and Dibut.

From the data, reef health can be determined using a four-point index where the proportion of live hard corals is compared to other benthic components (e.g. dead corals, soft coral algae, rubble, etc.). Coral reefs were classified as poor having 0-24.9 percent live hard coral cover, fair (25-49.9 percent), good (50-74.9 percent) and excellent (75-100 percent cover) (Gomez *et al.*, 1981). Based on this scale, the reef of Dikapinisan, Dibut and Dibayabay are considered to be in good condition and Dimanayatis in fair condition.

Reef fish resources

In the reef fish survey, a total of 292 fishes from 12 different families were recorded. Among the three coastal barangays, the most abundant fish families were Pomacentrids (damsel fishes), Acanthurids (surgeon fishes), Labrids (wrasses) and Chaetodotids (butterfly fishes). Small number of fish, however were also observed from the family of Scarids (parrot fish), Mullids (goat fish), Zanclids (moorish idol), Apogonids (cardinal fish), Balistids (trigger fish), Siganids (rabbit fish), Cirrithids (hawk fish) and Lutjanids (snapper). Results from the survey were mean values except on Dimanayat. Readings on Dimanayat were not duplicated due to low visibility underwater. Relative to the single reading on the area, damsel fishes were also dominant, followed by surgeon fishes, wrasses and butterfly fishes. Other species also seen in the area included goatfish, cardinal fish, moorish idol, and hawk fish (Figure 2).

Reef fish survey in Brgy Dibut

A Reef fish survey had been previously conducted in Barangay Dibut as part of the process of establishing the site as an MPA. Table I summarizes the results from that survey.

Dominant fish family in Ulol (Marine protected area core zone):

- Matalos (*Dussumeria sp*. 350).
- Maragta (*Acanthurustiistis*, 62).

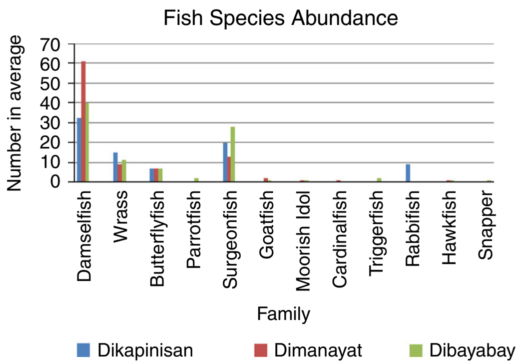


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Figure 2. Fish species abundance at three sites in the Municipality of San Luis, Aurora, Philippines

- Dayandang (*Latjanuskasmira*, 50).
- Dahon (*Chaetodonlunulatus*, 46).
- Maragta (*Ctenochaetusstriatus*, 39).

Dominant fish family in Kabonwangan (Marine protected area core zone):

- Maragta (*Ctecahaetusstiatus*, 81).
- Molmol (*Chlorusbowersi*, 42).
- Maragta (*Ctenocaheatusstrogosus*, 34).
- Tarupelas (*Abudefdafsexfasciatus*, 31).

Fish abundance related to size

Most of the fish seen in the survey were small, 1-10 cm in size at the Dikapinisan, Dimanayat and Dibayabay with abundance (fish numbers) of 85, 95, 81. Some fish, however were observed to be in the range of 10-20 cm in both Dikapinisan and Dibayabay. Species in 10-20 cm seen include surgeon fishes and wrasses (Figure 3). Data on fish size was not available for Dibut.

Abundance and density can be an indicator of fishing activity in the area. Generally, small fish size is one indication that the area is overfished and suggests that there is significant pressure exerted on resources. In the next section consideration is given to a comparative approach to measuring biodiversity as it differs over time and space.

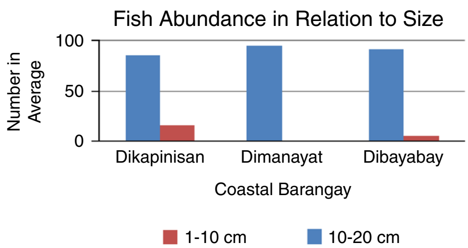
Biodiversity indices across marine bioregions

Indices of biodiversity could be applied to the development of a standard approach to MPA surveying and as well incorporated into Municipal and Barangay planning. The current work compares biodiversity in three Barangays of San Luis Aurora, in the

Table I.
Fish visual census was conducted by the Aurora State College of Technology in 2005 (unpublished) on two marine protected areas

Marine sanctuary	Number of fish	Family	Species
Ulol (core zone)	1,009	19	86
Kabonwangan (core zone)	816	24	98
Total	1,825	26	118

Sources: Municipality of San Luis (2008). Dibut Marine Protected Area Management Plan 2008-2012



Source: Author's own elaboration

Figure 3.
Fish abundance in relation to size

Northern Philippine Sea Bioregion with other sites in the Southern Philippine Sea, Western Philippine Sea and Visayan Sea bioregions (Table II).

Simpson's biodiversity indices were calculated on different areas across marine bioregions including Northern and Southern Philippine Sea, Visayan Sea and West Philippine Sea. The result show varying biodiversity indices with highest calculated in Surigao del Sur and lowest in Bohol.

