MARINE AQUACULTURE IN INDONESIA: THE PRESENT AND FUTURE DEVELOPMENTS

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ABSTRACT

The ultimate goals of marine aquaculture are to create a sustainable fisheries industry, increase the farmer's income and to protect endangered species. This paper provides information on the current marine aquaculture in Indonesia including finfish, crustaceans, mollusks and seaweeds. Improved legal framework, financing, human resources and technologies are required for future development.

Keywords: marine aquaculture, sustainable fisheries.

INTRODUCTION

Indonesia is an archipelago of 17,000 islands with a coastline of 81,000 km. The marine ecosystem along this shoreline is characterized by high diversity and therefore has great potential for marine aquaculture. The purpose of marine aquaculture is to faster aquaculture production to meet demands for fish product (local consumption and export) and to generate income and employment opportunities.

Indonesia has a strong commitment to support the sustainable utilization of marine resources. In the early 1990s, the Indonesian government decided to advance mariculture development in an effort to maintain sustainability of marine resources. To date, Indonesia has made inroads in mariculture such as finfish, crustaceans, mollusks and seaweeds.

OVERVIEW OF MARINE AQUACULTURE: THE PRESENT

The marine organisms that are potentially suitable for culture in Indonesia include finfish (groupers, wrasses and snappers), crustaceans (shrimps and crabs), mollusks (mussels and oysters) and seaweeds (*Euchema* spp. and *Gracillaria* spp.)

Finfish Culture

Coral fishes that are suitable to rear in floating net-cages and pen systems in Indonesia include

groupers and some other coral reef species. The culture system is divided into two phases, the nursery and grow-out phases.

The purpose of nursery usually is to produce larvae that could be sold to the fish farmers while the products from grow-out will go directly to the market system (export and/or local consumption). There are two types of nursing phase: nursing from fingerling to juvenile (3-4 months) and from juvenile prior to actual grow-out (1-4 weeks).

The first step in seed production is the collection and domestication of spawners. This step is the most difficult as concerns the collection of male from the wild. Groupers are protogynous hermaphrodites, and there are fewer males due to overexploitation of the largest individuals in the population.

In order to obtain good quality eggs, a special diet for spawners needs to be developed. Fertilization rate, hatching rate, larval viability and feeding success depend entirely on the quality of eggs produced by the broodstock. Mortality will be high during the first week after hatching from low quality eggs (Murdjani, 2000). Algae (*Chlorella* sp), rotifers (*Brachiounus* spp.) and brine shrimp nauplii (*Artemia* spp.) are given as natural diet for larvae and minced sardines are given to the larger fish.

Disease is another factor that causes high mortality in aquaculture systems. Some symptoms of disease during larval rearing are loss of appetite, loss of scales, change of body color and occurrence of white spots on the body. Treatment must be started immediately after the symptom is detected.

The most important finfish species cultured in Indonesia are shown in table 1.

Crustacean Culture

Crustacean culture in Indonesia developed as an alternative policy for national shrimp production after the government issued decree No. 39, 1980, limiting the use of shrimp trawls (“pukat harimau”), which were considered harmful to fish populations. The impact of the decree was positive and many fishermen and companies shifted their activity from catching to cultivating shrimp.

Table 1. Species of marine fish cultured in Indonesia

Indonesian name	**English name**	**Scientific name**	**Phase** **A= larvae** **B= grow out**
Kerapu Tikus	Humpback grouper	*Cromileptes altivelis*	A, B
Kerapu Lumpur	Estuarine grouper	*Epinephelus tauvina*	A, B
Kerapu Malabar	Malabar grouper	*E. malabaricus*	B
Kerapu Macan	Mottled grouper	*E. fuscogutattus*	A, B
Kerapu Sunu	Leopard coral trout	*Plectropomus leopardus*	B
Ikan Napoleon	Hump head wrasse	*Cheilinus undulatus*	B
Ikan Bandeng	Milkfish	*Chanos chanos*	A, B

Indonesian government supported the newborn shrimp culture by regulating on investment and permitting the conversion of wetland, particularly mangrove forest, to shrimp ponds. There was also additional financial support from ADB and World Bank in 1983-1984. As a result of those policies, the total area of shrimp ponds in Indonesia in 1998 was around 305.000 ha.

