ICLARM mcc p.o. box 1501, makati, metro manila, philippines

Technical Assistance on Hatchery Research for Coastal Aquaculture Development in Sabah, Malaysia

A Cooperative Project Between

THE INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT (ICLARM)
MANILA, PHILIPPINES

and

THE MINISTRY OF AGRICULTURE AND FISHERIES DEVELOPMENT (MAFD)
SABAH, MALAYSIA

Phase I. Report to the Department of Fisheries on Site Selection and Design for a Marine Research Hatchery

by

JACQUES FUCHS

Consultant,
France Aquaculture,
Centre National pour
L' Exploitation des Océans,
Centre Océanologique du
Pacifique,
B.P. 7004,
Taravao, Tahiti,
Polynésie Française.

and

ROGER S.V. PULLIN

Senior Scientist in-charge
of Aquaculture Program,
International Center
for Living Aquatic
Resources Management,
MCC P.O. Box 1501,
Makati,
Metro Manila,
Philippines.

December 1982

international center for living aquatic resources management

CONTENTS

Introduction

On 22 January 1982, the International Center for Living Aquatic Resources Management (ICLARM) and the Ministry of Agriculture and Fisheries Development of Sabah, Malaysia (MAFD), signed a Memorandum of Agreement to cooperate and assist each other in research and development projects related to fisheries and aquaculture development. Both parties recognized the tremendous potential for coastal aquaculture development along Sabah's extensive and relatively unpolluted coastline. The first project under this Memorandum of Agreement is the development of a marine hatchery for research on finfish.

From the experience gained in the marine research hatchery, a pilot production hatchery and demonstration/pilot production activities will be developed. The objectives of the project are:

a. To establish a research hatchery in Sabah for the development of hatchery techniques for mass seed production of marine and brackishwater finfish species suitable for economically viable forms of aquaculture.

b. To implement this technology in a pilot production hatchery.

c. To initiate aquaculture demonstration projects using seed produced at the research and pilot production hatcheries.

The work is being undertaken in phases:

Phase I — Site selection, planning and design of the research hatchery (2 weeks — late 1982).

Phase II — Construction of the research hatchery (one year — 1983).

Phase III — Hatchery research program (long term — commencing 1983-84).

Phase IV — Design and construction of a pilot production hatchery and instigation of aquaculture demonstration and pilot production projects (long term — commencing 1984-85).

This report covers Phase I of the project and describes the work of a two-week consultancy mission to the Department of Fisheries (DOF), Sabah (November 29-December 13, 1982) by Dr. Jacques Fuchs, Consultant for fish hatchery projects, France Aquaculture, Centre National pour L'Éxploitation des Océans (CNÉXO), Centre Océanologique du Pacific, Taravao, Tahiti, Polynésie Francaise and Dr. Roger S.V. Pullin, Senior Scientist in-charge of the Aquaculture Program, International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines. The consultants' terms of reference, itinerary and program of activities are given in Appendices I and II.

Site Selection

GENERAL CONSIDERATIONS

The principal criteria for a suitable site for a marine research hatchery are well-established. The most important requirements are:

1. High quality seawater supply.
2. High quality freshwater supply.
3. Reliable electricity supply.
4. Good communication lines.
5. Good road and sea access.
6. Suitable soil type and land levels for construction.
7. Shelter and freedom from flooding.
8. Security.

9. Room for future expansion.
10. Proximity to sites for grow-out trials and for extending technology to a developing aquaculture industry.

AVAILABLE SITES

Sites which fulfill all these criteria are few. For Sabah, this initial marine hatchery development *must* be sited on the West Coast for easy access to and from Kota Kinabalu. This is essential for staffing, management, access and ease of construction. Three West Coast sites were previously identified by the Department of Fisheries (DOF):

1. at Likas, north of the Sabah Foundation building, Kota Kinabalu
2. at Tanjong Kaitan, Karambunai and
3. at Tanjong Badak, Mengkabong.

Descriptions of these sites from previous DOF visits are given in Appendix III. Fig. 1 shows the area of Sabah in which these sites are located.

The Likas site appears unsuitable because of poor quality seawater (from suspended solids blown north from the nearby Inanam River estuary and from existing and future pollution risks from industrial developments), difficulty of building an access road and scarcity of land for future expansion. The water quality and pollution risks are the paramount reasons for rejecting this site.

The Tanjong Kaitan site has higher quality water and sufficient land for future expansion but has several defects: shallow beach profile (which means a very long seawater uptake system, unless a well or buried intake is used); exposure to northeasterly winds and wave action and uncertain ownership of the required land.

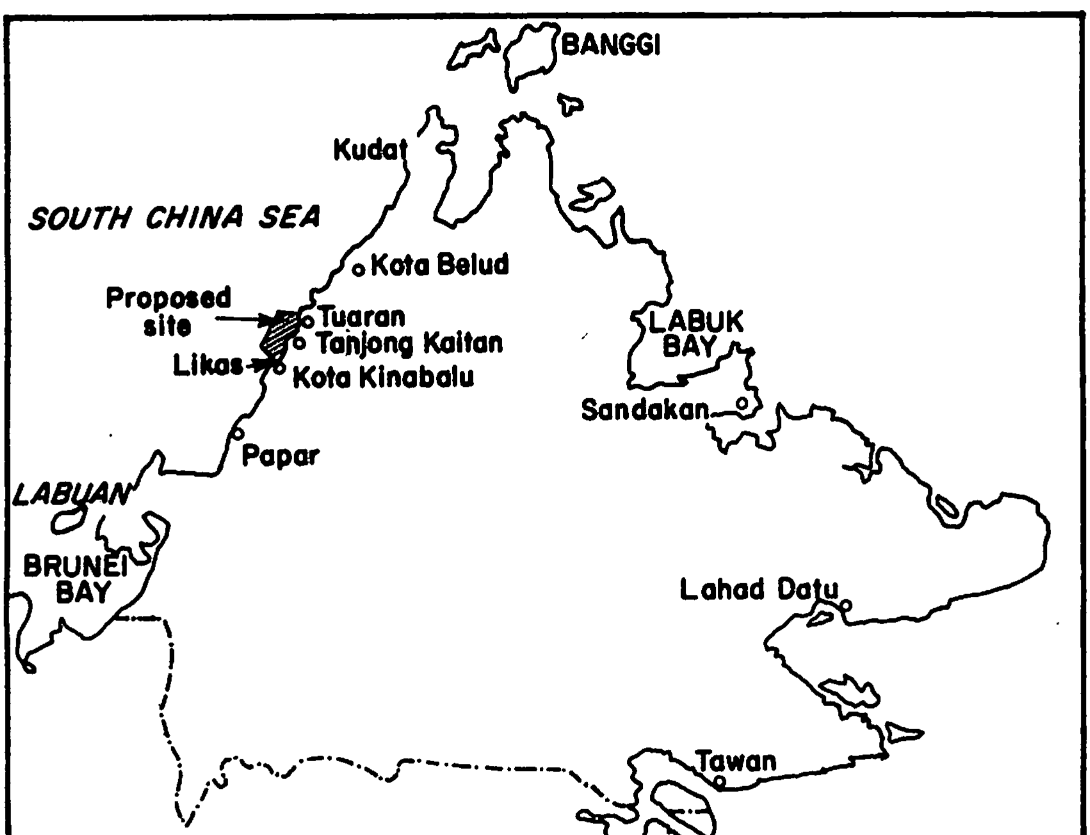


Fig. 1. Map of Sabah showing the area (shaded) in which the sites visited are located (scale about 1:4,000,000.

The Tanjong Badak site appears to be excellent and will fulfill all the requirements listed above provided that attention is given to strengthen the following:

1. Complete self-sufficiency for electricity and freshwater supplies.*
2. A thorough investigation of any risks of temporary flooding, from tidal and/or storm surges. This and the measurement of land levels are essential as the land available for construction is only just above the highest strand line. Earth filling is possibly needed.
3. An access road.
4. Good communication by radio-telephone.
5. Security—fencing and constant supervision.

The only possible water quality problems in this area are for seawater the need to filter organic detritus for hatchery purposes and for freshwater the quantity available and its suitability for human consumption.

DESCRIPTION OF THE TANJONG BADAK, MENGKABONG SITE (PLANS 1 AND 2)

A brief survey was made of the Tanjong Badak site. The suggested land available for the hatchery and associated amenities is shown in Figs. 2 and 3 and plans 1 and 2. Table 1 lists some parameters measured at the site.

A series of depth profiles was taken along the channel shore to investigate pump intake siting. The profiles were taken by snorkel diving at 5 m intervals along 25 m transects out from the shore at stations 20 m apart along the shore (plan 2). Table 2 gives the results and plan 2 and Fig. 3, representation of depth contours. The pump intake should be sited in the region of stations 1-2 where there is good shelter, good deep water inshore and a low probability of the sand banks changing shape (compared to more seaward sites). The sea level at 11:30 a.m. on December 7, 1982

Table 1. Measurements made at the Tanjong Badak Site, December 7, 1982.

Location (see plans 1 and 2)	Measurements
Near beach	Seawater salinity 29-30‰; temperature 31°C; pH, about 7.8
25 m offshore	Surface seawater salinity 30‰, temperature 30°C; pH, about 7.8 water from 5-m deep, salinity 31‰.
'Freshwater pond'	Depth 1.0 m, salinity 4‰.
Groundwater from 1.5 m test-hole	Salinity—undetectable, good taste.
Well-water from adjacent land**	pH <5.5, foul taste, H_2S smell*.

*Sulphide tests on all water samples suggest low levels (<0.2 ppm) but the reagents could be suspect.
**About 1 km NE.

*The freshwater available from wells needs a thorough investigation for both quality and available quantity.

Table 2. Depth profile from transects at Tanjong Badak, Mengkabong. Transect 1 was sampled at 1200 hr and transect 5 at 1300 hr, i.e., 2.5 to 3.5 hours after low tide (0.5 m) on December 7, 1982. Depths are in meters.

Distance from shore (m)	Transect no. 1	2	3	4	5
5	1.4	1.1	0.3	1.0	1.3
10	2.2	2.1	1.3	2.2	2.1
15	3.1	3.0	2.6	3.0	2.7
20	4.5	3.5	3.1	3.9	3.2
25	5.2	5.0	4.0	missed	3.6

