

論文の内容の要旨

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論文題目

Stock enhancement of tiger shrimp (*Penaeus monodon*):

Studies and assessments for the Batan Estuary in northern Panay Island, central Philippines

(ウシエビの放流：フィリピン・バタン湾における有効性と可能性の調査)

Introduction

The world's wild fisheries resources are shown to be declining while demand for fisheries products is ever increasing. Fisheries scientists have been looking for ways of restoring natural fisheries stocks, and about a century ago, stock enhancement started with the release of juvenile freshwater fishes in lakes and rivers. Marine stock enhancement started recently and crustacean restocking initiatives, especially for shrimps, were limited because of problems in tagging and monitoring. Shrimps are a major commodity in the world market. In the Philippines, the tiger shrimp *Penaeus monodon* (Fabricius) is regarded as the most valuable shrimp species and commands high market prices. For these reasons, majority of aquaculture ponds were constructed from mangrove areas mostly for shrimp culture, as in the present study site – Batan Estuary. In the past, tiger shrimps were reported to be very abundant in this estuary, where the natural brackish environment was conducive as breeding and nursery habitat; giving continuous supply of wild stocks for sustainable artisanal shrimp fishing. Presently however, there were claims that the estuary has been degrading and shrimp catches declining.

This study aims to establish the present situation in the Batan Estuary of northern Panay Island, Philippines in terms of its natural environment, inshore fisheries, and social atmosphere; and to assess the prospects, benefits and requirements of tiger shrimp *Penaeus monodon* stock enhancement in the area.

The Batan Estuary

This study focuses on one important coastal zone and fishing ground in central Philippines located in northern Panay Island – the Batan Estuary in the province of Aklan. Reports show that this was once a very rich and productive area but people claim of intense mangrove loss and shoaling of rivers and lagoons. This chapter discusses key changes in this estuarine coast that occurred in the past decades that may have been the main causes for the decline in fisheries resources especially within the estuary.

Physical water parameters were within normal levels throughout the estuary with an average depth of 3 m. Temperature was relatively higher while salinity was lower in the upper rivers than in the lower lagoon areas, making the river areas more conducive for shrimp juveniles that prefer lower salinities and higher temperatures for faster growth. In 1953, mangroves covered 4,923 ha of the Batan Estuary while current results revealed scattered patches of trees totalling 409 ha only, while aquaculture ponds covered 3,747 ha. Mangrove loss also devoid the estuary with buffer zones from typhoons, pollution and erosion. Siltation rate since 1979 was calculated at 5.3 cm yr^{-1} . Mangrove rehabilitation projects launched in the area remained unsuccessful because of insufficient funds, weak political will, low technical training of staff, and absence of reliable scientific data.

Inshore Fisheries in the Batan Estuary

The Batan Estuary is one of the most important fishing grounds in Panay Island, supporting 29 coastal villages and more than 15,000 fishing households. The fishing member of a family is most commonly the father, between 40-50 years old with 10-20 years of fishing experience in the estuary (interview, $n=107$) and 92% of them are fishing full-time with no other forms of employment. Analysis of responses by fishers on existing concerns revealed that the most regarded problem was having a meager income caused by very poor catch.

Because of low daily catch, fishers increased fishing effort resulting to the overcrowding of 2,309 fixed fishing gears. Majority (81%) of these, were fish corrals made with bamboos and nets. Data also revealed that 24% of these were illegally operating in the estuary. Inshore fishing in the Batan Estuary is multi-species but shrimps were considered to be the most valuable commodity. Decades ago, fishes and shrimps were abundantly caught at 10-25 kg per fisher, but at present, even a 3-kg catch per day is rare. The high-priced tiger shrimp *Penaeus monodon* comprised 61.9% of total shrimp catch by weight in 1976-80, but greatly decreased to 6.22% in 1990-91. Presently, daily shrimp catch (majority is the low-priced *Metapenaeus ensis*) only averages 1-2 kg or about $\text{¥}100 \text{ fisher}^{-1} \text{ day}^{-1}$, while tiger shrimps can barely be caught. Also, catch composition is skewed towards smaller juvenile shrimps especially in the rivers where small-meshed nets are also illegally being used by some.

Results also showed a trend of 50% decrease in catch per unit effort (CPUE) every decade since 1970. From an abundant catch of about 24 kg d^{-1} in the 70s, fishers only harvest 8-10 kg daily in the 80s and 90s. This was further reduced to only 3 to 5 kg in year 2000. In as short as six years after that, present data showed only an average total of $1.65 \pm 0.14 \text{ kg d}^{-1}$ and only $0.70 \pm 0.01 \text{ kg d}^{-1}$ for shrimps (without *P. monodon*). Therefore, it is important that Batan Estuary be restored, fishing be effectively managed, and shrimp stocks be enhanced.