In general, shrimp culture is divided into seed production and grows out of juveniles in ponds up to the commercial size. Based on the amount of technology employed and the productivity, shrimp culture is classified into three types: traditional, semi intensive and intensive culture. The traditional system produces less than 500 kg/ha and does not involve much capital or technology. The semi intensive system produces 1-2 ton/ha while the intensive system could produce up to 3 ton/ha. Semi intensive and intensive systems apply various kinds of technologies to keep water quality and provide artificial food to achieve better growth.

Shrimp culture can also be classified based on the tidal range: shrimp are cultured in high tidal areas (> 1.5 m) such as in coast of Aceh, North Sumatera, Riau, Kalimantan, Sulawesi, West Nusa Tenggara and Maluku or in low tidal areas such as the coast of Lampung and North Java (Harris, 2002).

The massive growth of shrimp culture activities in Indonesia was not steady. In 1992, shrimp culture suffered greatly with the viral disease called white spot. This viral disease broke out throughout Indonesia, especially in the semi intensive and intensive systems. As a result, many shrimp farmers from East Java and companies from the north coast of Java stopped their activities and relocated their facilities to new areas in south coast Java (Dirjen PK2P, 2003). Recently, fishermen began to replace giant tiger shrimp (*Penaeus monodon*), which is considered

vulnerable to viral disease, with the more robust and disease-resistant banana shrimp (*P. vannamei*) (Dirjen PK2P, 2003).

Other problems are related to social conflicts and security, which coincided with the economic recession from 1996 until the present. There were several cases of land conflicts and robberies around shrimp ponds ("tambak"). As a result, in the north coast of Java many farmers quitted their activity and abandoned their ponds.

Production of other crustaceans such as lobster and mud crab still depend on catching wild juveniles for grows out. Gorontalo and North Sulawesi are two examples of provinces in Indonesia that have started grow out culture of mud crabs for export and local consumption (personal obs.). The main constraint on crab and lobster culture in Indonesia is still the inefficient seed production, which shows high mortality during the larval stage.

The types of crustaceans cultured in Indonesia are shown in table 2.

Table 2. Species of crustaceans cultured in Indonesia

Indonesian name	**English name**	**Scientific name**	**Phase** **A= larvae** **B= grow out**
Udang Windu	Giant Tiger Shrimp	*Penaeus monodon*	A, B
Udang Putih	White Shrimp	*Penaeus vannamei*	A, B
Kepiting bakau	Mud Crab	*Scylla* spp.	B
Udang Barong	Lobster	*Panulirus* spp.	B

Mollusk Culture

Mollusks are the most easily recognized among the aquatic invertebrates, however only bivalves (mussels and oysters) are extensively cultured in Indonesia. Culture of gastropods (abalone) is currently under development.

There are several methods of growing mussels including bottom culture, raft culture, bouchot culture, Philippine culture and long line culture. The choice of the method depends on the physical environment and the social traditions in the area (Landau, 1992). Mussels (*Mytilus* spp.) have been cultured in Indonesia using raft method. The culture of mussels begins with the collection of seeds from natural substrates or with placing a spat collector, a sort of substrate

(rope or bamboo), in the water where the larvae settle on.

Another mollusk, the goldlip pearl oyster, has been cultured in Lombok, Bali, Waigeo Island, Talise Island and Maluku (Avault, Jr. 1997; Knauer and Taylor, 2002; Taylor, 2002, personal obs.). There are two types of pearl oyster stocks in Indonesia, the silver and the gold-nacred. Research has been done to analyze the growth rate of these stocks. After 20-24 routine production runs, it was found that gold-nacred stocks have faster growing rates than silver ones. Next, comparisons of post-operation survival and nuclei retention were made between oyster placed on the seafloor or held in 1 mm mesh bags or rice sacks. It was shown that oyster placed on the seafloor had the highest proportion of operable stock; however, higher survival and nuclei retention has encouraged the use of mesh bags to condition stock (O'Connor, 2002). The optimum temperature range for *P. maxima* is approximately 23-32ºC (Yukihira et.al, 2002).

Abalones are expensive but poorly known by Indonesian. However, culturing abalone could become a favored export commodity in Indonesia. Lombok, Bali, North and South Sulawesi are trying to get outside funding for pearl oysters, abalones and *Trochus* culture research (APEC, 2003).

The types of mollusks cultured in Indonesia are shown in table 3.

