The Philippines

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INTRODUCTION

For the past several years, aquaculture has dominated the fisheries sector and is considered at the forefront of the government's food security and poverty alleviation programmes. Seaweeds and milkfish are the top-two commercially important species produced from aquaculture. Other species are tilapia, grouper, siganids and mussels.

With the vast growing population of the country, the need to expand aquaculture areas is obvious, from the traditional freshwater and brackishwater ponds to marine farming in fish pens and cages. The increasing volume of produce from cages compared to the modest production from fishponds has encouraged fish farmers to venture into deep-water-based or off-shore aquaculture enterprises.

The proliferation of fish pens and fish cages in shallow, narrow tributaries and rivers has resulted in occasional fish kills. These structures have obstructed the tidal flow of freshwater into brackishwater ponds, thereby affecting pond production in some areas. Moreover, polluted water caused by excessive feed inputs resulted to some extent in retardation in the growth of oysters. The continuous increase in the number of structures may also have contributed to siltation in aquaculture zones.

The establishment of mariculture parks is foreseen to play a significant role in solving these negative impacts. It also aims to promote zoning in municipal waters by delineating areas for mariculture and providing opportunities for marginal farmers to engage in off-shore fish-cage operation.

This paper will include information on the current status and challenges in the establishment of mariculture parks including the management concepts, legal mandates, organization, technical services offered, opportunities, constraints and issues.

OVERVIEW OF THE FISHERIES SECTOR

Contribution to world production

In 2003, the Philippines ranked eigth among the top fish-producing countries in the world, with a total production of 3.62 million tonnes of fish, crustaceans, molluscs and aquatic plants. The production constitutes 2.5 percent of the total world production of 146.27 million tonnes (FAO, 2004).

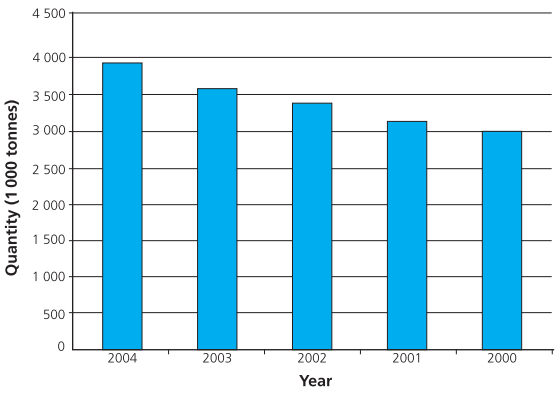
The Philippines aquaculture production of 0.459 million tonnes in 2003 was eleventh in the world, contributing 1.1 percent to the total global aquaculture production of 42.3 million tonnes and amounting to about US$600 million in terms of farm-gate value (FAO, 2004).

The Philippines is also the world's second-largest producer of aquatic plants (including seaweeds), having produced a total of 0.989 million tonnes or nearly 8 percent of the total world production of 12 million tonnes (FAO, 2004).

TABLE 1
Five-year fish production trend, 2000–2004 (Source: BFAR, 2004)

Year	Quantity (tonnes)	% Increase (Decrease)	Value (1 000 PHP)	% Increase (Decrease)
2000	2 993 332.00	2.38	98 622 134.00	6.82
2001	3 166 530.00	5.79	106 944 716.00	8.44
2002	3 369 524.00	6.41	113 258 218.00	5.90
2003	3 619 282.38	7.41	119 866 326.00	5.83
2004	3 926 173.36	8.48	138 846 377.29	15.83

Figure 1
Five-year fish production trend, 2000–2004



Contribution to national economy

In 2004 the fishing industry contributed 2.3 percent and 2.4 percent to the country's gross domestic product (GDP), equivalent to some PHP 111 billion and PHP 48 billion for current and constant prices, respectively (Table 1 and Figure 1).

The industry's contribution to the Gross Value Added (GVA) in Agriculture, Fishery and Forestry Group is 14.9 percent (PHP 111 billion) and 21.6 percent (PHP 48.7 billion) out of the total PHP 742 billion and PHP 225 billion at current and constant prices, respectively. It has the largest share next to agricultural crops.

The fishing industry provided employment to a labour force of more than 1.6 million nation wide (NSO 2002). Of the total labour force, 1.3 million are employed in the municipal fisheries, 226 195 in commercial fisheries and 16 497 in the aquaculture sector.

Performance of the fishing industry

In 2005, the total fisheries production reached 4.16 million tonnes (Table 2). In that year, the aquaculture sector provided the highest share of 45.5 percent, while commercial and municipal fisheries contributed 27.3 percent and 27.2 percent, respectively.

Total fisheries production grew from 3.17 million tonnes in 2001 to 4.16 in 2005. The average total annual production within the period 2001–2005 was 3.648 million tonnes.

From 2001 to 2005, the contribution of aquaculture to total fish production increased steadily from 38.5 percent in 2001 to 45.5 percent, for a five-year average contribution of 41.6 percent to the total production (Table 2). In comparison, commercial and municipal fisheries productions have similar contributions of about 30 percent and 29 percent, respectively, to the total fish production. Within the aquaculture subsector, production grew at an average rate of 11.6 percent per year between 2001 and 2005. The aquaculture growth rate in fish production in 2005 was a 10.4 percent increase over the year 2004.

TABLE 2
Volume (x1 000) of fish production by subsector, 2001–2005 (Source: BFAR, 2004 and preliminary data from Bureau of Statistics)

Year	Total production (tonnes)	Commercial		Municipal		Aquaculture		
		Volume (tonnes)	% of Total	Volume (tonnes)	% of Total	Volume (tonnes)	% of Total	Annual growth (%)
2001	3 166	976	30.8	969	30.6	1 221	38.5	10.8
2002	3 369	1 042	30.9	989	29.4	1 338	39.7	9.6
2003	3 619	1 109	30.6	1 055	29.2	1 454	40.2	8.6
2004	3 924	1 137	28.9	1 059	26.9	1 726	43.9	8.7
2005	4 163	1 135	27.3	1 132	27.2	1 895	45.5	10.4
Avg.	3 648	1 079.8	29.7	1 040.8	28.7	1 526.8	41.6	9.6

Marine waters production

Production in 2004 reached 23 542.35 tonnes in marine cages and 14 294.42 tonnes in pens. Commodities produced include milkfish, grouper and other marine species (Table 3 and Figure 2).

TABLE 3
Production (tonnes) from marine waters, 2004 (Source: BFAR, 2004)

Culture environment	Total	Milkfish	Grouper	Others
Fishcage	23 542.35	23 179.06	136.45	226.84
Fishpen	14 294.42	14 172.61	33.69	88.12
Total	37 836.77	37 351.67	170.14	312.96

Brackishwater production

For the year 2004, production from brackishwater fishponds was 253 848.52 tonnes, the bulk of which was the production of milkfish. Fish pens recorded a production of 4 499.50 tonnes, while fish cages added about 4 205.71 tonnes. Commodities from brackishwater production are milkfish, tiger prawn, white shrimp, endeavour prawn, tilapia and other species (Table 4 and Figure 3).

Figure 2
Production from marine aquaculture in 2004

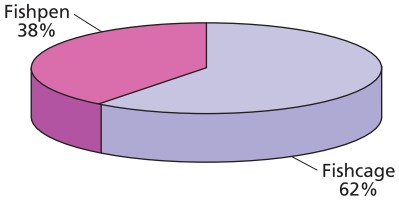


TABLE 4
Production (tonnes) from brackishwater, 2004 (Source: BFAR, 2004)

Culture environment	Total	Milkfish	Tiger prawn	White shrimp & endeavour prawn	Tilapia	Others
Fishpond	253 848.52	200 530.90	35 916.52	2 029.60	9 045.93	6 325.57
Fishcage	4 205.71	4 056.08	-	-	115.90	33.73
Fishpen	4 499.50	4 388.30	-	-	97.30	13.90
Total	262 553.73	208 975.28	35 916.52	2 029.6	9 259.13	6 373.20

Mariculture production

Regional production from mariculture yields a total of 1 235 761.09 tonnes. Seaweeds contributed the largest share of 97.5 percent. The rest is contributed by oysters and mussels, with percentage shares of 1.3 percent and 1.2 percent, respectively (Table 5). Regional production trend showed that the Autonomous Region in Muslim Mindanao (ARMM) remained the highest contributor of mariculture products, followed by Regions IV-B and IX, respectively (Figure 4).

Figure 3
Production from brackishwater, 2004

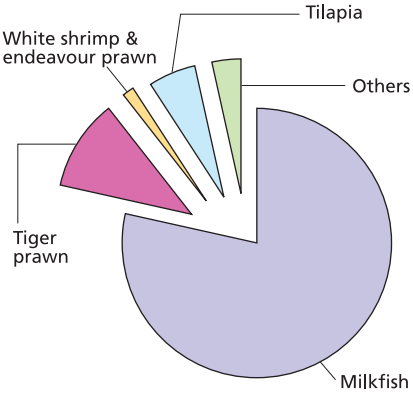


TABLE 5
Production (tonnes) from mariculture by region and commodity, 2004 (Source: BFAR, 2004)

Region	Total	Oysters	Mussels	Seaweeds
I	2 704.65	2 677.15	-	27.50
II	325.50	319.00	-	6.50
III	6 772.77	6 147.10	598.30	27.37
IV-A	30 008.44	343.44	4 227.00	25 438.00
IV-B	329 140.43	-	-	329 140.43
V	17 748.99	47.02	735.17	16 966.80
VI	62 971.60	5 354.73	6 633.25	50 983.62
VII	83 594.05	187.94	-	83 406.11
VIII	16 213.00	2.00	2 840.00	13 371.00
IX	155 102.67	312.21	4.50	154 785.96
X	39 155.64	-	-	39 155.64
XI	1 670.36	524.72	-	1 145.64
ARMM	472 514.80	-	-	472 514.80

Figure 4
Total production (tonnes) from mariculture by region, 2004

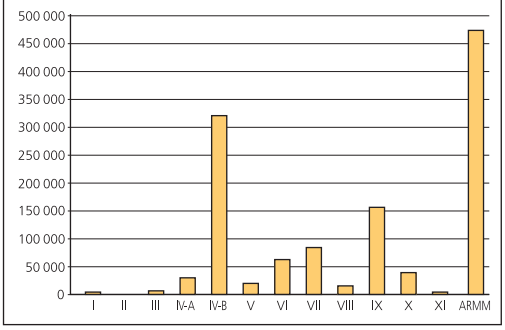
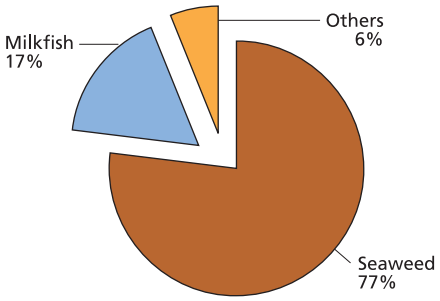


Figure 5
Major farmed species in 2004



Commodities

The top three major aquaculture commodities are seaweeds, milkfish and tilapia (Table 6 and Figure 5). Seaweeds recorded the highest volume, constituting 70.2 percent of the total aquaculture production. Milkfish ranked second with a share of 15.9 percent, followed by tilapia with 8.5 percent. The rest contributed 5.4 percent.

