Project Reports: Agriculture and Community Development

APO SEMINAR ON AQUACULTURE MANAGEMENT

Report of the APO Seminar on Aquaculture Management held in Republic of China, 3–8 December 2001

INTRODUCTION

The Seminar on Aquaculture Management which was organized by the Asian Productivity Organization (APO) and hosted by the Government of Republic of China was held in Tungkang from 3 to 8 December 2001. The Council of Agriculture (COA), Executive Yuan; China Productivity Center (CPC), and Tungkang Marine Laboratory (TML) of Taiwan Fisheries Research Institute (TFRI), COA implemented the program. Fourteen participants from 11 member countries and 6 resource speakers from Asian Institute of Technology (AIT), Thailand; Japan International Research Center for Agricultural Sciences (JIRCAS); and Republic of China (Taiwan Fisheries Research Institute, National Taiwan Ocean University, and Hanaqua Tech Incorporation) attended the seminar. The objectives of the seminar were to: 1) discuss the recent developments as well as issues and problems in the production and management of aquaculture in the member countries, and 2) suggest strategies to address issue and problems in aquaculture management.

The seminar consisted of the presentation and discussion of resource papers and country papers, workshop, as well as, field visits to Aquaculture Hatcheries and Farms in Southern Taiwan. The topics covered by the resource papers were: 1) Trends and Perspectives in Asian Aquaculture; 2) Microbial Interactions in the Aquaculture Environment; 3) Socioeconomics of Sustainability of Aquaculture Industry in Taiwan; 4) Cryopreservation of Gametes and Larvae of Selected Aquatic Species in Taiwan — Research, Development and Application; 5) Building Competitive Edges of Tilapia and Cobia for Taiwan's Aquaculture Industry during the Transition Period; and 6) Aquaculture in Thailand - With Emphasis on Cage Culture. The country papers, on the other hand, focused on the present status of aquaculture production, main issues and problems in aquaculture management, traditional and modern technologies/systems used in aquaculture production, role of the public and private sectors in the development of aquaculture, and long-term and short-term measures for sustainable development of aquaculture in the respective countries.

The highlights of the seminar are presented below:

RESOURCE PAPERS

Trends and Perspectives in Asian Aquaculture (Dr. I-Chiu Liao)

Asia is one of the earliest cradles of aquaculture. For thousands of years, fish farming has evolved together with many traditions in the region. Correspondingly, fish consumption is particularly high among the majority of Asians. The industrialization of aquaculture began in the 1960s. In this regard, Asia has been instrumental once again. Technologies primarily developed in Japan and Taiwan spurred the modernization of aquaculture in other Asian countries. Together with the shift in production scale, aquaculture has not only become a major food supplier but has also increased its importance in monetary terms.

Today, Asia dominates aquaculture production, contributing 91% of the world total by volume and 82% by value. Asian countries have been the top ten aquaculture producers in

the world. The region has the highest variety of culture species. It must be mentioned, however, that Asia has also been the highest seafood-consuming region of the world, accounting for two-thirds of the world's food fish supply, the increase of which mainly came from aquaculture in recent years. With the projected economic growth and increase in population in the region, this trend will most likely continue.

There are several factors that must be addressed now in order for Asian aquaculture to continue prospering in the coming years. Among them are the current nature of the industry that has become too profit oriented, lack of implementation of sustainable aquaculture strategies, increasing bias of the society against the industry, and most importantly, declining resources for aquaculture. There are other trends that must be similarly considered in carrying out aquaculture developments, such as the membership of Asian countries to the World Trade Organization, the variable economic conditions in the region, and the increasing Asian population.

Aquaculture development must be pursued in an environmental friendly and responsible manner in order to become sustainable. If risks are minimized and development proceeds with caution, aquaculture can potentially relieve the heavy exploitation in capture fisheries. Significant advances in aquaculture that have been achieved over the recent years must be applied to achieve these goals. Regional and international collaboration must be promoted to share technical and research advances, implement regulatory and management strategies, and effectively avoid similar inadvertent errors in the past. Furthermore, aquaculture development must be carried out in the context of integrated ecosystem management and not as an isolated endeavor by itself in order to make it responsive to the global concerns for sustainability and environment conservation.

In this paper, the development and status of Asian aquaculture are briefly described. Current challenges are discussed and strategies are proposed. As one of Asia's enduring foundations for survival, aquaculture would remain vital in the region for the 21st century and further.

