Using local ecological knowledge and environmental education in resource management of abalone in Carot, Anda, Pangasinan

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ABSTRACT

The objectives of the present study were to (1) determine the local ecological knowledge (LEK) of abalone gatherers through interviews and mentoring, and assess the correspondence between scientific information and LEK, so that areas where local knowledge may be most useful in resource management could be identified, and (2) to empower selected gatherers/farmers with knowledge and technical skills through environmental education to help develop or build their capacity to become sustainable resource managers. The LEK of abalone fishers was determined using three complementary approaches – group interview, individual interview, and mentoring sessions.

Local fishers possess a wealth of knowledge about the interactions of species gained through many years of observations, and this knowledge may be useful in guiding biologists in ecological restoration or management regimes. Additionally, the fishers' LEK, validated by modern scientific ecological findings, could be a source of important and effective ideas in resource management. The knowledge of the abalone gatherers about important abalone fishing grounds should help in pinpointing critical areas that need to be managed. Abalone mariculture in cages should be set up in these areas to routinely create dense breeding populations which can help in enhancing recovery and in providing fishers with a source of additional income. The continued enforcement of marine protected areas and the periodic release or re-seeding of abalone in sanctuaries could also be considered viable resource management options. Other recommendations for resource management based on gathered local knowledge and lessons learned from the environmental education (EE) seminars are also presented.

Keywords: Abalone, local ecological knowledge, environmental education, resource management

INTRODUCTION

The coastal ecosystems of the Philippines are some of the most productive and biologically diverse in the world. However, these coastal ecosystems are under severe stress from the combined impacts of human overexploitation, physical disturbance, pollution, sedimentation, and general neglect.

Unregulated harvesting of commercially important fish and invertebrates is rampant and the lack of resource management is a problem. One example is the abalone resource of Anda, Pangasinan, which has been degraded by activities related to rapidly expanding human populations such as overharvesting and destructive fishing (e.g. destroying rocks which are known habitats of cryptic abalone, cyanide fishing, etc.). One possible option for resource management is to educate local fishers to develop a corps of local resource managers who would promote sustainable fishing practices and resource conservation in Carot, Anda, Pangasinan.

In developing countries, many sites are poorly studied because of remoteness; in such areas, local or indigenous peoples may be the only source of biological information (Johannes, 1982; Poizat & Baran, 1997; Aswani & Hamilton, 2004). Through years of observation, local people acquire a wealth of knowledge about the interactions of species, and this knowledge may be useful in guiding biologists in formulating ecological restoration or management schemes (Drew, 2005; Gilchrist et al., 2005). Moreover, soliciting local knowledge could also help identify areas of concern for communities and resource users, making conservation and management more locally relevant.

Hence, in this study, the objectives were to (1) determine the local ecological knowledge (LEK) of abalone gatherers through interviews and mentoring, and assess the correspondence between scientific information and LEK, so that areas where local knowledge may be most useful in resource management could be identified, and (2) empower six selected gatherers/farmers with knowledge and technical skills through environmental education, to develop their capacity to become sustainable resource managers.

MATERIALS AND METHODS

Compilation of local ecological knowledge (LEK)

Data on the fishers'LEK were collected using three complementary methods – group interview, individual interview, and mentoring sessions during the Environmental Education (EE) sessions. In all cases, data were recorded digitally and in a notebook, and maps and charts were used where applicable. Data gathering was conducted in January to September 2011.

The group and individual interviews began by outlining the objectives and procedures of the interview; this was done to secure the fishers' cooperation. Additionally, the benefits of the study for the community were explained. The researcher also took care to develop trust and mutually respectful relationships with the cooperators and enter into a dialogue on terms set by them, who are the holders of local knowledge (Drew, 2005).

Focused group discussion/group interview with abalone gatherers

The group interviews were conducted through informal meetings or dialogues with groups of local informants that included abalone fishers, elders, and the youth from the local community. This method helps in determining if there exists a consensus among the informants and allows both informants and scientists to better understand one another's perspectives (Fraser et al., 2006).