TABLE 6
Major species produced by aquaculture, 2004 (Source: BFAR, 2004)

Species	Quantity (tonnes)	Percent (%)
Seaweeds	1 204 807.56	70.2
Milkfish	273 593.36	15.9
Tilapia	145 860.36	8.5
Others	92 757.38	5.4
Total	1 717 026.66	100

Seaweeds

In the Philippines, seaweed is the most valuable commodity produced from aquaculture. More than 800 species of seaweed have been recorded in the Philippines. The major commercial seaweeds are *Eucheuma, Kappaphycus, Gracilaria* and *Caulerpa*. Others include *Codium, Gelidiela, Halymenia, Porphyra* and *Sargassum*.

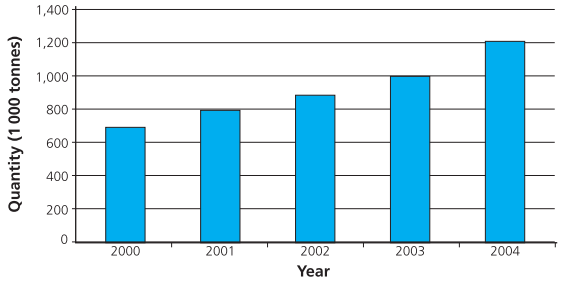
Production of seaweeds has continuously increased from 707 039 tonnes in 2000 to 1 204 808 tonnes in 2004. The yearly improvement in production can be attributed to high market demand, better prices and good weather conditions that encouraged farmers to expand their areas for seaweed culture.

TABLE 7
Seaweed production, 2000–2004 (Source: BAS and BFAR, 2005b)

Year	Production (tonnes)
2000	707 039
2001	785 795
2002	894 856
2003	988 888
2004	1 204 808

Seaweed culture is now emerging as an important and major livelihood in the coastal areas, specifically in Regions ARMM, IV-B and IX. The provinces of Tawi-Tawi, Sulu, Basilan, Palawan, Antique, Bohol, Quezon, Zamboanga del Norte, Camarines Sur, Eastern Samar, Surigao del Sur, Zamboanga Sibugay, Lanao del Norte and Maguindanao are potential areas for seaweed culture.

Figure 6
Five-year fish seaweed production, 2000–2004
(Source: BFAR, 2004)



Seaweeds contributed 31 percent to the total 2004 fisheries production (Table 7 and Figure 6). *Kappaphycus alvarezii* and *Euchema denticulatum* are the major species cultivated. The culture methods used by farmers are fixed bottom monoline and floating monoline.

The seaweed industry employs between 100 000 and 120 000 people. Of the total individuals employed, 90 percent are seaweed farmers and the rest are seaweed processors and traders. Sixty-five percent of the total production is processed into semi-refined chips/carrageenan, 13 percent is exported raw (dried) and the remaining 22 percent is processed into refined carrageenan.

The Philippines is among the top producers of seaweeds in the world, specifically the red seaweeds – next to the People's Republic of China and Japan. In 2004, about 24.8 million tonnes valued at PHP 1.2 billion was exported to the United States of America, France, Republic of Korea, China and China, Hong Kong SAR.

Problems and constraints

The main problems facing seaedweed cultivation in the Philippines are:

- pollution in production areas;
- inadequate supply of dried seaweeds for processing leading to processors' losses;
- the peace and order situation in seaweed-producing areas;
- diseases affecting seaweeds (e.g. ice-ice);
- inconsistency in quality due to adulteration of the processed product with foreign materials; and
- increasing competition in *Eucheuma* production from other countries such as Malaysia, Indonesia and some African nations.

Milkfish

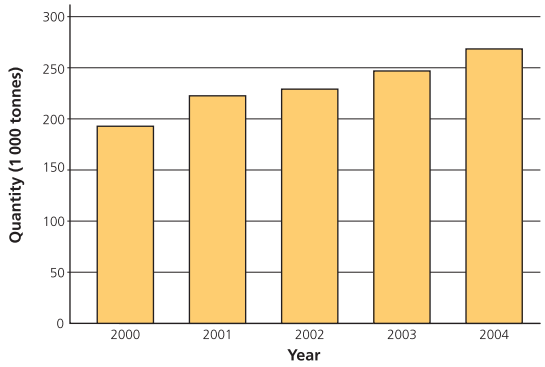
Milkfish is an important aquaculture commodity. Over the past five years, production has steadily increased from 194 023 tonnes in 2000 to 269 930 tonnes in 2004, with an average annual growth rate of 8.7 percent (Table 8 and Figure 7). Harvests from the different culture environments were as follows:

- freshwater contributed 10 percent to the total milkfish production;
- brackishwater recorded the highest share of 77.4 percent due to improved technology such as increase in stocking density and expansion of operations; and
- marine fish cages and fish pens contributed 12.6 percent.

TABLE 8
Milkfish production, 2000–2004 (Source: BFAR, 2005a)

Year	Production (tonnes)
2000	194 023
2001	225 337
2002	231 968
2003	246 504
2004	269 930

Figure 7
Five year total milkfish production, 2000–2004
(Source: BFAR, 2004)



Based on regional milkfish production and requirements in the year 2004, regions I, III, IV-A & B, VI, IX, XI and XII recorded a surplus, while deficits were incurred in regions II, NCR, V, VI, VII, VIII, X, ARMM and Caraga. However, based on the national production, a surplus of more than 100 000 tonnes was determined (Table 9).

TABLE 9
2004 milkfish production and requirements at 1.98 kg per capita consumption (Source: BAS, 2004; BFAR, 2005a)

Region	Population	Production (tonnes)	Consumption (tonnes)	Gap
I	4 422 483	48 634.3	8 756.5	39 878.1
II	3 032 872	240.4	6 005.1	(5 764.7)
III	8 297 012	58 794.0	16 428.1	42 365.9
NCR	11 070 287	3 160.0	21 919.2	(18 759.2)
IV-A	10 940.575	32 665.9	21 662.3	11 003.6
IV-B	1 612 601	3 582.7	3 192.9	389.8
V	5 079 867	1 669.9	10 058.1	(8 388.2)
VI	6 778 143	63 991.7	13 420.7	50 571.0
VII	5 970 149	7 582.0	11 820.9	(4 238.9)
VIII	4 058 787	2 362.4	8 036.4	(5 674.0)
IX	3 452 079	9 776.3	6 835.1	2 941.2
X	3 013 186	5 907.4	5 966.1	(58.7)
XI	5 771 878	12 446.9	11 428.3	1 018.6
XII	2 910 459	13 311.7	5 762.7	7 549.0
ARMM	2 330 394	2 004.6	4 614.2	(2 609.6)
Caraga	2 393 402	3 799.7	4 738.9	(939.2)
Total	82 663 599	269 930.2	163 673.9	109 284.5

Problems

Problems faced by milkfish culture in the Philippines include:

- degradation of quality fingerling stocks due to inbreeding;
- insufficient supply of quality milkfish fry in far-flung areas;
- high cost of farm inputs and poor quality feeds;
- lack of manpower to effectively transfer technology to the municipal level; marketing layers that stand between producer and consumer; and
- lost opportunities to participate in the global market for value-added products.

GOVERNMENT PROGRAMMES/INTERVENTIONS

Seaweeds

Interventions of the government through the Department of Agriculture, Bureau of Fisheries and Aquatic Resources (DA-BFAR) include:

- expansion of seaweeds farming in traditional areas (currently there are 57 seaweed nurseries nation wide, using *lantay* technology in non-traditional areas);
- introduction of seaweed farming in non-traditional areas;
- adoption of appropriate technologies to increase productivity;
- conduct of research and development;
- improvement of post-harvest techniques;
- establishment of semi-processing plants in strategic areas;
- promotion of seaweed and seaweed products;
- credit facilitation/credit access;
- monitoring of seaweed price; and
- organization of seaweed farmers.

Milkfish

In line with the implementation of the Medium-Term Philippine Development Plan (MTPDP) 2005–2010 to support President Gloria Macapagal Arroyo's (PGMA) 10-point agenda, BFAR is expected to:

- Expand the present milkfish production areas by 3 190 ha. The expansion is expected to generate a total of 86 260 jobs and an annual milkfish production increment of at least 25 000 tonnes.
- Establish additional central hatcheries in strategic areas to sustain the supply of cheap but high-quality milkfish fry to fish farmers all over the country through the Philippine Bangus Development Program. The intervention is expected to help reduce the cost of fingerlings by 50 percent.
- Establish lead price including tri-media information dissemination of wholesale and farm gate prices in fish ports in order to reduce percentage of mark-up of marketing layers by 20–30 percent. The long-term goal is to eliminate marketing layers through the organization of cooperatives and provision of credit facilities.

The Philippine Bangus Development Program is a government intervention that aims to ensure the sustainable supply of milkfish fry. The programme utilizes the simple protocol of producing milkfish fry on a commercial scale. The concept includes the use of government, academic and private hatcheries as satellites. Central hatcheries will produce good-quality eggs that will be sold to the satellites for hatching and larval rearing.

Currently, there are 2 714 breeders being utilized for the programme. The central milkfish hatcheries and satellite hatcheries established nation wide are as follows:

Central Hatcheries

- BFAR-NIFTDC, Dagupan City
- BFAR-CALAPE, Bohol
- BFAR Sta. Lucia, Palawan

- BFAR-Naujan, Oriental Mindoro
- BFAR-Tiwi, Albay
- Hipolito-Damortis, Sto, Tomas, La Union
- Hautea-Dumangs, Iloilo
- Ibabao-Kalibo, Aklan
- Rivera-Cabangan, Zambales

Satellite Hatcheries
- Argao, Cebu - operational
- Bais City, Negros Occidental (operational)
- University of Northern Philippines (UNP), Sta. Maria, Ilocos Sur (operational)
- Young-Bolinao, Pangasinan (operational)
- San Felipe, Zambales (100 percent completed)
- Claveria Cagayan (launched 24 January 2006)
- Bongabon, Oriental Mindoro (under construction – 25 percent completed)

In 2005 milkfish egg production reached 195 million eggs. The recorded fry production is 9.6 million. Total clients served were 188.

Establishment of marine parks management concept of mariculture park

The objectives of this programme include:
- employment generation and poverty alleviation in the countryside;
- promotion of marine fish culture as an alternative source of livelihood for marginalized and sustenance fisher folk;
- development of an area with appropriate equipment and infrastructure that will allow fishermen, fish farmers and investors to operate cost-effectively and securely;
- development of skilled and technically capable fisher folk to support the mariculture industry; and
- promotion of the use of environmentally friendly inputs and farm management practices.

The project will be implemented at the village level wherein local government unit (LGU) participation is needed in zoning a parcel of at least 100 ha of coastal municipal water to be declared as a mariculture park. It will utilize modern floating cages that tolerate 2–3 m wave action and that will last at least five years with little maintenance.

