

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTION
OF
MARINE AQUACULTURE DEVELOPMENT CENTER
IN
CAMBODIA

JUNE 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

OVERSEAS AGRO-FISHERIES CONSULTANTS, CO., LTD.

FUYO OCEAN DEVELOPMENT & ENGINEERING CO., LTD.

Preface

In response to a request from the Royal Government of Cambodia, the Government of Japan decided to conduct a basic design study on The Project for Construction of Marine Aquaculture Development Center and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia two basic design study teams in October 2008 and December 2008.

The team held discussions with the officials concerned of the Royal Government of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia from April 26 to April 26, 2009 in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Royal Government of Cambodia for their close cooperation extended to the teams.

June 2009

Ariyuki Matsumoto
Vice President
Japan International Cooperation Agency

June, 2009

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Construction of Marine Aquaculture Development Center in Kingdom of Cambodia.

This study was conducted by Overseas Agro-Fisheries Consultants Co., Ltd., and Fuyo Ocean Development & Engineering Co., Ltd under a contract to JICA, during the period from September, 2008 to June, 2009. In conducting the study, we have examined the feasibility and rationale of the project with due to consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours.

Toru Fujiki
Project Manager,
Basic design study team on the Project for
Construction of Marine Aquaculture Development Center
Overseas Agro-Fisheries Consultants Co.,Ltd.
Fuyo Ocean Development & Engineering Co., Ltd

Summary

(1) Outline of the Country

Kingdom of Cambodia (hereinafter called “Cambodia”) is located in southwestern side of the Indochina Peninsula with 181,035 km² of land area. The national land spreads to 575 km in west – east direction, and to 446 km in north – south direction. It shares the north and west borders with Laos and Thailand, respectively, and the east and southeastern borders with Viet Nam. The south west side of the country faces Gulf of Thailand with 435 km of coastline. The central part of country extends to form a plane land meshed with large scale river systems of Tonle Sap, Bassac, and Mekong running from the north to the south. The other part of land is mostly elevated and covered under forests. The national population based on the government statistics (2008) is 13.4 million and the population density is 74/km². The site of this Project is located in Sihanoukville on the Kampong Cham Bay. The Project site with its north shoreline facing the sea is in the landscape protected from winds and waves of typhoon and other severe weather conditions. The climate of Sihanoukville is hot and humid throughout the year, and rainfall is especially high from June to October.

(2) Background and Outline of the Project

The gross domestic product (GDP) of Cambodia is US\$8,620 million and the per capita GDP is US\$594. The annual inflation is 5.9% (2007). The primary, secondary, and tertiary industrial productions share 32% (agriculture, fisheries, etc.), 27% (mining, manufacturing, etc.), and 41% (tourism, servicing, etc.) in GDP, respectively.

The fisheries sector of Cambodia is important for the national economy sharing approximately one tenths of GDP (10 – 12%). It is also important for food security of the country as Cambodian people take more than 70% of animal protein from fisheries products.

The “Quadrangle Strategy” formulated by the Royal Government of Cambodia in 2004 is emphasizing the four strategic fields for the development; 1) agricultural development, 2) promotion and creation of employment in private sector, 3) rehabilitation and construction of infrastructures, and 4) capacity building and human resources development. The fisheries reform is one of the four strategic pillars in the agricultural development along with the productivity improvement and diversification, land improvement and mine-clearance, forestry reform. Upon this strategic emphasis, National Strategic Development Plan (NSDP) 2006 – 2010 listed the following priority measures; 1) community reinforcement, 2) livelihood improvement with efficient utilization of fisheries products, 3) establishment of protected zones for fisheries organisms, 4) protection of inland fisheries, and 5) aquaculture development by private sector initiatives. In regards to the marine aquaculture development plans of the Royal Government of Cambodia, there are “National Fisheries Policy”, “Strategic Development Plan in Agricultural Sector 2006 – 1010” and “Aquaculture Development Plan 2000 – 2020”. In addition, the Fisheries Administration of the Royal

Government of Cambodia formulated “Fisheries Development Action Plan (FDAP) 2005 – 2008” which identifies the following prioritized issues; revisions of fisheries policy, plans, laws, etc., fishing ground improvement, strengthening the fisheries resources, promotion of fisheries resources management in participatory approach, livelihood improvement of poverty groups through sustainable utilization of fisheries resources and aquaculture development, and livelihood improvement of poverty groups through reduction of post-harvest loss.

The aquaculture in Cambodia can be classified into two divisions; freshwater aquaculture carried out in rivers and lakes in the inland areas and marine aquaculture practiced in the sea and estuary areas. The freshwater aquaculture which is practiced in traditional culture systems of fish and prawns in Mekong River, Tonle Sap Lake, and other freshwater waters plays an important role for the supply of animal protein to the Cambodian people. The sector is receiving international supports from Japan, Norway, Denmark and other international institutions.

On the other hand, the marine aquaculture is a recent development evolving along with the economic development of the country, and currently practiced in coastal areas in Kampot, Sihanoukville, Koh Kong, Kep. Despite the continuously developing marine aquaculture is identified as a priority area, its promotion has not sufficiently supported as it can be seen in the current situation in which the appropriate aquaculture techniques have not developed yet and the aquaculture seeds are still obtained from wild or imported from the neighboring countries. These situations that are causing pressure to the natural fisheries resources and outbreaks of imported infectious fish diseases are impeding the development of marine aquaculture. The marine aquaculture operators are requesting stable supply of healthy aquaculture seeds and development of appropriate aquaculture technology. In recognition of these requests, the Royal Government of Cambodia is trying to setup an organizational structure for marine aquaculture development requested Grant-Aid assistance to the Japanese government for establishment of “Marine Aquaculture Development Centre (MADeC)” with the facility construction and the equipment supply.