High school students' response to marine symposium

The quantitative analysis of individual response to surveys (Pajaro *et al.*, 2013b) when analysed through the cultural consensus model (Romney *et al.*, 1986), provided a strong statistical indication of agreement. Collectively, the students found that the symposium enhanced the existing curriculum at all grade levels and as well as their understanding of the marine environment.

3. Discussion

Although the high school student survey analysis was a small component of the current work, the long-term mitigation of destructive activities and unmanaged harvest can perhaps best be advanced through the school system. For coastal efforts in San Luis, further efforts could include a Municipal-wide school program and locally on an in-depth marine science focus within the Dikapinisan High School. The analysis demonstrated that societal traits associated with science cognition and the marine environment could be measured by a statistical analysis to determine cultural

Site	Simpson's diversity index (1-D)	Marine bioregion	Surveyed area	Source of information
Asinan Reef Fish Sanctuary, Bohol	0.84	Visayan Sea	250 m^2	NagkakaisangmgaMangingisda ng Asinan (NAMASIN) (2003)
Lomboy-Cahayag Fish Sanctuary, Bohol	0.38	Visayan Sea	500 m^2	Uychiaoco *et al.* (2003)
Lanuza Marine Park and Sanctuary, Surigao del Sur	0.88	Southern Philippine Sea	500 m^2	Bringas *et al.* (2004)
Balingasay Marine Sanctuary, Pangasinan	0.64	West Philippine Sea	500 m^2	UP-MSI; Arceo *et al.* (2005)
Carot Fish Sanctuary, Pangasinan	0.83	West Philippine Sea	500 m^2	Salmo *et al.* (2005)
Brgy. Dikapinisan, San Luis Aurora	0.80	Northern Philippine Sea	500 m^2	PCRA conducted
Brgy. Dimanayat, San Luis Aurora	0.56	Northern Philippine Sea	500 m^2	PCRA conducted
Brgy. Dibayabay, San Luis Aurora	0.72	Northern Philippine Sea	500 m^2	PCRA conducted

Source: Author's own elaboration

Table II. Calculated Simpson's biodiversity indices across marine bioregions consensus. The next steps in applying CCT would build off of the current approach to cognition and apply the techniques to fisherfolk themselves.

The development of Barangay and Municipal approaches to the monitoring of marine resources could be built into a participatory tourism strategy which in part, engages youth. Municipal planning along the Pacific Seaboard needs to be a combination of local and large scale processes, due to the fact that much of the fish harvest involves highly migratory species. However, community-based action to establish and monitor fish sanctuaries and fisheries status is locally empowering and could be initiated and duplicated across the broader NPS bioregion. Further, complex considerations such as biodiversity can potentially be compared to other locations under other development strategies and provide a method for further spatial analysis as well as data to support inter-community enhancement programs and best practice transfer. Thus, biodiversity comparisons could be used to scale-up ecologically and focus on resilience regarding climate change (Bernhardt and Leslie, 2013). The biodiversity indices for the three MPAs in San Luis, when compared to other marine bioregions, indicate a high degree of variability. There is a need to expand upon this level of biodiversity assessment across environmental gradients to assist in determining effective long-term monitoring strategies. Further, an integration of existing tools such as the Simpson Index with local quantification of factors regarding socio-economics could lead to a broader tool for application in local and regional development plans.

The comparison of fish biodiversity within the three Barangays where PCRA was conducted infers that Dikapinisan has a more diverse reef fish community than that of Dimanayat and Dibayabay. Computation on biodiversity for Dibut was not possible due to a lack of available data. It is, however, perhaps important to note that Dibut has large number of fish families and abundance compared to the other Barangay considered (Table I). These results can be linked directly to the status of the corals of the area. Corals provide food and shelter and serve as nursing grounds to many fish species (Labrosse *et al.*, 2002). Considering the percentage of hard live coral from the current PCRA (Figure 1), the biodiversity of reef fishes increases as the percent cover of corals increases. Biodiversity in Dikapinisan is highest where the percentage of live hard coral cover was also highest for the sites studied. This is also true to the succeeding values recorded in Dibayabay and Dimanayat. These initial results demonstrate how local monitoring can be linked to resource assessment through biodiversity considerations. Development plans could, for example aim to increase the biodiversity in these sites as an approach to maximizing ecology and the fisheries sector and even tourism sustainability. Reef restoration, conservation measures and the re-establishment of specific species and groups of organisms such as sea grasses could best be considered as part of the Barangay and Municipal Development plans. These approaches could also be integrated with a tourism development plan that encouraged visitors and local high school youth to conduct specific activities as part of the local development process.