To facilitate data gathering, an interview guide was developed. A half-day group interview was conducted in Barangay Carot in coordination with the Office of the Municipal Agriculturist and the concerned barangay captain. Selected community members who were able to provide information on particular subjects based on their local knowledge, skills, and experience were invited to participate in the activity.

It was important to include older community residents since they could provide information about biology over longer periods of ~40 years. Older fishermen are

familiar with environmental changes that younger residents might not have observed. For instance, a reduction in abalone sizes in the past decades might have been observed by people with longer fishing experiences but not by those who have been fishing for only a few years.

Individual interview with identified cooperators

For the individual interview, the same interview guide used in the focused group discussion was employed. The advantage of the one-on-one interview is that it allows for in-depth clarification and follow-up or probing questions.

As a form of validation, the informants' LEK were compared with available scientific information. Further clarification and validation were also sought during the EE sessions and meetings with the informants.

Mentoring sessions

A third and final method of gathering information about LEK was undertaken during the process of EE sessions and meetings. Meetings, one-on-one or group, were done regularly to discuss results and share experiences and reflections.

Selected environmental education (EE) programs/strategies

Experiential activity: abalone mariculture

This activity was done following the Farmer Field School (FFS) concept and was designed to be experiential, participatory, hands-on work. Six abalone gatherers participated in this activity.

The activity addressed both management and economic needs, and was envisioned to contribute to increasing abalone populations while heightening the fishers' ecological awareness and knowledge of the life history of abalone and its culture. At the same time, abalone mariculture was viewed as a potential means to provide supplemental livelihood to the fishers. There are existing abalone mariculture protocols available (Capinpin et al., 1999).

EE seminars

Three seminar modules (Biology and Culture of Abalone, Basic Marine Ecology, and Resource Management Options) were provided to the cooperators and other interested members of the community. Seminars were conducted and the contents of the modules were translated into the vernacular using simple terms. Activity-based modules were also provided during the EE seminars, such as identification of seaweeds, drawings, motivational exercises, games, and reflections to help the participants gain a better understanding of the topics.

Field trips

The cooperators went on field trips to an abalone hatchery at the Bureau of Fisheries and Aquatic Resources (BFAR RMaTDeC) in Alaminos City and a sea cucumber hatchery at the UP Marine Science Institute in Bolinao. This activity was intended to supplement the EE seminars, so that the cooperators will be able to better appreciate the issues discussed in the seminars.

Film/Video showings

Documentary film showings on abalone and its culture and on marine protected areas (MPAs) particularly in Region 1 (localized examples) were shown to enhance the knowledge and interest of the participants on resource management options.

RESULTS AND DISCUSSION

Determination of local ecological knowledge

Knowledge on sites/locations of abalone habitats

Many research projects are being conducted in remote, infrequently visited areas. Local people can aid researchers by furnishing information about species presence and distribution (Poizat & Baran, 1997), juvenile habitats (Aswani & Hamilton, 2004) or spawning aggregations (Johannes, 1982).

The local cooperators in this study have knowledge of the sites where abalone can be found (Table 1 and

Figure 1). They also have peculiar names for some islands/islets not seen on the map. All of the names used for the location of abalone fishing grounds date back to the past except for one, Cory Island, which got its name from former President Corazon Aquino.There are also places where abalone can be found but with no special name such as "sa tapat ng Imbo". However, the cooperators cannot pinpoint the location of recently-settled abalone post-larvae or the places where very small abalone (<1 cm) can be found. This was not surprising because of the cryptic coloration and habits of small abalone.

Most of the cooperators in Carot collect abalone at "Mitumpa" or "Mindanao" because they are near their residence and can be easily reached using only bamboo rafts or balsa. The fishers also have favorite areas for collection because these are where they can find more abalone. In nature, all adult abalone grounds are also the settlement places for abalone larvae. This is because