(3) Summary of Study Results and Project component

In respond to the request from the Royal Government of Cambodia, the Japanese Government dispatched a preliminary study team in June of 2007. Subsequent to this preliminary study and consideration its results, the Japanese Government decided to carryout the two-stage Basic Design Study according to the following schedule;

Basic Design Study (I)	: 2 – 22 October 2008
Basic Design Study (II)	: 2 – 26 December 2008
Explanation of the Draft Basic Design	: 26 – 30 April 2009

This Basic Design Study aimed to confirm the necessity, urgency, site appropriateness, implementation

capacity for the requested contents and to define the appropriate extent and scale of the assistance.

The Study concluded that construction of the central facility with appropriate equipment for implementations aquaculture research and development programs is necessary for improvement of the current situation and development of marine aquaculture in Cambodia, and the facility has to carry out the following activities: 1) development of marine aquaculture technology and production and supply of aquaculture seeds to the aquaculture operators, 2) implementation of training and education programs for extension of marine aquaculture techniques, and 3) monitoring for aquaculture environment. In addition, from the view point of supporting the smooth launching of the project programs, it is also concluded that the Project should include soft components (technical assistances) with contents of preparation of a draft version of technical manual for fingerling production of sea bass and formulation of the first year annual work plan for MADeC.

Considering these results of the Basic Design Study, the Project is considered to be appropriate to have the following components:

Summary of Facilities

Name of facility	Structure	Components	Floor area
Research and Administration Building	RC structure, two-story	Director's room, research rooms, administration and general affairs rooms, meeting rooms, library, etc.	1,121.5 m ²
Brood stock maturation building	RC structure	Aquaculture tank room	324.0 m ²
Hatchery & breeding building	RC structure	Aquaculture tank room, recording room, etc.	792.0 m ²
Crustacean building	RC structure	Aquaculture tank room, rotifer culture room, recording room, etc.	432.0 m ²
Outdoor live feed culture tanks	RC structure	Aquaculture tanks	-
Seawater intake facilities	RC structure	Intake pump room, blower room, elevated water tank, etc.	185.9 m ²
Electrical substation	RC structure	Transformer room, generator set room	119.0 m ²
Security guard house	RC structure		27.5 m ²
Outdoor earthen bottom ponds	RC structure		-
Total floor area			3,001.9 m ²
Seawater intake facilities	Underwater filtration method, intake pipes 265m, 200 mm diameter × 2 lines		
Effluent treatment facility	Sedimentation tank for aquaculture effluents (120m ³), internal pavement (footway 148.7 m ² and driveway 1726 m ²)		

List of Major Equipment

Name of equipment	Intended application	Quantity
Educational and training equipment		
Liquid crystal projector	Seminar on fish disease and disease control	1
Research equipment		
Draft chamber	Exhaustion of toxic gases produced in feed development and analysis, etc.	1
Clean bench (Air circulation and horizontal blowout airflow type)	Aseptic manipulations such as preparation of culture media, etc.	1
Clean bench (vertical airflow type)	Isolation of fish disease pathogens and others	1
Plankton incubator	Preservation of micro algae	1
PCR	Preparation of fish disease diagnosis sample	1
Electrophoretic apparatus	Preparation of fish disease diagnosis sample	2
Refrigerated centrifuge	Preparation of fish disease diagnosis sample	1
Aquaculture equipment		
Multipurpose workboat	Inspection and maintenance of intake water pipes	1
Truck (fingerling transportation vehicle)	Distribution of aquaculture seeds to aquaculture operators	1
Compressor for scuba cylinders	Inspection and maintenance of intake water pipes	1
Artemia incubator (100-liter capacity)	Incubation of artemias used as the first live feeds in fingerling production	10
Rearing tanks (FRP circular type)	Rearing of early stage aquaculture organisms	20

Soft components

Item	Contents	Duration
Operation and maintenance of facilities	<ul style="list-style-type: none"> • Guidance for preparation of the first annual work plan (draft) • Guidance for preparation of monitoring inventory for the facilities and equipment • Holding workshop on operation and maintenance for the facility • Survey on potential buyers for the produced aquaculture seeds 	1.5MM
Aquaculture seeds production technology	<ul style="list-style-type: none"> • Collection of information on brood fish collection and support for the collection • Review on reproduction biology of sea bass and examination on the existing manuals • Preparation of sea bass fingerling production manual (draft) 	1.5MM

(4) Estimated Project Duration and Approximate Project Cost

The expected total duration for implementation this Project in the Japanese Grand Aid system is 20.5 months made up of 5.5 months for the implementation designing, 11.5 months for the actual construction

and 8.5 months for procurement and installation of the equipment. The approximate cost borne by the Cambodian side is estimated as US\$18,000 .

The annual return from the implementation of the Project facility operation is estimated to be negative in the first three years; deficits of US\$70,000, US\$68,000, and US\$54,000 in the first, second and third year, respectively. Thereafter, from the fourth year, the return is expected to turn to generate profits. The Royal Government of Cambodia has budgeted US\$80,000 as the annual operational cost for MADeC, which assures a trouble free operation and maintenance of the Project facilities.

(5) Validation of Appropriateness for the Project

The following benefits are expected from the implementation of this Project:

1) Direct benefits

- a. Establishment of facilities that enable implementation of research and development activities for marine aquaculture species and production of 400,000/year of sea bass fingerlings
- b. Preparation of fingerling production manual for sea bass and other species suitable for the specific Cambodian conditions, and development of appropriate techniques suitable for the experience, scale and natural conditions of the local aquaculture operators
- c. Implementations of aquaculture training and seminars for extension and education of aquaculture techniques developed at MADeC

2) Indirect benefits

- a. Increased survival rate in aquaculture operations by the supplying healthy seeds
- b. Increased sustainability in aquaculture development by conservation of aquaculture environment
- c. Reduction in fishing pressure to the natural resources of aquaculture organisms
- d. Reduction in occurrence of imported infectious fish diseases
- e. Contribution for the economic improvement of the aquaculture operators
- f. Expected contribution to the stable supply of marine fish products

Based on the following points, this Project is concluded as appropriate to be implemented as a Japanese Grant Aid project.