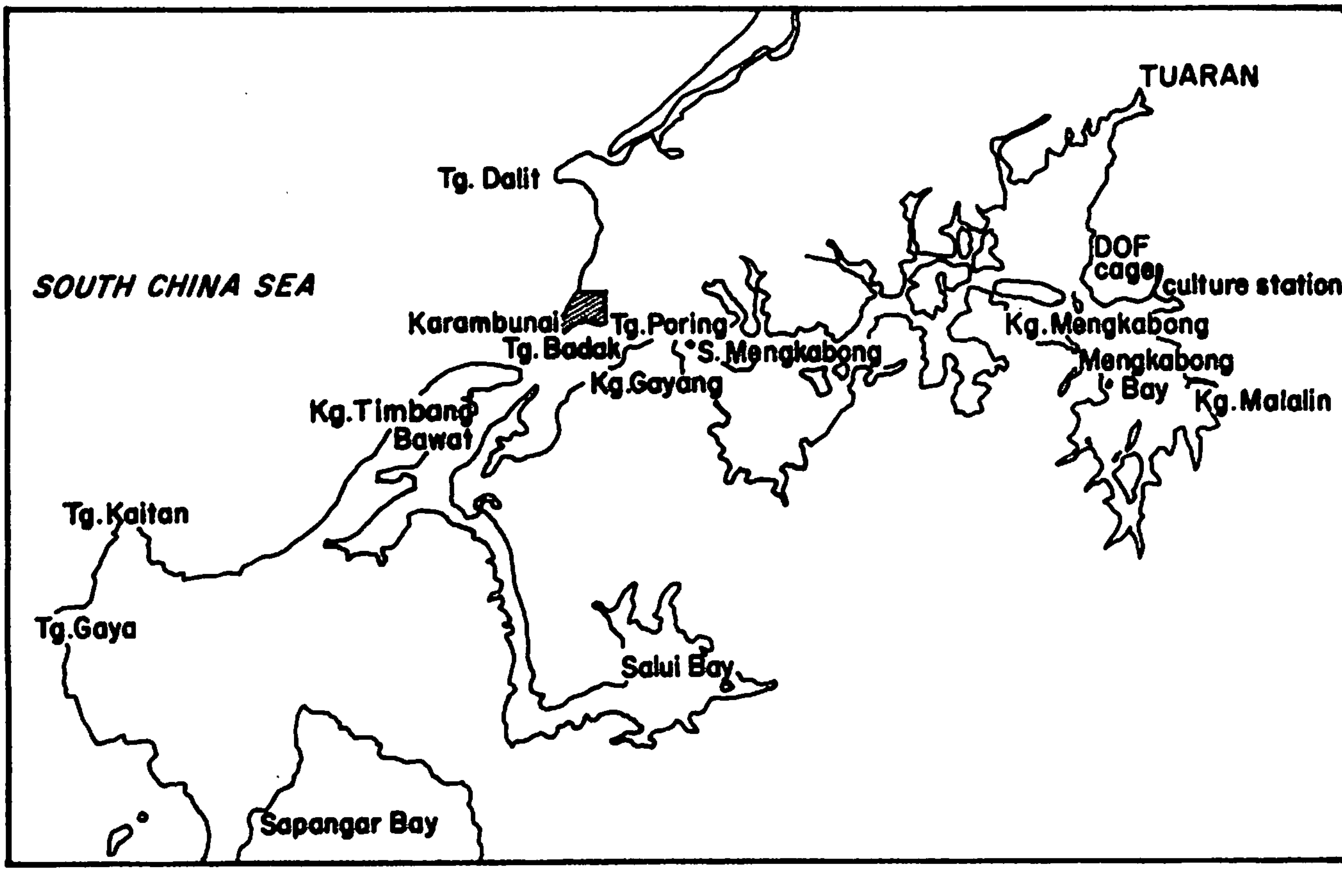


Fig. 2. Proposed research hatchery site at Tanjong Badak, Mengkabong, Sabah.

was 1.5 m below the strand line. Some examination of the substratum using glass tube corers revealed pockets of anoxic layers of decaying vegetation close to the sand surface along the shore stations 1-5. These pockets contained H_2S. However, they are very shallow and should not trouble pumping operations or affect water quality adversely. A 200-m plankton tow near the surface showed high quantities of zooplankton and organic detritus. This is a likely feature of all West Coast sites. The detritus must be filtered out for all hatchery operations, but the water can be used unfiltered for broodstock and nursery purposes.

A test-hole on the site showed that the land is sand down to a depth of almost 1.5 m, with no earth layers. The water table is at 1.5 m (freshwater). A more thorough investigation of deeper layers is recommended.

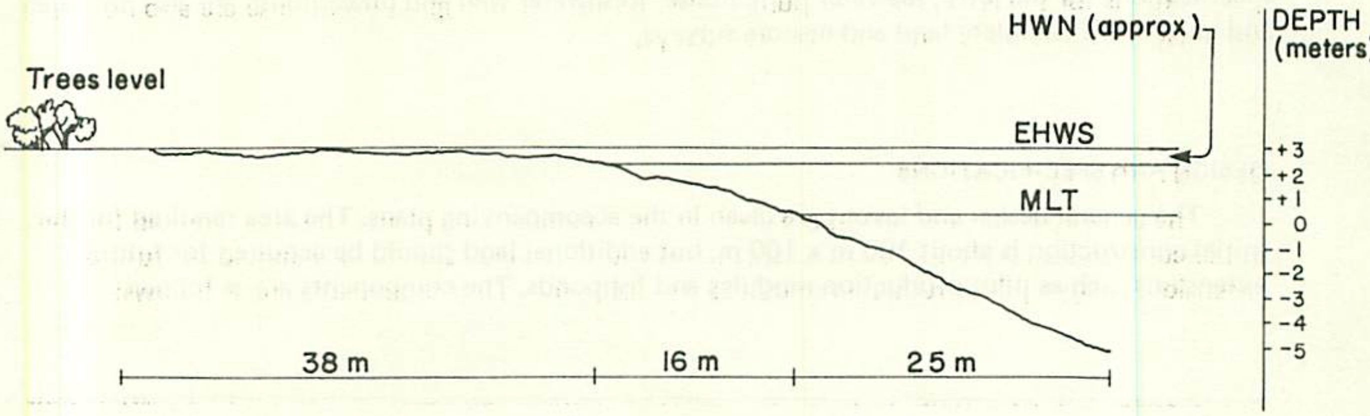


Fig. 3. Approximate profile of the beach and seabed in the area for location of the seawater pumping system. Levels have been judged by eye and from tide tables. EHWS = Extreme High Water Springs; HWN = High Water Neaps; MLT = Mean Low Tide.

FUTURE SITES

The Tanjong Badak site is adjacent to a large area of sheltered water suitable for cage culture. However, as coastal aquaculture develops in Sabah there is likely to be a demand for additional sites for hatcheries and growout for both finfish and shellfish culture. A detailed survey of the Sabah coastline is therefore needed to identify suitable sites for hatcheries and growout. This information will allow policies to be formulated for future coastal zone development and will avoid wasteful use of good sites—for example the pollution of bays by industrial developments.

Hatchery Design (Plans 3 and 4)

GENERAL CONSIDERATIONS

The hatchery envisaged has a dual purpose: research and technology development. For research, a *flexible* facility is needed to work with a variety of species and to study nutrition (both with live food and artificial diets), reproduction (both natural spawning and controlled maturation with photoperiod control and/or hormone injections) and environmental conditions (effects of light, temperature, salinity and tank size). For technology development, the hatchery must have sufficient space to implement and adapt existing techniques on a scale from which pilot production projects can begin. For this hatchery, therefore, the design allows for both small-scale research and technology development for groupers *(Epinephelus* spp.) (aiming at production of say 1,000-5,000 fingerlings initially) and a larger capacity to produce seabass *(Lates calcarifer)* fingerlings (1,000-500,000 per spawning season).

This seabass production can then be scaled up by the addition of one or more pilot production modules parallel to the research hatchery-nursery systems. The same can be done for grouper and other species in the future as technologies are developed. The offices, housing, laboratories and support systems have been located with such development from research to pilot production in mind. The production of 100,000 seabass fingerlings should allow growout of a crop of about 25 tonnes which can give rapid visibility and credibility to coastal aquaculture development in Sabah.

General specifications are now given for the major components of the hatchery: broodstock facilities; office/laboratory/algal culture building; hatchery and nursery and ancillary facilities. Designs for staff housing are not included as these are a matter for MAFD decisions. Detailed specifications for the jetty, seawater pumphouse, freshwater well and powerhouse are also not given and must await complete land and inshore surveys.

DESIGN AND SPECIFICATIONS

The general design and layout are given in the accompanying plans. The area required for the initial construction is about 100 m x 100 m, but additional land should be acquired for future extensions such as pilot production modules and fishponds. The components are as follows:

Component	Width (m)	Length (m)	Area (m^2)	Comments
1. Broodstock facilities*	15	29	435	Simple roof cover, no walls.
2. Laboratories and preparation rooms	12	9	108	Enclosed building; airconditioned.
Offices and washroom	12	7	84	Enclosed building; airconditioned.
3. Hatchery	12	29	348	Simple, walled, industrial building.
4. Nursery	12	21	252	Simple roof cover, no walls.
5. Technical support facilities	6	16	96	See hatchery plans.
6. Pumphouse	4	4	16	See hatchery plans.
7. Powerhouse	–	–	–	Depends on equipment purchased.
8. Housing	–	–	–	To government specifications.

*Excluding 2 additional large uncovered tanks—see plan 3—and broodstock cages which can be moved to the jetty to increase holding capacity.

The locations of these various components can be changed if technical problems become apparent during more detailed surveys and construction. The accompanying plan omits lines of drainage for the seawater, freshwater and foul drainage effluents. The seawater could be coursed through a series of ponds. This would allow sedimentation of wastes (although an effluent with high BOD and suspended solids requiring settlement and other treatment is not anticipated). The ponds could also be used for holding fish and for experimental pond culture. The soil types and water table fluctuations must be thoroughly investigated before ponds are built. For the foul drainage from the laboratories, washroom, offices, workshop and housing, separate drainage towards the sea is needed, with the construction of septic tanks. Any effluents containing toxic chemicals, including chlorine solutions and disinfectants used for cleaning tanks and equipment *must* be given separate drainage from water passing to fish ponds and/or to septic tanks which depend on microbial action.

Broodstock facilities

Type	No.	Comments
6 x 7 x 1.2 m rectangular concrete tanks (i.e., 50 m^3 each)	2	Outdoor; covered only with black nylon net; equipped with egg collectors* for natural spawning.
6 x 1.2 m circular tanks (see Fig. 4) (i.e., 30 m^3 each)	6	Undercover; use best available materials; equipped with egg collectors.*
5.5 x 1 x 1 m raceway/tanks—concrete or fiberglass (i.e., 5.5 m^3 each)	5	Undercover; for broodstock sorting, isolation, injection, stripping; needs adjacent table and sink for working.
Adjacent work area for washing equipment. (See plan 3).	–	–

*See Figs. 4 and 5.

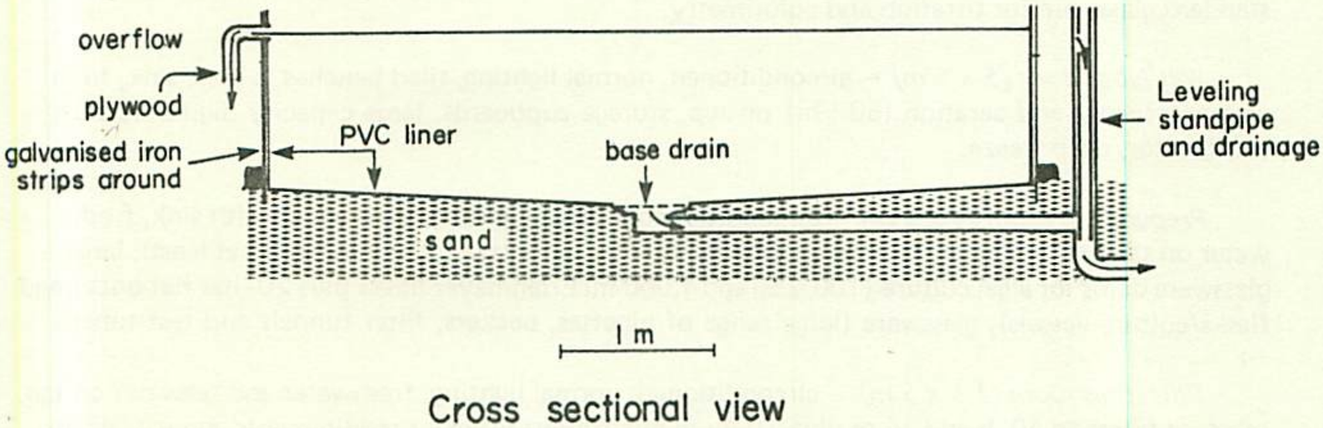


Fig. 4. Design for a 30-m^3 broodstock tank. A variety of materials can be used for the tank wall and its support.

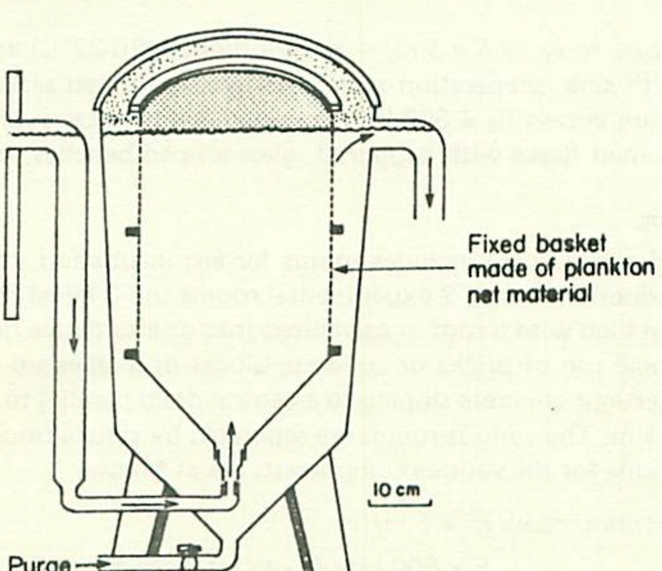


Fig. 5. Collector for floating (pelagic) eggs, to be mounted on the overflow of tanks used for natural spawning of broodstock. The eggs are trapped by the net screen (250-300 μm mesh size) and are concentrated in the basket (27 liters capacity).