Table 1. Abalone collection sites known to gatherers

Abalone Collection Site	Local Meaning	Other Meaning in Filipino
Mitumpa	The sound and movement of merging strong waves remind one of the handclap (mitumpa in the vernacular)	"Nagsasalubong ang alon"
Mindanao	The extensive use of dynamite has caused accidents which, in many instances, have led to the amputation of their victims' arms	"Kasi yung mga nag-didinamita napuputulan ng kamay"
Saloy putot	There is a sudden drop-off in the water's depth	"Putol yung lalim niya dahil sa biglang pagbabaw"
Pangrapogan	This area is exposed during low tide, allowing fishermen to cook there	"Pag-ihawan"
Mâdol	The water in the area is too shallow, giving a sense of bumping into the sea floor when one dives into it	"Pag sumisisid parang nauumpog sila"
Imondayon	The bottom topography is shaped like a moon	"korteng duyan"
Purod alaki	"Alaki" means wide	"Malapad na batuhan"
Purod daikling	"Daikling" means small	"Maliit na batuhan"
Tapat ng Imbo	Front of Imbo	

abalone do not migrate far from their natal reef; they also have short planktonic phase. It means that the areas where adult abalone can be found also are the settlement areas of larvae.

According to the cooperators, they can collect more abalone during spring tides ("*kapag malaki ang kati"*). This is especially true for gatherers at night because spring tides occur during new and full moon periods, which are the known spawning periods of abalone. Hence, during this time, most mature abalone are out of the crevices.

Knowledge of spawning patterns

Because many indigenous peoples view their environment in a holistic fashion, they have a sense of the linkages among various ecological processes, multiple species, and abiotic factors that influence species biology (Nabhan, 2000; Vogt et al., 2002). For instance, in this study, the knowledge of the spawning patterns of the abalone by local people closely matched the one formalized by researchers. According to the fishers, they were able to observe the abalone's spawning every full moon and new moon periods. The informants have noted that during spawning, the abalone release a cloud of smoke ("*nagpapausok sila"*) with their cephalic tentacles extended. This happens beginning 11-12 pm up to 2 am.

In an earlier study, abalone were observed to spawn year round and the spawning events coincided with the new and full moon for recently captured *H. asinina* held in tanks (Capinpin & Hosoya, 1995). This lunar periodicity in spawning lasted for two months. Spawning still continued every two weeks thereafter but no longer coincided with the lunar cycle. In *H. asinina*, the time interval between successive spawning of hatchery-reared abalone provided with optimal rearing conditions and adequate algal food was 13-15 days (Capinpin et al., 1998). Similar results were observed in Australia and Malaysia (D. Nair, University Sains Malaysia, personal communication). During the spawning season in Australia, recently-captured abalone held in aquaria released gametes for two nights every two weeks during the new and full moons (Counihan et al., 2001). The researchers observed that the time of spawning of either sex is highly correlated with evening high tides; males spawned about 19 min prior to high tide and females spawned 11 min after high tide. Synchronous spawning patterns persisted for six weeks; after this period, spawning continued but were irregular and asynchronous.

In the Bolinao hatchery, *H. asinina* spawning begins at 10 pm and lasts up to 2 am. Males usually spawn first, their cephalic tentacles extended in order to detect spawns from other abalone. Milt from male abalone usually stimulates other nearby male abalone to spawn. Females spawn after the males, and this ensures synchronous fertilization upon the release of eggs from female abalone (Capinpin & Hosoya, 1995).

The fishers' knowledge about abalone's habitat and spawning behavior could help generate future management plans. For instance, in the present study,

Table 2. Recommendations for abalone resource management based on gathered local knowledge

Local Ecological Knowledge	Resource Management
Knowledge of spawning pattern	1. Imposition of catch quotas for night gatherers 2. Imposition of closed/temporarily-closed season
Knowledge of abalone habitat	1. Setting up of abalone mariculture to help protect breeders and supply off-spring to these areas 2. Setting up of abalone sanctuary

the knowledge of the abalone gatherers on important abalone fishing grounds will help in pinpointing critical areas that need to be managed. Perhaps, abalone cage culture should be set up in these areas to help in protecting adult breeders and help in supplying offspring to these areas. The continued enforcement of marine protected areas and reseeding of abalone in sanctuaries can also be considered viable resource management options. Table 2 presents the recommendations for abalone management to the LGU based on collected information from local informants during interviews and mentoring sessions.