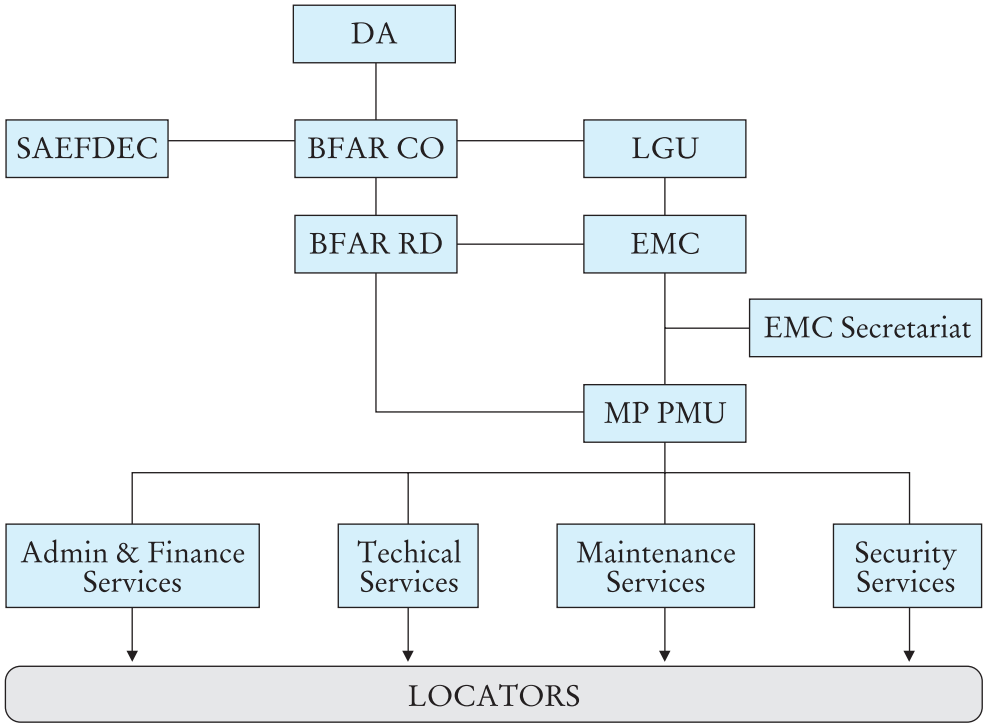
A component of the park is an Executive Management Council (EMC) that governs the establishment of a grid-type "community" storm-mooring system and cluster of marine sea-cages. Aside from providing the necessary security for the cages during seasonal rough weather, a standardized mooring facility is expected to help prevent problems of uncontrolled growth and expansion, encroachment, entanglement of moorings and navigational hazards.

The following sections describe the features and activities within different stakeholders and management units (see Figure 8).

Features
- multi-product onshore warehouse, cold storage and ice plant facility service as well as ferry boats;
- sufficient navigational lanes and a communal mooring system;
- internal and external security;
- well-defined sites for investment category for small, medium and large-scale investors;

- readily available mooring support services for small-scale operators; and
- availability of seeds and feeds supplier, cage fabricator and manpower services.

Figure 8
Organizational structure and functions[1]



[1] DA as the Executing Agency.
BFAR-SEAFDEC-LGU Signatories of the MOA.
EMC-Executive Management Committee takes charge for the over-all administration of the Marine Park Project.
BFAR-RD coordinates with the EMC on day-to-day operations.
RD as Project Management Unit (MPMU) Project Manager.
Project Management Unit (MPMU) implements the day-to-day operations of the MP.

Benefits to the LGU per hectare

- Mayor's/business permits
- PHP 1 500/mooring space/year x 30 spaces/ha = PHP 45 000
- Executive Management Council rentals
- PHP 5 000/mooring space/year x 30 spaces/ha = PHP 150 000
- employment benefits as outlined below:

Direct:
caretaker (60), security (2), maintenance (5)
Indirect:
cage fabricators (360), mooring development (15),
fry producer (133), transport and handling (5 346)

- other business/permits
- value-adding (milkfish deboning)
- cage suppliers

- feed suppliers
- fish dealers
- warehouse
- ice plant and cold storage
- milkfish hatchery operations
- milkfish nursery operations

Legal mandates

- Republic Act No. 8550
  - Section 47: Code of Practice for Aquaculture (FAO 214)
  - Section 51: License to Operate Fish Pen, Fish Cage, Fish Traps and Other Structures for Fish Culture and Other Fishery Products
  - Section 53: Grant of Privileges for Operation for Fish Pens, Cages, Corrals/ Traps and Similar Structures
  - Section 54: Insurance for Fish Pond, Fish Cages and Fish Pens (FAO 215)
  - Section 55: Non-Obstruction to Navigation (FAO 216)
  - Section 56: Non-Obstruction to Defined Migratory Paths (FAO 217)
  - Section 57: Registration of Fish Hatcheries and Private Fishponds, etc. (FAO 218)

- DA-DENR Joint Memorandum Order No. 01 (series of 2000)
  - Article III, Sec. 3. Code of Practice for Aquaculture
  - Article IV, Sec. 1.a.3-4-5. Zonation of existing or potential areas for mariculture, sea farming or sea ranching operations; navigational lanes and passage in fishery areas; migration paths of migratory fishes

- Municipal Fisheries Ordinance
  - Municipal Resolution declaring, reserving or segregating an area for Mariculture Zone (in coordination and collaboration with DENR/FARMC)
  - Stipulations of fees and rentals (Mayors Permit/Annual Lease)

Development process

The development process occurs in the following sequence:

- Site selection and prioritization
- Pre-assessment of site suitability
- Public hearing/consultations
- Municipal resolution
- Municipal ordinance
- Development plan
- RRA/EIA
- Organization of EMC
- Detailed survey/ECC
- Subdivision plan
- Installation layout (mooring/cages)
- Training/IEC
- Lease/permit issuance
- Operation and management
- Regular monitoring (physico-chemical)

Technical services

Technical services for the mariculture parks are described below in Table 10.

TABLE 10
Technical assistance

Project Operations Unit	Project Assistance/Information, Education Component Unit
1. Oversee the project staff assigned at the project site	1. Recommend guidelines for the Project Operations
2. Implement all projects at the BFAR R&D Area	2. Prepare Management Plan and programme for the future development and long-term sustainability of the Mariculture Park.
Develop/implement work plan for every project	3. Production of Project Operation Manual
Assign appropriate project staff, including on-the-job trainees	4. Develop brochures for the whole MP
Implement project monitoring and evaluation	5. Develop manuscript for R&D results
Implement researches	6. Develop new project proposals and implement pilot models at the BFAR R&D Area
3. Render technical assistance to locators at different stages of project development, such as:	7. Provide assistance in the preparation of locators' business plan outline
Project installation	8. Provide assistance to locators' documentation requirements (Mayor's Permit/lease agreement)
Grow-out/culture techniques	9. Assist with other information needs of the locators
Harvesting	10. Act as resource persons during community dialogues, conferences, trainings and other related activities
Post-harvest activities	11. Develop IEC materials
4. Render services as resource persons during dialogues/conferences, trainings and other related activities	
Provide technical back-up staff to the EMC during project deliberation and conferences	

Management and operation

- Hatchery and nursery
- Species selection
- Species selection
- Cage maintenance
- PCP-environmental impact monitoring
- Harvest and post-harvest

Status of mariculture parks

Table 11 shows the status of mariculture parks in the Philippines.

TABLE 11
Status of mariculture parks

SITE/LOCATION	STATUS	REMARKS
Samal Island Mariculture Park	Launched and established 11 August 2001 in Davao. Now on its 3rd year of operation (4 locators, 4 cooperatives and cluster of fisherfolks; 11 cages all engaged in semi-intensive polyculture system (milkfish))	LGU failed to provide parcel of land for warehouse and auxiliary service area. More locators are encouraged.
	Fully operational with BFAR Demo cages and 3 locators in full operation. BFAR techno-demo cages now contain 3 000 pompano, 2 000 snapper and 2 500 grouper fingerlings. Another 12 x 12 m cage has been set for seeding.	
	Re-established 26 mooring lines in the mariculture park.	
	Constructed and deployed 32 units (2x2) square cages owned by Coral Aqua Ventures stocked with high-value species. For recreational purposes, they planned to combine their cages with floating cottages and restaurants for the public while promoting eco-tourism in the area. Maintained 57 compartments and restocked with various high-value species like abalone, cobia, snapper and grouper.	
	Most locators harvested and restocked their cages with fingerlings. Jorona Aquaventures opted for staggered harvesting to be processed in their own processing plant.	
	Corona Aquatic Resources Trading was consistent with their fish processing activities and expansion programme. Two units of 19 x18 m cages were each stocked with 25 000 milkfish fingerlings. Other newly constructed cages were stocked with milkfish and pompano. Nine units of cages with stocks are now available, while fabrication of additional cages is on-going to meet the 30-unit targets.	
	Monteverde Aquaventures resumed its operation with one unit 10 x10 m cage ready for re-installation. Seeding has been scheduled in July 2005.	
	GE cattle Trading's three units of 10 x 10 m cages ready for seeding, while fabrication of additional units is on-going. The constructed floating house have been scheduled for installation.	
	Individual fish-cage operators and fisherfolk in the vicinity now maintain a substantial number of siganid fingerlings for the investors.	
Masinloc-Palauig, Zambales	MOU with DA-BFAR/LGUs and SEAFDEC signed January 2002. Municipal resolutions endorsed by respective Sangguniang Bayan, RRA/Profile completed. Boundaries and bouys established.	NIPAS exclusion request endorsed to DENR. Awaiting Municipal Ordinances from both municipalities and layout/ development plan prepared by Region III.
	Final copy of the Environmental Impact Statement (EIS) submitted to the EMB-DENR Central Office for review. An inventory of existing fish cage units was made on 30 March 2004 together with the current water quality assessment on the proposed site. The ECC granted to BFAR was, however, cancelled.	
Subic-Morong, Mabayo Cove	Public consultation with local officials conducted; awaiting formal endorsement to SB of Morong, Site assessment conducted by Region III.	8 locators visited the site. LGU decided to operate and manage the site on their own administration

TABLE 11
Continued

SITE/LOCATION	STATUS	REMARKS
Silangun Bay, Zambales	Survey assessment jointly conducted by BFAR-NDCP team, MOA formally signed between AFP-NDCP and DA-BFAR last 13 February	Implementation/development plan prepared. Detailed RRA conducted jointly by BFAR-Philippine Navy and NDCP. Operation and management to be privately administered by a corporation.
Honda Bay, Palawan	Site to be identified by Reg. IV	For implementation
Ragay Bay, Camarines Sur	Survey assessment jointly conducted by BFAR-LGU team. Profile and development plan prepared by the LGU.	For implementation
Sto. Tomas Cove, La Union	Launched and established 17 October 2002 in St. Tomas, La Union	27 investors were awarded with Mariculture Zone Economic Agreement.
Region 1	Assessed 16 sites for proposed seaweed mariculture zones in the four provinces of Region 1. Established seven seaweed mariculture zones in Pasuquin and Badoc, Ilocos Norte; Cabugao, Santiago and San Esteban, Ilocos Sur; Dasol and Balaoan Pangasinan.	
Tilik Cove, Lubang Island	Survey assessment jointly conducted by BFAR-LGU team 20 October 2003	Ordinance drafted by LGU. Limited sites suitable for Mariculture Project.
SEAFDEC-AQD Igang, Guimaras Sub-province	Mariculture Park Pilot-Demo and Training Project fully operational	JMANTTP Prototype Mariculture Park
Samar-Leyte	Existing Mariparks established in Leyte as of 2004 2 new areas proposed in Biliran and Tacloban 3 existing Mariparks established in Samar 2 proposed new sites in Quinapondan and Marabut, Samar	8 Mariculture Zone Established 42 units of cages installed Production of 2005: 255 tonnes Average production/unit 7.5–8 tonnes
Malajog, Calbayog Nothern Samar and Basey Eastern Samar	11 BFAR demo cages (9 units square and 2 units circular) maintained at the mariculture parks located. 47 cages (32 square GI pipes, 4 units circular and 11 units square) installed by investors while regular technical assistance was provided by BFAR.	