- 1) The establishment of aquaculture facilities with the equipment will enable implementation of research and development activities, production and stable supply of aquaculture seeds and extension of the developed techniques to the aquaculture operators. MADeC will become able to produce and distribute sea bass fingerlings as a short-term achievement, which opens a gate for the stable supply of healthy aquaculture seeds to the private operators.
- 2) The operation and maintenances of the Project facilities and equipment do not require excessively

sophisticated technology and can be managed within the capacity of Cambodian human resources and technology.

- 3) The operational cost for the Project will be borne by appropriate budgetary measures taken by the Royal Government of Cambodia and a trouble-free operation and maintenance is expected for the Project implementation.
- 4) There is no specific negative environmental impact anticipated from the implementation of this Project.
- 5) This Project can be implemented in the Japanese Grand Aid scheme without any hindrances.

The following recommendations are made for smooth and effective implementation of the Project.

Securing of the operational budgets

Despite the fact that MADeC is a research and development institute in its fundamental nature, it is designed to produce revenues from the operation in this Project. Nevertheless, it would be difficult to achieve financial feasibility in the first three years of the operation when the Centre expects to make revenues only from fingerlings sales. The Royal Government of Cambodia therefore needs to take and implement adequate budgetary measures for the operation on the centre in the initial period.

Inspection and maintenance of machinery

Establishment of the operation and maintenance system by securing the trained maintenance personnel especially for the pumps and electric equipment is an important factor for trouble-free operation of the MADeC facilities. The maintenance program for the seawater intake equipment which is the fundamental infrastructure of the centre must be operated reliably with appropriate maintenance plan.

Capacity building for research personnel

Technical and staff exchange programs between MADeC and fisheries research institutes of neighboring countries like Vietnam, Malaysia, Thailand, Indonesia, etc. should be enhanced for improving the efficiency of research activities. Acquirements of aquaculture technology and research results through interactions with Southeast Asian Fisheries Development Centre (SEAFDEC) and other international institutions are expected to increase the operating effectiveness. In the future, MACDeC should not only receive the benefits through the exchange programs but also become able to give actively the own techniques and research results achieved by the staffs to the other countries as the regional and international contributions.

Conservation of aquatic environment

The Royal Government of Cambodia and the relevant ministries need to pay sufficient attentions on the conservation of coastal aquatic environment in the Sihanoukville area as the area contains tourist attractions with precious beaches. Continuous monitoring of aquaculture environment is important not only from the view point of tourism development but also from the view point of aquaculture industrial development as

such monitoring program contributes for appropriate aquaculture operations and sustainable marine aquaculture development.

Financial support to the aquaculture fishers

The aquaculture fishers are the end beneficiaries of the technical development to be achieved at MADeC. Therefore, it is desirable to provide necessary financial supports to the aquaculture fishers with establishment of soft loan programs so that they can apply the developed techniques for realization of the aquaculture development.

Establishment of aquatic disease control and prevention system

Examination for viral diseases of fingerlings, disease diagnosis for brood fish as well as young fish, and control of fish disease in general are important for securing the sustainability in marine aquaculture development. Establishment of monitoring and prevention system for infectious diseases is especially vital since they could cause significant damage to the aquaculture industry.

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Location Map



Kingdom of Cambodia



Sihanoukville & Project Site



Marine Aquaculture Development Center

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Abbreviations

BOD	Biological Oxygen Demand
C.D.L.	Chart Datum Level
COD	Chemical Oxygen Demand
DANIDA	Danish International Development Association
DO	Dissolved Oxygen
EIA	Environment Impact Assessment
FAO	Food and Agriculture Organization
FL	Floor Level
FRP	Fiber Reinforced Plastic
GDP	Gross Domestic Production
GL	Ground Level
ICLARM	International Center for Living Aquatic Resources Management
IEE	Initial Environment Examination
IFReDI	Institute for Freshwater Aquaculture Research and Development Center
JIS	Japan Industrial Standard
MADeC	Marine Aquaculture Development Center
NACA	Network of Aquaculture Centres in Asia-Pacific
NCDD	National Committee for Democratic Development through Decentralization and Deconcentration
PAS	Sihanoukville Autonomous Port
NSDP	National Strategic Development Plan
PCR	Polymerase Chain Reaction
PL	Post Larva
PVC	Polyvinyl Chloride Pipe
SEAFDEC	South East Asia Fisheries Development Center
SEZ	Special Economic Zone
SGP	Carbon steel Pipes for Ordinary Piping(JIS)
STPG	Carbon steel Pipes for Pressure Piping(JIS)
UNEP/GEF	United Nations Environment Programme / Grobal Environmental Facility

Chapter 1 Background of the Project

1-1 Background of the Project

The fisheries sector in Cambodia plays important roles in the national economy of Cambodia employing approximately 4 million or 30% of the national population and contributing for 10 to 12 % of Gross Domestic Product. Importance is also high in the aspect of food security as Cambodian people obtain 70 % of animal protein from fisheries products. Expectation for increasing fisheries products through marine aquaculture is high as the production from the marine capture fisheries remains broadly flat in recent years. The increase in marine aquaculture production, while keeping the total production from sea, is also expected to result in suppression and reduction of excessive pressure to the coastal fisheries resources and therefore facilitate the resources recovery. Inasmuch, it is recognized in Cambodia that development of aquaculture should be achieved in balance with conservation of coastal fisheries environment. The priority areas identified in the Fisheries Development Action Plan (FDAP 2005 – 2008) adopted by Fisheries Administration includes; improving livelihoods of poor population by aquaculture development through sustainable utilization of fisheries resources, reduction of post-harvest loss of captured fisheries products, revisions of policy, plans and legislations pertaining to fisheries activities, improvement of condition in fisheries grounds, stock enhancement of fisheries resource, promotion of resources management through participatory approach.