Total water requirement = 20 m^3/hr. Aeration requirements = 4 m^3/hr. Provision should be made for the erection of screens and controlled artificial lighting around the undercover circular tanks for photoperiod control.

Laboratory facilities, offices and preparation rooms

A solid airconditioned building with watertight concrete or tiled floor, galvanized iron or alternative roofing plus separate ceiling for rooms; height of building 3.5 m, probably airconditioned independently for each room.

Dry laboratory (4 x 5 m) — airconditioned, normal lighting, tiled benches, chemical—resistant sink, freshwater and seawater on tap, independent drainage, suspended cupboards for glassware, solid bench for chemical balances and microscopy, poisons cabinet.

— equipment: top pan and analytical digital balances, water analysis kits, bench colorimeter, pH meter, salinometer, oxygen meters, 'still' for distilled water supply, refrigerator, drying oven, low power and compound microscopes, cupboards for chemical reagents and expendable supplies, standard glassware for titration and colorimetry.

Wet laboratory (5 x 5 m) — airconditioned, normal lighting, tiled benches, a large sink, freshwater, seawater and aeration (50 l/hr) on tap, storage cupboards, large capacity digital balance, refrigerator, deep freeze.

Preparation room (4 x 5 m) — airconditioned, normal lighting, tiled bench with sink, freshwater on tap, water heater, storage cupboards, 50-liter autoclave (50-cm diameter at least), large glassware items for algal culture (100, 250 and 1,000-ml Erlenmeyer flasks plus 20-liter flat-bottomed flasks/culture vessels), glassware (large range of pipettes, beakers, filter tunnels and test tubes).

Filtration room (1.5 x 5 m) — airconditioned, normal lighting, freshwater and seawater on tap, pressure filters to 10, 5 and 1μ m plus a 0.4μ m microfilter; seawater requirements about 1 m^3/hr. CO_2 unit with control valves and flowmeter (for the algal culture room).

Algal culture room (3.5 x 5 m) — airconditioned (20-22°C) artificial lighting (1,600 watts), tiled bench with sink, preparation table; freshwater, filtered seawater (1 m^3/hr) and aeration (50 l/hr); culture vessels (5 x 300-liter transparent fiberglass cylindrical tasks; 4 — 6 x 20-liter glass flat-bottomed flasks with supports), glass-topped benches, racks for stock algal cultures.

Hatchery building

The hatchery building includes rooms for egg incubation, rotifer *(Brachionus)* production, 2 *Artemia* production rooms, 2 experimental rooms and 3 larval rearing areas. The building should be about 4.5 m high with a roof in galvanized iron or alternative material and simple walls (for example, a single run of bricks or concrete blocks or a standard industrial building). The floor should be watertight concrete sloping to a central drain parallel to the long axis of the building: slope 1 cm in 1 m. The various rooms are separated by simple brick walls or wooden partitions. The specifications for the various components are as follows:*

Egg incubation room (5 x 5 m)

Tanks	— 5 x 600-liter fiberglass raceways (2.5 x 0.5 x 0.5 m)
	— 25 x 50-liter fiberglass incubation tanks (0.5 x 0.5 x 0.5 m) (see Fig. 6)

*For summaries, see Tables 3 and 4.

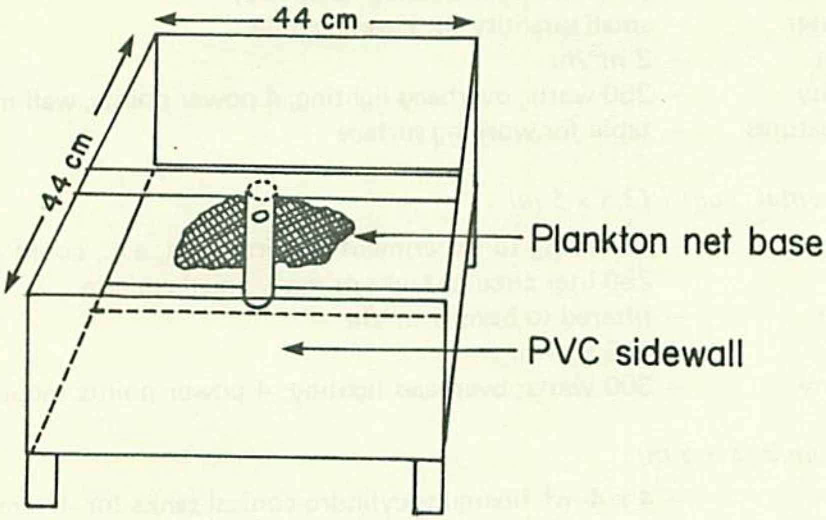


Fig. 6. Egg incubator for placing in raceways or tanks. The 44 x 44-cm dimensions given here are not fixed and can be modified to suit rectangular tanks. The incubator has PVC walls and base supports and a 600-μm plankton net floor. The central tube is an airlift.

Seawater	– filtered through sand filter; 3 m^3/hr
Freshwater	– 1.5 m^3/hr for cleaning or work with brackishwater species
Aeration	– 300 l/hr
Electricity	– 250 watts; overhead lighting; 4 wall power points

Rotifer (Brachionus) production (5 x 5 m)

Tanks	– 6 x 1-m^3 fiberglass cylindro-conical tanks (see Fig. 8)
Seawater	– filtered through 10μm filter; 2 m^3/day
Freshwater	– small quantity for cleaning only
Aeration	– 600 l/hr
Electricity	– 1,000 watts; overhead lighting; 4 power points above the tanks
Special equipment	– 45μm nylon mesh filter to concentrate *Brachionus*
Other features	– table for working surface

Artemia production rooms

Room 1 (8 x 5 m)

Tanks	– 4 x 4-m^3 fiberglass cylindro-conical tanks for *Artemia* culture (see Fig. 7)
	– 4 x 1-m^3 fiberglass cylindro-conical tanks for *Artemia* incubation (see Fig. 8)
Seawater	– pressure/sand-filtered; 10 m^3/day
Aeration	– 2 m^3/hr
Electricity	– 250 watts; overhead lighting
Other features	– table for working surface

Seawater	– pressure/sand-filtered; 10 m^3/day
Freshwater	– small quantity for cleaning only
Aeration	– 2 m^3/hr
Electricity	– 250 watts; overhead lighting; 4 power points, wall-mounted
Other features	– table for working surface

Experimental room 1 (3.5 x 5 m)

Tanks	– according to experiment requirements, e.g., could accommodate 10 x 250-liter circular tanks or many small aquaria
Seawater	– filtered to 5μm; 1 m^3/hr
Aeration	– 125 liter/hr
Electricity	– 300 watts; overhead lighting; 4 power points mounted high on walls

Room 2 (8 x 5 m)

Tanks	– 4 x 4-m^3 fiberglass cylindro-conical tanks for *Artemia* culture (Fig. 7)
	– 2 x 1-m^3 fiberglass cylindro-conical tanks for *Artemia* incubation (Fig. 8)
	– 3 x 25-liter fiberglass cylindro-conical tanks for *Artemia* cyst decapsulation using chlorine solution

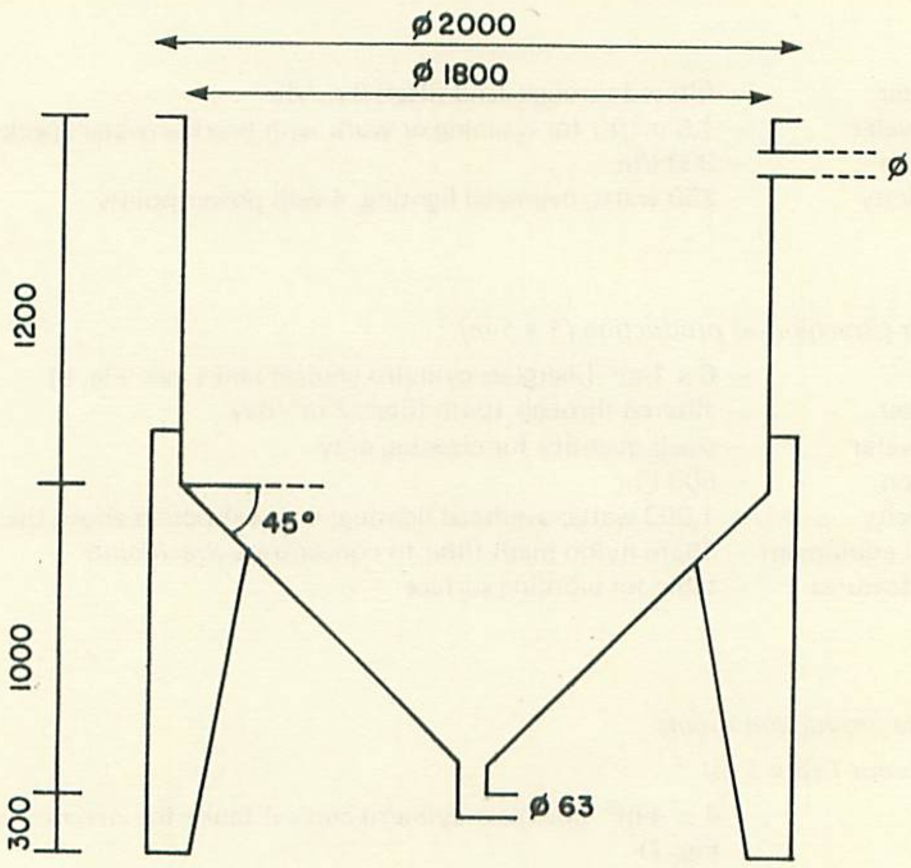


Fig. 7. 4-m^3 cylindro-conical tank (4 supporting legs); units are mm.

Experimental room 2 (3.5 x 5 m)

Tanks	– 7 x 500-liter circular fiberglass tanks (Fig. 9)
Seawater	– filtered to 10μm; 2 m^3/hr; gravity–fed to tanks from a 60-liter fiberglass header tank
Freshwater	– filtered to 5μm; 1.5 m^3/hr with connections to the seawater circuit for mixing brackishwater
Aeration	– 175 liter/hr
Electricity	– 300 watts; overhead lighting; 4 power points mounted high on walls
Other features	– table for working surface

Larval rearing room 1 (7 x 5 m)

Tanks	– 16 x 0.5-m^3 fiberglass cylindro-conical tanks (see Fig. 9)
Seawater	– filtered to 10μm; 2 m^3/hr; gravity–fed to tanks from a 60-liter fiberglass header tank
Freshwater	– filtered to 10μm; 1 m^3/hr; facility for mixing with seawater for brackishwater work and cleaning
Aeration	– 400 liter/hr
Electricity .	– 400 watts; overhead lighting; 4 wall-mounted power points

An outflow filter design suitable for all cylindro-conical tanks is shown in Fig. 10

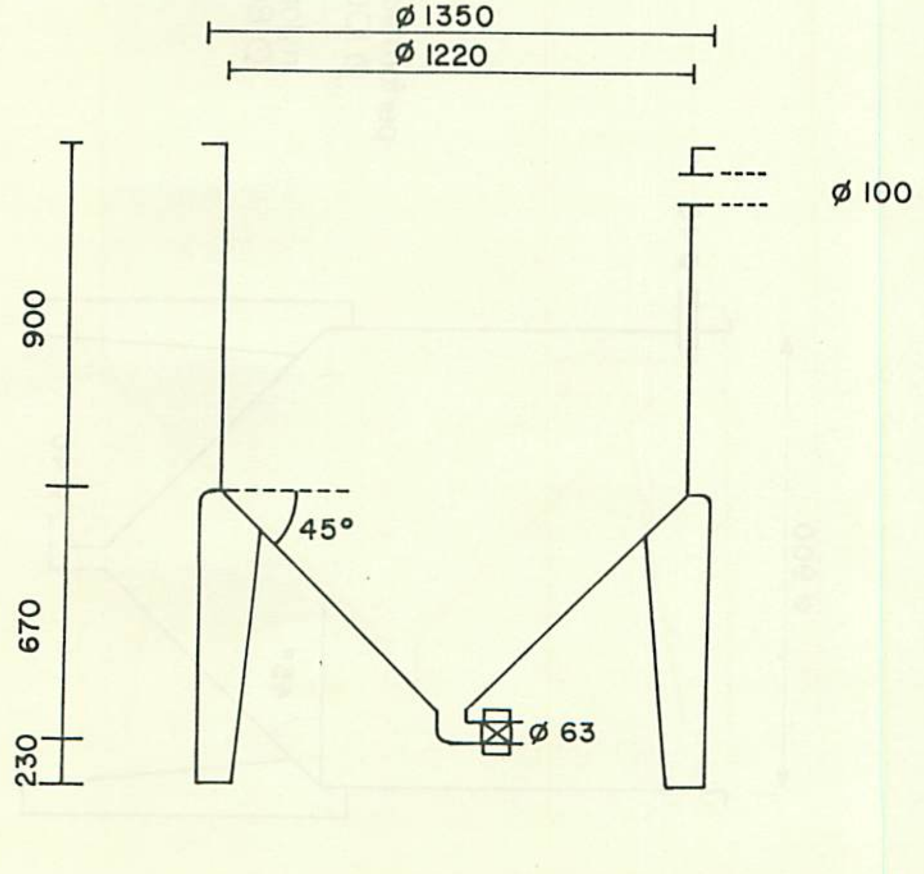


Fig. 8. 1-m^3 cylindro-conical tank (3 supporting legs); units are mm.