An example of protected areas management that had its origin in traditional knowledge can be found in Gladden Spit in Belize. Gladden Spit is an area of the Mesoamerican Barrier Reef located off the coast of Belize, which has long been known by fishers as a spawning aggregation site for mutton snappers (*Lutjanus analis*). Local fishers have known about this area since at least the 1920s (Heyman et al., 2001), but the aggregations remained unreported in the scientific literature until 2001. Additional examples of spawning sites that have gained protected-area status through the interaction of traditional fishers and researchers can be found in Palau (Johannes et al., 1999), the Solomon Islands (Aswani & Hamilton, 2004), and Glover's Reef in Belize (Sala et al., 2001).

There is growing recognition that ecological knowledge can and should play an important role in wildlife conservation, particularly in remote areas where standard scientific approaches may be impractical or difficult to apply (Gilchrist et al., 2005; Fraser et al., 2006). LEK can be a useful companion to standard scientific approaches provided that it has undergone rigorous testing prior to its incorporation into management plans (Gilchrist et al., 2005; Rist et al., 2010). LEK helps to engage local stakeholders as part of a team addressing a shared conservation concern, an approach that generally yields more productive results than scientific studies alone.

Environmental education (EE) modules/ strategies/approaches

The EE seminar modules can serve as a venue for the cooperators to enhance their ecological awareness. In one of the EE seminars on resource management options, the researcher discussed the different management options specifically for abalone, one of which is mariculture. It was reiterated to the participants that mariculture activity can be used to address both management and economic needs. This strategy can be a potential source of supplemental livelihood for the community. At the same time, it was envisioned to contribute in enhancing depleted abalone stocks while improving the people's ecological knowledge. Residents should be taught that they should harvest only the sexually mature individuals at the right time, and that they should leave a few abalone to reseed the area for future replenishment.

EE seminar on abalone biology and culture

The EE session on the biology of abalone and its culture was held on March 23, 2011 at the Barangay Hall of Carot. To capture the audience's interest, the session started with a presentation on the different abalone species of the world (*Haliotis rufescens, H. discus hannai, H. iris*, etc.). The advantages of abalone culture in the Philippines, as compared to temperate countries, such as fast growth rates, availability of suitable sites and seaweeds, were noted. Highlighted in the discussion was the biology of abalone, with emphasis on its life cycle. This gave the cooperators an understanding and appreciation of the development of abalone from eggs to sexually mature individuals. The cooperators also realized the significance of allowing abalone to spawn before they are harvested to ensure the replenishment of remaining natural stocks. It was pointed out to the participants that it was important to put together sexually mature individuals during spawning (e.g. mariculture cages) to ensure fertilization success which, among abalone, happens outside the bodies of the parents (external fertilization). Additionally, posters and a film (local example aired on *Kapuso Mo, Jessica Soho*) on abalone culture and its life cycle were also shown to give participants a better appreciation of the experiential abalone mariculture project that they carried out.

EE seminar on basic marine ecology

The Basic Marine Ecology Seminar was held on May 9, 2011. The seminar took place at the house of Mang

Junior, one of the cooperators who joined the abalone mariculture activity. Prior to the seminar proper, a video presentation on abalone hatchery practices was shown and a motivational exercise was given to the participants. Highlighted in this seminar were discussions on the concepts of ecosystems and basic ecology terms such as food chain, habitat, niche, photosynthesis, producers, consumers, etc. A brief discussion on the important features of the marine environment, the different types of marine organisms, and the different marine ecosystems such as coral reefs, mangroves, seagrass, and estuaries also was provided. The discussions were linked to the seven environmental principles, especially when giving examples of human impacts on the environment.

Field trip

In the morning of May 27, 2011, the group went on a field trip to Bolinao Marine Laboratory of the University of the Philippines - Marine Science Institute (UP-MSI). The first activity undertaken was an orientation on the projects of the research staff of the Invertebrates Laboratory. Highlighted in the orientation was the community-based project on sea urchin culture and reseeding of protected areas, which resulted in the recovery of the sea urchin population in Bolinao and nearby areas. The orientation was followed by a brief presentation on the progress of the research staff's current research on the culture and resource management of tropical sea cucumbers. The venue also allowed for an exchange of ideas between the research staff and the group of cooperators.