International assistance for development in the marine fisheries sector of Cambodia has been limited except in some aspects like conservation of coastal fisheries resources, while that in the inland fisheries sector has received assistances from various countries. In respect to the marine aquaculture sector in which little technical development is observed, aquaculture operators are depending on the fingerlings captured from natural environment or imported from neighbouring countries because there is no domestic hatchery yet in Cambodia. The collection of natural aquaculture seeds is said to be resulting in acceleration of pressure to the natural resources as well as outbreaks of fish diseases originated from the fingerlings, which in turn is preventing the development of marine aquaculture despite that the promotion of marine aquaculture has identified as a priority area in the fisheries sector in Cambodia.

1-2 Overall goal and project objectives

(1) Goal of the Project

The goal of the Project is set as “to improve the livelihoods of coastal population and to increase marine fisheries production through development of marine aquaculture, and thereby contributing for

improvements in nutritional status of national population and increase in exportation of fisheries products and their quantity.”

Fisheries Administration is listed the functions that the Project facility bears as follows; 1) production and distribution of healthy aquaculture seeds (fish, prawns, clams, shellfish, and seaweeds), 2) research and development in aquaculture technology including brood stock rearing, seed production, fry and larval rearing, culture of live feed organisms, and feed formulation, 3) training, extension and consultation for aquaculture operators, hatcheries, and coastal fishers on promotion of aquaculture, 4) research & development and supply of genetically superior brood stock organisms, 5) protection and management of marine biodiversity and conservation of marine environment, 6) cooperation with academic institutions in training and education to build human capacity in marine aquaculture development, and 7) establishment of collaborative working relationships with national and international research and development institutions for exchange of technology and information on marine aquaculture development. More specifically, the Centre aims to achieve the following targets in the short term; 1) seed production of marine organisms, 2) research and development on genetically superior brood fish and its distribution, 3) development of aquaculture technology (appropriate for extension to the small-scale aquaculture operators and fishers, 4) extension and training on aquaculture technology (to civil servants, small-scale aquaculture operators, and NGOs).

The medium and long term targets of the Centre are; 1) establishment of stable production and distribution system of marine aquaculture seed organisms, 2) shifting from capture fisheries to aquaculture for small-scale fishers and creation of employment opportunities for women, 3) support for establishment of marine fisheries product supply systems to domestic tourism and other similar industries, 4) promotion of exportation of marine fisheries products, 5) establishment of a network for increased sharing of information on aquaculture and establishment, and 6) capacity building of the MADeC staff in formulation of a medium and long term marine aquaculture development plan.

(2) Objectives of the Project

The objective of the Project is, by improving the facility and equipment for technical development of marine aquaculture in Sihanoukville municipality, “to develop marine aquaculture in Cambodia through development of basic marine aquaculture technology, supply of aquaculture seeds, and provision of training and consultation opportunities for aquaculture operators and other stakeholders”.

1.-3 Natural Condition

The purpose of this study is to collect basic data required for determination of necessary facilities and the appropriate construction methods in conformity with the natural conditions at the Project site, which is located along a bay in the eastern part of the Gulf of Thailand. The bay is very shallow with the average depth of 45 m and the maximum depth of 80 m. The survey in the coastal area was carried out focusing on examination of the marine environment around the site in order to find the appropriate seawater intake method. The items of study in this natural condition study are; topographic survey, geological survey (land and sea areas), acoustic sounding survey, water quality survey, measurements of tide level, waves, and tidal current, bottom survey, meteorological survey, littoral drift survey, and survey on bio-fouling.

(1)Topography

The study team confirmed the boundary of the site premises with the staffs of Department of Fisheries before the survey. The area of the premises was 1.77 ha according to the land registration certificate of the site facility. The survey was conducted by confirming the distances recorded on the land registration certificate from the base point set at a corner of the concrete wall that forms the boundary with private houses located north-western side of the premises. The southern end of the premises was confirmed along the existing boundary with the private factory. The result of survey confirmed the exact area of the premises is 17,975 m² (1.7975 ha). A topographic map of the site was produced from the survey results.

(2)Geology

The geological survey was conducted with the purpose of confirming the bearing capacity of the site foundation that is necessary for structural designing of the land and marine facilities. On the land survey, in consideration of the nature of the laterite soil that cover the site premises, drilling survey (all cores), standard penetration test, and sampling collections were conducted for collecting the necessary data for setting the support base levels of the facilities under the ground. On the marine survey, drilling survey similar to the one conducted on land was done for collecting data necessary for determination of the intake pipe laying design and the seawater intake method. The measurements was carried out at three points on land in the expected facility construction site (the drilling depth up to 15 m), and at two points in the sea in the expected pipe laying area (the drilling depth up to 10 m).

1)Land geological condition

The borehole drillings were done at three points shown in the location map of survey points (Figure 2-3). On the contrary to the prior expectation, the surface soil layer was shallow covering immediately

over the bedrock layer at all the points. The depths to the bedrock layer were as follows.

Table 1 Result of drilling survey in the land area

Drilling point	Ground height	Thickness of bedrock layer	Drilling depth
Borehole No1	3.43m	1.0m	15.0m
Borehole No2	2.81m	2.45m	15.0m
Borehole No3	2.53m	2.45m	15.0m

The soil cores sampled to the depth of 15 m was made of bedrocks and high density materials without sandy soil layer showing no evidence of aquifer to the depth. And therefore, it suggested that pumping from wells is not possible at the site. Meanwhile, the water level in the borehole was 1.1 m.

2) Marine geological condition

At the borehole No. 4 drilling point in the sea area, the silt layer appeared from 6.5 m to 9.0 m depth from the surface of water, and the bedrock layer appeared thereafter. At the borehole No. 5 drilling point located near the shore, the surface bottom soil layer covering the bedrock layer was 1.5 m in the thickness and consisted of sandy soil and sand stones.