Microbial Interactions in the Aquaculture Environment (Dr. M. Maeda)

The microbial interaction can broadly be divided to neutralism, commensalism, mutualism, competition, and antagonism. Neutralism is rare in microbial communities, only occurring when populations are either located too far apart or when they have different environmental requirements and so have little impact on each other. Organism populations that have extremely diverse environmental requirements are more likely to exhibit neutralism. A commensal relationship is where one organism benefits another organism but remains unaffected itself. Mutualism is where two organisms benefit each other so that they can exist together in an environment where neither organism could exist on its own. Since mutualism and commensalism involve two organism populations interacting in a close and permanent association, both are types of symbiosis (literally, "living together"). The benefits obtained through symbiotic interaction include food, protection, support and other life-sustaining factors.

Microorganisms inhabit the aquatic environment, often at a density of more than ten million per milliliter, and interact with each other in complex ways, mainly through the substances they synthesize and excrete. The functions and activities of microorganisms are the key factors in understanding the quality of an aquaculture environment. The health of fish in aquaculture, as well as in nature, depends primarily upon their inherent resistance to microbial invasion, as well as the biological equilibrium between competing beneficial and detrimental microorganisms at the fish interface as mediated by the environment. Outbreaks of fish diseases occur when three factors combine: the presence of pathogens,

poor fish health, and a decline in environmental conditions. Even when there is a constant supply of fresh and clean seawater and the ponds are stocked with healthy fish, fish diseases still occur, resulting in the need for frequent use of drugs such as antibiotics. When drugs are used in aquaculture water, the following changes in microbial communities often result: (1) a decrease in the total number of microbes, (2) an increase in the population of drug-resistant microbes due to suspension of natural competition among microbes, and (3) an increase in the number of microorganisms that actually prefer an environment containing drugs.

As alternatives to controlling disease with drugs, new techniques using biocontrol agents (BCAs) have been adopted. There are several kinds of BCAs, for example, those promote fish growth (same as probiotics) and repress the growth of pathogens in aquaculture. In recent experiments these BCAs have been added directly or by means of prepared feed, biofilters, for instance, to the fish rearing biotope. In this series of experiments involving the utilization of BCAs, the results of rearing the shrimp species *Penaeus monodon* and *P. japonicus,* the crab species *Portunus trituberculatus,* and fish species including *Caranx delicatissimus* and *Pagrus major,* showed that the presence of these microbes resulted in higher survival rates. There was also potential for the utilization of BCAs that repressed the multiplication of viruses to prevent viral diseases of fish.

In addition, when phytoalgae were used as the main live food, the survival rates of shrimp, crabs and finfish were still disappointing. However, if certain species of bacteria were present in addition to the algae, the survival rates increased significantly. It is, therefore, considered preferable to feed microbes to fish along with algae, although the control of these microbial assemblages is essential to prevent pathogens from dominating the microbial ecosystem in aquaculture.

The paper discusses biological control agents (BCAs) and probiotics, general control methods of fish pathogens, biocontrol of bacterial pathogens in aquaculture, biocontrol of viral pathogens in aquaculture, use of anti-virus bacteria for rearing fish larvae, isolation of biocontrol agents used in aquaculture, virus distribution and survival in seawater, inactivation of viruses in seawater, antagonism of bacteria and microalgae, as well as probiotic effects and antagonism of intestinal microorganisms of fish.

Socioeconomics of Sustainability of Aquaculture Industry in Taiwan (Dr. David S. Liao)

Aquaculture has a long history in Taiwan and is making a significant and increasing contribution to the value of the nation's aquatic products and economy. Aquaculture industry has grown rapidly during the past four decades. In recent years, the development of aquaculture has been declined. There are many socio-economic and environmental constraints that hamper the sustainable development of aquaculture in Taiwan as well as other nations in the Asian region. Thus, this paper examines certain socio-economic aspects and sustainability of aquaculture in Taiwan.

In this paper, the development of aquaculture over the decade is briefly reviewed and the key factors that have contributed to the success of aquaculture development are discussed. The main factors of past success are diligent fish farmers, geographic and climate conditions, advanced techniques of feed production and breeding, and strong support from related industries and research sector. Based on both the primary and the secondary data, the economic aspects of aquaculture industry are analyzed. It focuses on the economic characteristics of fish farms, farm size, production costs, productivity, profitability, prices and marketing problems.