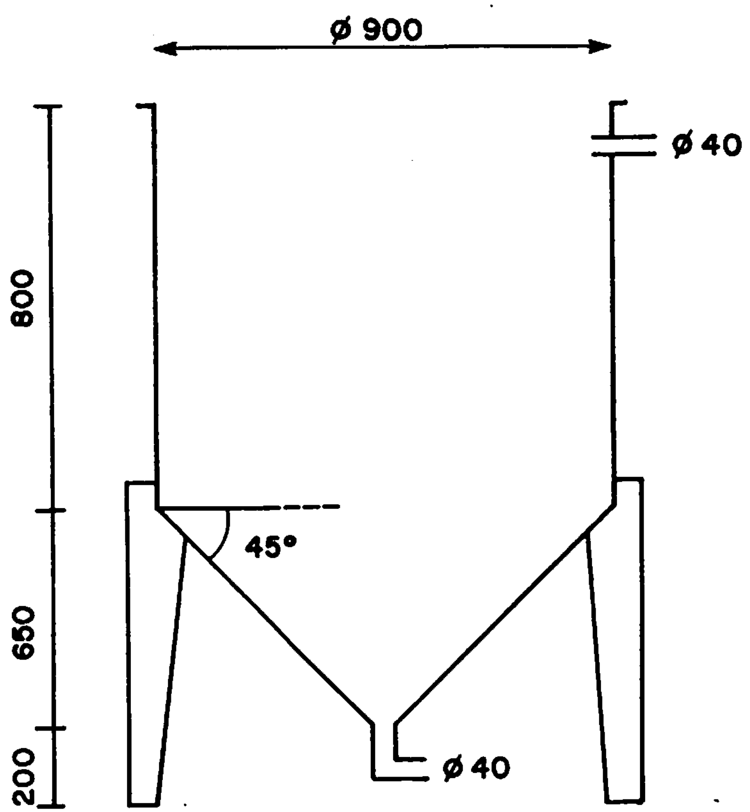


Fig. 9. 0.5-m^3 cylindro-conical tank (3 supporting legs); units are mm.

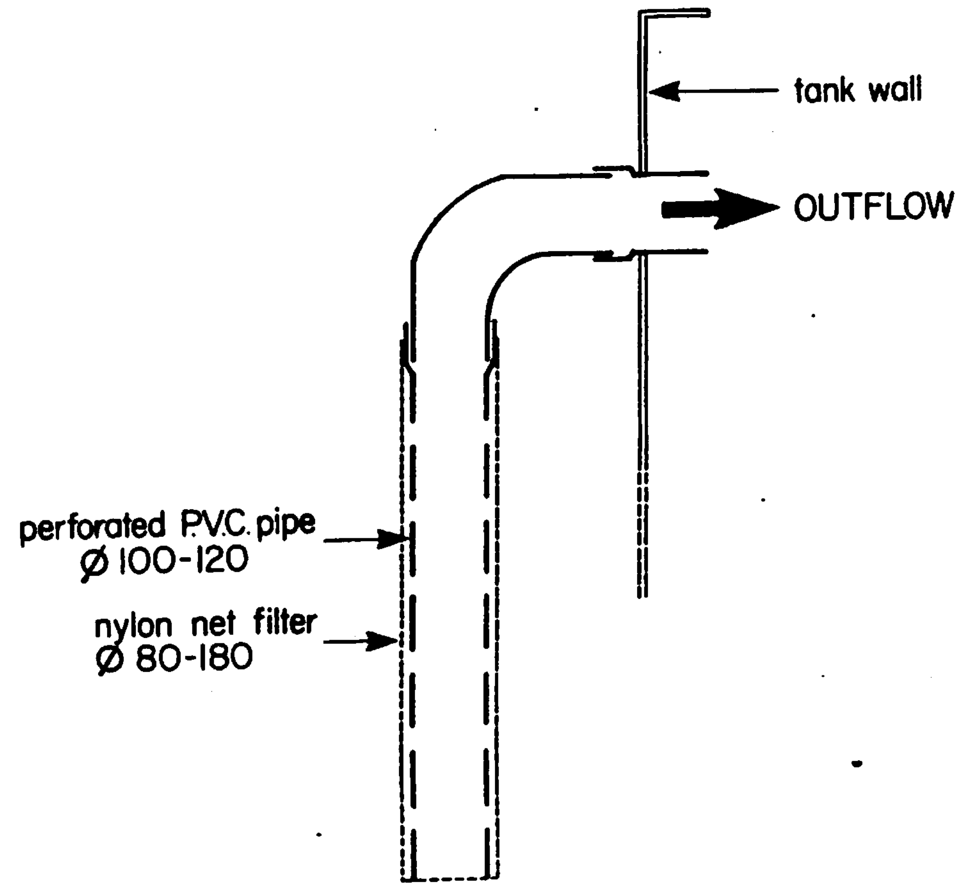


Fig. 10. Outflow filter for cylindro-conical tanks; units are mm.

Larval rearing rooms 2 and 3 (both are 7 x 5 m)

Each room requires:

Tanks	– 4 x 4-m^3 fiberglass cylindro-conical tanks (Fig. 7)
Seawater	– sand-filtered; 4 m^3/hr; gravity fed to tanks from a 60-liter fiberglass header tank
Freshwater	– normal supply; 2 m^3/hr for mixing with seawater for brackishwater work and for cleaning
Aeration	– 800 liter/hr
Electricity	– 400 watts; overhead lighting
Other features	– 1.4-m high wooden walkway and ramp for access to the tanks

Summary of hatchery building needs

Seawater

Requirements for pressure/sand-filtered seawater total about 20 m^3/hr. The filtered seawater should be stored in a 4-m^3 header tank for gravity feed to hatchery locations. This is additional to the individual 60-liter header tanks in the experimental room (2) and larval rearing rooms. The production of high-quality seawater filtered to 5 and 10μm with pressure cartridge filters and the transfer of water between locations will require small pumps.

Freshwater	– the total requirement is about 4 m^3/hr with filtration to 10μm at some locations.
Aeration	– the total requirement is about 7,200 l/hr. A low pressure blower system is preferred, operating at around 15-20 p.s.i.
Electricity	– total lighting requirements are about 3.55 kw with 24 power points for equipment/experimental work.

Nursery

The nursery is a covered area (21 x 12 = 252 m^2) with a simple roof cover: galvanized iron or alternative material with a slope. The height of the roof cover should be about 3.5 m. No walls are needed. The floor should be watertight concrete with drains or a drainage channel down the center of the building. The requirements are as follows:

Tanks	– 12 x 3-m^3 rectangular tanks (2 x 2 x 0.8 m) for nutritional trials and 6 x 10-m^3 raceways (9 x 1.4 x 0.8 m) foı small-scale production trials; all preferably in fiberglass (see Fig. 11)
Seawater	– from main supply; no special treatment; 30 m^3/hr
Freshwater	– from normal supply; no special treatment; 1-2 m^3/hr
Water outflow	– covered concrete drainage channels
Aeration	– 2 m^3/hr with emergency back-up system
Electricity	– 2,000 watts for lighting and portable equipment
Special features	– working surface with sink; 2-m wide concrete path to the hatchery for transportation of fry on wheeled trolleys

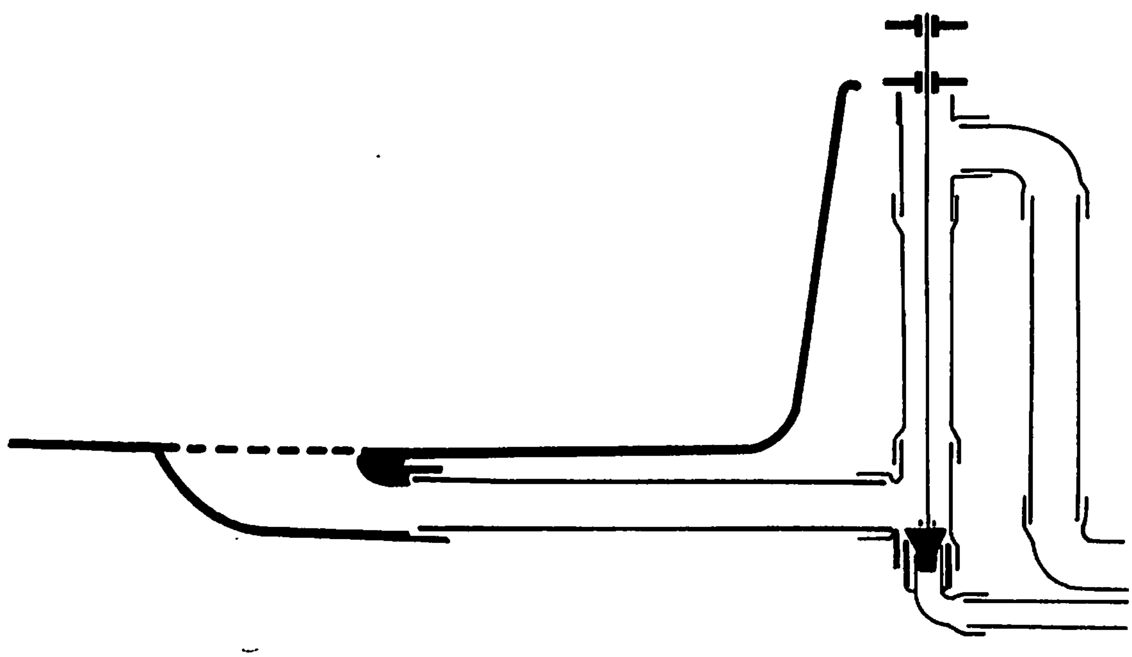


Fig. 11. Cross-section of the levelling and drainage assembly for a nursery tank. The adjustable plug allows water to flow down the drainpipe to waste and/or up the standpipe for drainage elsewhere.

Ancillary facilities

The ancillary facilities comprise a workshop, equipment room (including air compressors), feed preparation room and store, all of which are to be built attached to the main office/laboratory block. The specification for other facilities such as the jetty, housing quarters, and powerhouse are not given in this report as they depend on DOF policy, on more accurate surveying and on the type of equipment to be purchased.

The building required for ancillary facilities can be a standard industrial building with concrete block or brick walls and a concrete floor, height 3.5 m. All these buildings are to be secure and lockable.

Workshop (3 x 4 m) – needs solid wooden workbench, storage cupboards for tools, shelves, basic equipment for wood, PVC, fiberglass and metalworking–vice, vertical drill, pipefitting equipment and electrical testing gear, especially a universal test meter.

Equipment room (3 x 4 m) – contains air blowers; electrical switchgear (circuit breakers); freshwater heater; batteries for emergency systems.

Feed preparation room (3 x 4 m) – for all feed preparation and storage; needs large refrigerator and deep freeze for feed and feed component storage; wet bench with large sink and freshwater tap for wet preparation; dry bench with large capacity balance and food blender; small-scale mixer/pellet maker.