Table 2 Result of drilling survey in the sea area

Drilling point	Bottom level from water surface	Thickness of bedrock layer	Drilling depth
Borehole No4	-6.5m	2.5m	-9.0m (including depth of seawater)
Borehole No5	-1.5m	3.0m	-4.5m (including depth of seawater)

(3) Acoustic sounding survey

The depth measurements were conducted with a precision acoustic sounder in order to collect basic data for considering the intake pipe laying design and also for assessing the stability of the shore condition. The dimensions of the survey area were 200 m × 500 m as shown in the location map of sampling points for the natural condition survey.

The sounding measurements were conducted at the points 20 m apart each other along the 11 parallel lines set across the 500m end line of the survey area. The results of the measurements were plotted onto a plain view map and also used to draw a 3-dimensional birds-eye view map (attached in Annex). The littoral condition in the marine site was presumed to be continuous plane sandy beach, but in fact, the survey found the area around 250 m off the shore is made of rough underwater terrain of bedrocks.

(4) Water quality survey

The water quality survey was conducted to find the vertical profiles of water temperature, salinity, etc. in order to determine the position of seawater intake structure and also to assess the level of organic pollution in the coastal area in front of the Project site. The data collected by the survey by sampling site are presented below.

MADeC Project Site						
13 December 2008 16:00						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.00	28.62	31.65	8.12	7.87	2.63	-

Ramdol Cheng Phnom village						
14 December 2008 15:39						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.00	28.79	31.64	8.11	7.29	6.81	1.52

St.No1						
14 December 2008 15:10						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	28.12	31.71	8.10	6.98	1.68	0.78
4.30	28.04	31.69	8.10	6.92	2.45	0.98

St.No2						
14 December 2008 14:40						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	28.07	31.69	8.09	6.93	1.72	0.83
5.00	27.99	31.69	8.10	6.94	3.21	1.20

St.No1						
14 December 2008 16:10						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	28.26	31.69	8.11	7.01	1.83	1.07
5.70	28.08	31.69	8.11	6.88	4.85	1.40

St.No2						
14 December 2008 16:00						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	28.34	31.67	8.11	7.07	1.65	0.93
5.00	28.02	31.68	8.11	6.91	5.24	1.17

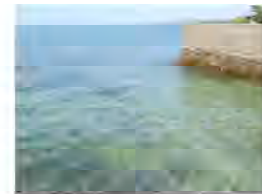
MADeC Project Site						
18 December 2008 15:05						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.00	27.38	31.55	8.06	7.32	6.87	1.30

St.No1						
19 December 2008 9:19						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	27.10	31.78	8.03	6.59	1.68	1.15
5.00	27.11	31.79	8.04	6.52	1.84	1.01

St.No2						
19 December 2008 9:35						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	27.11	31.79	8.07	6.57	1.90	0.90
5.00	27.11	31.79	8.07	6.55	2.68	1.18

St.No1						
19 December 2008 16:55						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	27.26	31.81	8.11	6.83	2.91	0.73
5.00	27.28	31.82	8.10	6.78	1.83	0.90

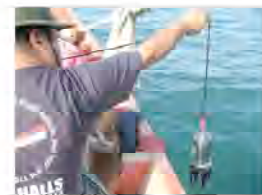
St.No2						
19 December 2008 16:40						
Depth	Temp(C)	Sal	pH	DO(mg/L)	Tur(FTU)	Chl(ppb)
0.50	27.20	31.74	8.07	6.87	2.32	1.07
5.00	27.22	31.75	8.08	6.85	2.32	0.87



MADeC Project Site



Ramdol Cheng Phnom



St.No1



St.No2

Remark:
 Temp: water temperature (C)
 Sal: Salinity
 pH:
 DO: Dissolved Oxygen
 Tur: Turbulence
 Chl: Chlorophyll

(5) Tide level, Waves, and Tidal current

These measurements were conducted with the purpose of collecting basic data necessary for considering the seawater intake method. The tidal current measurements were done with a direct measuring type instrument during the spring tide when the current speed increases to the maximum.

Additional data on these items were also collected from the existing records and used for designing the facilities.

(6)Bottom condition

The soil samples were collected from the surface layer of sea bottom using a bottom sampler for collecting the basic information necessary for considering the location of seawater intake structure. There were two sampling points as shown in the location map of the natural condition survey. The sampling was carried out by divers. The collected samples were analysed for the particle size compositions. The divers also drove 10-mm reinforcing steel bars into the bottom soil to measure the thickness of the surface sand layer. According to the particle size analysis, the surface sand layers were made of less than 2mm particles at St. No. 1 and St. No. 2. More precisely, they were predominantly consisted of very fine particles of less than 0.075mm diameter. The results of the bottom condition survey are summarized together with the results of measurements of the sand layer thickness.. The survey revealed that the sea bottom is made of mixture of rocks and sands up to the area 210 m off the shore, but changes to the fine silt accumulation of 0.5 to 1.2 m thickness thereafter up to the 500 m off shore area.

(7)Meteorological Survey

In order to comprehend the climate condition at the site for considering the design and construction process of the facilities, the data on rainfall, wind direction, wind velocity, record of major natural hazards were collected from the meteorological stations and other relevant government offices.

1)Air temperature

The average monthly maximum, minimum, and medium temperatures at Sihanoukville from 2000 to 2008 were as shown below. The average monthly maximum temperature during this period was 33.1 °C and the minimum was 22.6 °C.

2)Wind velocity and direction

The maximum wind velocity was 21.5 m/s and the dominant wind was from north - northwest - west direction, according to the meteorological data in the last 9 years (2000 – 2009). High velocity wind blew in two rainy months of June and July, and the direction was from west - northwest. During these two months, local storms caused by tropical depressions strikes the area. The maximum wind velocity was recorded also in July. The wind direction changes to blow from the north during the dry season from November to January. There are few occasional days with strong wind more than 10m/s, but in general the relatively calm days continue during the dry season.

3)Rainfall

The annual rainfall was about 2600 to 4000 mm during the period from 1997 to 2008 and the average

rainfall was 3272.3 mm/year.

