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ORIGINAL RESEARCH PAPER

The way forward to sustaining coastal fisheries through implementing the aquasilviculture program

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ABSTRACT: Declining fish catch, conversion of mangroves into fish ponds and overexploitation of coastal resources were rampant among the coastal areas of Philippines. Hence, the national government initiated the implementation of Philippine National Aquasilviculture Program aimed to achieve food security, promote sustainable development of fisheries resources, and reduce poverty incidence among fisherfolk and other disadvantaged groups. To this, the Mindanao State University at Naawan served as the academic partner of the Bureau of Fisheries and Aquatic Resources Region 10 in implementing three major projects namely, mangrove plantation, aquasilviculture and king crab hatchery in the community. Several people's organizations in Misamis Oriental, Misamis Occidental and Lanao del Norte served as the project beneficiaries and implementors, particularly on mangrove plantation and aquasilviculture projects. After a year of mangrove planting, 621,852 living propagules survived (48.47%) from 1,282,770 propagules planted. In terms of aquasilviculture project, bangus cultured had a harvest of 3,513 from 4,500 juveniles reared, while only 50 individuals matured crabs were harvested out of 8,700 crablets raised simultaneously with the bangus in the same aquasilviculture pens. Hatchery of king crab attained ~1% zoeas that turned to megalopa stage. Only few reached to crablet stage due to severe cannibalism and microbial contamination. Major challenges of the project included the lack of support from local governments, internal issues of the organizations and natural disturbances like storm occurrences. All issues and concerns were brought to the partners people's organizations and Regional Steering Committee for further deliberations and appropriate actions should similar projects be undertaken in the future.

KEYWORDS: A*quasilviculture; Ccoastal Resources; Fisherfolk; Mangroves; Philippine National Aquasilviculture Program (PNAP)*

INTRODUCTION

Mangroves are woody plants that inhabit the upper intertidal zones of saltwater areas, primarily in tropical and subtropical coastal regions around the world. The term "mangrove" describes both the ecosystem and the plants that have developed specialized adaptations to live in a coastal environment. They are valuable sources of forest products (e.g. Firewood, timber, medicinal and others) and aquatic resources which are beneficial to local economies in approximately 123 countries/territories (Luther and Greenberg, 2009; Dieta

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and Dieta, 2015; Kathiresan, 2012; Carter *et al.*, 2015; Friess, 2016). Mangrove forests are commonly viewed as biodiversity-rich ecosystems on earth and provide a variety of niches to organisms at various trophic levels, where these organisms are dependent for survival (Maiti and Chowdhury, 2013; Hendy *et al.*, 2014). They also protect the inland communities living near the forest from damage caused by coastal erosion and storms. However, due to increased anthropogenic pressures, primarily from unregulated human interventions such as timber cutting, aquaculture and coastal development, mangrove forests are declining worldwide. As such, much research has been carried out on mangroves in the last 50 years. In fact, in 2010, there were more than 8,000 publications on mangrove indexed by the Web of Science (Polidoro *et al.*, 2010; Van Loon *et al.*, 2016; Lee *et al.*, 2014; Andradi-Brown *et al.*, 2013; Motamedi *et al.*, 2014). The goods and services provided by these ecosystems are so important for our needs and survival, yet the widespread decline would bring drastic consequences. (Mukherjee *et al.*, 2014).

One of the crucial issues in coastal development, based on the use of natural resources, is on how to integrate economic development, while mitigating negative impacts and problems in the future leading to natural resources conservation and environmental sustainability (Malik *et al.*, 2015). Globally, mangroves are disappearing at an alarming rate of 1 to 2% per year, faster than the adjacent coral reefs or tropical rainforests (Chen *et al.*, 2009; DasGupta and Shaw, 2013; Nwosu and Holzlçhner, 2016). In the Philippines, 76.6% of the mangrove areas were lost in less than a century with an estimated national deforestation rate of 4,432 ha/year between 1951 and 1988. The deforestation rates in the mangroves are four times greater than those in terrestrial tropical rainforests (Flores *et al.*, 2015; Blanco *et al.*, 2012). The lost mangrove may eventually lead to reduced coastal water quality and biodiversity, and altered nursery and habitat for fish, mollusks and crustaceans. This, in turn, affects the adjacent coastal habitats which will remove a major resource for human communities that rely on mangroves for numerous products and services (Sahu *et al.*, 2015). To address such problems, increased mangrove plantation and rehabilitation programs have been implemented. Mangrove reforestation and management are being promoted enthusiastically by governments, non-governmental organizations, and aid agencies throughout South and Southeast Asia, and increasingly in Africa, the Caribbean, and Latin America (Walters, 2004). In the Philippines, there are more than 44,000 hectares of mangroves planted during the past few decades (Samson and Rollon, 2008).