Mariculture Park Region VIII

Existing

- Malajog,Calbayog Nothern Samar (300 ha)
- Basey Eastern Samar (400 ha)
- Merida, Leyte
- Ormoc Bay, Northern Leyte (600 ha, launched 7 December 2005)
- Ormoc/ Merida Mariculture Zone (100 ha)
- Babatngon, Leyte (950 ha, launched 27 December 2004)
- Sta Rita, Mariculture Park, Western Samar (500 ha)
- Liloan, Sagud Bay, Southern Leyte (75 ha, launched 30 July 2004)
- San Jose City, Northern Samar (3 150 ha, launched 30 June 2004)
- Lawaan, Eastern Samar *(*launched 4 August 2004)

Proposed

- Biliran/Leyte, Leyte
- Quinapondan Mariculture Zone, Eastern Samar
- Marabut
- Tacloban, Leyte

Sea cages

- Established 8 mariculture zones
- No. of established cages: 142 units
- Production as of 2004: 255 tonnes
- Average production/unit: 7.5–8 tonnes

Challenges and opportunities

The challenges and opportunities for mariculture parks include the following:

Macro-scale benefits

- Food security
- Employment generation
- Long-term sustainability

Micro-scale benefits

- Ancillary services (seed stocks, ice-plant, cold storage, feed warehouses, ports, etc.)
- Post-harvest facilities, road and transport access
- Lesser investment cost
- Amenities (water supply, power supply, communications, guard house, working platforms)
- Full security
- Revenue assurance to LGUs

Other opportunities

- Tax incentives (ITH)
- Crop insurance
- Choice of commercially important species
- Market assurance
- Fish health management services
- ISO/HACCP standards
- Programmatic compliance to DENR (EIA/EIS/ECC)
- Other livelihood opportunities

Environmental issues

Over the last few years, the rapid development of marine fish-cage and fish-pen culture in certain areas of the Philippines has led to unsustainable production. In 2002 for example, fishkills occurred in milkfish culture areas in Pangasinan and in tilapia areas

in Taal Lake. Possible reasons for these fishkills are: euthrophication, over production, overstocking of cages and pens, toxic algal tide or algal bloom, poor production management and reduction of water refreshment due to poor zoning and regulation.

In 2005 a study on Environmental Monitoring and Modelling of Aquaculture Areas was conducted. The primary objective was to undertake an environmental survey of the risk areas and adapt a mathematical model based on MOM Standard (Modeling–Ongrowing fish farms-Monitoring) developed by Norway for the prediction of impact of the fish cages on the recipient water. The study was implemented in collaboration with AKVAPLAN NIVA and the Norwegian Agency for Cooperation and Development (NORAD).

The survey was conducted in Bolinao marine waters, Dagupan City River system and Taal Lake during summer, rainy and cold seasons. The following activities were conducted:

- detailed survey of production in the area (including physical area, production, statistics etc);
- analysis of the bathymetry;
- profiling of temperature, salinity and oxygen levels through the water;
- sediment analysis;
- survey of current speed and direction;
- recording of tidal range observations; and
- monitoring of wind direction, frequency and speed.

Initial results of the survey in Bolinao showed that there are 460 fishcages, 266 fishpens and 254 mussel farms. Soil samples taken by grabs are grey to black in colour and with a hydrogen sulphide (H_2S) smell.

Results of the survey in Dagupan showed that there are 124 fishcages, 553 fishpens, 528 fish traps and 94 oyster farms. Soil samples taken by grabs have no smell, with greyish silty sediment. Oysters were found to abound in the river.

The initial findings were:

- food conversion rate was varied and was relatively poor (1.5 to 3:1);
- impact was relatively high in areas where there are large numbers of fishcages;
- impact was relatively low in areas where there is a mix of fish and mollusc culture (fed species and extractive species);
- carrying capacity was not related to numbers of structures but to fish production; and
- carrying capacity varied through the year depending on other factors (dynamic)

The initial recommendations were to come up with constructive and implementable recommendations that allow efficient production and minimize impact. An example is the use of feeding trays. In this way a farmer has better food conversion rate (more fish per kilogram of feed) and there is less impact on the environment (reduction of nutrients and organic material released to the environment).

CONCLUSIONS

With the increasing population, the government has to choose between food security/sustainability and environmental protection/conservation. The government has to decide which areas to regulate for mariculture and which areas to allow open access to fish farming.

Another issue to consider is zonation vs. degradation. Mariculture areas should be identified but properly regulated to prevent degradation of the rivers and seas.

Government policies/regulations have to be put in place to prevent environmental degradation, thereby sustaining production. Research and development should focus in determining the carrying capacity of water. The Local Government Units (LGUs) should ensure that their fishery ordinances are strictly enforced, giving emphasis to the interest of the less fortunate fish farmers.

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Thailand

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BACKGROUND

Thailand has a coastline of 2 769 km, of which 1 875 km is facing the Gulf of Thailand from Trad to Narathiwat Province, and the remaining 894 km faces the Andaman Sea from Satul to Trang Province. Coastal and marine aquaculture in Thailand has a long history that dates back to when mass seed production from hatcheries first succeeded in raising marine shrimp (banana shrimp, *Penaeus merguiensis* and black tiger shrimp, *P. monodon*) and Asian seabass (*Lates calcarifer*) around 1969 to 1976. Coastal and marine aquaculture has developed under the administration of the Ministry of Agriculture, Department of Fisheries (DOF). The Coastal Fisheries Research and Development Bureau has 19 Coastal Fisheries Research and Development Centers (CFRDC) and three Coastal Aquaculture Research and Development Stations. Provincial Fisheries Offices (PFO) in 24 coastal provinces also have the duty of supporting development of coastal aquaculture and enforcing the fisheries laws and regulations. The national fisheries development policies on aquaculture development are as follows:

- increase aquaculture production sufficiently in both quantity and quality for domestic consumption and export;
- accelerate research in support of commercial aquaculture industries to increase trade volume, improve quality standards and reduce production costs;
- develop sustainable marine shrimp culture systems for domestic trade as well as for export; and
- develop the production and marketing of ornamental fish and aquatic plants for export in order to raise the income from aquaculture.

MARINE AQUACULTURE PRODUCTS DEMAND, TRADE AND MARKETS

Analysis of marine aquaculture products demand, trade and markets trend in Thailand

Demand for export, product demand, trade and markets

The foreign trade in fisheries commodities was 1 647 866 tonnes by quantity and more than US$4 377 million by value in 2003. The major exports are fresh chilled and frozen marine shrimps (118 913 tonnes) and fishes (377 736 tonnes) and their products. Marine shrimps (chilled or frozen) were exported mainly to the United States of America (62 861 tonnes) and Japan (22 363 tonnes). Marine fishes were exported to Malaysia (133 791 tonnes), Japan (105 088 tonnes), the People's Republic of China (28 464 tonnes), Singapore (20 397 tonnes), Taiwan Province of China (13 194 tonnes) and the Republic of Korea (11 317 tonnes) (CITC, 2003). Italy imported 27 723 tonnes of fresh chilled or frozen squids. Tuna is the major fish exported with >326 402 tonnes both packed in

air-tight and non-air tight containers in 2003, mainly for the United States of America, Australia, Canada, Japan and the United Kingdom (see Appendix I).

Thailand imported products of more than US$1 162.8 million in value and 1 095 059 tonnes in quantity in 2003, mostly fresh chilled or frozen fish (>950 000 tonnes) (Table 1) from Indonesia, Japan, Taiwan Province of China, Republic of Korea, China and the United States of America. The other major imported seafoods were fresh, frozen or salted molluscs from Malaysia (18 255 tonnes) and shrimps in non-air tight containers from Indonesia and Malaysia (3 276 and 1 536 tonnes, respectively).

Marine aquaculture for domestic markets

The main species supplied for the domestic market are finfish, some small shrimps and mussel. Marine fishes are sent by truck or car to northern Thailand. Shrimp, fish and molluscs from farm sites along the coastline are always transported as fresh chilled or frozen products to Bangkok and other local destinations within one or two days. Goods will be sent directly to the market and to distributors who will use small cold storage or ice boxes. Live fish and molluscs are preferred by restaurants. Food safety standards are being applied.

TABLE 1
Quantity of imported seafood by selected country and commodity, 2003 (tonnes)

Country of Origin	Total	Live	Fresh chilled or frozen			
		Fish	Fish	Shrimp	Crab	Squid
Australia	10 444	-	1 042	172	-	-
Canada	6 528	-	1 907	1 847	2 433	-
China	24 696	1	17 598	1 522	53	432
EU	16 252	-	13 325	648	249	379
Indonesia	262 861	4	252 436	1 529	-	4 367
India	11 364	-	5 730	4 304	23	1 169
Japan	107 423	5	100 007	309	63	1 219
Malaysia	34 525	31	6 645	2 403	14	654
Philippines	3 384	2	3 290	10	-	6
Republic of Korea	40 536	-	30 368	151	72	1 178
Singapore	1 109	1	963	-	-	-
Taiwan PC	123 124	1	122 026	11	-	281
USA	20 667	-	14 573	218	265	-
Viet Nam	10 145	-	2 679	1 440	43	2 164
Others	422 272	4	38 2533	11 960	2 399	12 937
Total	1 095 059	49	955 122	26 524	5 614	24 777

Role of aquaculture versus fisheries

Data from the 13-year period since 1993 show that capture fisheries tended to decline, while the culture production has increased and only declined again in 2005 (Figures 1 and 2). The average supply was 73.1 percent from marine capture and 14.2 percent from mariculture, clearly indicating that the main supplies of seafood were from capture fisheries rather than culture. The majority of coastal aquaculture is shrimp, fish and mollusc farming. Their production and the number of farms are shown in Figures 3 and 4.