This paper also deals with the social and environmental aspects of aquaculture, including

user conflicts, environmental degradation, fish disease, improving employment and the standard of living of rural areas as well as lack of regulations and enforcement. The paper concludes with a discussion of strategies/policies for promoting aquaculture on an economically profitable, socially sound and sustainable basis as follows:

- ***Implement special aquaculture zone programs:***
  In order to have a better infrastructure such as irrigation and drainage system and to avoid the over-exploitation of groundwater, government should plan to establish special aquaculture zones. The zones should be located near coastal areas and engaged in brackish water aquaculture. The government should construct public water supply systems and other infrastructure for fish farmers in the special aquaculture zones.
- ***Implement appropriate licensing system and environmental regulations:***
  The implementation of a licensing system and appropriate environmental regulations is needed to minimize the effects of aquaculture on the environment. The fishery agencies should develop licensing conditions, which ensure that aquaculture operates within acceptable environmental standards. The law enforcement should ensure compliance with license conditions and codes of practices from fish farmers.
- ***Develop ocean cage aquaculture and water recirculation system:***
  Fish farmers using the water recirculation system indicated that their water consumption was much less than of traditional aquaculture systems. Aquaculture should be encouraged to adopt such systems to reduce their freshwater consumption. To replace land-based aquaculture, fish farmers should be assisted in their participation in ocean cage aquaculture.
- ***Implement fish disease control programs:***
  Disease is one of the major problems for the aquaculture industry. To combat disease problems, the establishment of fish disease control programs is needed. The programs can provide diagnostic services and disease prevention measures for farmers to reduce production losses due to disease problems.
- ***Implement a price stabilization fund and cooperative marketing programs:***
  To minimize price fluctuations and marketing inefficiency, price stabilization fund and cooperative marketing programs should be implemented.
- ***Establish feed and seed research and extension programs:***
  Feed and seed are the major cost items in fish farming. They are contributing to high production costs and are serious constraints for aquaculture development. The solution to the problems could be found from research and extension programs.
  There is an urgent need in Taiwan and other nations for the creation of better regulations that can guide the development of more sustainable aquaculture.

Cryopreservation of Gametes and Larvae of Selected Aquatic Species in Taiwan — Research, Development and Application (Dr. Nai-Hsien Chao)

In general, low temperature preservation is a pretreatment of experimental materials, followed by a short-term storage at 4°C, while cryopreservation involves a short- or long-term storage of living cells or treated materials using liquid nitrogen as a coolant. Cells must survive freezing and thawing at such low temperature for any cryopreservation method to be successful. Many cells frozen above –80°C are not stable for a long time. Stability of cells for centuries requires storing them at temperatures below –130°C to ensure survival after the subsequent return to ambient temperature. One of the challenges to the cryobiologist is to prevent the damages in cells caused by freezing during cryostorage.

Advances in research on cryopreservation of gametes and embryos of aquatic organisms are modest compared with work done in terrestrial animals and plants. While sperm has been successfully cryopreserved in a number of cultured finfish and shellfish species, utilization at the fam level is still very limited. Modest success has been achieved in the cryopreservation of shellfish embryos and early larvae. On the other hand, cryopreservation of finfish ova and embryos has not been successful so far. Unlike shellfish eggs and embryos, finfish ova and embryos are large, contain a large amount of yolk and are covered with a relatively thick chorion. Uniformity in the penetration of conventional cryoprotectants and in cooling during the freezing process has not been attained in these large and dense specimens.

Just as cryopreservation has enormous applications in terrestrial plant and animal breeding, cryopreservation also offers the same potential in the artificial propagation of widely diverse aquatic animals. Cryopreservation also has a significant role to play in such concerns as aquatic biodiversity, ecotoxicology, and environmental conservation. Regarding aquatic organisms, sperm cryopreservation has been successful in a number of finfish and shellfish species. Forward-looking aquaculturists are now using cryopreservation to conserve monosex sperm and sperm from special broodstock. Also, oyster trochophores are being used as starter feed for valuable marine finfish species. On the other hand, egg and embryo cryopreservation remains a major challenge.

In both gamete and embryo research, major work is limited to species that are commercially cultured. The enormous potential for application of cryopreservation in aquatic organisms calls for more vigorous research efforts in this area. Efforts may be prioritized on endangered, economically important, and representative species from various aquatic habitats. The current programs in cultured aquatic species must be reinforced. Additional ìgene banksî for cryopreserved specimens should be established. The preservation of germ plasma and embryos should be a top priority among the many goals of cryopreservation. There is a need to promote the applications of sperm cryopreservation at the policymaking, research and hatchery level. More policy makers, scientists and aquaculturists have to be informed about the benefits and the techniques of cryopreservation. An international/regional network for technology transfer, equipment availability, and manpower training must be established to reach this goal.

In conclusion, long-term cryopreservation of gametes of selected aquatic species has increasing and immense value in terms of linking with other aquatic biotechnologies, providing a mean of protecting endangered species, and time- and location- independent distribution of genetic material. Without any doubt, the establishment of networks to utilize cryopreservation worldwide would be a significant and promising task in the 21st century.