Table 3. Species of mollusks cultured in Indonesia

Indonesian name	**English name**	**Scientific name**	**Phase (A = larvae) (B = grow-out)**
Kerang Hijau	Green mussel	*Mytilus* spp.	B
Kerang Mutiara	Goldlip pearl oyster	*Pinctada maxima*	B
Abalone	Abalone	*Haliotis* spp.	B

Seaweed Culture

Many seaweed species have been cultured in the world (Laminaria, Undaria, Porphyra, Euchema, Gracillaria and many others) however, only *Euchema* spp., *Gracillaria* and *Gellidium* are successfully produced in Indonesia.

Both Euchema and Gracillaria are red algae (Rhodophyta), found in tropical and temperate

waters. The two methods employed for seaweed culture are net and rope. These methods (net and rope) were adapted by seaweed farmers in Nain (North Sulawesi) and Nusa Dua (Bali) to culture *Euchema* spp. and *Gracillaria* spp. in South Sulawesi. During culture the farmers have to be sure that none of the seaweeds are floating and that there are no grazing herbivores around. In addition, if growth of *Euchema* is poor, the poorly growing parts are replaced with new pieces.

Gracillaria grows best in low-wave areas with salinity range of 8-25 ppt (Landau, 1992). Women commonly take care of the culture of Gracillaria in South Sulawesi over a 60-90 days culture cycle. Most of the harvest of *Euchema*, *Gracillaria* and *Gellidium* goes to the production of sun-dried, half-processed, chopped and finely powdered algae. Very little of these products are used for local consumption. The majority goes for export even though limitations sometimes occur during drying process.

The seaweeds species cultured in Indonesia are shown in table 4.

Table 4. Species of seaweeds cultured in Indonesia

Indonesian name	**English name**	**Scientific name**	**Phase (B= grow-out)**
Rumput laut	Seaweed	*Euchema alvarezii*	B
		Kappaphycus alverezii (Doty)	B
	Sea grass	*Gracillaria verrurosa*	B
		Gracillaria foliifera	B
		Gellidium sp.	B

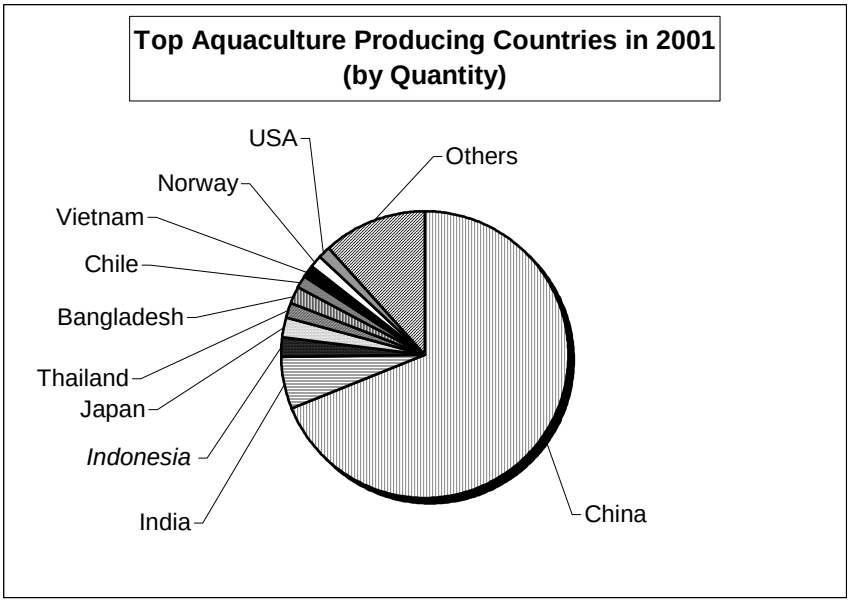
The total aquaculture production of Indonesia in comparison to that of other countries in Asia is shown in table 5.

Recent data provided by Sugiyama and Funge-Smith (2004) showing the total aquaculture production by country in 2001 indicates that Indonesia is the third largest in terms of quantity (864,276 mt) (fig.1) and the fourth in terms of value 2,397,368 USD (fig.2).

Table 5. Aquaculture production (mt) in Asia (1995).