One third of the world's major fisheries had already collapsed by 2003 and many continue to decline. These worldwide declines of ocean fisheries stocks has provided a way for a rapid growth in aquaculture. The fish produced from farming activities currently accounts for over one quarter of all fish directly consumed by humans. Aquaculture has grown three times faster than agriculture, at an amazing rate of 8.3% per year since 1970 and provided 48.4% of the world's seafood consumed in 2009. In 2012-2014, the Philippines fish catch ratio increased regardless of the super typhoons and other natural calamities that hit the country. In Asian countries, one-half of the animal protein intake comes from fish, specifically, in the Philippines, they had an estimated average of 43% of their animal protein diet derived from fish (Naylor *et al.*, 2000; Cagauan, 2007; Diana *et al.*, 2013; Mukherjee *et al.*, 2014; Anticamara and Go, 2016). Other organisms good for farming is mud crab, and it is widely practiced in many Southeast Asian countries and Australia, that in turn, has resulted in higher prices in the local and international markets (Santhanakumar *et al.*, 2010).

In addressing the issues and concerns of depleting coastal resources in the Philippines, the Bureau of Fisheries and Aquatic Resources (BFAR) initiated the implementation of the Philippine National Aquasilviculture Program (PNAP). This program aims to achieve food security, promote sustainable development of fisheries resources, and reduce poverty incidence among fisherfolk and other disadvantaged groups (Dieta and Dieta, 2015; Masagca, 2016). Aquasilviculture is an environment-friendly enhanced fisheries production in the wild with aquatic organisms cultured within a mangrove area

without cutting down a single tree (Enate *et al.*, 2013).

As such, the Philippine National Aquasilviculture Program (PNAP) is established and implemented by the Bureau of Fisheries and Aquatic Resources Region 10 in partnership with the Extension Division of the Mindanao State University (MSU) at Naawan. PNAP is a community-based project that provides assistance to the duly registered and accredited people's organizations in the provinces of Misamis Oriental, Misamis Occidental and Lanao del Norte (Fig. 1).

Three major project components are implemented such as mangrove plantation, aquasilviculture of bangus and king crab, and king crab hatchery. These project components are implemented to enhance and restore the disturbed coastal habitats, to protect the residents from natural calamities like storm surges, to improve natural stocks of fisheries and to help and improve the livelihood of the people living near and within the coastal zones.

MATERIALS AND METHODS

Mangrove plantation

Entry protocol was done in the identified areas of mangrove plantation. Proper coordination was done with the Local Government Unit (LGU), Department of Environment and Natural Resources, Department of Agriculture, Barangay and People's Organizations (POs). Meetings were conducted for orientation and levelling-off of the project objectives. PO beneficiaries must be duly recognized by the LGU, and once agreed, a Memorandum of Agreement was initiated. A payment was made for every mangrove propagule planted, that is, Philippine Peso (PhP) 6.00 all in all after a year of planting. Validation and monitoring were conducted to