Building Competitive Edges of Tilapia and Cobia for Taiwan's Aquaculture Industry during the Transition Period (Dr. Peter Chiang, Dr. Fu-Sung Chiang, and Dr. I-Chiu Liao)

During the last three decades, Taiwan's aquaculture has developed rapidly due to the combined efforts of aquafarmers, investors, and experts from academia and research institutes. Taiwan has gained worldwide reputation in aquaculture technologies. Although aquaculture has contributed greatly to the fisheries production and value, Taiwan's aquaculture sector is facing many problems and challenges. The major factors that may affect the sustainable development of Taiwan's aquaculture are availability of suitable land, high cost of labor, regulatory constraints, changing consumption patterns, and the increasing trend toward globalization.

Taiwan's aquaculture industry needs to prepare to enter an era of restructuring and increasing concern for sustainability. In order to make a successful transition, Taiwan's aquaculture industry has designed a number of strategies and/or policies in the last few years. These strategies aim to 1) develop more high-tech aquaculture technologies, 2) develop fish breeding industry, 3) develop offshore cage aquaculture industry, 4) establish special zones for aquaculture production, 5) enhance the research and development effort on biotechnologies, 6) revise inappropriate regulations, 7) seek opportunities to invest overseas, and 8) adjust market structure and marketing channels to meet the growing competition from imported seafood.

This paper used two of Taiwan's aquaculture products, tilapia and cobia, as examples to demonstrate the advantages and challenges facing the Taiwan's aquaculture sector during this transition period. In the discussion, the current production and market situation of these two products is presented first, followed by an overview of their export trends.

Commercial production of tilapia has gained popularity in Taiwan in the last two decades. Taiwan is one of the major farmed-tilapia producing countries in Asia. In addition, Taiwan is the largest whole frozen tilapia exporter in the US market. Taiwan also exports high quality fresh and chilled fillets to the Japanese sashimi market.

Cobia cage aquaculture started in Taiwan about a decade ago. Cobia production in 2000 was about 3,635 metric tons. Majority of the farmed cobia was for domestic consumption and a small portion was exported to Japan, Hong Kong, Russia, Singapore, Australia, and the US. The cobia-aquaculture industry is still in its early stage of development when compared to the tilapia aquaculture industry. Because cobia grows fast (average 5-8 kg/year), it has great potential to become a valuable product substituting for the declining tuna species.

In order to have a sustainable aquaculture industry, Taiwan's aquaculture sector has to become more market responsive, socially acceptable, technically appropriate, economically viable, and environmental friendly.

Aquaculture in Thailand - With Emphasis on Cage Culture (Dr. C. K. Lin)

Thailand is endowed with rich aquatic resources in its marine and freshwater environment. The fisheries resources constitute a major national economic base and social component as the value of fisheries products consists of 2.9% of GDP amounting to US$ 2.4 billion annually. Between capture fisheries and aquaculture the fishery sector provides over 800,000 jobs with 50% devoted to inland aquaculture The annual 3-million tonnes of fishery products provide not only healthy domestic consumption to 60 million Thais at 20 kg/person/year, but also significant export revenue. While marine capture fisheries contribute over 2.5 million tonnes annually, it has far exceeded the estimated maximum sustainable yield of 1.7 million tonnes. Aquaculture has become a significant contributor with an annual production of 0.5 million tonnes.

The major aquaculture systems and species in Thailand are diverse. Among those cultured species, tilapia and catfish, with combined production of 120,000 tonnes, are most important contributors to food security, while marine shrimp, with annual production of 250,000 tonnes, are the major revenue from foreign trade. Resulting from constraints and competitive uses of land and water resources, intensification in aquaculture has been an apparent developmental trend. Consequently, the environmental impact of intensive aquaculture in relation to its sustainability is a major concern. Significant efforts and progress have been made toward sustainable aquaculture by government, producers and NGOs.