The Simpson Biodiversity Index could potentially be applied across the NPS and even to compare changes and/or difference in biodiversity between bioregions. Existing data allows us to compare marine bioregions within the Philippines at a limited number of surveys (Table II). While the Simpson's Biodiversity Index measures species richness and evenness, species that are not observed in a sample but are considered part of the community make no contribution to the index. In general, the results from the current work demonstrate the potential for further development of an integrated approach to biodiversity monitoring across and between bioregions. This could best be considered through a systematic and scientific assessment within the Philippine archipelago but perhaps needs to be piloted in one specific bioregion. A systematic approach to developing biodiversity monitoring across the NPS could be a step forward in desired strengthening (Wamukota *et al.*, 2012) of the science for MPAs and biodiversity conservation for the Philippines. A future study on designing a Philippine and/or Northern Philippine Sea biodiversity monitoring system could consider additional analysis such as genetic distance (McInerney *et al.*, 2012), food web models (Samhouri *et al.*, 2009) larger marine approaches (Greenstreet *et al.*, 2012) as well as socio-economics. However, the initial goal should be to establish an approach that can be done involving local expertise and limited budgets, for the purpose of maximizing comparative bioregional value. Systematic biodiversity indices among MPAs across marine bioregions could be used to develop comparison in detecting environmental changes and provide much needed (Buckland *et al.*, 2012) valid inferences on biodiversity trends through bioregions.

4. Future directions and recommendations

Based upon the surveys, the coastal Barangays of San Luis' marine and coastal resources are still in good condition. However, the threat of coral reef destruction and degradation continues as well as the possible issue of overfishing. Some of the challenges for local sustainability require larger scale biodiversity and ecological applications, such as consideration of regional biodiversity (bioregions) and the relationship to pelagic fish stocks. In these isolated communities with extremely limited economic alternatives, it is socially critical to insure that the pressure on the marine resources is within a sustainable harvest strategy. Tourism represents the primary option for the development of either alternative or supplemental livelihoods for fisherfolk and could be constructively based upon marine monitoring and management. Increasing the success of alternative livelihood projects might best be done by engaging the unrealized leadership potential of women, based upon their household management skills (Pajaro *et al.*, 2013b). Several other considerations should also be incorporated for effective alternative livelihood interventions. These include institutional involvement, development through democratic decentralization and education system, and sustainable development through continuous refinement and adaptation to local setting (Watts and Oatley, 2005). As part of the next action research cycle for the San Luis Barangay communities, there is a need to further investigate the culture in terms of science cognition and how that relates to spatial and temporal aspects of biodiversity and related management.

Coastal resource management (CRM) has come a long way in promoting Philippine sustainability; protecting and conserving marine resources. The signing into law of the Philippine Fisheries Code (RA 8550) in 1998 provided a tool to address the rapidly depleting coastal and marine resources. Local political will and available expertise for some form of pulsed facilitation of local action remains somewhat problematic in general. The Municipality of San Luis continues to advance through the CRM challenge by enhancing organizational relationships and bringing the community residents into the management system. Community participation is a good way of tapping local strengths and knowledge in promoting protection and conservation of marine resources as well as identifying valuable information on the issues and concerns that they are facing. Continued institutional and legislative support in this management endeavor will have positive effects in helping damaged marine habitats to recover and fisheries to be sustainable. Another milestone in CRM through which the municipality of San Luis can participate in developing management interventions is the Aurora MPA network. As part of the current intervention, representatives from Dikapinisan and the Municipal Agriculturist were able to attend the first Aurora MPA Congress. This helps to introduce municipalities to broader marine/coastal management frameworks, ecological scaling and best practice transfer. A network of MPAs organized at the provincial (Aurora) level provides an optimal approach to LGU engagement across the NPS bioregion. Best practice transfer of this Aurora province approach is now being considered through the application of the Philippine academic discipline of Development Communication (Pajaro *et al.*, 2013a) applied to the other nine provinces of the NPS.

MPAs can combat local problems and challenges associated with marine management and link communities to larger scale ecological considerations. Effective MPAs have been found to improve fisherfolks health and nutrition (Aswani and Furusawa, 2007; Gjertsen, 2005). Fisherfolk through MPA development and management can move toward stronger roles as stewards of the environment or Paraprofessional Ecohealth Practitioners (Anabieza *et al.*, 2010). The further use of CCT can assist in defining the related needs of both fisherfolk as direct beneficiaries and those of jurisdictions. The pilot use of CCT herein demonstrated the statistical measurement of cognitive perception for targeted education approaches to promote long-term marine sustainability and participatory social transformation. Progressions toward a comprehensive marine biodiversity conservation strategy will require further enhancement of both cultural awareness and engagement. Coastal biodiversity management can best evolve through community-based socio-economic considerations that encompass the linkages between forest, agricultural and marine ecosystems. The current work provides a low-cost technique to measure change in local marine biodiversity and the potential for quantitative consideration of down-stream results associated with management in these other ecosystems.

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Dr Marivic Pajaro's research and much of her biological work has focussed on aspects of coastal and marine management over the past several decades. Marivic returned to school mid-career to complete her doctorate on the study of indicators and participation associated with marine protected area management. After completing her doctorate at the University of British Columbia, Canada in 2009, Marivic returned to the Philippines and became a founding partner of the non-governmental organization Daluhay. She also helped develop a community-based research program at the Aurora State College of Technology. Marivic is currently working through the Research Department of the Haribon Foundation for the Conservation of Natural Resources.

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