Store (3 x 4 m) – for dry foods, nets and minor equipment (must be insect- and rodent-proof).

Pumphouse and seawater system

The choice of pumping system depends upon the depth profile of the inshore water, the topography of the beach and the distance to the hatchery. The suggested location for the pumphouse in Fig. 1 is *provisional.* The water depth is good there, but the location is also farthest from the hatchery. A more complete set of depth contours should be taken and a compromise reached between depth and distance, depending on costs. Successful pumping could, in fact, be achieved at almost any point along the 20-25 m offshore line. The pump intake and pipework can be associated with the building of a jetty. The following are options for pumping systems:

1. Pumphouse on hatchery site; long intake pipe (on this site at least 40 m) with a jetty for support; vertical intake with foot valve and screen; centrifugal pumps (Fig. 12A) *or* a similar system but with no jetty for support and the pipeline part-buried, weighted and running along the seabed (Fig. 12B).

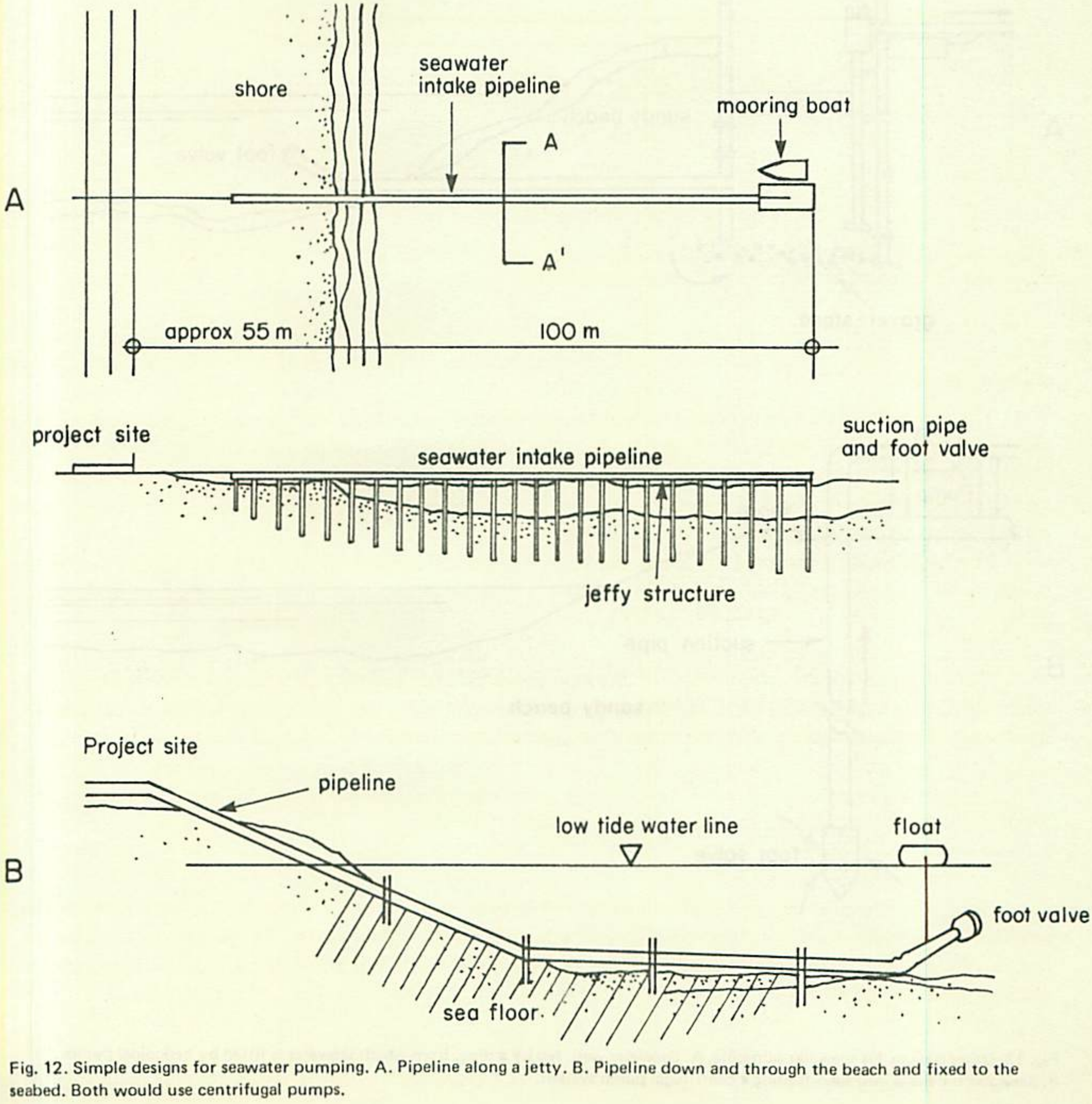
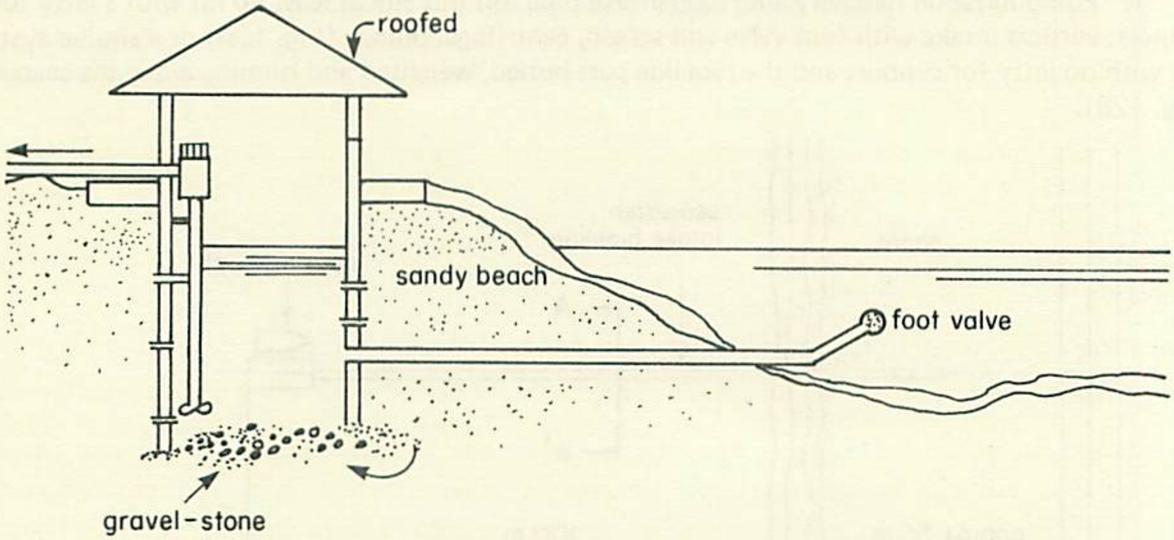


Fig. 12. Simple designs for seawater pumping. A. Pipeline along a jetty. B. Pipeline down and through the beach and fixed to the seabed. Both would use centrifugal pumps.

2. Pumphouse on the beach with a pipeline through to deep seawater, with foot valve and screen, supplying a deep well with helicoidal lift pumps to the site (Fig. 13A).

3. Pumphouse on the beach with a vertical intake pipe sunk into the sand; the foot valve has a screen guard (Fig. 13B).

A



B

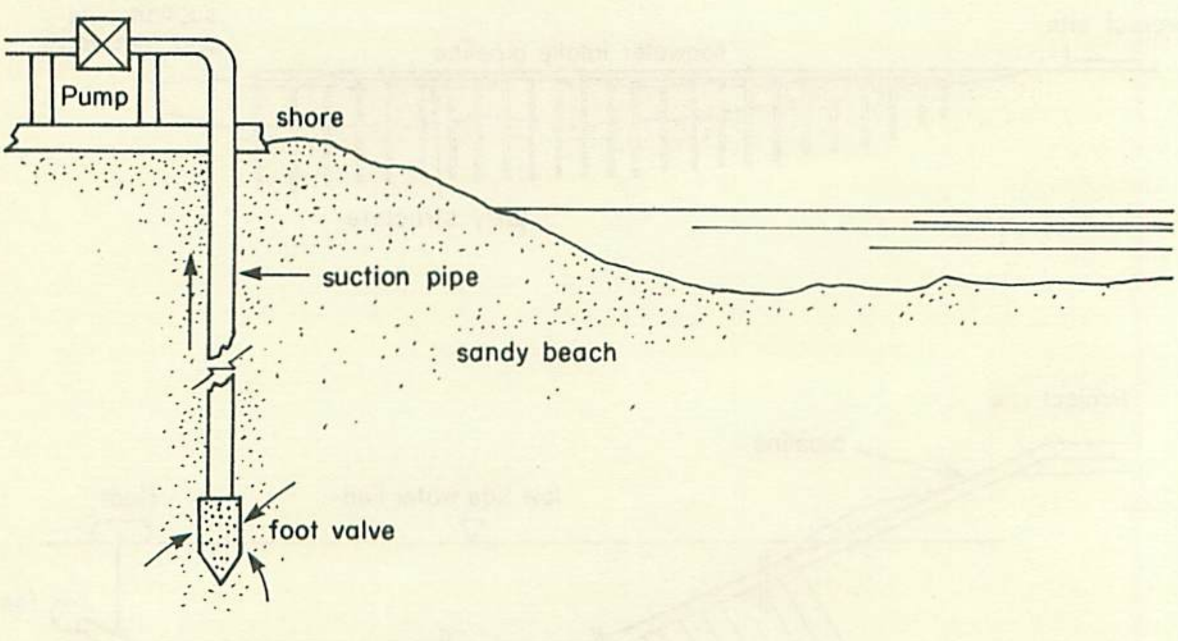


Fig. 13. Other designs for seawater pumping. A. Seawater well, fed by a pipe, from which seawater is lifted by helicoidal pumps. B. Seawater borehole into sand feeding a centrifugal pump system.

The design chosen for this hatchery will depend on further survey work. The main considerations are—stability of the beach; presence or absence of freshwater influence under the beach; pumping heads and distances; costs. A simple design with a jetty and the pumphouse on the hatchery site appears the best option at present. Whatever the chosen design, there must be *TWO INTAKE PIPES* to allow for cleaning and for security against blockages. The preferred material for the pipes is PVC. The design of the screen guard depends upon the type of system chosen.

The maximum total site requirement for seawater is about 70 m^3/hr, with great variation in demand according to operational procedures and the time of year. This can best be supplied by installing 3 X 40-m^3/hr electrical pumps with the capability of coupling any or all together. Under normal operation, one pump would be sufficient. A second pump can be switched in to cope with heavy demand. All pumps should be rotated in and out of service. A 50-m^3/hr diesel motor pump is also required for emergency backup. This should be tested and run regularly and adequate fuel supplies kept in stock. Each pump should have a logbook for recording hours of running, servicing and repairs. Responsibility for pump logbooks and all seawater supply matters should be assigned to one responsible person and a deputy. A pumphouse of 4 m X 4 m area should be adequate. IT MUST BE PROTECTED FROM SEAWATER AND RAINWATER INTRUSION. All pipework must be accessible for cleaning.

Electricity

The power requirements for the site can only be estimated when the specifications for major equipment such as pumps, airconditioners, and water heater are known. There must be 2 main diesel generators in a powerhouse, *each* capable of supplying the maximum needs of the hatchery, with spare capacity for future expansion. In addition, one or more portable generators of about 25-KVA capacity are needed for emergency backup. A battery-powered emergency lighting and alarm system should also be considered. All generators should be alternated in and out of service and each must have a logbook (as for pumps above).

The combination of seawater and high voltage supplies, especially 3-phase systems, in a fish hatchery is potentially dangerous. Great care should be taken in the siting of all electrical installations to protect them completely from seawater intrusion. *The separation of the phases from 3-phase systems is critical* to ensure that hatchery personnel can never be exposed to the risk of short-circuits from high voltages. All circuit breakers, fuses and switchgear should be properly enclosed and an emergency procedure should be established for summoning help to deal with any power or systems failures.

Aeration

There are 2 basic types of aeration supply equipment—compressors with air storage tanks and blowers which run continuously at low pressure. For this hatchery, 2 blowers are recommended with PVC piping for aeration ring mains. Each blower should be capable of supplying *all* the aeration requirements of the site.