In 2003 there were 34 977 shrimp farms with a total pond area of 512 620 rai (82 019.2 ha; 1 rai =1 600 m^2), with a total yield of 330 725 tonnes. Production was 194 909 tonnes of black tiger shrimp, 132 365 tonnes of white shrimp, 2 849 tonnes of banana shrimp and 602 tonnes of other shrimp.

For finfish culture, there were 8 226 farms, out of which there were 1 073 pond operators and 7 153 cage operators with a total area of 6 625 rai (1 019.23 ha, 1 ha = 6.5 rai), with a total yield of 14 568 tonnes, of which 12 229 tonnes were seabass and 2 339

tonnes were groupers. The total yield of pond culture was 3 456 tonnes, of which 3 102 tonnes were seabass and 354 tonnes were groupers. The total yield from cage culture was 11 112 tonnes, of which 9 127 tonnes were seabass and 1 985 tonnes were groupers.

For mollusc culture, there were 5 935 farms with a total area of 75 888 rai (11 676 ha), of which 73.8 percent of the area was for blood cockle, 17.8 percent for green mussel and 8.4 percent for oyster. Total yield was 357 944 tonnes, with 67 359 tonnes from blood cockle, 263 946 tonnes from green mussel and 26 639 tonnes from oysters (FITC, 2003).

Figure 1
Aquaculture vs capture fisheries from 1993 to 2005 in Thailand
(estimates for 2004 and 2005)

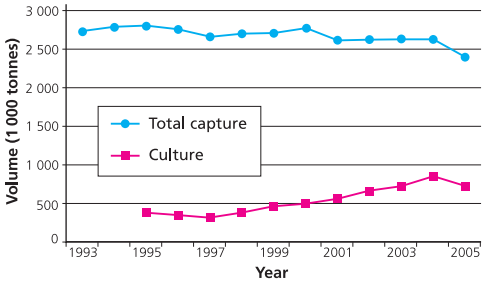


Figure 2
Total production declined in year 2005

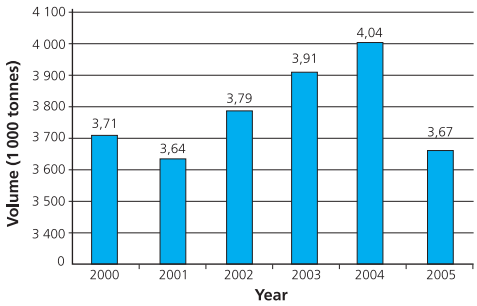


Figure 3
Number of coastal aquaculture farms, 2000–2005

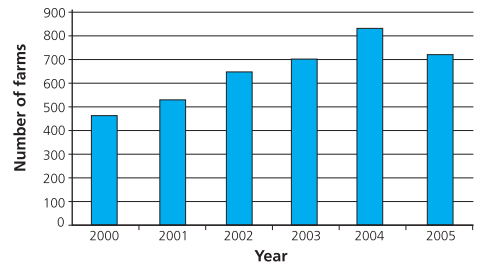
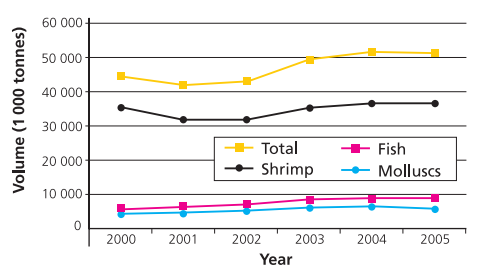


Figure 4
Annual production from coastal aquaculture, 2000–2005



2.3 Consumer trends, preferences, buying patterns

Analysis from Thailand's two major markets, Japan and the United States of America, reveals different preferences and products, as shown in Table 2.

TABLE 2
Buyer preferences – analysis for two major clients of Thailand's marine products, Japan and the United States of America (tonnes) (Source: modified from FITC, 2003)

Product	Japan			USA		
	Fishes	Shrimps	Others	Fishes	Shrimps	Others
Fresh chilled or frozen	105 088	22 363	31 323 (squids)	10 132	62 861	5 711 (squids)
Packed in air-tight container	15 743 (tuna)	522	65 871 (others)	83 839 (tuna)	3 734	15 267 (others)
	116 (sardine)		171 (crabs)	3 768 (sardine)		4 633 (crabs)
			142 (asari)			2 642 (asari)
Packed in non-air tight container	8 339 (tuna)	22 892	7 500 (squids)	24 222 (tuna)	65 568	159 (squids)
	6 (sardine)		991 (crabs)	33 (sardine)		92 (crabs)
			331 (asari)			25 (asari)
Prepared or preserved	28 714	-	2 638 (others)	11 902	-	2 251 (others)
Total	158 006	45 777	68 509 (others)	133 896	132 163	17 518 (others)
	24 082 (tuna)		38 832 (squids)	108 061 (tuna)		5 870 (squids)
	122 (sardine)		1 162 (crabs)	3 801 (sardine)		4 725 (crabs)
			473 (asari)			2 667 (asari)

Market chain organization, market trends and vulnerability

The seafood market chains in Thailand are divided into many channels for shrimp, fish and other aquatic animals. The market chain for marine shrimp is rather complicated, involving hatcheries, nurseries, grow-out farms and harvest/partial harvest, with sales to domestic markets and cold stores, and processing for export. Thailand has developed standards for hatcheries, nurseries and farms under a Good Aquaculture Practice (GAP) and Code of Conduct (COC) programme. There are 24 Raw Materials Inspection Units for coastal shrimp farms for checking quality, diseases and antibiotic residues of shrimp. Aside from fresh chilled products and products frozen in many ways, shrimp are also processed in steamed, cooked and precooked forms in different packages or containers. Factories as well as cold storages are also operated under international standards to ensure safety and quality of products.

Market chains for fish and molluscs are more common than for shrimp. Most of the finfish are from capture fisheries. The chain starts from the fishermen to the fish landing, then to middlemen or collectors, who place the product in cold storage or in ice boxes to distribute to the market, and then to consumers or exporters. For cultured finfish, farmers will sell their products to a wholesaler via middlemen or direct, then distribute to consumers via sellers in the market or to exporters.

For molluscs, harvests will be transported to markets, either via distributors or directly, or to exporters. Some will be processed and then repacked and sold.

LIVELIHOOD OPPORTUNITIES RELATED TO MARICULTURE DEVELOPMENT

Information on coastal communities, poverty status, livelihoods, trends and vulnerability, and identification of key target communities

Coastal communities comprise fishermen and their families. The main operations are small-scale fisheries and aquaculture (gill netting, net-cage culture; blood cockle, mussel and oyster culture; aquatic animal collection, etc.). Farming of marine fish is connected to the wild capture fishery, as fishers collect fish from their traps/fishing gear for use as seed and feed. Survey results from the National Statistic Office and DOF on small fishery households (SFH) in fisheries show a total of 50 732 households, of which the Province of Songkhla had the biggest number (6 175 households) followed by Krabi, Phang-nga and Nakhon Si Thamarat. The top income of SFH was from Samut Prakan Province, with US$4 736[1], and the lowest income was from Samut Songkhram with US$1 829 per household per year (Table 3).

Songkhla Lake fisheries communities in Songhkla, southern Thailand provide an example of good aquaculture and fisheries management, with cage culture of seabass, small-scale shrimp culture, culture of green mussel and small fishing boats all operating. Technical cooperation and services to promote Good Aquaculture Practice (GAP) by the National Institute of Coastal Aquaculture (NICA), the Institute of Coastal Aquatic Health Research (ICAHR) and the Provincial Fisheries Officer (PFO) have helped this development. Coastal Fisheries Patrols are also assigned to enforce laws and regulations in Songkhla Lake.

According to Boonchuwong and Lawapong (1999), on average each marine fishfarmer in the Andaman sea coast of southern Thailand owns four cages (4x4x4 m^3 each). The average production is 210 kg/cage (175 fish), with a size range from 1.0–1.2 kg from a culture period of 9–12 months. The production cost is US$3.5/kg, of which 75 percent is feed cost. Most farmers start to harvest fish after nine months of culture at a selling price of US$7.3 /kg.

[1] Calculated from Table 3 using an exchange rate of US$1 = 40 baht (B).

TABLE 3
Average annual income for small households in fisheries commodities by province (Source: Office of National Statistics and Department of Fisheries, 2000)

Province	Total income (B)	Capture fisheries	Aquaculture	Processing	Non-fisheries income
Trat	106 017	87 463	3 107	525	14 922
Chanthaburi	96 410	84 933	604	773	10 100
Rayong	102 195	75 484	1 122	563	25 026
Chonburi	140 864	122 428	2 391	1 344	14 701
Chachoengsao	133 283	87 159	14 274	27 566	4 284
Samut Prakan	189 454	164 132	4 107	96	21 119
Samut Sakhon	171 754	102 335	2 234	19 164	48 021
Samut Songkhram	73 179	59 533	-	833	12 813
Petchaburi	100 061	91 425	22	65	8 549
Prajoub Kiri Khan	135 223	119 938	-	-	15 285
Chumphon	155 001	128 018	1 473	4 789	20 721
Surat Thani	86 274	70 778	-	2 787	12 709
Nakhon Si Thamarat	94 912	86 482	339	22	8 069
Songkhla	76 811	52 598	1 906	1 776	20 531
Pattani	96 277	89 426	-	-	6 851
Narathiwat	78 570	67 342	33	1	11 194
Ranong	92 627	77 039	318	2 857	12 413
Phang-nga	76 686	66 821	39	775	9 051
Phuket	103 987	72 121	203	407	31 256
Krabi	74 786	54 974	-	1 523	18 289
Trang	68 428	54 561	-	154	13 713
Satul	74 516	65 487	2 181	36	6 812
Total	2 327 315	1 880 477	34 353	66 056	346 429

Markets and coastal community development linkages

Development of coastal communities is necessary for sustainable management of coastal fisheries and aquaculture. Suitable roles for women in coastal fisheries and aquaculture are very important. The harvest in some seasons provides an over supply to local markets, and women get involved in preservation and preparation of products such as shrimp paste, dried fish and mussel and fish sauce. The PFO in every coastal province is also active in providing training on preservation and fisheries products.

EXISTING AND POTENTIAL MECHANISMS FOR TECHNOLOGY TRANSFER

Technology for mariculture had been transferred in Thailand through many channels. These include via discussions and meetings in small groups or seminars that can be done at any time at the CFRDC of DOF in coastal provinces. DOF then provides training that is divided into (i) training for trainers, technicians and fisheries officers, in order to be good trainers; and (ii) training for farmers and other stakeholders through lectures, workshops, demonstrations and practicals in laboratory or on farm, including study tours to view activities at other sites.

The DOF also has a website (www.fisheries.go.th) for information dissemination. Every PFO and CFRDC can have its own website where farmers and other interested stakeholders can gain knowledge and ask questions.

Present training activities and likely future requirements

Training
Annually 25 000 farmers and other interested parties are trained through training courses for fisheries technology and fish farming. These courses include basic techniques and practical methods for aquaculture, including inland aquaculture. The typical training curriculum includes:

- culturing of economically important fishes including ornamental fishes, pond culture, cage culture, etc.
- breeding and nursing of aquatics species;
- homemade formulated diet for fish culture;
- diseases and prophylactic measures; and
- preserving and processing of aquatic species.