Despite its abundant inland surface water and marine environment in Thailand the production from cage culture is relatively insignificant as it contributes less than 5,000 tonnes, or 1% of total aquaculture production. The most recent production from sea cages was around 4,000 tonnes, consisting of 3,200 tonnes of sea bass *(Lates calcalifer)* and 800 tonnes of grouper *(Epinephelus spp.).* While limited market holds back sea bass culture, the shortage in seed supply constrains grouper production. In comparison, the production from freshwater cage, ranging from 500 to 1,000 tonnes annually in recent years, has been even less significant. Despite various habitats, such as river, reservoirs, irrigation canals and large ponds, are available cage culture takes place predominantly in flowing waters. Among a dozen of cultured species, red snakehead *(Channa micropeltes),* catfish *(Pangasius spp.),* marble goby *(Oxyeleotris marmoratus)* and tilapia *(Oreochromis spp.)* are most common. The production of those species fluctuated drastically resulting mainly from deteriorating water quality, competing for fish feed, changing market value, and shifting culture practices. However, disease and fingerling supply caused the reduction and limitation in culture of the most valued marble goby. Recently, the cage culture of tilapia has gained great popularity in certain parts of the country. Cage culture has been a small-scale, artisanal operation with little technical innovation. Further development of cage cultures in freshwater lies on ecologically sound multiple uses of reservoirs and flowing waters. In addition, integration of intensive cage culture with semi-intensive species in ponds should also be promoted.

There are many problems that constrain further development of marine cage culture. The most common ones are market and profitability, seed supplies and environmental conditions. Those fish are commonly marketed as life fish to regional traders or restaurants, for which capacity is limited and requires well managed transportation logistics. While successful domestication of sea bass provides abundant seed supply from hatcheries, the uncertainty of grouper reproduction in captivity makes chronic shortage in seed supply as it is totally dependent on limited natural recruitment. The often-unplanned and excessive exploitation of coastal zones is causing progressive deterioration of water quality for cage culture.

COUNTRY PAPERS

Aquaculture provides food security and animal protein, source of livelihood etc for many people, in particular, those living in rural areas of Asia. Asia has been the main producer and consumer of aquaculture products as it contributes more than 90 percent of the world production. Asian countries comprise the top ten aquaculture producers with China, India and Japan occupying the first three slots by contributing 70, 5 and 3 percent of the world production, respectively. Such progress has been largely achieved through both horizontal and vertical development of aquaculture. The vertical aquaculture development evolved from improvements in traditional techniques such as intensification and diversification, as well as development of new aquaculture technologies in feeds and breeding. The technological success in Japan and Taiwan has served as a model for other Asian countries to transform aquaculture from traditional livelihood activity to a profit-oriented industry in the region. However, there is fear that number of aquaculture scientists is decreasing in some member countries.

Different member countries are at different stages of aquaculture development. For instance, Japan and Taiwan are using advanced technologies for aquaculture development that fully exploited their aquaculture resources. Similar trend is followed by Thailand and Philippines. India, Indonesia, Iran and Vietnam exhibit large potential for aquaculture

development. In Vietnam aquaculture is expanding rapidly. Although Nepal, being landlocked has relatively limited potential for aquaculture development, the country shows strong determination to utilize its rivers, reservoirs, etc to develop aquaculture. Regardless the stage of development, all countries show strong desire to further develop their aquaculture. The trend for developing aquaculture is not only for enhancing food security and foreign revenue but also for recreational purpose to enhance incomes and public enjoyment.

Many countries in the region, Taiwan as an example, have achieved unprecedented increase in their aquaculture production that has led to serious socio-economic and environmental problems due to the short-term profit-driven strategies adopted by the farmers/investors. The unstrained use of water, land and other natural resources resulted in over extraction of groundwater, land subsidence, flooding during storms, deterioration of groundwater quality and destruction of coastal ecology. In some countries disease epidemics emerged due to lack of proper management, and fishery resources are threatened as a result of destruction of the coastal areas.

Most of the developing member countries show commonality of issues/problems in aquaculture management such as poor infrastructure, particularly in storage and marketing; use of ineffective traditional technologies; conflict among users, lack of financial resources, lack of proper legislation and policy/program implementation, disease incidence, among others. More developed countries like Japan and Taiwan are confronted with problems such as high cost of aquaculture production, marketing, lack of interest among young generation to pursue activities related to aquaculture, etc.

Regardless of the diverse issues and problems in aquaculture production, all countries are aware of the considerable potential for aquaculture expansion in the respective member countries provided that development proceeds in an environmentally sustainable and responsible manner.

FIELD VISITS

For field studies, participants visited the following relevant facilities in the host country:

1. Tungkang Marine Laboratory (TML)
2. Abalone Farm, Linyuan
3. Marine Shrimp Broodstock Farm - Aquaculture Taiwan Resource Co. Ltd., Linyuan
4. Marine Shrimp Broodstock Farm - Apex Aquaculture Co. Ltd., Linyuan
5. Freshwater Tilapia Farm — Fortune Ent. Co. Ltd., Shinpie Shiang
6. Grouper Broodstock Farm — Long Diann Trading Co. Ltd., Fangliou Shiang