After the lecture-orientation, the group toured the algal room and also viewed the exhibit about the other studies completed and currently being done by UP-MSI on seaweeds, giant clams, corals, etc. The cooperators expressed appreciation for the type of work of the research staff, which involved simulating the work of nature (i.e. artificial propagation of seeds), as well as strengthening resource management. The participants themselves witnessed the recovery of sea urchin population in their coastal area in recent years and they now understood clearly the rationale of culturing sea urchin in cages to serve as reproductive reserves to supply offspring to different areas and reseeding some in protected areas. They appreciated this new knowledge which can be applied to abalone and other marine resources in their area.

The group made a side trip to the Bolinao Museum on the way to the Bureau of Fisheries and Aquatic Resources (BFAR) Abalone Hatchery in Alaminos City. The cooperators enjoyed viewing the natural sciences section, which contains display of different types of rocks, a fossilized bill fish from the Pleistocene Period, preserved organisms such as birds and aquatic organisms, and dioramas depicting different aquatic ecosystems of Bolinao such as coral reefs, mangroves, etc. There was also an anthropological exhibit showing the evolution of early tools of Bolinao townspeople.

After lunch, the group proceeded to BFAR Alaminos to visit the abalone hatchery. During this visit, they learned and appreciated the life history of the abalone and the critical life history stages that are vulnerable to unsustainable fishing practices. After the tour, the group had a brief meeting with the hatchery technician to discuss their concerns and observations. It was also an opportunity for them to ask assistance for such concerns as the possible supply of healthy abalone juveniles and technical help in the future.

EE seminar on resource management

On June 7, the last segment of the EE seminar series on Resource Management Options was held. Prior to the seminar proper, the cooperators viewed a video showing titled "On These Grounds". This film about the benefits of marine protected areas was produced by BFAR Region 1 and featured examples from Pangasinan. The film features the different environmental advocates of various MPAs in Pangasinan such as barangay captains, students and teachers, i.e. people who are familiar to the cooperators. Hence, they found the film showing interesting and personally relevant.

The film showing was followed by a game called "Fishing Game/Open Access" (Deguit et al., 2004). In this game, cut-out pictures of different marine

organisms were posted on different areas of the room, with some pictures hidden (behind curtains, under chairs) and some visible. The participants were asked to fish for the organisms. The person who fished the most number of organisms won the game and was given a prize. As expected, the participants scrambled to catch as many fish as they could. It was pointed out to them that if the training area was physically a coastal habitat, it would now be destroyed due to the frenetic fishing activity. It was explained to them that this game showed how open access fishing causes depletion of resources. As such, this activity illustrated what is now happening in the country, and the urgent need for coastal resource management.

A good example of resource management for abalone done in Tawi-Tawi by researchers at Mindanao State University was shared with the participants. The project involved translocation of adult abalone in a sanctuary. After only 10 months the researchers already observed a multiple increase in recruits (R. Tajil, personal communication).

The ensuing discussion revolved around fishery regulations and environmental interventions (Juinio-Meñez et al., 2000). Fishery regulations include closed and open seasons/areas, catch and size quotas, and prohibition of illegal fishing methods. Environmental interventions include habitat enhancement/rehabilitation, mariculture/sea ranching, reseeding/transplantation, marine protected areas, and pollution regulation. It was noted that the mariculture of abalone in sea cages undertaken by the participants was actually one resource management option.

During this seminar, there was a lot of discussion on what resource management options the participants would like to take. One of these is the community-based culture of abalone. There was a fruitful exchange of ideas. There was also a discussion regarding what

Table 3. Recommendations for abalone resource management based on lessons learned from the EE activities