(8) Littoral drift

The littoral drift study was carried out by field visits to the area around the site and supplemental collection of existing data in order to consider the seawater intake method and the piping layout design. Interviews with the fishers and other persons in the site area during the field visits collected the information on to the conditions of clam and bad weather days, dominant wave height, accretion of sand, etc. in order to clarify the situation of shorefront erosion and accretion. According to the results, there was no apparent change on the shorefront condition. There was no large stream and therefore it suggested little effect of fluvial deposition from the inland region to the coastal area. A few cyclones strike the area during the rainy season especially in June and July, but waves and currents are not considered strong enough to change the shoreline conditions of area.

(9) Bio-fouling

The condition of sessile organisms grown on the marine structures and rocks around the planned route for laying out the seawater intake pipes was examined. The examination was done visually to find the quantity and kind of the sessile organisms.

1) Around the designed position where the intake pipes emerge

There were accumulations of large quantity of dead bivalves on the shoreline. Approximately 10 – 20 individuals per m² of tritons, limpets, and balanus were observed on the rocks around the area. These shells were also observed on pillars of houses that were built over the shoreline and on the foundations of jetty, but the quantity was also not dense enough to cover up the surface but relatively thin.

2) Around the designed position where seawater intake structure is installed

The divers visually examined underwater condition at about 5 m depth around the area where the seawater intake structure was considered to be installed. They found sea urchins and sea pens in the area.

1-4 Environmental and Social Considerations

(1) Development plans around the project site

Development plan of Shihanouk Ville port

“The Study on the Master Plan for Maritime and Port Sectors in the Kingdom of Cambodia” has been carried out by JICA in 2007 partly aiming at examination of future development of Shihanookville port. Based on this master planning study, construction of oil base and multipurpose terminal is now being examined assuming the Japanese yen loan. Concerning the construction plan, JBIC (which was integrated into present JICA) has carried out a Special Assistance for Project Formulation (SAPROF), namely the SAPROF for Sihanookville Port Urgent Development for Oil Supply Base & Multipurpose Terminal, 2008, following which the loan agreement is to be signed in March 2009. After the signature of agreement, construction works will be commenced around autumn 2011 after detailed design study and tendering procedures for construction companies, and completed around spring 2014

According to the long-term vision of Shihanookville port development, there is an alternative plan to develop existing breakwater body as a new cargo terminal, and construct a canal across the breakwater near the site. When this alternative is realized, polluted water in the port would flow out to open sea, and there would be an anxious about negative influence to the water quality at the point that MADeC is going to intake water. Concerning this, the Sihanookville port authority (Sihanookville Autonomous Port: PAS) explained that extension of the port will be forwarded to the direction of the above multi-purpose terminal namely southwest ward basically, or other substitutive site will be examined. Conclusively we confirmed that the idea on the opening of existing breakwater was not discussed presently as remarked in the Minute.

Establishment of Special Economic Zone (SEZ)

A special economic zone (SEZ) is proposed at the east side of existing Shihanookville port, and the foundation work is to be started from June 2009. In this construction works, relevant infrastructures such as road, electricity and water will be developed inside the SEZ. Regarding the SEZ plan, in order to unify SEZ and the port physically, the existing road towards the project site of MADeC will be closed at the point near the office of PAS. However, since an alternative road is planned to be constructed along the eastern edge of the SEZ, there will be no problem about access to the project site. In a rapid scenario of the SEZ plan, sale of the developed land lots for entrepreneurs is started in 2010 and it is expected parts of them start operation from 2011. There were 4-5 residents who refused relocation, and among those, two households opposed to the relocation plan strongly and it took about 2 years to compromise about compensation conditions from them. Also there is a village that refused adamantly to relocate so that a detour layout plan is applied for the facilities.

(2) Procedures of environmental and social consideration

Environmental Impact Assessment (EIA) would not be required legally for this Project as shown in the preliminary study report of the Project. In this B/D study we reconfirmed the same with the Director of EIA, Ministry of Environment and remarked in the Minute. The same understanding was confirmed with the Environmental Division of Shihanookville. Exemption of EIA for fishery-related projects was determined at the Minister meeting during the arguments about relevant laws and regulations on EIA taken into account the aspect of food security of major food items as well as economic importance of fisheries. Among fishery-related facilities, EIA is required only for fishing port according to the current Sub-Decree on EIA launched in 1999, and no remarks are given for other facilities such as aquaculture.

The Sub-Decree indicates the necessity of EIA for buildings having more than 12 m in height or architectural area of 8000m². The planned facilities are smaller than those criteria. Whereas, considering that the Project is implemented by the scheme of Japanese grant aid, environmental evaluation had already been carried out at the level of Initial Environmental Evaluation (IEE) in the preliminary study. In this B/D study an additional stakeholder meeting was held and opinions of residents and other stakeholders have been compiled. In conclusion, environmental and social consideration for the Project would be appropriate and sufficient.

(3) Stakeholder meeting

Stakeholder meeting was held on 17 December 2008 at MADeC with more than 50 participants including residents inside and around the proposed project site, aquaculture farm operators, seed traders, local authorities, officials of the Department of Environment, Shihanookville and officials of the Marine Fisheries Administration Inspectorate (MFAI) and Cantonment Kompong Som, FiA. Mr. Ing Try, the Deputy Director General of FiA chaired the meeting.

As for the principle on the social environment, the subjects which were confirmed in the four previous stakeholder meetings shall be esteemed in order to avoid future contradictions. In addition to the principle, following opinions or construction plan were confirmed in this meeting.

- ① In general all the stakeholders agreed upon the concept of MADeC which aims at development of coastal aquaculture. An aquaculture operator cum seed trader expressed his observation about fish and crustacean seeds which were mostly imported from Thailand and marketed commonly at present. He told that they were not satisfactory in quality so that he would like to use the healthy seeds to be produced at MADeC.
- ② The existing two buildings of the MFAI will be moved to the western edge of the site. In this case, there would be no disturbance about daily work and commuting of the staff.
- ③ The existing staff house of the MFAI that has been functioned as a temporary resting place

for marine inspectors will be removed. However, it does not draw a problem, because the decision of removal is done in line with comprehensive coordination of FiA.