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1. **Tungkang Marine Laboratory**
   (5 December 200, Afternoon)
   The participants visited research and other facilities at Tungkang Marine Laboratory (TML) of Taiwan Fisheries Research Institute (TFRI). Dr. Tzyy-Ing Chen, Director (TML) with assistance of her staff guided the Lab tour. Dr. I-Chiu Liao, Director General of TFRI also accompanied the participants.
   The TML was established in 1968. The TML aims to accelerate the

technical improvement and development of commercial aquaculture in Taiwan and promote fishery production in its surrounding waters. The TML is one of the eight Marine Labs working under administration of TRFI. Present number of TML staff is 52 including 14 full-time research members. There are nine main divisions of research. TML occupies an area of 6.8 hectares. Its facilities, supporting all aspects of aquaculture research and development, include a main administrative building, eight research buildings, three hatchery houses, three staff housing units, a water supply building and over 90 experimental ponds in various sizes with a total area of slightly more than two hectares. The main administrative building houses an aquarium, an exhibition room, an auditorium, library, a cafeteria, nine guest houses, among other offices and facilities. Participants were able to visit important facilities of TML. The TML through its R&D efforts looks forward to play a vital role in promoting development of aquaculture and marineculture as an industry and alleviating food shortage in Taiwan and elsewhere. The participants showed keen interest in the work and facilities of TML and appreciated the TML staff for their excellent hard work and accomplishments.

2. **Abalone Farm, Linyuan**
(7 December 2001, Morning)
Mr. Fong Lin Hwang, owner of the farm who is academically an Electrical Engineering Graduate, welcomed the participants. He briefed the participants on farm facilities and activities and guided their tour through various facilities of the farm. The Abalone Farm at Linyuan (AFL) was established 20 years ago with an area of 0.4 ha. The farm has been developed gradually over the years, without any financial assistance of commercial banks/Government. This small-scale intensive unit is run primarily by family labor together with 10 paid employees. The daily wages of an employee are 800 NT$ per eight hours. The farm is engaged in production of Abalone (mollusk, Haliotis sp) exclusively. One crop cycle of Abalone from spat to marketable size of 25 pieces /600 g needs the culture period around 14 months. The FCR is about 30:1. The water used in the farm is recycled. The culture Abalone needs the simple depuration for a few days before transported to the market.
The farm produces about 30,000 tonnes Abalone per year, in 2 crops — one million Abalone per crop. The selling price of the product is about US$ 9.7 per kg, resulting in a net profit of one million NT$ (US$ 29,000) per year. There is no tax on aquaculture production and income in Taiwan to promote the aquaculture industry.

3. **White Shrimp Broodstock Farm - Aquaculture Taiwan Resources Co. Ltd., Linyuan**
(7 December 2001, Morning)
Mr. Henry Wang, President, Aquaculture Taiwan Resources Co. Ltd., welcomed the participants. He briefed the participants on White Shrimp Broodstock Farm and guided them through various farm operation and management facilities. Mr. Henry started his business as a hatchery with germplasm from the Hawaii about four years ago. But due to poor performance of hatchery enterprise, he switched to the breeding of L. vannamei (South American white shrimp) with technical guidance from the TML. The company has committed fully to this species for the last

two years (since 1999). The reasons for such commitment are: species tolerance to high density (more than 100m-2), low FCR (1.0 — 1.2 is achievable), commercially successful operation of broodstock domestication, and market acceptance of product both locally and internationally. The farm has been innovated into indoor/outdoor white shrimp spawner farm, a nucleus hatchery. The seawater at 30 ppt was filtered and ozonated for use in the spawner tanks. The female and male were reared separately in cement tanks. The spawners are fed with in-house moisture feed plus fresh feeds of oyster, squid and krill. Second generation of broodstock was being domesticated. Maturation operation consisted of 12 million nauplii produced a day from constant 1,000 pairs of broods. Market outlets include Taiwan and China. The priorities of the company's commercial research are: 1) selective breeding programs of high growth and disease resistance to TSV and WSSV, and 2) recirculation is set up for maturation operation to ensure smoother production. Future expansion plans of the company include: 1) pilot trial of factory—oriented growout for vertical integration, and 2) nuclear broodstock joint ventures in other Asian areas, only for L. vannamei technology dissemination.