Hatchery Program

CHOICE OF SPECIES

The hatchery program should concentrate initially on the seabass *(Lates calcarifer)* and grouper species (especially *Epinephelus tauvina).* Technology for seabass rearing and growout is well-developed (SCS 1982a) and sufficient information exists for *E. tauvina* for an experimental program to be started in Sabah. Summary information on these two species is given in Appendix IV. These species were also among the priorities chosen for Malaysian aquaculture by FAO (1976) and Chua (1979) although the latter referred to the grouper *E. salmoides. E. akaara* is also potentially a good species to culture (Tseng, W.Y., pers. comm.)* growout techniques in seacages have been developed in West

*Tseng, Wen Young, marine fish hatchery, Chinese University of Hongkong, Shatin, New Territories, Hongkong.

Malaysia and Singapore. The experimental hatchery program can expand in the future to encompass work with other species. Mullets *(Mugil* spp.) are a possibility for pond culture, but the taxonomy of local species must first be investigated and the availability of broodstock determined. Professor J.M. Thompson, University of Queensland is the world authority on mullet taxonomy and can identify specimens. A nearer source of expertise on mullet identification is Dr. Thosaporn Wongratana, Department of Biology, Chulalongkorn University, Bangkok. Nash and Shehadeh (1980) have documented hatchery techniques for *Mugil cephalus* and a training film on this is available from the Oceanic Institute, Hawaii.

Other marine species, such as *Lutjanus* spp., are also a possibility. However, work on these is at a very early stage. Suzuki and Hioki (1979), Pullin and Kuo (1981) and Barlow and Turnbull (1981) provide summaries of the information available on marine species for culture.

HATCHERY AND NURSERY PROCEDURES

The equipment and procedures outlined here can be used for experimentation on a wide variety of brackishwater and marine species. However, it is assumed that the initial programs will be on adaptation and implementation of existing technology for seabass rearing and experimentation with groupers, *Epinephelus tauvina, E. akaara* and *E. salmoides*, and possibly *Lutjanus* spp. The hatchery technology for seabass rearing will be developed into a pilot hatchery production project. Seabass-rearing technology has been developed by CNEXO/France Aquaculture for the European seabass *(Dicentrarchus labrax)* (see CNEXO 1977, 1978), and can be adapted for *Lates calcarifer*. Thai technology used successfully for *Lates calcarifer* is reported by SCS (1982a). The procedures can be categorized as follows:

1. **Broodstock maintenance and spawning.**
   - broodstock collection (with quarantine and acclimatization) and/or growth of juveniles to maturity; broodstock maintenance with high standards of nutrition and husbandry;
   - spawning in captivity with egg collection/concentration and/or stripping with or without prior hormone injections;
   - development of out-of-phase broodstock by imposition of artificial photoperiod to extend the spawning season and/or to influence lunar periodicity within the natural spawning season.
2. **Egg incubation/larval rearing (0 to 25-30 days).**
   - egg incubation and hatching;
   - larval rearing in small experimental tanks (live foods).
3. **Nursery phase (25 to 30-90 days).**
   - post-larval growth and weaning on to artificial dry diets or mixed trash fish.
   - growth to a size large enough for shipping out to cage culture sites (1-2 g).

The tank sizes, utility and other requirements for these procedures and the specific requirements for live food production during larval rearing are summarized in Table 3 and Table 4. Some Asian experience in live food production is reported by SCS (1982b).

For broodstock nutrition and the development of artificial feeds for weaning postlarvae and for the nursery phase, a program of feed technology development is necessary. Broodstock may be fed on trash fish in net cages as is done at present by the DOF, but dry pelleted diets are cleaner, easier to handle and store and preferable for tank-held stocks. Artificial diets for the weaning phase from live foods are critical and will require close attention for each species. As a first step, high quality fish foods could be imported (for example from Japan), but local manufacturers of animal feeds should also be approached once successful feeding trials have been done, to aim for local feed production for the developing industry. The hatchery should ideally produce its own feeds on site for all critical phases of production, especially weaning and early nursing, but can buy stocks of broodstock and fingerling feeds from foreign producers.

Table 3. Summary of tank, utility and other requirements for hatchery and nursery procedures for seabass *(Lates calcarifer)* and grouper *(Epinephelus* spp.): the data given are from SCS (1982a) for seabass *(Lates calcarifer)* survival, and from CNEXO/France Aquaculture experience with *Dicentrarchus labrax* for other parameters.

Procedure	Tank Type	Volume	Stocking density	Maximum water flow needed (turnover rate)	Duration	Best expected survival	Expected production	Temperature: salinity (°C:‰)	Light intensity	Aeration (liter/m³/hr)
Broodstock Maintenance	Circular Rectangular	30 m^3 60 m^3	2 kg/m^3	5-10%/hour	Continuous	20% stock renewal/year	Sea bass *(Lates)* 30,000/kg ♀	28-32°: variable 28-32‰ before spawning	Natural or artificial ± controlled photoperiod 10 $watts/m^2$	10
Egg incubation	Square	50 liters	4,000/liter	100%/hour	12-36 hours	50-70%	Sea bass *(Lates)* 15-20 x 10^6/30 m^3	28-32°: 20-30‰	Natural or artificial 10 $watts/m^2$	100
Larval rearing	Cylindro-conical	0.5-4 m^3	80/liter	25%/hour	25-30 days	Sea bass 15% grouper <5%	Sea bass *(Lates)* 12-15,000/m^3	28-32°: 20-30‰	20 $watts/m^2$ (continuous)	50
Nursery phase	Square Rectangular	3 m^3 10 m^3	5-8/liter	25-50%/hour	60 days	Sea bass 50-70% grouper <2%	Sea bass *(Lates)* 4-5,000/m^3	28-32°: about 20‰	Natural or artificial 10 $watts/m^2$ (natural photo-period)	10

Table 4. Summary of tank, utility and other requirements for live food production for marine fish rearing: data from CNEXO/France Aquaculture experience with seabass *(Dicentrarchus labrax)*.

Live food	Tanks: Type	Tanks: Volume	Stocking density	Production	Temperature (°C)	Light intensity watts/m^2	Aeration (liter/hr/m^3)	Food
Algae	Erlenmeyer flask (glass)	250-1,000 ml	*Platymonas*	1 x 10^9/liter	20-22	800 (continuous)	50 plus CO_2 at 95 liter/hr/m^3	Mineral nutrients: culture media
	Circular (fiberglass)	100-300 liter	1 x 10^6/ml					
Rotifers	Cylindro-conical	1 m^3	100-200/ml	25-50 x 10^6/m^3	28-32	50-100 (continuous)	100	20% algae; baker's yeast; artificial diets
Artemia nauplii	Cylindro-conical	0.5-1 m^3	1 kg/m^3	150 x 10^6/m^3	28-32	10 (natural photoperiod)	100	–
2-day *Artemia*	Cylindro-conical	4 m^3	12 x 10^6/m^3	10 x 10^6/m^3	28-32	10 (natural photoperiod)	100	Algae; artificial diets; yeast

*Example—cell densities vary with species.

ESTIMATES FOR SEABASS PRODUCTION/SURVIVAL DURING HATCHERY, NURSERY AND GROWOUT

The hatchery has a capacity of 300,000 newly hatched larvae per 4-m^3 unit i.e., a total capacity of 1,200,000. The likely survivals per 4-m^3 unit through development are after 30 days, 45,000 and after 90 days, 30,000. This gives a total capacity for the hatchery of 100,000 to 120,000 ninety-day fry. Eight-month growout of 100,000 90-day fry of about 1 g individual weight should yield around 50,000 fish of 500 g, i.e., 25,000 kg production. With a 2-3 months long spawning season each year there could be 2 hatchery/nursery cycles.

FUTURE DEVELOPMENTS (PILOT PRODUCTION AND EXTENSION)

The design given here can easily be expanded by adding further hatchery/nursery modules. For seabass, an expansion of production from 100,000 to 5 million fingerlings could be accomplished by the construction of one hatchery/nursery module. Additional broodstock tanks can be built or more cheaply, broodstock can be held in net cages until the spawning season. The development of an out-of-season broodstock by photoperiod control is an important consideration for the future. This would allow nearly continuous hatchery production and year-round availability of fingerlings.

The adjacent sheltered waters of Mengkabong will support net cage culture as evidenced by the grouper broodstock already held by the DOF. However, the best stocking density for seabass in cages in these waters has not been determined. Thai experience suggests a minimum DO of 3 ppm. Cages should be sited in areas with good water flow and low turbidity.

STAFF DEVELOPMENT, TRAINING AND INFORMATION

A program of staff development will be essential for the success of the hatchery and future aquaculture projects in Sabah. Once the hatchery is completed, training can take place on the site, using invited experts as and when appropriate. However, there is also an opportunity to commence training by overseas visits during the construction phase.

After 1983, when the hatchery is completed, fish are in place and projects running, it will be more difficult for key staff to get away to benefit from overseas training assignments. A review of aquaculture training opportunities is available from ICLARM (see Appendix V and Pullin 1982).

For information, a small library of practical handbooks and other volumes on fish husbandry and hatchery methods should be kept at the hatchery. For more detailed sources of information, reference should be made to standard texts and scientific journals. ICLARM has reviewed aquaculture information sources in its April 1982 Newsletter. This review includes detailed advice on how to approach databases to keep abreast of recent research findings and how to build up a reprint collection (Pauly 1982). It is strongly recommended that the hatchery establish its own reprint collection for marine fish rearing, properly cataloged and run as a small library.

GENERAL CONSIDERATIONS, SOCIOECONOMICS

Chua (1979) has provided an overall estimate of the prospects for coastal aquaculture in Malaysia. The culture of carnivorous finfish in cages has good prospects and can generate much-needed employment opportunities. However, the scale of the industry will be determined by economic factors, particularly markets and cost/availability of inputs. The cost/availability of trash fish and alternative feeds is particularly important. Chua (1979) estimates that 320,000 t of trash fish would be needed to produce 80,000 t of cultured marine fish, the 1979 landings for trash fish in being only 167,475 t.

The possibility of small-scale fishermen improving their income by part-time or full-time cage culture appears attractive, but it is essential that comprehensive socioeconomic studies are made *before* development schemes are initiated. The advent of cultured fish in fish markets in Sabah will affect market prices. The various options for domestic and export markets of live and dead fish require thorough economic analysis. This is outside the scope of the present report, although a few data are given in Appendix IV.

Summary and Followup

SITE SELECTION

The site at Tanjong Badak, Mengkabong is suitable for a marine research hatchery provided that it can be ascertained that freshwater supplies from groundwater or storage are adequate at all times of the year and that risk of flooding from tidal/storm surges is minimal and can be overcome by appropriate siting and/or filling and design of buildings housing sensitive equipment (quarters, offices, laboratories, pumps, and generators).

HATCHERY DESIGN

A flexible design is presented to allow experimental work and small-scale production with scope for expansion to pilot production.

HATCHERY PROGRAM

A program is suggested for experimental work with groupers, principally *Epinephelus tauvina*, and production of 100,000 seabass, *Lates calcarifer*, juveniles for cage culture.

FOLLOWUP

France Aquaculture has considerable experience in marine hatchery design, construction and operation for finfish and shellfish hatcheries and is well-qualified to provide further assistance to the DOF for this hatchery and other aquaculture developments in Sabah, should the DOF so desire.

France Aquaculture can offer on a commercial basis several options for further assistance:

1. Formulation of a complete set of plans and equipment specification for the hatchery including executive design plans for immediate implementation/construction; accurate costings for construction, major equipment and running costs and complete listings and costs for all fish rearing and laboratory equipment and materials.

2. Supervision by a technical supervisor during commissioning and start-up of the hatchery for 1-3 months.

3. Technical assistance from a hatchery research expert (professional fish biologist) for 1-2 years to assist with research and technology development planning and execution.

4. All types of assistance with other aquaculture developments, such as shrimp hatcheries.

Details concerning France Aquaculture are given in Appendix VI.