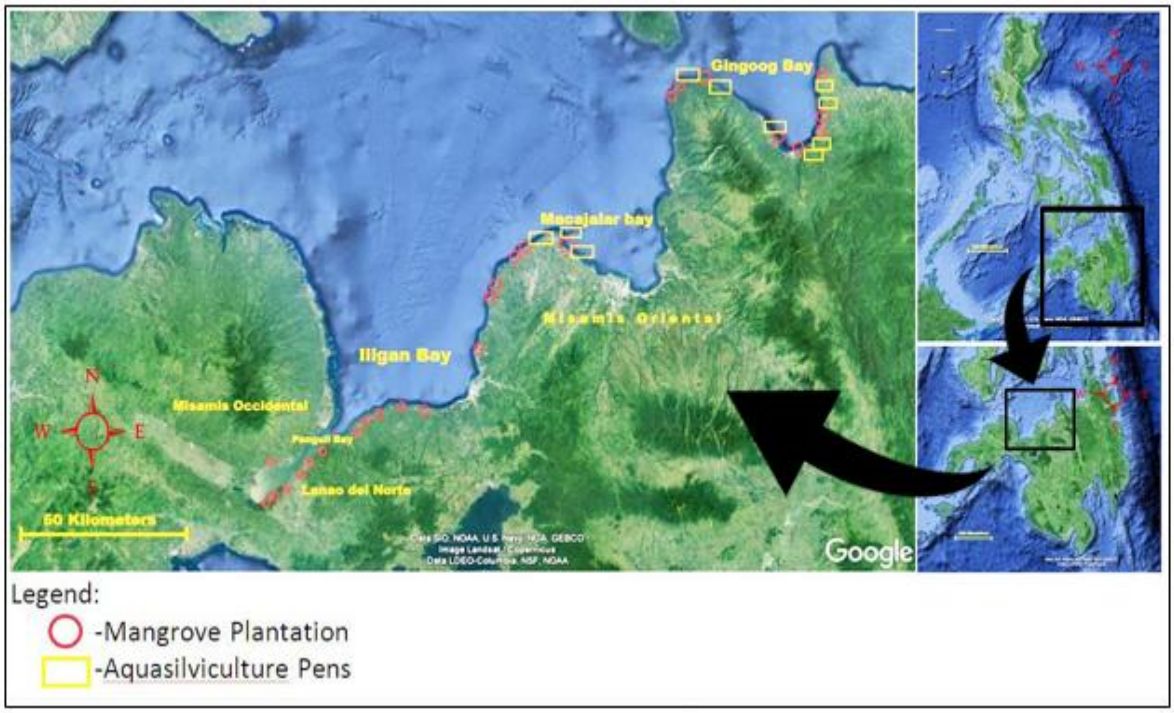

Fig. 1: The PNAP project areas in Region 10 in Lanao del Norte, Misamis Occidental and Misamis Oriental

ensure a higher percentage of mangrove survival after a year of planting. Standard planting schemes were followed based on the guidelines provided by the National Steering Committee of PNAP.

Aquasilviculture project

In aquasilviculture project, simultaneous rearing of bangus (*Chanos chanos*(and king crab)*Scylla serrate*(was done in one aquasilviculture pen inside a mangrove area. The construction materials such as bamboo poles and net enclosures for aquasilviculture pen measuring 10x10 square meter were given to the PO beneficiaries, as well as the cultured species and feeds. After one culture period, the established aquasilviculture pens were turned-over to the PO beneficiaries for future uses and management.

Community-Based Multi-Species Hatchery

Community-based multi-species hatchery was implemented by MSU Naawan in its wet laboratory. King crab (*Scylla serrata*) was reared; where gravid female stocks were obtained from the province of Surigao del Sur. Separate tanks for the brood stock were used, while the newly-hatched eggs were transferred to larval rearing tanks (LRTs). Constant watering and feeding management were observed until crablets were produced. Standard protocol for king crab hatchery from Southeast Asian Fisheries Development Center (SEAFDEC) was followed.

RESULTS AND DISCUSSION

Mangrove plantation

In PNAP 1 and 2 phases, there were 1,282,770 mangrove propagules planted with a survival rate of 48.47% equivalent to 621,852 survived after a year of planting in the three provinces of Misamis Oriental, Misamis Occidental and Lanao del Norte.