EE Activities	Resource Management
Biology of abalone/Resource management	1. Only abalone that meet the minimum size limit of 5 cm should be harvested 2. Ban on destructive fishing practices (i.e. destroying rocks to gather cryptic abalone) 3. Stricter enforcement of existing MPAs (i.e. Carot MPA which is actually an abalone fishing ground) 4. Conduct EE activities in other areas with the help of corps of enlightened abalone fishers in this study as resource persons 5. Impose closed/temporarily-closed season
Experiential mariculture	1. Setting aside a portion of harvest to reseed MPAs or abalone sanctuary 2. Harvest only sexually mature abalone (i.e. 5 cm) 3. Consider setting up a network of marciulture cages in different areas to serve as reproductive reserves, or lobby for limited exclusive use rights for a mariculture area 4. Continue mariculture and involve other community members in this activity

the participants could do to help raise the ecological awareness of the rest of the community. During the discussions, they realized the importance and the potential of the mariculture activity to enhance the recovery of abalone resources and they would like to continue the activity even after the current research was completed. They also realized the potential of saving some of their harvest for reseeding a nearby marine sanctuary.

Essential to building local capability for coastal resource management is raising awareness of other members of the community. This can be done through information dissemination about the activities being done by the group related to resources management, such as the abalone mariculture. This can take the form of informal conversations with fishers and between fishers, which has proved effective in convincing the other members of the community of the ecological and economic relevance of the resource management related activities of the group. Other mechanisms include regular group meetings, EE seminars and field trip, all of which could be attended by other members of the community.

The confidence generated by these formal and informal activities can convince more local residents to set up their own grow-out cages and practice sustainable fishing activities. Table 3 presents a summary of the recommendations for resource management of abalone based on lessons learned from the EE activities.

Final assessment meeting

On September 20, 2011, the group had their final assessment meeting to evaluate the abalone mariculture activity that they did (reported elsewhere) and other activities. The meeting was presided by the researcher as well as the group leader. It was attended by the Municipal Agriculturist, Ms. Elizabeth T. Tomas, who also represented the Municipal Mayor Aldrin Cerdan. The municipal agriculturist is the one in charge of updating and spearheading the various coastal resources management plans and activities of the town. Hence, the group decided that it would be proper and beneficial to be able to voice out their plans and concerns regarding their coastal resources to Ms. Tomas.

Discussed during the meeting were the various EE activities taken, lessons learned from the abalone mariculture activity, and recommendations to further improve the mariculture activity as a supplemental livelihood. The meeting also became a venue for the cooperators to discuss their experiences and opinions regarding the various EE activities. Ms. Tomas, who has more than 20 years of experience in coastal resources management, reiterated and reminded the attendees that it is urgent to conserve not just the abalone resources but all other important marine resources for use of future generations. She also emphasized that mariculture activity using small wild juveniles should be continued as well as other sustainable activities like regulating the harvest of abalone and other marine resources.

The municipality, through the efforts of the Office of the Municipal Agriculturist, also plans to incorporate the fishers' recommendations into their coastal resource management plan, which will feature, among others, setting a legal size limit of 5 cm for abalone, prohibition of illegal fishing activities that threaten abalone habitat such as cyanide and dynamite fishing, and stricter enforcement of the network of MPAs in Anda when it is time to update their CRM plan.

Need for sustainable resource management

The abalone fishery of Anda provides a significant source of employment and income to the coastal community. From a socio-economic perspective, the long-term sustainability of abalone fisheries is of great importance to coastal communities. Unfortunately, abalone stocks have been overfished in many areas as a result of ever-increasing market demand, uncontrolled exploitation and/or inadequate fisheries management.

Unless the direct users and the policy makers are educated about the status and proper management of their resources, a cascading event of overexploitation of different species may eventuate. For instance, overfishing is the main problem contributing to the depletion of sea cucumber resources. Except for Japan, other Asian countries are generally lacking in management measures to conserve and sustain their sea cucumber fisheries. The two most important

producing countries, Indonesia and the Philippines, do not have management plans specific to sea cucumber conservation (Bruckner et al., 2003). It is not surprising that there are also no management measures for conserving abalone resources that exist in the Philippines.

In Asia, Japan has the longest history of managing sea cucumber resources. Mitsukuri (1903 as cited by Choo, 2008) noted that for hundreds of years, the people of Oki Island used to put up loose stone piles in the shallow seas to provide adult *A. japonicus* a place to aestivate, and metamorphosing larvae and juveniles to aggregate. Japan has enforced regulations setting aside certain localities as breeding reserves where stone piles have been constructed, and in these places, sea cucumber fishing is strictly prohibited.