Aside from such training courses, DOF sets up demonstration sites in selected fisheries communities and assists with mobile clinics, which includes technical assistance to farmers to help solve their problems, water analysis, disease diagnostics, etc.

Training for technicians and government officers through training of trainer programmes is provided to update the knowledge of officers and technicians (trainers). Special emphasis in recent years has been on training in GAP, COC and other measures.

Seminars
Special seminars are provided on the breeding and culture of selected aquatic animals, such as Babylon snail and of selected groupers and clown fishes.

Food safety for fisheries production programme
This programme was set up to promote clean seafood and its production for domestic markets and export. Many training programmes with this concept have been conducted to train government officers, farmers and other stakeholders.

Developing information technology
IT for fisheries is needed to provide up-to-date information and for compilation and dissemination of relevant information to farmers and the general public.

EXISTING MAJOR MARICULTURE SPECIES AND FARMING TECHNOLOGIES

Coastal aquaculture in Thailand involves the culture of shrimp, fish, shellfish and small quantities of other aquatic animals.

Status of farming of selected species

Marine finfish farming in Thailand began four or five decades ago. The two predominant species groups are groupers and seabass, which are cultured in both earthern ponds and coastal cages. Most of the seabass farms are located in estuarine areas, but almost all groupers are cultured in cages located in more marine waters. Bays or coastal enclosed areas protected from wave action and strong winds are preferred.

Grouper culture has proved to be commercially viable, depending on the export market in the region. The price for live fish weighing 1.2–1.5 kg has been US$9–10 each or US$7–8/kg since the 1990s, with limited long-term price fluctuations. Most fishfarmers culture grouper in floating netcages in sheltered coastal areas with salinity ranging from 12 to 30 ppt.

Due to unreliable and limited hatchery production, the majority of grouper seed are obtained from the wild. Grouper fry of size 1.0–2.5 cm are usually collected from the coastal areas of Songkhla and Pattani provinces from October to March. The fry

are reared up to a size of 7–10 cm prior to stocking in grow-out cages. The majority of these seed are exported to other countries. Seed of sizes longer than 10 cm are collected using traps, and the fish are stocked directly into grow-out cages without nursing. Fishfarmers prefer this type of seed to the reared fry because of the shorter grow-out period and better survival. The quantity of fish produced from cage culture is steadily increasing and its future appears to be promising.

The grouper culture system involves a series of farms specialized in one of several areas:

- Hatcheries produce fertilized eggs
  - broodstock ponds (outdoor)
  - induced spawning
  - natural spawning
- Fertilized eggs → fry farm
  - nursing indoor (raise to 3 cm total length)
  - nursing outdoor
- Fingerling farms → until 7–9 cm total length
- Grow-out farm → market size (600–700 g)
  - pond culture (10–14 months)
  - cage culture (8–10 months from 6 cm)

Fry and fingerling production

The demand for live marine finfish such as groupers and seabass for consumption has increased. To produce marine fish seed, we have to understand the reproductive biology and physiology of each species.

TABLE 4
Production yields from grouper culture and their food used, in weight (tonnes), 1999–2002

Year	Seabass/Feed		Groupers/Feed		Total feed used
	Weight	FCR=7.5	Weight	FCR=5.5	
1999	6 056	54 120	1 143	7 339	61 459
2000	7 752	70 040	1 312	8 299	78 339
2001	8 003	72 750	1 443	9 507	82 257
2002	11 032	105 100	1 170	7 794	112 894

The use of destructive fishing methods has destroyed the habitats on which reef-associated species such as groupers depend for shelter and food. The requirements needed to assist the development of marine finfish culture are as follows:

- efficient live feed production in the hatchery/nursery;
- steady supply of live feeds for commercial-scale culture of difficult species;
- strong government support for the industry and research;
- seed supply centers in the country and region;
- good cooperation between fisheries organizations, information networks, market chains and research laboratories (fisheries institution/university integration); and
- continuation of government policies/plans for hatchery-reared seed to restock over-exploited coastal fisheries.

Hatcheries that produce groupers are the five main government hatcheries and two private hatcheries in Rayong Province. The government hatcheries, with names of key R&D species, are listed below:

Southern region

- National Institute of Coastal Aquaculture (NICA), Songkhla Province
  Epinephelus coioides, *E. malabaricus*

- Krabi Coastal Fisheries Research and Development Center, Krabi
  E. coioides, *E. lanceolatus*, *E. fuscoguttatus*
- Satul CFRDC, Satul
  E. coioides, *E. malabaricus*

Eastern region
- Rayong CFRDC, Rayong Province
  Cromileptes altivelis
- Trat Coastal Aquaculture Station, Trat Province
  Plectropomus leopardus

Cobia (*Rachycentron canadum*) has been produced at Phuket and Satul CFRDC since 2004, and at Rayong CFRDC in 2005.

Future prospects for finfish research and development (R&D) include:
- developing closed recirculation systems for fish hatcheries and nurseries;
- providing education and training on marine fish farming; and
- organizing an enhanced network for cooperation among fish culturists (the whole cycle) using IT.

Priorities for research and development

R&D for shrimp, finfish and molluscs should be on:
- developing suitable feeds for each species (and each life stage);
- changing traditional destructive culture methods, such as feeding with small fresh fish by training fishfarmers to use formulated feeds, and other means to make the transition to formulated feeds;
- improving disease prevention and prophylactic measures;
- enhancing the capacity and awareness of all aquatic farms to follow GAP and later, to practice more comprehensive environmentally friendly farming under the Code of Conduct (COC) in order to have sustainable aquaculture in Thailand and the region.

Identification of better management practices (BMPs) for existing farmed species and systems to mitigate environmental impacts

Freshwater runoff is the major cause of impacts on mariculture in Thailand. The DOF has been active with a GAP and COC for all shrimp farming areas since 2003. These programmes should also be applied to other aquatic animal farming systems. The COC, in particular, will mitigate environmental impacts as a result of applying environmentally friendly practices. Laws and regulations protecting the environment also need strengthening. Youth are more aware of the environment and the need for better environmental management and should be involved in educational and awareness programmes to enhance the environmentally sustainable development of aquaculture.

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APPENDIX I

Quantity of exports by country and commodity from Thailand in 2003 in tonnes (Source: CITC, 2003)

Country of destination	Total	Aquatic live animal		Fresh, chilled or frozen					Steamed, boiled, salted, dried or smoked				Fresh, frozen and salted	
		Fish	Other	Fish	Shrimp	Crab	Squid	Other	Fish	Shrimp	Crab	Squid	Mollusc	Others
Australia	78 308	18	-	2 099	4 034	16	4 761	195	-	-	-	-	-	-
Belgium	4 233	15	-	1 409	140	-	338	9	-	-	-	-	-	-
Canada	47 745	31	-	655	6 690	45	1 981	-	-	-	-	-	-	-
China	40 134	174	389	28 464	2 781	2	4 009	7	-	-	-	-	-	-
Germany	17 862	61	-	1 253	182	3	1 176	9	-	-	-	-	-	-
Denmark	5 059	3	-	43	1	-	276	-	-	-	-	-	-	-
Spain	9 264	24	-	1 274	29	3	2 443	-	-	-	-	-	-	-
Finland	4 861	1	-	-	-	-	-	-	-	-	-	-	-	-
France	16 093	24	-	2 509	88	80	2 397	-	-	-	-	-	-	-
UK	32 045	24	1	1 080	132	5	660	-	-	-	-	-	-	-
Indonesia	9 571	3	-	639	143	-	-	-	5 319	-	-	-	3	3
Italy	39967	16	-	1 831	74	10	27 723	12	-	-	-	-	-	-
Japan	370 851	61	-	105 088	22 363	544	31 323	10	-	-	-	-	-	-
Korea Rep.	30 692	26	58	11 317	6 430	277	1 221	10	-	-	-	-	-	-
Malaysia	170 005	71	3	133 791	250	224	643	-	16 376	3	14		1	427
Netherlands	9 947	24	-	858	49	-	367	1	-	-	-	-	-	-
Philippines	7 030	16	-	1 368	-	-	-	-	-	-	-	-	-	-
Sweden	6 051	4	-	74	3	-	1	-	-	-	-	-	-	-
Singapore	40 903	250	1	20 397	4 921	83	797	-	-	-	-	-	-	-
Taiwan PC	51 599	248	76	13 194	2 600	977	5 712	16	3 883	-	2	4	953	293
USA	320 648	615	4	10 132	62 861	833	5 711	501	-	-	-	-	-	-
Viet Nam	3 799	10	43	607	142	20	14	-	-	-	-	-	-	-
Others	331 199	4 114	1 923	39 654	5 000	994	6 208	40	22 931	461	84	1 928	14 515	8 912
Total	1 647 866	5 833	2 498	377 736	118 913	4 116	97 761	810	48 509	464	100	1 932	15 472	9 635

Quantity of exports by country and commodity from Thailand in 2003 in tonnes (Source: CITC, 2003)

	In airtight containers							Not in airtight containers						Prepared or preserved			
	Sardine	Tuna	Other	Shrimp	Crab	Squid	Asari	Sardine	Tuna	Shrimp	Crab	Squid	Asari	Fish	Shrimp	Crab	Other
Australia	1 420	26 626	7 632	202	207	1	32	6	1 980	3 614	-	48	341	4 481	-	-	565
Belgium	-	-	-					-	-	-	-	-	-	-	-	-	-
Canada	429	23 660	137	263	422	1	1 443	-	1 627	7 215	1	69	-	-	-	-	-
China	-	-	-					-	-	-	-	-	-	-	-	-	-
Germany	34	9 081	515	15	4		70	-	-	-	-	-	-	-	-	-	-
Denmark	-	-	-					-	-	-	-	-	-	-	-	-	-
Spain	-	-	-					-	-	-	-	-	-	4 200	-	-	-
Finland	132	4 218	248					-	-	-	-	-	-	-	-	-	-
France	-	-	-					-	3 435	-	-	-	-	-	-	-	-
United Kingdom	173	14 689	1 307	209	332		148	-	-	772	-	9	1	6 766	-	-	132
Indonesia	-	-	-					-	-	-	-	-	-	-	-	-	-
Italy	-	-	-					-	2 828	3	7	987	31	-	-	-	-
Japan	116	15 743	65 871	522	171		142	6	8 339	22 892	991	7 500	331	28 714	-	-	2 638
Korea Rep.		-	-					-	-	-	-	-	-	-	-	-	-
Malaysia	4 193	1 956	616		2		1	-	-	-	-	-	-	3 899	-	-	115
Netherlands	426	2 806	145	117	35	219	7	-	-	-	-	-	-	-	-	-	-
Philippines		-	-					-	-	-	-	-	-	-	-	-	-
Sweden		4 068	596	25	113			-	-	-	-	-	-	-	-	-	-
Singapore	2 205	1 631	761	3	29		22	-	-	-	-	-	-	5 615	-	-	81
Taiwan PC	28	1 706	1 355	-	1		3	-	-	-	-	-	-	-	-	-	-
USA	3 768	83 839	15 267	3 734	4 633	16	2 642	33	24 222	65 568	92	159	25	11 902	-	-	2 251
Viet Nam	-	-	-		-			-	-	-	-	-	-	-	-	-	-
Others	30 841	136 379	7 071	1 346	1 956	844	202	2 039	26 595	8 215	22	1 285	168	49 026	9	-	3 028
Total	43 765	326 402	101 521	6 436	7 905	1 081	4 712	2 084	69 026	108 279	1 113	10 057	897	114 603	9	-	8 810

Viet Nam

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BACKGROUND

Viet Nam has more than 3 200 km of coastline with many bays and coastal areas, and thus thousands of hectares of brackish and marine areas with favourable natural conditions that are suitable for mariculture development. However, mariculture in Viet Nam has only developed within the past few years. The Vietnamese government has plans for the future development of mariculture and hopes to reach the target of 200 000 tonnes of farmed marine fishes by the year 2010.