Shrimp Stock Enhancement Studies in the Batan Estuary

Based on results from previous chapters, the main problems in the Batan Estuary can be summarized into three main points. First, poverty situation among local fishers is worsening due to low quality and quantity of catch, especially of shrimps. Secondly, the intense overfishing in the area is evident with overcrowded fishing gears, and the use of illegal fishing methods. Third, the natural environment was extremely degraded where about 95% of mangroves were lost, mostly to aquaculture ponds. It is therefore important to: (1) increase fishers' income, (2) reduce number of fishing gears, and (3) rehabilitate mangroves. It is with these ideas that shrimp stock enhancement plays a crucial role, as discussed in this paper. However, prior restocking, site- and species-specific studies must be conducted. In this connection, basic information like source of stocks, pre-release culture method, optimal age at release, practical shrimp marking techniques, and natural shrimp mortality were addressed in this research through on site experimental studies on tiger shrimps.

Hatchery-reared juveniles are much cheaper than wild sources and are thereby practical for the Batan Estuary where a number of shrimp hatcheries still operate along nearby coasts. Based on site assessments, the river areas are more conducive for juvenile shrimps. Moreover, a 32-ha mangrove reserve site called the "*Isla Kapispisan*" in the northern rivers can provide good environment and protection for juvenile shrimps.

Field experiments on natural mortality of shrimps showed that 2-mo old juveniles achieved optimum survival and growth when released in the *Isla Kapispisan* area. This suggests that shrimp larvae need to be reared until about 60-d old prior to release. In a separate study, two rearing options were compared: enclosed pond and open-area net enclosures at the release site. Growth and survival of shrimps were significantly higher by 50% and 20%, respectively, in ponds than in open area. Also, rearing management in ponds was more convenient, minimally affected by tides, flooding and wind like in the open. Total costs were lower with pond culture (except actual pond construction). However, unlike pond rearing, open-area culture does not require complicated transport of stocks during release because nets can simply be opened. Also, cultured juveniles are readily adapted, being acclimated in the open area during the whole culture period. This can be further confirmed through pilot stocking activities with assessments and monitoring of released stocks.

One important component of stock enhancement monitoring is marking or tagging of stocks. For this purpose, three low-cost marking methods (staining with food color, uropod trimming, and T-bar tagging) were tested on 2-mo old juvenile tiger shrimps *Penaeus monodon* with 8.42 ± 0.1 mm mean carapace length (CL) for 8 weeks. Food color stain was proven to be a poor shrimp marker because its retention was limited to a week at most. T-bar tags are not effective markers despite having excellent tag retention because of low shrimp survival after 6 weeks. Uropod trimming is a more practical option because shrimps showed comparable survival and growth with the control group and marker distinction through unique uropod regrowth was high.

Natural predation on shrimps was also assessed through laboratory and field experiments. Although gobies *Acentrogobius* sp. were abundant, their predation on shrimps was more lax, compared with more aggressive

predators like *Lutjanus* sp. and *Therapon* sp. Mud crabs *Scylla* sp. were also abundant especially in the mangrove areas and have been found to also feed on small shrimps. Both mangrove and barren areas showed high shrimp predation during the night, but day-time survival of shrimps was higher in mangrove areas. This suggests that releasing shrimp juveniles at day-time in mangrove areas can provide higher chances of survival.

Additional studies were also planned for this study, including a pilot small-scale release experiment. However, due to unfavorable circumstances like a series of typhoons hitting the study site in the past years, the implementation of the trials was hampered. In addition, other important sub-studies were consequently postponed as caused by these unforeseen delays and insufficient time and funds.

Concluding Remarks

Although there were projects implemented and various ordinances and laws exist in the Batan Estuary, the usual environmental and fisheries problems are still evident. The perceived weak law enforcement and political will, together with the feeble cooperation among leaders and local communities, further complicate the situation. With the observations and results above, it is clear that the Batan Estuary urgently needs effective measures for rehabilitation. One alternative fisheries and environmental management option suggested is through stock enhancement of the tiger shrimp *P. monodon* in the Batan Estuary. Theoretically, by restoring wild populations of this highly-priced shrimp species, fishers can directly increase income. With this incentive, reduction of fishing gears and mangrove rehabilitation can be promoted. The prospects of tiger shrimp stock enhancement in the area are high and the benefits are clear. However, some important points need to be considered prior to actual implementation of the program, based on established guidelines and recommendations discussed in this paper. Importantly, the support of sectors like the government, local universities, people's organizations, stakeholders, and local fishers must be solicited to create unbiased management plans.

This study has made some important scientific contributions, where there are currently only very few studies on stock enhancement specific for tiger shrimps *Penaeus monodon*. Basic concerns like source of stocks, rearing methods, optimal age of shrimps at release and practical tagging methods were determined, specifically for the Batan Estuary. However, many other necessary studies are yet to be conducted, following established guidelines, for an effective and responsible stock enhancement program. These include genetic considerations, health management, risk assessments, bio-economic modelling, and social impact studies. Although, the actual stock enhancement activity was not realized within the duration of this study (mainly caused by unforeseen circumstances like typhoons), the results and information gathered especially on the current status of the Batan Estuary, are crucial for future programs, management and legislations. It is an important recommendation in this study to consider a more social and community-based approach towards stock enhancement initiatives in the future. Moreover, other concerns like proper education, alternative livelihood, and community empowerment must also be similarly incorporated.