4. **Marine Shrimp Broodstock Farm — Apex Aquaculture Co. Ltd., Linyuan**
   (7 December 2001, Morning)
   Mr. Benny Chung, Director, Apex Aquaculture Co. Ltd., who is academically an Environmental Engineering Graduate, welcomed the participants. He briefed the participants on various activities of the Broodstock Farm and guided their tour through different farm facilities. This shrimp farm was rented about three years ago on lease for 10 years for shrimp spawner domestication in captivity. The farm occupies an area of one ha. Mr. and Mrs. Benny both work on the farm along with seven paid employees. The salary of one employee is NT$35,000 per month. The farm has broodstock of different varieties of marine shrimp. The main species is P. vannamei. However, P. stylirostris (American white shrimp) is also reared and experimented on SPF (Specific pathogen free) of P. monodon (Black tiger shrimp). The P. vannamei spawner is usually bought from SPF farm from Hawaii (Dr. J. Wyban's Farm). However, culture selection has also been conducted on this farm. The spawner is usually fed with natural food such as worm, oyster, etc. The farm is also equipped with PCR testing facilities. Mr. Benny intends to be a SPF spawner. The farm produces about one billion nauplii per season, which are then reared by other farmers to PL stages. According to Mr. Benny, he was running a high-risk business and incomes were not stable due to high price fluctuations.

5. **Freshwater Tilapia Farm — Fortune Ent Co. Ltd., Shinpie Shiang**
   (7 December 2001, Afternoon)
   Mr. James Chang owner of the Company welcomed the participants. He guided the participants' tour through various facilities of the farm and responded to various queries raised by the participants.
   The farm occupies an area of eight ha. This farm was established about 28 years ago. It has specialised in production of Tilapia using high technology. The fingerlings are produced at the farm's own hatcheries.

The culture period is as follows: Larvae rearing in nurseries for about a month, further rearing to about 100 g weight in nursing cement ponds (about a month), followed by culture in grow out ponds for 4 months. The farm produces monosex red Tilapia. The final grow-out ponds can rear for three crops per year at a high stocking density (one million per ha) with about 15-20% water exchange per day. The FCR is around 1.5. The survival rate is more than 90 percent. The red Tilapia is sold live @ NT$ 95 (US$ 2.5) per kg to seafood restaurants. This farm also cultures soft-shell turtle and crocodile. There are about 20 crocodiles, the oldest one is of 28-year age.

6. **Grouper Broodstock Farm — Long Diann Trading Co. Ltd., Fangliou Shiang**
   (7 December 2001, Afternoon)
   Mrs. Tai Kun Tsai - wife of the farm owner - welcomed the participants. She took participants around the farm facilities and responded to queries raised by them. This farm started its operations in 1985 with lobsters but has taken up grouper seed production for about last 10 years. The fish farmer Mr. Tai Kun Tsai has been adjudged by the National Government of Taiwan as the Best Finfish Culturist in Taiwan for the year 2000. The farm can produce 1,800 kg of giant grouper (Epinephelus lanceolatus) eggs per year in the operative cycle of 6 months from May to October. The activity appears to be highly profitable as the eggs are sold at a price of NT$10,000 to 15,000 for 300 g of eggs. Please note there are about 0.5 million eggs per 300 g of eggs.
   At present farm is raising Giant Grouper, Potato cod (Potato Grouper), Broodstock and some other endangered species.

Notes:

- *All the field visits were very much relevant to the subject of the seminar. The participants seemed to be delighted and satisfied from the field visits.*
- *Dr. I-Chiu Liao, Director General of TFRI, and Dr. Tzyy-Ing Chen, Director; Dr. Huei-Meei Su and Dr. Jin-Hua Cheng of TML, accompanied the participants throughout field visits.*

WORKSHOP OUTPUT

A workshop was conducted to provide an opportunity for further discussion and sharing of views and experiences among the participants. The objectives of the workshop were as follows:

- To identify issues/problems in aquaculture management for improving aquaculture productivity and environmental sustainability, and
- To suggest strategies to address such issues.

To facilitate discussions the participants were divided into two groups. The outputs of the two groups were presented in a plenary session and these have been summarized as follows:

WORKSHOP OUTPUT (Group I)

Group I:
Mr. Tzyh-Chung Miaw (ROC), Ms. Enny Ratnaningtyas (Indonesia), Dr. Toshimichi Maeda (Japan), Mr. Kriangsak Mengumpan (Thailand), Mr. Tran Van Bom (Vietnam)

Chairperson: Mr. Juan Alerto K. Montalvo

Rapporteur: Mr. Nik Ab. Wahab Bin Mat Diah

Facilitator: Dr. Masachika Maeda

A. Policy/Legislation

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Lack of adequate legislation/policies/programs on environmental friendly aquaculture Lack of appropriate zoning programs Excessive use of ground water Users conflicts Lack of credit and insurance	Come up with a declaration on the code of conduct for environmental friendly aquaculture Reduce impact of environmental degradation in aquaculture To plan, implement, enforce and monitor the adopted policy and regulation	Organize all sectors of the industry to come up with a declaration for sustainable aquaculture Aqua-farms must be accredited and the farmers should be trained/informed about eco-aquaculture Government should exercise its powers in protecting the environment Government should relax the requirement of credit and to come up with the insurance scheme