- ④ Two families living beside the existing gate will have to be relocated. They are basically agreed with relocation, since the FiA has explained them to allocate alternative land lots inside the sites.
- ⑤ The land owner at the site of underground pipe lines for seawater intake, who is a FiA staff, understands and agrees on the necessary civil works in his property.
- ⑥ The existing community road in the site will be moved to the western border of the site. No specific changes are expected regarding such situations as distance, road width and convenience.
- ⑦ The Department of Environment, Shihanooville asked about expected load of discharge water from MADeC. FiA officers and Japanese consultants explained that the water will be discharged through sedimentation tank following the environmental regulation, and water quality monitoring had been proposed using the equipment granted.
- ⑧ In addition to the above, further explanation and agreement were made about noise and discharge water, etc.

(4) Scooping on environmental and social consideration

Scooping result shown in the preliminary study report were re-examined in this B/D study based on the latest information and the results of stakeholder meeting. Overall rating for the Project was unchanged as “B”. This Project is to establish research facilities for fish seed production and disease so that it is necessary to keep strictly the national regulations on discharge water from fish rearing facilities and on fishery medicines. Establishing a system for water environment monitoring including private farms will also be necessary in future.

Table 3 Scoping for environmental and social consideration (at the Basic Design Study)

Environmental Index	Extend of the Impact (Rating)							
	Preliminary Study				Basic Design Study			
	A	B	C	D	A	B	C	D
1. Social life								
(1) Resident life								
1. Planned resettlement		○				○		
2. Involuntary resettlement		○				○		
3. Change of life style				○			○	
4. Friction among residents				○			○	
5. Indigenous and minorities				○			○	
6. Increase of road and maritime traffic volume		○					○	
7. Road blockade within planned project site		○					○	
(2) Population problem								
1. Increase of population		○					○	
2. Rapid change of composition of population		○					○	
3. Working place, environmental change		○					○	
(3) Economic activities for resident								
1. Resettlement of base for economic activities		○					○	
2. Change of economic activities, unemployment		○					○	
3. Expansion of income disparities		○					○	
(4) Institution/Custom								
1. Readjustment of fishing right and water irrigation right			○				○	
2. Change of social structure such as organization etc		○				○		
3. Reform for existing institution and Custom		○				○		
2. Health								
1. Increase of consumption volume for fishery chemicals				○		○		
2. Occurrence of local diseases				○			○	
3. Spread of epidemics				○		○		
4. Toxicity of shells			○				○	
5. Residual chemicals (Fishery chemicals etc)				○		○		
6. Increase of wastes and excrements		○				○		

3. Historical site/Cultural heritage/View etc					
1. Damage and demolition of historical site and cultural heritage			○		○
2. Loss of precious view			○		○
3. Effect on ground resources			○		○
4. Valuable life and ecosystem					
1. Change of vegetation			○		○
2. Effect on precious and unique flora and fauna			○		○
3. Effect on biodiversity			○		○
4. Effect on fishery resources			○		○
5. Invasion and propagation of harmful species			○		○
6. Loss of tideland			○		○
7. Loss of sea grass beds			○		○
8. Loss of mangrove			○		○
9. Loss of coral reef			○		○
5. Soil/land					
(1) Soil					
Soil erosion			○		○
(2) Land					
Subsidence			○		○
6. Hydrology/water quality					
(1) Hydrology					
1. Change of river flow			○		○
2. Change of flow or level of underground water		○			○
3. Sedimentation			○		○
4. Effect on the water flow			○		○
5. Effect on the waves			○		○
6. Effect on the drift sand			○		○
7. Effect on the boat transportation			○		○
(2) Water quality/bottom quality					
1. Water pollution		○			○
2. Bottom pollution		○			○
3. Eutrophication		○			○
4. Change of water temperature		○			○
(3) Air etc					
1. Offensive odor			○		○
2. Noise and Vibration			○		○
Overall rating					
			○		○

Rating:

A: Serious impact is expected.

B: Some impact is expected.

C: Extent of impact is unknown.

D: Unknown.

Table 4 Overall rating matrix (at the Basic Design Study)

Precondition : Evaluation for construction of MADeC facilities and its impacts after 5 years operation

Environmental subject	Pre.study	Result of this Study	Evidence/Future Policy	Remarks
Planned resettlement	B	B	Temporary accommodation facility for the staff of MFAI, FiA in the Project site is planned to be removed. Explanation to related persons was completed already and internal adjustment will be made in MFAI.	
Involuntary resettlement	B	B	Resettlement of 2 households at the entrance of the site will be necessary. Pre-explanation was done to those families and they agreed basically on the resettlement. Alternative land will be secured within the site of FiA. It is necessary for Japanese side to monitor the exact location of the land and procedure of their resettlement. Parts of seawater intake and drain pipes will be laid underground of the private estate (currently vacant). Although agreement with land owner (staff of FiA) has been concluded, it is necessary to monitor coast land usage continuously.	
Change of life style	D	C	Under the Project, fishers are expected to be new fish farmers. However most of them are likely to be part-time activities considering the available initial cost and sustainability. Therefore no large change occurs in their life style.	
Friction among residents	D	C	There were no objections shown at stakeholder meetings which were held more than 4 times. It is not expected that resident friction will be elaborated.	
Indigenous and minorities	D	C	It was confirmed that there are no indigenous and minorities in the Project site.	
Increase of road and maritime traffic volume	B	C	Traffic volume increased by the Project is only truck transportation to distribute seeds.	Remark 1
Road blockade within planned project site	B	C	There is a small earthen road in the Project site towards the port. This road will be substituted with a new road which will be constructed at the border of the site. Residents already agreed with this option at the stakeholder meetings.	Remark 1
Increase of population	B	C	Number of staff for the operation and management of the projected facilities will be 37 persons, and among them, worker level staffs will be hired from local peoples. It is not expected that population will increase drastically by the Project.	Remark 1
Rapid change of composition of population	B	C	It is not expected that composition of population will change drastically by the construction of the facilities.	Remark 1
Working place, environmental change	B	C	It is not expected that working place of resident will be change.	Remark 1
Resettlement of base for economic activities	B	C	It is not expected that resettlement of economic activity base will be changed largely.	Remark 1