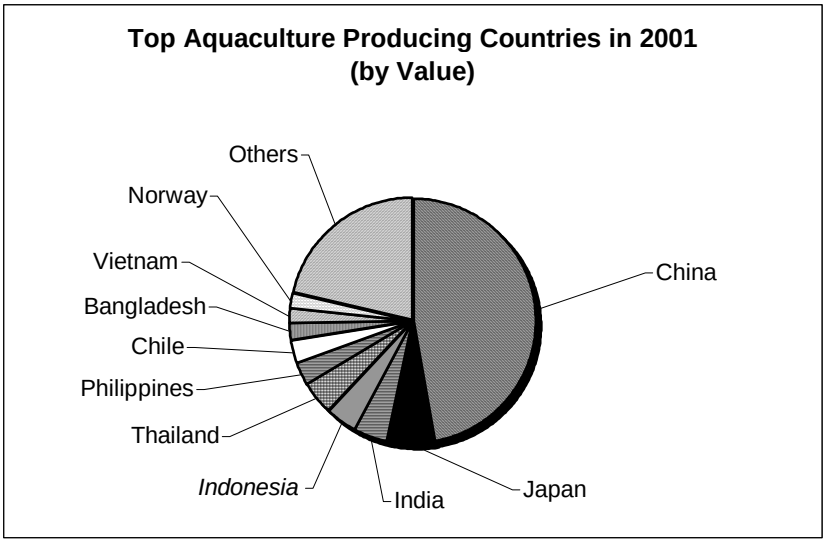
COUNTRY	Marine Fish	Crustacean	Mollusks	Seaweeds	TOTAL
Bangladesh	-	34,030	-	-	34,030
China	182,401	181,880	3,099,099	4,807,066	8,270,446
Hong Kong	5,035	-	371	-	5,406
India	-	96,873	-	-	96,873
Indonesia	*10,000*	*142,170*	-	*108,000*	*260,170*
Iran IR	2,130	-	-	-	2,130
Korea DPR	-	13,700	57,250	130,500	201,450
Malaysia	3,493	7,481	101,080	-	112,054
Nepal	-	-	-	-	-
Pakistan	-	48	-	-	48
Philippines	927	93,239	25,155	466,054	585,375
Sri Lanka	-	3,329	-	-	3,329
Thailand	1,066	285,718	79,530	-	366,314
Vietnam	-	-	-	8,000	8,000

Source: FAO, 1997



China	26,050,101
India	2,202,630
Indonesia	**864,276**
Japan	801,948
Thailand	724,228
Bangladesh	687,000
Chile	566,096
Vietnam	518,500
Norway	512,101
USA	460,998
Others	4,463,478

fig 1. Top ten aquaculture-producing countries in 2001 by quantity.
Unit: mt.



China	26,245,691
Japan	3,383,416
India	2,537,569
Indonesia	**2,397,368**
Thailand	2,376,712
Philippines	1,725,413
Chile	1,718,185
Bangladesh	1,219,700
Vietnam	1,135,575
Norway	1,022,967
Others	11,923,886

fig. 2. Top ten aquaculture-producing countries in 2001 by value.
Unit: 1000 USD.

FUTURE DEVELOPMENTS

To be able to increase export earnings, secure domestic food supply and support sustainable coastal development, a strategy for future development of marine aquaculture in Indonesia needs to be developed. In achieving these objectives, special attention should be given to the improvement of legal framework, financing, human resources and technology (Ramelan, 2000).

Legal Framework

Strong and efficient legislation is required to expand further marine aquaculture in Indonesia. Legislation would provide the basis for the resolution of conflicts among users. New regulations should be supported by strict enforcement of licensing requirements, coastal planning, environmental standards and product quality.

Financing

The main constraint to aquaculture development in Indonesia is the lack of affordable financing. This applies mostly to small-scale farmers and cooperatives but also to larger concerns.

Besides financing from external sources, government support is also needed to develop and transfer improved technologies, supervision of management for small-scale farmers, infrastructure (public services), certification of products, monitoring, control and surveillance.

Human Resources

Qualified human resources are also important to enable increase an in marine aquaculture production. However, the majorities of the workers are unskilled, and if anything, are specialized in biological sciences. Few have specialization in engineering and physical sciences and even fewer in legislation, management, planning and socio-economics. This imbalance may hamper aquaculture development in Indonesia. Therefore, integrated approaches between institutions that focus on human resources are needed for future development.