In Anda, enhancing abalone habitat by placing stones and boulders in the sea may not be that urgent. What is more important is the strict enforcement of MPAs that are already identified. Anda has five MPAs situated in Carot (13.3 ha), Cabungan (18 ha), Caniogan (9.8 ha), Magsaysay (14.8 ha) and Panacalan (48.59 ha). The MPAs in Carot and Cabungan were the earliest established (1998) while Panacalan is the most recent (2003) (Salmo et al., 2005).

In the broad context, MPAs are areas managed to enhance conservation of marine resources. MPAs are believed to serve as a management tool by supplementing fished stocks in surrounding areas (Sale et al., 2005). MPAs may be particularly useful alternative for abalone management because effective spawning and fertilization seems to require high densities of spawners, which may not occur in most of the "open" fishing grounds (Bell et al., 2008).

When it comes to sustainability, one of the very important things to consider is for the coastal fishers to reduce pressure on their marine resources by identifying other means of livelihood that are also sea-based. For this reason, the option of mariculture of abalone should be explored to address both resource management and the development of livelihood. As a resource enhancement activity, mariculture guarantees that abalones of high economic value are allowed to grow to sexual maturity before they are harvested. Mariculture also ensures that some reproductive individuals are left for reseeding. As supplemental livelihood activity, the cultured abalone can help supplement the food and income of the communities. This resource conservation strategy had worked well with sea urchins in Bolinao as a result of the intervention of the UP-MSI, as discussed earlier. Presently, the sea urchin industry in Bolinao has been revived and is thriving very well.

The most important actions for fisheries managers are sociological in nature, indicating that management of abalone stocks must embrace social science more strongly than in the past. This can be achieved with greater involvement of stakeholders and capacity building of local-level institutions. Agencies with modest capacity for developing management plans and enforcement should at least apply a minimum set of the most important and simple regulatory measures and actions in implementing management. Hence, it is important for LGUs to have a management plan featuring at least the minimum regulations (i.e. regulations imposed on fishers) and actions (by the manager). Regulations may include a minimum legal size limit (5 cm for abalone), ban on destruction of rocks, marine reserves, licensing, monitoring, and reporting along the market chain. Actions should include the conduct of fishery-independent stock surveys, of fishery-dependent surveys of catch and effort, of socio-economic surveys, and education programs for various stakeholders.

There should be a size limit or a minimum length or weight of abalone that can be legally fished or traded. Two principal purposes of size limits in fisheries are to protect juveniles and to allow recently matured adults one or more seasons to spawn before they can be fished (Purcell et al., 2009). Minimum size limits must therefore have some biological basis, corresponding to the size at which individuals first become mature plus some additional buffer so that they have time to contribute to spawning. A recommended conservative approach is to add some centimeters to the minimum size at maturity which, for *H. asinina*, is 3.5 cm (Capinpin et al., 1998).

By setting the size limit at 5 cm, individual mature abalone could have significantly contributed to replenishment of larvae in surrounding areas for several months and aided in the recovery of depleted abalone populations before they are harvested. Purcell et al. (2009) also recommend that fishery managers prepare simple plastic rulers, with graduations to give to fishers, which they can use to verify sizes of animals in the water.

The objective of enhancing the recovery of natural abalone populations through community-based mariculture and through selective harvesting (i.e. the harvest, collection, and sale of abalone that have reached the agreed legal size limit of 5 cm), will largely depend on the success of the expansion of the activity to other areas, and hence will depend on the institutionalization of a system that will grant limited exclusive use rights for fishermen to set up sea cages in their areas and/or granting subsidy in the form of hatchery seed stock which the farmers could use in this activity.