ICLARM is primarily a research organization (Appendix VII) and can best assist the DOF further when the hatchery is completed and research plans are formulated. It would be of considerable benefit to have one or more research fellow(s) or technical expert(s) working with DOF staff during the first few years of the hatchery operation. Both ICLARM and France Aquaculture can assist in identifying and recruiting such people if the DOF wishes to hire outside expertise. ICLARM is also able and willing to advise the DOF on all training and information requirements relating to this hatchery program and other aquaculture research and development.

Acknowledgements

The consultants wish to thank the Director of Fisheries, Mr. Joseph Wong Tung Sang and his staff, particularly Mr. Tang Twen Poh, for their excellent organization of facilities and services for this study and report preparation. The cooperation of Mr. Daniel Wong Kah Kap, Director of the Department of Drainage and Irrigation and his staff, Miss Yap Chui Chui, Mr. Yong Chat Sang and Mr. Heng Aik Kok is also gratefully acknowledged. Miss H.M. Aliah is thanked for her work on report preparation.

Literature Cited and Other Useful References

Anon. 1982. 1982 Buyer's Guide. Aquaculture Magazine. P.O. Box 2451, Little Rock, Arkansas. 72203 U.S.A. 96 p. (1983 issue in preparation)

Barlow, C.G. and D. Turnbull. 1981. Egg incubation and larval rearing of marine teleosts: a bibliography. IDRC-MR 52e. International Development Research Centre, Ottawa, Canada. 32 p.

Chen, F.Y. 1979. Progress and problems of netcage culture of grouper *(Epinephelus tauvina* F) Singapore. Proc. World Mariculture Soc. 10: 260-271.

Chen, F.Y., M. Chow, T.M. Chao and R. Lim. 1977. Artificial spawning and larval rearing of the grouper, *Epinephelus tauvina* (Forskal) in Singapore. Singapore J. Prim. Industry. S(1): 1-21.

Chua, T.E. 1979. Prospects for coastal aquaculture in Malaysia. Paper presented at the Fifth International Symposium of Tropical Ecology, Kuala Lumpur, Malaysia, 16-21 April 1979.

Chua, T.E. and S.K. Teng. 1978. Effects of feeding frequency on the growth of young estuary grouper, *Epinephelus tauvina* (Forskal), cultured in floating net-cages. Aquaculture 14: 31-47.

Chua, T.E. and S.K. Teng. 1980. Economic production of estuary grouper, *Epinephelus salmoides* Maxwell, reared in floating net cages. Aquaculture 20: 187-228.

CNEXO. 1977. Fiche 1 – L'aquaculture du loup: la production de juvéniles. Techniques de production. Supplément an Bulletin CNEXO – Numéro 114 (June 1978) Centre National pour L'Exploitation des Océans, Paris. 16 p. (In French)

CNEXO. 1978. Fiche 2 – L'aquaculture du loup: la production de juvéniles. E'léments économiques. Supplément an Bulletin CNEXO, Numéros 117-118, September-October 1978. Centre National pour L'Exploitation des Océans, Paris. 12 p. (In French)

Cuzon, G. 1980. Feasibility study for establishing a small aquaculture laboratory in United Arab Emirates. UNDP/FAO Regional Fishery Survey and Development Project. FI: DP/RAB/71/278/7. FAO, Rome. 26 p.

FAO. 1976. National plan for development of aquaculture in Malaysia, p. 77-82. *In* Aquaculture Planning in Asia, Report of the Regional Workshop and Aquaculture Planning in Asia, Bangkok, Thailand, 1-17 October 1975. UNDP/FAO report. ADCP/REP/76/2. FAO, Rome.

Hussain, N.A. and M. Higuchi. 1980. Larval rearing and development of the brown spotted grouper, *Epinephelus tauvina* (Forskal). Aquaculture 19(4): 339-350.

Morrisey, N.M., L.F. Reynolds and D.B. McCarraher. 1973. Draft synopsis on the biology of *Lates calcarifer* Bloch. Internal report for use by the Advisory Communittee on Imports of Live Food and Sport Fish. Department of Fisheries and Fauna, Perth, Western Australia. 36 p. (Mimeo)

Nash, C.E. and Z.H. Shehadeh, Editors. 1980. Review of breeding and propagation techniques for grey mullet, *Mugil cephalus* L. ICLARM Studies and Reviews 3, 87 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Pauly, D.P. 1982. Reprints as a neglected resource. ICLARM Newsletter. 5(2): 18-19. International Center for Living Aquatic Resources Management, Manila, Philippines.

Pullin, R.S.V. and C.M. Kuo. 1981. Developments in the breeding of cultured fishes, p. 899-978. *In* J.T. Manassah and E.J. Briskey (eds.) Advances in food producing systems for arid and semi-arid lands, Part B. Academic Press, New York.

Pullin, R.S.V. 1982. Aquaculture training: needs and opportunities. ICLARM Newsletter. 5(4): 7-12. International Center for Living Aquatic Resources Management, Manila, Philippines.

SCS. 1982a. Report of training course on seabass spawning and larval rearing, Songkhla, Thailand, 1-20 June 1982. SCS/GEN/82/39. South China Sea Fisheries Development and Coordinating Programme, Manila, Philippines. 105 p.

SCS. 1982b. Report on the training course on growing food organisms for fish hatcheries. Tigbauan, Iloilo, Philippines, 3-22 August 1981. SCS/GEN/82/37. South China Sea Fisheries Development and Coordinating Programme, Manila, Philippines. 225 p.

Suzuki, K. and S. Hioki. 1979. Spawning behaviour, eggs and larvae of the lutjanid fish, *Lutjanus kasmira,* in an aquarium. Jap. J. Ichthyol., 26(2): 161-166. (In English)

Tan, S.M. and K.S. Tan. 1974. Biology of the grouper, *Epinephelus tauvina* (Forskal) I. A preliminary study on hermaphroditism in *E. tauvina.* Singapore J. Prim. Indust., 2(2): 123-133.

Teng, S.K. and T.E. Chua. 1978. Effect of stockingdensity on the growth of estuary grouper, *Epinephelus salmoides* Maxwell, cultured in floating net-cages. Aquaculture 15: 273-287.

Teng, S.K., T.E. Chua and P.E. Lim. 1978. Preliminary observation on the dietary protein requirement of estuary grouper, *Epinephelus salmoides* Maxwell, cultured in floating net-cages. Aquaculture 15: 257-271.

Wongsomnuk, S. and S. Manevonk. 1973. Results of experiment on artificial breeding and larval rearing of the seabass *(Lates calcarifer* Bloch). Contribution No. 5. Songkhla Marine Fisheries Station, Songkhla, Thailand. 21 p. (Original in Thai with English summary). Translation available from Aquaculture International Australia, P.O. Box 180, Plympton, South Australia 5038.

Appendix I - Consultants' Terms of Reference as Drafted by the Department of Fisheries (DOF)

1.1 Visit the various potential sites and select a suitable location for the experimental cum pilot-scale marine fish hatchery.

The design and layout plan should include details of the following:

2.1 Design a hatchery with future expansion as an option. The target species are *Epinephelus tauvina, Lates calcarifer, Mugil* sp. and *Penaeus monodon.**
3.1 The overall layout of the site including staff quarters, office, store, laboratories and other amenities.
3.2 Seawater uptake system. Specify the type of suitable uptake well, pumps and distribution plumbings.
3.3 Water treatment including sedimentation, filtration, u.v. sterilization and other necessary on line treatment and water quality requirements for hatchery.
3.4 Aeration systems including aeration equipment and plumbings.
3.5 Freshwater (ground water) uptake and treatments.
3.6 Details of laboratory and hatchery layout.
3.7 Details of tanks arrangement and construction for storage, broodstock maintenance, spawning, hatching and rearing purposes.
3.8 Feeds e.g., phytoplankton and zooplankton culture facilities both indoor and outdoor.
3.9 Effluent treatment if necessary.
3.10 List of essential equipment for the hatchery.
3.11 Specifications of other major equipment for maintenance e.g., generator set.
4.1 A report on the results and a detail plan for the hatchery will then be submitted to Fisheries Department.

*In preliminary discussions with the DOF it was agreed that the hatchery be specifically designed for finfish.

Appendix II - Itinerary/Consultants' Activities
JF = Dr. Jacques Fuchs: RSVP = Dr. Roger S.V. Pullin

Date (time)	Itinerary/Activities	Consultant(s)
November 29 (0400)	Depart from Tahiti	JF
November 30 (1840)	Arrival Manila	JF
December 01	Discussions at ICLARM, Manila	JF, RSVP
December 02 (AM)	Discussions at ICLARM, Manila	JF, RSVP
(PM)	Travel, Manila-Kota Kinabalu	JF, RSVP
December 03 (AM)	Discussions with Department of Fisheries and Department of Irrigation Development staff; visit possible hatchery site at Likas	JF, RSVP
(PM)	Visit possible hatchery site at Tanjong Badak, Mengkabong	JF, RSVP
December 04 (AM)	Short meeting with Mr. Joseph Wong Tung Sang; general discussions on hatchery design	JF, RSVP
(PM)	Visit potential hatchery site at Tanjong Kaitan, Karambunai	JF, RSVP
December 05	Work on hatchery design with Mr. Tang Twen Poh	JF, RSVP
December 06	Work on hatchery design with Fisheries and Irrigation Department staff	JF, RSVP
December 07	All-day visit to the Tanjong Badak, Mengkabong site for further inspection, measurements	JF, RSVP
December 08-13	Discussions and report preparation, DOF headquarters, Kota Kinabalu	JF, RSVP
December 13 (PM)	Departure	JF, RSVP

Appendix III - Site Characteristics Determined by the Department of Fisheries

Site Characteristics	Likas	Tanjong Badak, Mengkabong	Tanjong Kaitan, Karambunai
1. General description	Very coarse granules on beach, with large rocks & pebbles, available area of about 4 ha. Flanked by slopes landwards up to 16 m in height. Narrow strip of land along beach. Max. width 100 m.	Fine beach sand with dark fine silt below 2 meters depth. Plenty of vegetable materials in the sublayer. Flat sandy ground.	Fine beach sand Flat sandy ground.
2. Accessibility	Build an access road along the beach, through Sabah Foundation.	Free access with minimum effort.	Access through Kg. Karambunai along beach.
3. Shelter	Good shelter offered by Gaya and Sapangar Island from the monsoon winds. Gently sloping shore.	Open coastline.	Open coastline.
4. Status	State land, high class commercial area.	State land, beach reserve.	Unclear status, very delicate.
5. Soil	Very sandy with clay subsoil.	Sandy top soil.	Sandy top soil. Fine silt below.
6. Utilities	Electricity and freshwater from municipal supplies.	Nil. End of power line 5 km away from site. Freshwater readily available from well even close to beach. However, high Fe content up to 10 ppm & vial count is high.	Nil. Water available from bore wells. High Fe (up to 10 ppm).
7. Water parameters (7 December 1982)			
a. Salinity	28-32‰	28-32‰	28-32‰
b. pH	8.1	8.1	8.1
c. Total vial count	<100/ml	<100/ml	<100/ml
d. Ammonia nitrogen	<1 ppm	<1 ppm	<1 ppm
e. Nitrate nitrogen	<1 ppm	<1 ppm	<1 ppm
f. Manganese	<0.2 ppm	<0.2 ppm	<0.2 ppm
g. Iron	<0.5 ppm	<0.5 ppm	<0.5 ppm
h. Sulphide*	<0.2 ppm	<0.2 ppm	<0.2 ppm
i. Turbidity	> 1 m	> 1 m	> 1 m

*Possibly suspect—see text.

Appendix III (Cont.)

Site Characteristics	Likas	Tanjong Badak, Mengkabong	Tanjong Kaitan, Karambunai
8. Inland drainage	Inanam River mouth is within 1 km. However, even after heavy rains, pH, S‰ and turbidity remain fairly constant.	Beside the estuary of Mengkabong Bay.	Nil.
9. Pollution risks	Faecal pollution from squatter settlements along river, but will be removed to settlement lot. Industrial effluent from Inanam light industry remains a threat. Potential pollution from oil spills in new industrial wharf at Sapangar Bay.	Villages around Mengkabong Bay. Insignificant faecal contamination. No industries. Little agricultural activity. Potential tourism development.	Nil. Potential tourism development.

Appendix IV - Synopses of Data on Principal Species

a. *Lates calcarifer*

Distribution – Tropical and subtropical Indo-Pacific from Japan and south China to the Persian Gulf and the Malaysian – Indonesian archipelago to northern Australia; limits are approximately 33°N to 25° 32'S and 58°E to 152° 30' E (Morrisey et al. 1973).