Change of economic activities, unemployment	B	C	The Project contributes to promote aquaculture as an alternative livelihood for fishers. Since fishery and aquaculture is similar economic activities, there will be no negative impact.	Remark 1
Increase of income differential	B	C	The Project aims to promote marine aquaculture, and income might be difference depending on the performance. However, the income gap will not be large up to the extent that is recognized as a social problem.	Remark 1
Change of social structure such as organization etc	B	B	Status of organizing fishers, progress of production efficiency by developing a distribution system and impact on social structure will be monitored. (same as preliminary study)	
Reform for existing institution and custom	B	B	Regarding aquaculture activities, current fisheries law (Fisheries Law 2005) stipulates a penal regulation in case of violation. The Project is not planned to revise the Law drastically, however, the Project will examine the necessity of revision of institutions in line with aquaculture development. At present net cage culture is implemented inside the Sihanoukville Port with permission of Provincial Fishery Office, however it is necessary to make adjustment on this activity with relevant organizations in future (Refer to the Remarks 2 on the bottom)	Remark 2
Increase of consumption volume for fishery chemicals	D	B	Development of countermeasure for fish diseases is one of the pillars of the Project. Fishery chemicals will be used experimentally and chemical treatment is deeply considered in facility design. However there is possibility that harmful antibiotics may be used privately in future. It is necessary to monitor fish farms according to the Fishery Chemicals Usage Standard (tentative name) which will be prepared in the next year.	
Occurrence of local diseases	D	C	Occurrence of local diseases has not been reported for the target species, i.e., sea bass and black tiger shrimp.	
Spread of epidemics	D	B	Since marine fish aquaculture may cause Viral Nervous Necrosis (VNN), countermeasure shall be considered. However since adult fish is never infected with VNN, there will be no serious damage on aquaculture farms. Microbe of epidemics originated from seawater fish never infect to human.	
Residual chemicals (Fishery chemicals etc)	D	B	In accordance with the Fishery Chemical Usage Standard (tentative name) to be prepared after 2009, it is necessary to monitor fish farms.	
Increase of wastes and excrements	B	B	The projected seed production facilities are categorized into small-scale, because seed production amount is only about 400 thousands per year. Therefore wastes and excrements from these facilities are not expected large, however it is necessary to monitor their ingredients and volume periodically.	
Soil erosion	D	C	Coast line on which intake and drain pipes are berried under the ground will be reinforced with concrete structure. Hence, soil erosion is not likely occurred by facility construction.	
Subsidence	D	C	Taking stratum status and N index of boring survey into account, land subsidence is not likely occurred by facility construction.	

Change in flow and level of underground water	B	C	As the Project plans to convey fresh water from tap water, drilling wells is not planned.
Water pollution	B	B	The Project will drain rearing water which is used for seed production at the ocean side in the north of the site. Therefore there will be no negative effect to the residents. Although waste water is to be treated primarily and the treatment is complied with the Waste Standard (Sub-Decree on Water Pollution Control, 1999), it is necessary to monitor the water quality at the drain point periodically.
Bottom pollution	B	B	Same as above. Bottom condition shall be included as a subject to be monitored as well.
Eutrophication	B	B	Same as above. As index of eutrophication, BOD and COD are to be monitored.
Change of water temperature	B	C	Except for some experimental tanks, there is no equipment for cooling and heating in the facilities. So water temperature is not likely affected.
Noise and vibration	D	C	Construction works which elaborate severe noise and vibration such as pile driving and existing concretes scrapping are not planned. Occurrence of some noise during construction works was explained at the stakeholder meetings and this was accepted by residents.
Overall evaluation	B	B	The Study reviewed and examined some environmental subjects which rated "B" and "D" by preliminary study. Since preliminary study took large-scale development project around the site such as establishment of Special Economic Zone (SEZ) and Sihanoukville multi-purpose port construction into account, there were many "B" grade evaluations for social issues. However since those are not considered as immediate impacts of the Project, ratings were revised as "C". Overall rating is unchanged as "B". The Project aims to establish an experimental and research facility for seed production and aquaculture technical development. It shall compile with Cambodian national regulations on waste water that is discharged from fish rearing tanks and fishery chemicals. In addition, it is necessary to establish water environment monitoring system including private fish farms in future.

Rating: A: Serious impact is expected.
B: Some impact is expected.
C: Extent of impact is unknown.
D: Unknown.

Remark 1) Despite the preliminary study took into account the large-scale development projects around the site such as establishment of Special Economic Zone (SEZ) and Sihanoukville multi-purpose port construction, there were many "B" grade evaluations for social issues. As mentioned in the table, impact caused by the Project is considered to be very limited.

Remark 2) Since Sihanoukville Port was originally established for cargo transportation, aquaculture activities are not positively recommendable in that port generally. FiA has been exchanged opinion with PAS continuously, however it is necessary to consider preparing clear regulations and/or rules for utilization of port waters. In addition, since there are illegal residents in the port, it is necessary to consider not buying fries which produced in the center to these peoples and not culturing illegally in the port.

(5) Treatment of discharge water and solid wastes

Regarding discharge water and solid wastes from MADeC, it is necessary to introduce measures to accomplish the criteria shown in the Sub-Decree on Water Pollution Control (1990) and Sub-Decree on Solid Waste Management (1999) of the Ministry of Environment. There is a regulation of total emission, which is to be applied for specific industrial factories discharging water more than 10m³/day, and those factories require notification to the Ministry. However, aquaculture facilities like those in the Project are not specified in the list of factories that shall obey the total emission regulation.