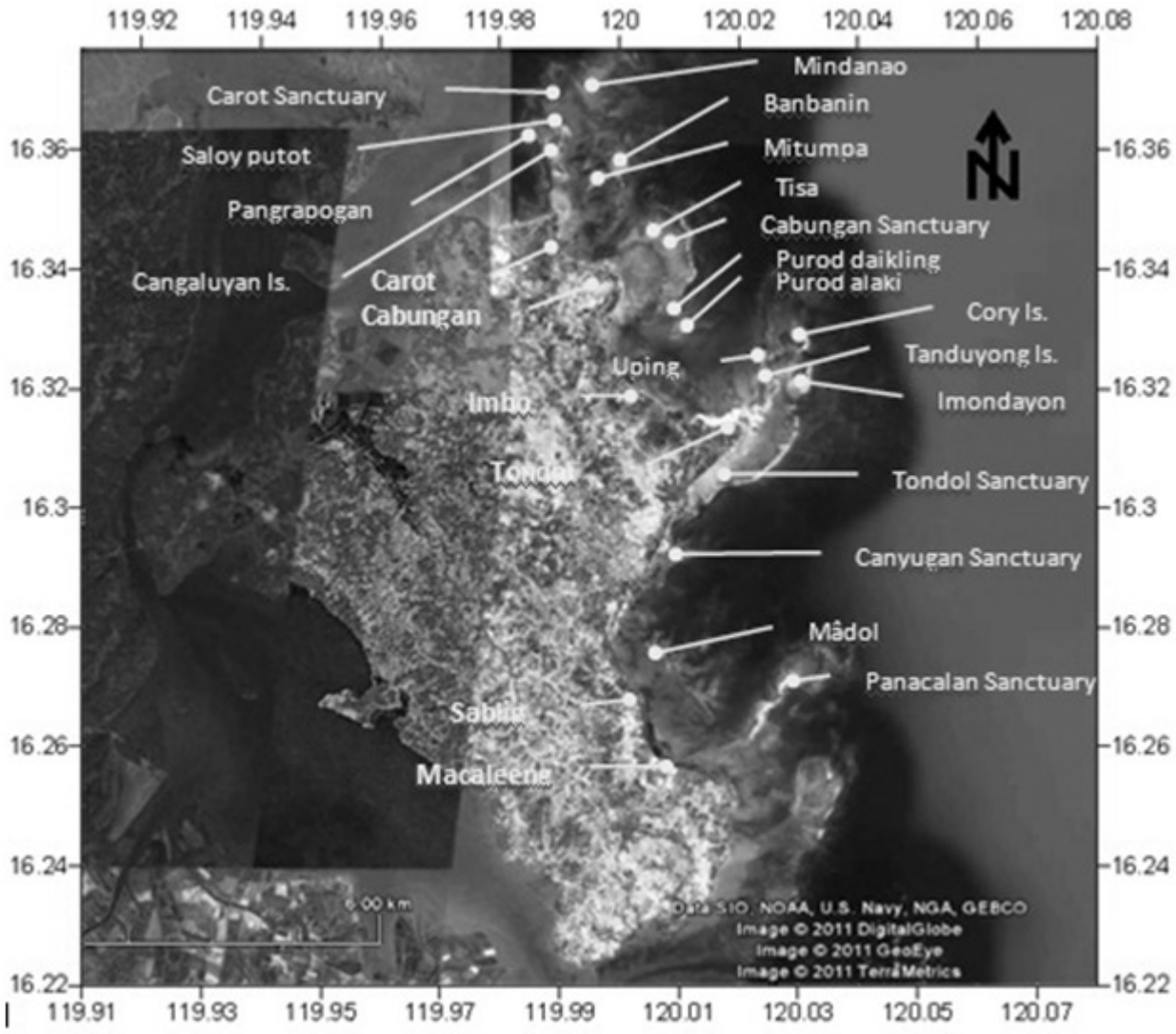

Figure 1. Map showing the location-specific knowledge of the cooperators regarding known productive abalone grounds in the island municipality of Anda in the province of Pangasinan

There are still many gaps in our current knowledge of abalone biology and fisheries. Nonetheless, it should be stressed that uncertainty should not prevent the development of operational management strategies that aim to maintain or rebuild the productive capacity of abalone fisheries and to safeguard the long-term social and economic benefits to local communities. The LEK and the lessons gained from the EE activities can be used as inputs in formulating management plans for abalone resource management by the LGU in Anda, Pangasinan, which should be incorporated into the larger, more encompassing coastal resource management plan.

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