Mariculture in Viet Nam's national economy

After only a few years of development, Viet Nam has become one of the top shrimp-producing countries in the world. In 2005 total production of fisheries in Viet Nam was 3 432 million tonnes, including:

- 1 437 million tonnes of aquaculture production;
- 330 000 tonnes of shrimp;
- 400 000 tonnes of catfish;
- 22 289 tonnes of crab;
- 114 570 tonnes of molluscs; and
- 20 257 tonnes of seaweeds.

With its favourable potential, including natural conditions, Viet Nam wishes to develop mariculture and to elevate it to an important sector that contributes to economic development, creating jobs, assisting in poverty alleviation and increasing living standards for the people.

The domestic market in Viet Nam has great potential for the consumption of marine fisheries products because shrimp, fish and molluscs are preferred foods. In the Vietnamese diet, 40–50 percent of the daily protein consumption comes from aquatic products. Marine fishes are preferred to freshwater fishes because of their value. With a population of more than 80 million people and living standards increasing day by day, Viet Nam has a high and growing demand for seafood. Cities and industrial zones are growing or forming, which creates local markets for seafood consumption. Like the Japanese and Chinese, the Vietnamese people prefer live seafood, which mostly comes only from aquaculture. Furthermore, Viet Nam is near markets in China, Hong Kong SAR and the southwestern part of the People's Republic of China. In recent years, ten tonnes of mariculture products, such as groupers, clams and lobsters have been sold daily in these markets.

With nearly 30 coastal provinces and half of the Vietnamese population living in coastal areas, mariculture plays an important role in poverty reduction. From the end

of the twentieth century, the Government of Viet Nam has had policies to reduce fishing, especially in coastal areas. Over the last five years, marine fishery production has only increased slightly, mainly from offshore fishing. The government has issued policies to support the shift of fishermen from fishing to aquaculture. These policies have promoted the important role of mariculture in Viet Nam's economy. Although mariculture has just developed within the last three to four years, the Ministry of Fisheries of Viet Nam has carried out its master plan for sustainable development as a guideline for local authorities to plan detailed aquaculture areas and issue their own policies to increase the development of mariculture. The Government of Viet Nam hopes to reach a target of 200 000 tonnes of marine fishes from mariculture by the year 2010 through its specific policies and methods.

CURRENT STATUS OF MARICULTURE IN VIET NAM

Seed production

Viet Nam began research on fish reproduction in 1996–1997. As of 2005, the following fish species have been reproduced:

***Orange-spotted grouper* (Epinephelus coioides)**

Currently, the Research Institute of Aquaculture No. 1 (RIA 1) can reproduce orange-spotted grouper with a 13–15 percent survival rate from larvae to fry (4–5 cm in length) over 60 days. The survival to 90 days (8–10 cm length) is 8–9 percent. Every year, with its facilities, RIA 1 can produce some 400 000–500 000 fry. This technology has been transferred to local areas in order to meet the demand of commercial mariculture.

***Cobia* (Rachycentron canadum)**

Rachycentron canadum is a species for mariculture with high commercial value. Currently, Viet Nam is one of a few countries that have successfully researched and established the breeding technology and commercial farming of this species. The species has very favourable breeding characteristics; the maturation rate of captive broodstock is about 65–78 percent; the spawning rate is more than 70 percent, the egg fertilization rate more than 60 percent, the hatching rate of eggs more than 70 percent; and survival rate from larvae to fingerling (5–6 cm in length) is on average 5 percent. In 2005 the survival rate had been increased to 15–20 percent. The technology has been transferred by RIA 1 to some private hatcheries. Over the past three years, RIA 1 has produced 250 000–400 000 fry (5–6 cm) per year for marine fish farms.

***Red drum* (Scaenops ocellatus)**

In 2003 artificial seed reproduction technology for red drum became well established. The maturation rate of broodstock is more than 72 percent, the egg fertilization rate is more than 75 percent, the egg hatching rate more than 80 percent; and the survival rate from larvae to 60-day fry more than 22 percent. In 2003, approximately 350 000 fry were produced, a figure that increased to 400 000 in 2004 and to 500 000 in 2005. The technology can be transferred to private hatcheries to increase the number of fry.

***Seabass* (Lates calcarifer) *and Waigieu seaperch* (Psammoperca waigiensis)**

RIA II and the University of Fisheries have successfully researched this technology. Now RIA I can manage this technology and transfer it to hatcheries. In 2005, research stations produced more than 400 000 fry (3–4 cm in length) to supply fish farms.

Molluscs, crabs and other species

Viet Nam has conducted successful research on the artificial seed production of mud crab, swimming crab, sea urchin and *Babylonia* snail, as summarized below (Table 1):

- Mud crab: Viet Nam achieved success in 2003. In 2005, the hatcheries produced more than 3.5 million juveniles with a survival rate of 10–12 percent.
- *Babylonia* snail: 150 million spat were produced from hatcheries in 10 provinces. Average survival rate is 20–25 percent.
- Otter clam (*Lutralia philippinarum*): This is a high-value mollusc in Viet Nam with a price of about US$12–13 per kg. In 2004, artificial seed reproduction was a success. The survival rate was about 10–12 percent. A total of 3.0 million otter clam spat were produced in 2005.
- Hard clam (*Meretrix meretrix*): The production of artificial seed from hatcheries in 2005 was about 20 million.

TABLE 1
Research results and propagation of marine fishes, 2005

Species	Research institute	Quantity produced
Orange-spotted grouper (*Epinephelus coioides*)	RIA 1	400 000 fry
Cobia (*Rachycentron canadum*)	RIA 1	500 000 fry
Red drum (*Scaenops ocellatus*)	RIA 1	500 000 fry
Seabass (*Lates calcarifer, Psammoperca waigiensis*)	RIA II	400 000 fry
Mud crab, swimming crab	RIA II	3.0 million
Babylonia snail	RIA II	150 million
Otter clam (*Lutralia philippinarum*)	RIA 1	3.0 million spat
Hard clam (*Meretrix meretrix*)	RIA 1	20.0 million

Culture

Species for mariculture

Major mariculture species in Viet Nam and the sources of seed are shown in Table 2.

TABLE 2
Major species for mariculture in Viet Nam

Species	Sources of seed
Epinephelus coioides	Hatchery + Wild
E. tauvina	Wild + Hatchery
E. malabaricus	Wild
E. bleekeri	Wild
Rachycentron canadum	Hatchery
Lates calcarifer	Hatchery + Wild
Psammoperca waigiensis	Hatchery
Lutjanus erythropterus	Wild
Sparus sarba	Wild
Scaenops ocellatus	Hatchery
Siganus sp.	Wild
Mud crab	Hatchery + Wild
Swimming crab	Wild + Hatchery
Lobster	Wild
Babylonia snail	Hatchery + Wild
Sea urchin	Wild
Otter clam *(Lutralia philippinarum)*	Wild + Hatchery
Hard clam *(Meretrix meretrix)*	Wild + Hatchery

Cage culture

According to the Department of Aquaculture of the Ministry of Fisheries (2004), there were 40 059 cages in 2004 (excluding cages for cultivated pearls). Production of marine fish from cage culture in 2005 is estimated as 5 000 tonnes. Cage farming of lobster produced another 1 795 tonnes.

Cage culture is found mostly in the provinces of Quang Ninh, Hai Phong, Thanh Hoa, Nghe An, Ha Tinh, Phu Yen and Ba Ria–Vung Tau. There are two kinds of cages found in Viet Nam:

- Cages with wooden frame with a size of 3x3x3 m or 5x5x5 m. This is the most popular cage in most provinces.
- Norwegian-style cages (produced in Viet Nam) that are popular in Nghe An and Vung Tau with plastic frames that can withstand a Force 9–10 storm and waves.

Pond culture

Mariculture in ponds has been developed since 2002–2003 in some northern and central provinces. Fish species for this type of culture are *Epinephelus coioides, Lates calcarifer, Psammoperca waigiensis, Sparus sarba* and *Scaenops ocellatus*. Production of fish from pond culture is on average 12–13 tonnes per year.

Current status and problems of mariculture

Aquatic animal seed

Viet Nam has the technology for reliable reproduction of five mariculture species, but this is still mainly on an experimental scale in research institutes. The quantity of seed is insufficient and the price is high. Farmers usually source seed from the wild or import from China or Taiwan Province of China.

Grow-out culture

Viet Nam is developing mariculture in closed bays in coastal areas that are sheltered from waves and wind. This farming is done mainly by small-household-operated cages. For this reason, market production is not concentrated and the product is mostly sold for the live fish trade. Almost all households use trash fish as food for mariculture, causing negative environmental impacts. Pollution in some culture areas is critical due to high cage densities without master planning. Cage culture in the open sea is not developed due to high investment costs and marketing concerns for large volumes of product from such systems.

Fish disease

Fish disease is associated with high densities of farms and poor seed quality. Vaccine development through research has just started. However, vaccine development is difficult for marine fish farming because of the many species of fish that are cultured and the wide variety of diseases. For this reason, seed quality, environmental management of mariculture and disease prevention must be the highest priority.

Technology transfer

Transfer of technology started in 2004–2005 but considerable constraints remain. Difficult and high-risk technology and lack of capital are major problems that constrain the uptake of technology at the farm level.

Mariculture was developed to assist households in transferring from coastal fishing to farming. In the future, a diverse mariculture development is required, including cage culture, pond culture and polyculture (e.g. 1 shrimp crop and 1 fish crop per year) that may assist farmers to manage risk and help in poverty reduction. However, environmental problems need urgent attention to ensure that water quality can be maintained for sustainable development.

FUTURE DEVELOPMENT STRATEGY

By 2010, the plan of the Government of Viet Nam is to achieve a production of 200 000 tonnes of farmed marine fish per year. To achieve this target, given the current state of mariculture development, natural and social conditions, investment, technology and market, we consider the strategy for development of mariculture in Viet Nam from 2006–2010 as follows:

Seed reproduction

Seed is the first condition for development. It is necessary to hasten development of technology for seed production and the transfer technology to hatcheries. This requires:

- Research on reproduction technology that is based on a multispecies hatchery approach with species that have a high market demand. Emphasis should be placed on fish that can enter frozen market chains (red drum, sea carp, red seabream) and fish low in the food chain (*Siganus*, milkfish, mullet).
- Work to manage and control broodstock quality for high-value species and to expand research on genetic quality in broodstock.
- Studies on high-quality seed, including specific pathogen-free (SPF) seed production; and
- Exploration of vaccines for selected species with potential for high-volume production.