Technology

The technology for nursing and growing marine species in Indonesia is not well developed. Artificial feeds are available to some extent but need to be improved. Use of fishmeal as the main ingredient is a problem in terms of supply and price. The supply of fry and fingerling is insufficient and their quality is poor. The mortality in hatcheries is very high, reducing the profitability. In order to improve the technology, bilateral or multilateral cooperation as well as private sector involvement has to be established. It would provide support to the marine aquaculture research and development center and other related institutions.

CONCLUSIONS AND RECOMMENDATIONS

The marine aquaculture in Indonesia has expanded greatly, however there are some main constraints to further development as follows:

- limited knowledge on the bio-ecology of the cultivable species; lack of hatchery technology;
- market price fluctuation;
- lack of monitoring, domestic financial support and foreign investment;
- lack of human resources, existence of social conflicts and security problems;

To address these constrains, the following actions are recommend:

- expand and intensify studies on the bio-ecology of cultivable species, genetically
- improved species that show diseases resistance and faster growth, water quality
- management and post harvest handling;
- foster participation by local stake holders so that the outcome could benefit the local community, develop new potential markets for the increased production and diversify culture species according to market demand;
- establish legislation that supports direct foreign investments, simplify bureaucracy, and minimize costs;

- promote and maintain international collaboration among institutions engaged in marine aquaculture and request support from developed countries.

The above recommendations would be a stepping-stone for stakeholders to overcome constraints and develop an improved management plan for future development of marine aquaculture in Indonesia.

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REFERENCES

Anonymous, 2003, Down to Earth No.58 August 2003, *Buletin Kelola*, 10pp.

APEC 2003, *Destructive Fishing Practices in South Sulawesi, Indonesia and the Role of Mariculture as a Potential Alternative Live hood, A Case Study for the APEC Sub-Project "Improving Coastal Live hood through Sustainable Aquaculture Practices"*, 53pp.

Dirjen PK2P, 2003, *Intisari Sidang Global Shrimp Outlook 2003*, Mexico 3-6 November 2003, Departemen Kelautan dan Perikanan Republik Indonesia, 11pp.

FAO, 1997, *Survey and Analysis of Aquaculture Development (Research Priorities and Capacities in Asia)*, FAO Fisheries Department Rome, Italy, FAO Fisheries Circular No.930 FIRI/C930.

Sugiyama, Shunji and Simon Funge-Smith, 2004, *Asian Regional Trends in Aquaculture and Related Fishery Activities*, Prepared by NACA and FAO, 8pp.

Harris Enang, 2002, Shrimp Culture in Indonesia, *Proceeding of the JSPS-DGHE International Seminar on Fisheries Science in Tropical Area*, Bogor 20-21 August, 2002, pp.16-19.

Knauer Jens, Joseph J.U Taylor, 2002, Production of Silver-nacred "saibo-oyster" of the Silver or Goldlip Pearl Oyster Pinctada maxima in Indonesia, *SPC Pearl Oyster Information Bulletin* #15 p.29.

Landau Matthew, 1992, *Introduction to Aquaculture*, John Wiley & Sons, Inc., 440 pp.

Murdjani, Muhammad, 2000, *Marine Fish Culture, Development and Status in Indonesia*, Network of Aquaculture Centres in Asia-Pacific, 6 pp.

NACA and FAO, 2004, *Emerging Trends and Experiences in Asia-Pacific Aquaculture: 2003*, 8pp.

O'Connor Wayne, 2002, *World Aquaculture Society's WAS 2002*, Beijing, pp.23-27.

Ramelan, Sri Hartati, 2000, Present Status and Strategy of Indonesian Mariculture Development, *APEC Grouper Research and Development Network (FWG 01/99) Report of the Regional Workshop on Sustainable Sea farming and Grouper Aquaculture*, 17-20 April 2000, Medan - Indonesia, pp. 29-32.

Taylor, Joseph J.U, 2002, Producing Golden and Silver South Sea Pearl from Indonesian Hatchery Reared Pinctada maxima, *SPC Pearl Oyster Information Bulletin* #15 p.30.

Yukihira, H.; J.S Lucas and D.W Klumpp, 2002, Comparative Effects of Temperature on Suspension Feeding and Energy Budgets of the Pearl Oysters Pinctada margaritifera and P. maxima, *SPC Pearl Oyster Information Bulletin* #15 p.35.