In the province of Lanao del Norte, there were 333,200 propagules planted in 67 hectares benefiting a total of 532 PO member beneficiaries. To this, a total of 130,788 mangroves survived after one year with a survival percentage of 39.25%. Less than 50% survival rate was attributed to various human disturbances and occurrences of typhoons that deposited huge amounts of debris and sediments onto the planted mangrove propagules. The achieved survival rate was attained in response to constant reminders to PO beneficiaries that they must do their roles in protecting the mangroves planted. It was emphasized to them that mangroves will provide the needed economic and ecological benefits for the present and future generations.

In Misamis Oriental, there were 920,428 propagules planted in 222.7 hectares and with the total of 510 PO member beneficiaries. It attained a survival percentage of 50.32% or 463,208 mangrove propagules survived after one year. Relatively similar anthropogenic disturbances (e.g. Gleaning and fishing and trampling of the propagules) and natural consequences were observed after spending a total amount of PhP 4,379,518.00.

In Misamis Occidental, there were 29,142 propagules planted in 6 hectares (ha) with only one PO beneficiary. A total of 27,856 mangroves survived after one year or 95.58% survival rate after spending an amount of PhP 171,637.00 (Fig. 2).

Aquasilviculture project

There were 8,700 crablets reared in 16-unit aquasilviculture pens, however, only 50 individuals were harvested in approximately 13.1 kg. This only accounted 0.57% success rate from crablets to marketable sizes of crabs. For bangus, the 4,500 fry reared had 3,513 matured marketable individuals harvested, hence a 78.06% success rate (Fig. 3). Bangus were harvested before typhoons occurred since many pens were destroyed, many crabs escaped from destroying pens resulting in little harvest.

On completion of the project, the PO beneficiaries could assess their losses as well as gains with aquasilviculture and are ready to build on their acquired experiences to improve the process. Lost could be attributed to the amounts of money spent despite the efforts, time and technical supports given. There were 8,700 crablets reared, yet only 50 individuals were harvested in approximately 13.1 kg amounting to about PhP 3,930.00, that is, assuming of a PhP300 price per kg. For bangus, it yielded an approximate income of PhP 98, 820.00, assuming that it was sold at P120 per kg. Thus, the total approximate income from aquasilviculture was roughly around PhP 102, 750.00, yet still was a deficit of about PhP 937, 250.00 of a total project cost of PhP1.04 million.

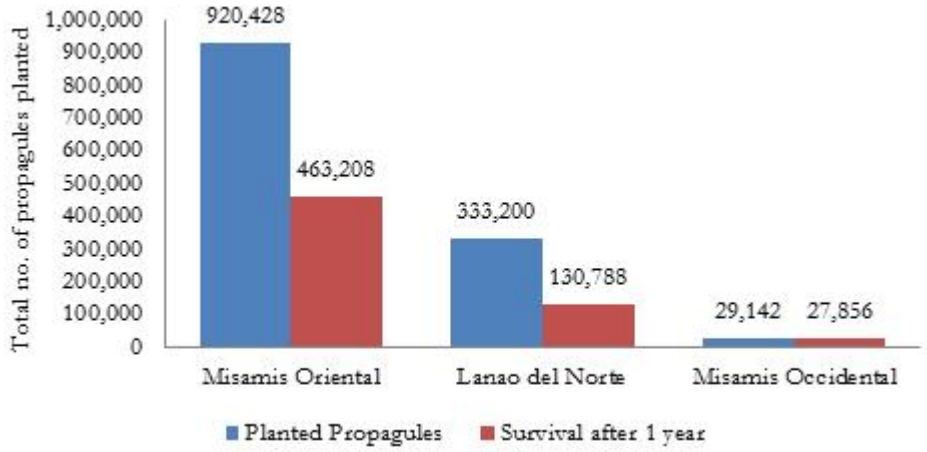

Fig. 2: Total number of mangrove propagules planted and mangrove survival after a year of planting in three provinces of Misamis Oriental, Misamis Occidental and Lanao del Norte.