Hatcheries that are inactive or have limited activities should be rehabilitated and developed to increase the number and output of high-quality seed from hatcheries.

Commercial mariculture

The development of grow-out systems for mariculture requires a number of priority activities:

- Local governments should hasten the preparation of master plans to identify and plan areas for mariculture, including marine fish and mollusc culture. Local-level policies and methods for development of mariculture should be specified in the plans. Intensive cage culture should not be concentrated at one place.
- Research on new culture technology, high productivity, biosecurity and safe product is required to support development of a modern industry.
- Feeds and feed management need urgent attention (including use of floating food) to assist and encourage farmers to adopt quality formulated diets to reduce use of trash fish.
- Fish species should be developed for mass production, based on pelleted feed, for culture in cages and ponds. Focus should be on markets that accept fresh, frozen or filleted product, such as red snapper, mangrove snapper, red drum and seabream.
- Multi-species culture should be developed for cages in closed and semi-closed bays and for pond culture. Shrimp ponds can be used to culture marine fish to produce export products and improve the pond environment. Hasten polyculture in shrimp culture areas in order to reduce shrimp disease, increase the effective use of land and improve the environment.

Intensified cooperation with Asian and other countries should be promoted to learn and exchange experiences in seed reproduction and marine culture fish, disease prevention and more generally, to facilitate rapid development of sustainable mariculture.

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BACKGROUND

Mariculture is a primary development option for the Pacific region[1] because it is essentially a coastal region with a network of some 500 inhabited islands. The region covers an exclusive economic zone (EEZ) of 32 million km^2 comprising 8 million inhabitants. Three-quarters of the population live in rural areas, often in remote locations.

Geographically and culturally the Pacific is often divided into three main areas: Melanesia, to the west, comprises the bulk of the landmass; Micronesia, to the north, is mostly atoll formations; and Polynesia, the triangular area in the central and eastern part of the region, is a mixture of high volcanic islands and atolls. The Pacific region is a hotspot for ethno-biodiversity, which translates into a diverse setting for aquaculture development.

KEY COMMODITIES

Cultured pearls

The world's supply of cultured black pearls from black-lip pearl oyster (*Pinctada margaritifera*) is provided almost entirely by French Polynesia and the Cook Islands, where the oysters are naturally plentiful. In these countries the pearl industry is the second most important economic sector after tourism. French Polynesia reached a peak in annual production in 1999 valued at US$164 million (Institut des statistiques de Polynésie française). In the Cook Islands, a production of about US$9 million was achieved in 2000 (Cook Islands Government Statistics). Thereafter an overproduction of poor quality pearls and disease mortality (particularly in the Cook Islands) reduced the total value of exports to around US$128 million in 2005. Elsewhere in the region, pearl farms have been established in the Fiji Islands, Marshall Islands, Federated States of Micronesia, Solomon Islands, Kiribati, Papua New Guinea and Tonga.

Marine prawns

New Caledonia is the largest producer of marine prawns in the region. In 2004 the country produced 2 200 tonnes (worth US$22 million) of the western blue prawn (*Litopenaeus stylirostris*). The domestic demand is estimated at 540 tonnes (Source: Government Statistics).

There are a number of marine prawn farms operating in the Pacific Islands, such as in French Polynesia, Fiji, Vanuatu and Saipan, raising a variety of species (i.e. *Penaeus monodon, L. vannamei* and *L. stylirostris*).

[1] The region is defined in this report as that area encompassing the 20 Pacific Island member countries and territories of the Secretariat of the Pacific Community (SPC).

Kappaphycus seaweed

For the past decade Kiribati has been the main source of seaweed in the Pacific. In 1999, 1 200 tonnes were exported with a value of US$360 000. In the past five years, a single atoll, Fanning Island, has been almost the sole producer of seaweed

In the late 1980s, Fiji rejuvenated its seaweed farming and for five years after that exported around 500 tonnes per annum. Thereafter production declined drastically, reportedly due to domestic marketing and distribution problems. The government has recently launched an aggressive campaign to rejuvenate the industry in the Lau Group atoll lagoons.

In 2002, seaweed farming was revived in the Solomon Islands after an earlier project ceased in 1991. Although this programme has restricted its target sites, the production has increased exponentially from just 4 tonnes in 2002 to an anticipated export crop of 500 tonnes for 2006 (Source: Government Statistics).

Others

The Pacific is an important source in the global marine ornamental industry. Most of the trade involves wild-caught fish, corals and invertebrates. About 75 percent of the region's export is from Fiji, where the industry is worth some US$19 million.

Giant clam cultivation for the marine ornamental market is one of the most common forms of aquaculture in the region. Commercial hatchery production occurs in Fiji, Palau, Marshall Islands, Tonga, Vanuatu, Cook Islands, Kiribati, Samoa and American Samoa. There are probably between 30 000–50 000 giant clam pieces exported per annum.

Coral cultivation for the ornamental market is done in several countries, particularly Fiji, Vanuatu and Marshall Islands. The largest commercial farm, in Fiji, produces 25 000 pieces from 40 species. In 2003 the annual trade in live rock was estimated at 700 000 tonnes, almost entirely wild harvested, with just 50 000 pieces currently under cultivation.

Several species of marine fish are farmed for commercial purposes. In French Polynesia the majority of commercial barramundi farms have turned their interest towards the local fish species *moi* (*Polydactylus sexfilis*) and the batfish (*P. orbicularis*). Several countries raise milkfish (*Chanos chanos*) for the tuna baitfish industry. Other varieties of marine finfish are also farmed.

Mozuku seaweed (*Cladosiphon* sp.) has a sushi market in Japan, traditionally supplied from Okinawa Island. However the seaweed occurs naturally in the sub-tropical belt of the Pacific. In Tonga about 250–350 tonnes of *mozuku* is harvested per year, of which between 50–100 tonnes is cultivated. The dried product exported to Japan fetches up to US$150/kg.

Perhaps the most interesting technology to emerge in recent times is the use of crest nets or light traps to attract settling larvae. The use of crest nets has been tested for a number of years in the region, particularly in the Solomon Islands and French Polynesia. In the latter, one commercial operator handles up to 160 species of fish and crustaceans, targeting ornamental species. Trial production of food species has been also successful.

Marine aquaculture products demand, trade and markets

The major constraint to market access in the Pacific is its remoteness, which leads to poor transportation links. Freight costs are high and space is scarce. It is particularly so for the high-value fresh or live food markets overseas.

Processing technology for high-value food products has been applied to overcome the hurdle of sea freight and meet stringent quality controls. The best example of this is *mozuku* seaweed (*Cladosiphon* sp.) from Tonga and paradise prawns (*L. stylirostris*) from New Caledonia, which are exported by sea to the demanding sushi market in Japan where they are reconstituted and eaten raw. For *mozuku* seaweed a patented drying technology was developed that reduces the seaweed to 25 times its original volume.

Given the diverse range of produce and the distances between farming centers, the marketing chains tend to operate separately, and so there are few examples of cooperative marketing approaches in the region. There are also geopolitical divisions under which traditional trading partnerships have been well forged. For example, French territories enjoy a special trading relationship with the European Union, as do the United States of America affiliated territories with the mainland. However, some producers remain outside these arrangements, and much work needs to be done to break down trade barriers between countries within the region.

Unstable production in the past had constrained long-term market development and regionally coordinated efforts. This can be attributed to a variety of reasons such as natural disasters, currency devaluation, economic downturns, political instability and even apathy among farmers. Another destablizing factor has been the tendency to fall prey to "travelling salespersons" and "spot prices", so that inflated market opportunities have fuelled hopes of success that were unfulfilled and expectations of high profits that did not materialize. Such problems have set back long-term development.

LIVELIHOOD OPPORTUNITIES RELATED TO MARICULTURE DEVELOPMENT

There are diverse types of fisheries in the Pacific but the majority of coastal fisheries are of a subsistence or semi-commercial nature. Commercial coastal fisheries often suffer from a "boom-bust" cycle caused by overfishing. In particular, this applies to slow-moving invertebrates such as trochus (*Trochus niloticus*) and sea cucumber (holothurians).

The consensus is that aquaculture may be a useful intervention to help sustain resource management of these types of fisheries, but it is unlikely that aquaculture alone will solve the problem. One reason for this is the long period before harvesting takes place. Also traditional tenure systems make it difficult to secure legally enforceable property rights, particularly if it impedes access to fishing grounds.

Many of the Pacific region's coastal dwellers in the rural areas rely on subsistence lifestyle and strong communal support. Therefore they often need cash for basic requirements, staple foods, school fees, church donations and other purposes.

The introduction of *Kappaphycus* seaweed has provided positive examples of mariculture providing rural livelihoods with household cash. Its relative ease of production and stable farm-gate price are suited to the rural lifestyle. Furthermore there are often few sources of cash income, and these may involve intensive manual labour such as copra making, sea cucumber collection or tuna fishing, which restricts the entry of women. Seaweed farming has therefore opened up an alternative pathway for women to earn money.

There is a general perception that the cash paid to women for seaweed is better directed towards essential household needs, i.e. education, health, food etc. as compared to the cash paid to men, which has been widely seen as being spent on household non-essentials such as alcohol.

EXISTING AND POTENTIAL MECHANISMS FOR TECHNOLOGY TRANSFER

Aquaculture research and development (R&D) has been a challenging experience for the region. Many of the early ventures failed because projects were simply initiated on the basis of their technical feasibility for cultivation and did not incorporate a holistic approach that included economic (marketability), social (labour costs) and environmental (impact on biodiversity) factors.

Even so, the applied research necessary to properly assess the biotechnical basis for aquaculture remains incomplete for many species. Furthermore, development agencies often lack the skills to translate research findings into practical extension training modules that farmers are able to understand and apply. There remains a critical need to build extension services capacity.

Similarly, there is limited capacity for socio-economic and environmental planning. Very few countries have proper systems for governance of aquaculture. There are hardly any policies and regulations specific to managing the aquaculture sector.

Bottlenecks in technology transfer have occurred when government-funded programmes became competitors with the private sector. The underlying requirement is that there is a need for a clear and agreed national development strategy that outlines the roles and responsibilities of key stakeholders within the sector. Such fundamental planning is lacking in many countries.

The Pacific region is fortunate to have a network of about a dozen key mariculture facilities in operation. Most are operated under government programmes that make collaboration possible through inter-governmental organizations such as the Secretariat of the Pacific Community (SPC). Essentially this provides a focal body through which lessons can be shared and a country can avoid the duplication of trials and pitfalls experienced elsewhere. Such a body also enables the region to prioritize common issues and act in a collective manner to deal with them.