B. Socio-economic

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Lack of interest among	Information	Promotion of

		aquaculture products among the people To implement guideline on quality and safety standard

C. Technology

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Lack of access to advanced aquaculture technology Inadequate methods to evaluate aquaculture impacts on biodiversity Use of fishmeal of extremely large quantity in formulated diet	Establish global networking on research principle information and technology To provide a focus R&D to address the present and future needs of aquaculture To provide a focus research and development to address present and future needs of aquaculture	Conduct research on coming up applicable technology for effective environment protection Regional seminars, workshops Information exchange to publish for aqua-farmers Reasonable and appropriated technology must be applied

D. Management

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Declining resources for aquaculture Too profit oriented High cost of production	To develop production systems that are sustainable, reversible, and re-focus aqua-farmers to consider productivity and the natural laws of nature besides profitability Information dissemination Review existing culture techniques	Organize and inform aqua-farmers on the issues in aquaculture Come up with a code of conduct for sound aquaculture practices for fish farmer self management Provide farmers with market information and the demands of the market Provide aqua-farmers

		with alternative culture techniques by implementing extension programs

E. Trade/Market

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Trade globalization under WTO initiatives International competitiveness	Cooperation between regional countries to homogenize position on trade issues Improve the quality of aquaculture products to explore value addition and open wider market	To provide safety-nets to protect local products from the effect of trade globalization Set up regional network for marketing information

WORKSHOP OUTPUT (Group II)

Group II:
Dr. Yu-Hui Chen (ROC), Mr. Rajendra Kumar K. C. (Nepal), Ms. Rosa F. Macas (Philippines), Mr. W.A.A.K. Fernando (Sri Lanka), Mr. Siri Tookwinas(Thailand)

Chairperson: Dr. Abdul Hamid Yazdani Jahromi

Rapporteur: Mr. Aprameya Sarvadeva

Facilitator: Dr. C. Kwei Lin

A. Policy/Legislation

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Improper/inadequate/lack	Participation of all	Responsible agencies

	Combination of top down and bottom up approach Upgrade management, technology, facilities, etc. Enhance quality control of inputs and products Strategic or long term planning

B. Socio-economic

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Too much profit-oriented aquaculture industry Bias against aquaculture Lack of interest in youth for aquaculture Changing food preferences Language barrier	Strike a balance between profit and other aspects of aquaculture industry Public Awareness Change image of the profession Health awareness Learn English/language of interest	Constant interaction between government, industry, aquafarmers, & consumers Publicity More qualitative education Publicity Audio-visual media Internet

C. Technology

ISSUE	STRATEGY	ACTIVITY/PROGRAM
High-cost technology	Develop low-cost	R & D

	HRD Extension Publicity R & D Education Training HRD APO may coordinate a program to identify collaborative opportunities

D. Management

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Inadequate or less efficient management systems	Integrated management CoC	Education Training Quality Management

E. Trade/Market

ISSUE	STRATEGY	ACTIVITY/PROGRAM
Negative impact of aquaculture on natural resources	Promote environmental friendly aquaculture to conserve natural resources	EIA Corrective measures CoC

CONCLUSION

Aquaculture contributes to food security, provides employment, and serves as a catalyst for regional as well as international collaboration, among other benefits. Asia has made remarkable progress in aquaculture. However, rapid aquaculture development without sound management and planning has led to several socio-economic and environmental degradation problems. Besides due to trade globalization under the initiatives of WTO Asian aquaculture needs to adopt strategies to enhance its competitiveness in both domestic and international market. Such problems/challenges require immediate attention of all the stakeholders.

There is wide disparity in aquaculture development in most of the Asian countries. Thus aquaculture development in developing countries should be based on the most urgent need, which in most cases is the reliable food supply. Priority must be given for culture of those species that are economical and would not require advanced skills and techniques and high capital investment. The technically advanced countries should share their

information and techniques with less developed countries in the region.

There is enormous potential for further development of aquaculture in most of the Asian countries provided that development proceeds in an economically viable, environment friendly and responsible manner. To meet such sustainability and environment conservation challenge recent advances in aquaculture development would need to be disseminated and shared through effective regional collaborations/networking, and integrated aquaculture management in the context of overall ecosystem management. Such a paradigm shift in aquaculture development would require strong political will of respective APO member governments coupled with more active participation of private sector, NGOs, CSOs, other people-based groups and aqua-producers and consumers.