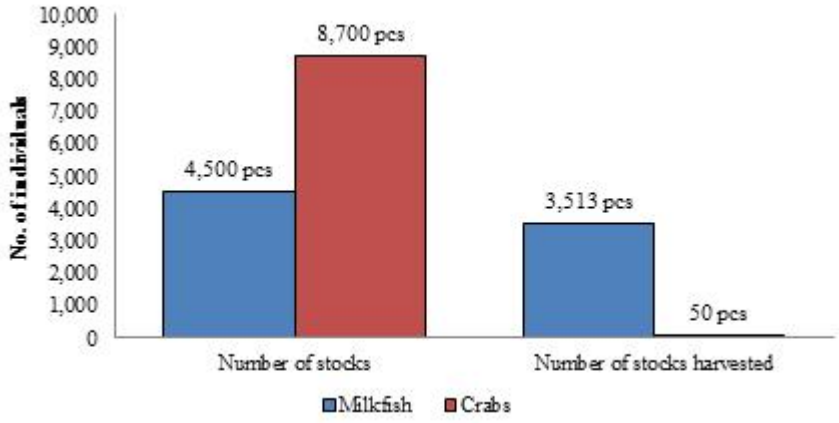

Fig. 3: Total number of individuals of bangus and crabs harvested in the 16-unit aquasilviculture pens.

Community-based multi-species hatchery

For the first collection period of gravid female crabs, two hatching/stacking sessions were obtained amounting to 8.855 million (M) zoeas spawned. This ranged from 9 to 25 days of culture in larval rearing tanks (LRTs). Prior to rearing the zoeas, there were 100 zoeas per liter contained in an 8-ton capacity LRTs. Out of the 8.8M zoeas spawned, only three (3) crablets were produced.

The second run of zoea production had a total of 11.8M. It comprised a range of 5 to12 days of culture with only four (4) crablets produced. Other female crabs spawned 3.7 and 4.1 million zoeas, respectively. However, only a few zoeas reached crablet stage. The relatively less production of crablets, even at their megalopa stage, was attributed to contaminated water source, relative lack of food organisms and extreme cannibalism. The major causes of high

mortality rates observed were: the hatching of underdeveloped eggs, death of the zoeas upon spawning, limited supply of rotifers as a food source that resulted to extreme cannibalism, and contamination of the water source and culture tanks by a microbe known as zoothalium. If careful water management and adequate food organisms is ensured for the next batch of zoeas to be spawned, it is hoped to produce more crablets for future utilization. This study implied that crab hatchery was feasible for future hatchery and aquaculture purposes.

CONCLUSION

Three major project components of PNAP such as mangrove plantation, aquasilviculture of bangus and king crab, and king crab hatchery were implemented. More than 40% mangrove propagules that survived after a year of planting in the three provinces would mean that they might relatively address the objectives set for PNAP implementation, on enhancing and restoring the disturbed coastal habitats, protecting the residents from natural calamities like storm surges, improving natural stocks of fisheries and help in improving the livelihood of the people living near and within the coastal zones.

Relative to this, important lessons were learned prior to planting and rearing of mangroves in the three provinces such as replant lost/dead propagules, find other areas which are not prone to wave action, regular maintenance and monitoring of the planted area, more information dissemination, meetings and discussions with the PO member beneficiaries to enhance the project implemented. In aquasilviculture project, the PO beneficiaries did not earn money yet it created important lessons for future related projects like use of trash fish as food for the crabs instead of commercial formulated feeds, avoid poaching of highly-priced reared crabs, and efficient site selection to prevent typhoon-induced damages.

In terms of the community-based multi-species hatchery of crabs, it turned out to be feasible, yet it needs very careful water management and feeding schemes to prevent microbial contamination and to avoid severe cannibalism. All these issues and concerns, as well as the recommendations set were presented and discussed by the Regional Steering Committee of PNAP which was composed of the BFAR 10 personnel and project implementers.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests regarding the publication of this manuscript.

ABBREVIATIONS

%	Percent
BFAR	Bureau of Fisheries and Aquatic Resources
CHED	Commission on Higher Education
Ha	Hectare
kg	Kilogram
LGU	Local Government Unit
LRT	Larval Rearing Tank
M	Million
MSU	Mindanao State University
PhP	Philippine Peso
PNAP	Philippine National Aquasilviculture Program
PO	People's Organization
SEAFDEC	Southeast Asian Fisheries Development Center

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