Importance as a food fish – An important foodfish in Australia, Hongkong, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, Taiwan and Thailand; in 1978 Southeast Asian landings totalled 10,142 tonnes/value US$5,362,000 (SCS 1982a).

History of culture – extensive pond culture in India and Pakistan from 1940s and earlier; pond culture in Thailand from 1943 and as an accidental entrant to Indonesian milkfish ponds; net-cage culture on a commercial scale in Thailand from about 1973; 1981 production in Thailand was 300 t (150 t from cage culture in Southern Thailand, 150 t from pond and cage culture in Central and Eastern Thailand) worth US$1 million; the market price in Thailand is about Baht 70 (US$3.5)/kg and the production cost Baht 50/kg (SCS 1982a); research and development projects in Australia, Hongkong, Indonesia, Malaysia, Philippines, Singapore and Taiwan.

State-of-the-art of hatchery work – successful mass rearing in Thailand from 1973 with 14-17% survival to 31 mm (60-day) postlarvae (Wongsomnuk and Manevonk 1973); current total Thai production potential is about 20 million fry/year from two private and three government hatcheries; 1981 fry production from the National Institute of Coastal Aquaculture, Songkhla was about 7 million (SCS 1982a); average survival from fertilized eggs to advanced fry should be around 10%; spawning season April-October with lunar periodicity.

General Comments – potentially a very important fish for culture throughout the tropics and subtropics; its merits are—high fecundity (around 500,000 to 1,500,00 eggs/spawning ♀); ease of rearing due to large egg size (0.8 mm) and rapid development (17 hours to hatching at 27°C; ease of larval rearing/nursing giving one of the highest survival and growth rates recorded for marine hatchery work (> 10% survival, 12 mm fry in 30 days); wide environmental tolerance of all larval, postlarval, juvenile and adult stages (salinity 5-35‰, temperature 19-32°C or wider, growout at DO > 3.0 ppm), rapid growth (0.8 to 1.2 kg in one year on trash-fish diets), low susceptibility to disease and high market demand, especially for live fish (SCS 1982a).

Sabah Statistics – 1981 seabass landings and price ranges for various markets.

Market	Landing (kg)	Retail price, range and mean (M$/kg)*
Kota Kinabalu	393	5.30 – 6.30 (5.80)
Sandakan	12,490	4.13 –12.40** (6.70)
Semporna	8,395	1.65 – 4.95 (3.65)
Tawau	13,340	1.65 – 4.95 (3.65)
Labuan	?	4.80 – 4.95 (4.95)
Total	90,472	

*1 US$ = 2.3M$.
**Live?

Appendix IV (Cont.)

b. *Epinephelus tauvina*

Distribution – Tropical and subtropical Indo-Pacific.

Importance as a food fish – An important foodfish in Hongkong, Indonesia, Kuwait, Malaysia, Philippines, Singapore, Taiwan, Thailand, United Arab Emirates (and probably other countries bordering the Indo-Pacific and the Persian Gulf.) Annual catch in Kuwait is about 500 t, worth over US$600,000 (Hussain et al. 1975); Sabah statistics below.

History of culture – very limited; commercial scale growout of wild caught fingerlings in netcages in Hongkong and Singapore (Chua 1979) since the 1970s; experimental tank culture in Kuwait; recent tank and cage culture trials in Peninsular Malaysia (Chua and Teng 1978) and Thailand; production in Singapore about 40 $kg/m^2/yr$ (Chen 1979).

State-of-the-art of hatchery work – experimental, apart from possibly one private hatchery in Rayong, Thailand; information available on sex reversal (Tan and Tan 1974), artificial spawning and larval rearing (Hussain et al. 1975; Chen et al. 1977; Hussain and Higuchi 1980); rearing success difficult to judge but survivals from fertilized egg to fingerlings are <1%.

Sabah Statistics – 1981 *E. tauvina* landings and price ranges for various markets.

Market	Landing (kg)	Retail price, range and mean (M$/kg)*
Kota Kinabalu	120,777	2.65 – 8.25 (5.45)
Sandakan	45,095	3.30 –13.20** (7.25)
Semporna	71,051	2.50 – 5.80 (3.40)
Tawau	52,494	2.50 – 7.45 (4.15)
Labuan	?	3.30 – 6.80 (3.30)
Total	(289,417)	

*1 US$ = 2.3M$,
**Live.

c. Other groupers

i) *Epinephelus salmoides.*

Successful net-cage culture in Peninsular Malaysia (Teng et al. 1978; Teng and Chua 1978; Chua and Teng 1980)* using wild-caught fish; no hatchery production of seed.

ii) *Epinephelus akaara.*

Recent work on mass rearing has been undertaken by Dr. Wen-Young Tseng, Mariculture Laboratory, Chinese University of Hongkong, Shatin, New Territories, Hongkong.

*Much of the data given in these publications is probably also applicable to *E. tauvina.*

Appendix V - Aquaculture Training

Table 1. A selected list of aquaculture higher degree programs and other courses in developed countries, based on information currently available to ICLARM.[1]

University/Institution	Program and Course Details 1. Higher degree program level; 2. Other aquaculture courses (type, duration); 3. Willing to offer special short courses/individual training on request; 4. Specialization and other comments.
Canada	
Biology Department, Dalhousie University, Halifax, N.S. B3A 4JI	1. M.Sc., Ph.D.; 2. No; 3. –; 4. Genetics of cultured organisms; encourages overseas students.
France	
Centre National pour l'Éxploitation des Océans (CNÉXO), 66 Avenue d'Iéna, 75116, Paris	1. No (unless through university links?); 2. No; 3. Yes (individual; in special skills); 4. Has cold-temperate culture stations in France and marine tropical stations in Tahiti and New Caledonia; hatchery and culture systems technology for finfish and shellfish.
Hungary	
Fisheries Research Institute 5541, Szarvas	1. Yes (?); 2. Yes (2-6 month courses, May-Sept); 3. No; 4. Advanced post-graduate training in aspects of hydrobiology, freshwater fish culture, integrated farming, etc.; trainees must be self-financed.
Warm-water Fish Breeding Farm, Százhalombatta	1. No; 2. Yes (various; on request); 3. Yes; 4. Will organize special short courses only at the request of international organizations and with their financial support.
Israel	
Fish and Aquaculture Research Station, DOR, D.N. Hof Hacarmel	1. No (unless through university links?); 2. No; 3. –; 4. Freshwater pond aquaculture.
Foreign Training Department, Ministry of Agriculture, P.O. Box 7054, Tel Aviv	1. No; 2. Yes (3 months, April-July, annual); 3. –; 4. A general course on carp, tilapia and mullet culture based at Natanya.
University training	1. Yes; 2. No; 3. Yes (individual; in special skills, e.g., electrophoresis); 4. Bar-Ilan University, Ramat Gan, Tel Aviv and the Hebrew University of Jerusalem both have strong links with Israeli aquaculture; details must be sought on a case-by-case basis.
Netherlands	
Department of Fish Culture and Inland Fisheries, P.O. Box 338, 6709 PC., State Agricultural University, Wageningen.	1. Yes; 2. No; 3. Yes (individual); 4. Carp and *Clarias lazera* culture; regular university courses are in Dutch.
United Kingdom	
Fish Culture Unit, Department of Biological Sciences, University of Aston, Birmingham B4 7ET	1. Yes; 2. Yes (various; on request); 3. Yes (individual or small groups); 4. Reproduction and nutrition of cyprinids, salmonids and other freshwater fish.
Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland	1. M.Sc., Ph.D. and Diplomas; 2. Yes (various e.g., fish diseases, health control; vary in timing and duration); 3. Yes (will consider any training needs); 4. M.Sc. courses in Aquaculture and Fishery Management, Aquatic Veterinary Studies, Aquatic Pathobiology; Diploma courses in Aquaculture; cold- and warm-water aquaculture; pathology and nutrition; links with Scottish Marine Biological Association, Oban for marine work; encourages foreign students and fields training staff in developing countries.
Plymouth Polytechnic, Drake Circus, Plymouth PL48AA	1. M.Sc.; 2. No; 3. –; 4. Fulltime 12-month M.Sc. (Oct-Sept) in Applied Fish Biology concentrating on fish culture, nutrition, fish health and economics.
Department of Genetics and Center for Development Studies, University College of Swansea, Singleton Park, Swansea SA2 8PP	1. M.Sc.; 2. No; 3. No; 4. M.Sc. course (21 months, commencing October) on Applications of Genetics in Developing Areas; scope for project work on cultured aquatic organisms; relevant socio-economic studies possible in the Center for Overseas Development.
Training Services Manager, White Fish Authority, Industrial Development Unit, St. Andrew's Dock, Hull, HU3 4QE	1. No; 2. Yes (25 days, repeated several times each year); 3. –; 4. Short course entitled Introduction to Mariculture

Appendix V (Cont.)

University/Institution	Program and Course Details 1. Higher degree program level; 2. Other aquaculture courses (type, duration); 3. Willing to offer special short courses/individual training on request; 4. Specialization and other comments.
U.S.A.[2]	
University of Alaska, Corlasier Highway, Juneau, Alaska 99803	1. M.Sc.; 2. No; 3. –; 4. Salmonid aquaculture and ranching.
Department of Fisheries and Allied Aquacultures/International Center for Aquaculture, Auburn University, Auburn, Alabama 36849	1. M.Sc., Ph.D. and Diplomas; 2. Yes (annual 3.5 month training course, March-July); 3. Yes (will consider any training needs; 4. Freshwater pond culture, tilapias, catfish, carps, nutrition, water quality, reproduction; the short course and higher degree programs are specifically designed for foreign students from developing countries; frequently fields training staff in developing countries.
University of California/California State University Systems—interests depend on campus, e.g., Davis, California 95616	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Multidisciplinary programs, aquacultural engineering, water quality, wastewater use, genetics, larval rearing, marine and freshwater.
Consortium for International Fisheries and Aquaculture Development (CIFAD), Extension Hall 330, Oregon State University, Corvallis, Oregon 97331	1. Yes; 2. Yes; 3. Yes; 4. A consortium of 5 universities—Arkansas (Pine Bluff), Hawaii, Michigan State/Michigan and Oregon State—see separate listings for details; CIFAD is aimed at international work and has already conducted an aquaculture course for USAID in Zaïre (in French).
Department of Entomology, Fisheries and Wildlife, Clemson University, Clemson, South Carolina 29631	1. Yes (M.Sc.); 2. –; 3. –; 4. A wildlife biology course including formal courses in aquaculture; encourages overseas students on a new International Agriculture Program.
College of Marine Studies, University of Delaware, Newark 19711, Delaware	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Controlled environment mariculture.
Fisheries Academy, National Fisheries Center, RE3, Box 41, Kearneysville, West Virginia 25430	1. –; 2. Yes (a wide range of short courses); 3. Yes; 4. Typical courses include coldwater fish culture (11 days), pond management (4 days); warmwater ponds available.
Department of Medicine Microbiology, College of Veterinary Medicine, University of Georgia, Athens, Georgia 30602	1. M.Sc.; 2. –; 3. –; 4. Fish health management for graduate veterinarians; encourages overseas students.
College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, Idaho 83843	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Nutrition, reproduction and production systems; freshwater fish, mainly salmonids.
Oklahoma State University, Stillwater, Oklahoma 74074	1. –; 2. –; 3. –; 4. Reproduction, nutrition and feed technology, genetics, production systems; mainly catfish.
University of Hawaii, Honolulu, Hawaii 96822	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Marine and freshwater aquaculture especially *Macrobrachium* and tilapias.
Department of Agricultural Engineering, College of Agriculture, University of Maryland, College Park 20742	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Aquaculture engineering.
Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Fish nutrition, fish physiology and limnology; new aquaculture courses are being developed; encourages overseas students.
The Oceanic Institute, Makapuu Point, Waimanalo, Hawaii 96795	1. No; 2. –; 3. Yes; 4. Experienced in hatchery work, especially marine prawns and mullet.
Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331	1. Master of Agriculture; M.Sc., Ph.D.; 2. –; 3. –; 4. The non-thesis Master of Agriculture emphasizes aquaculture; topics include resource economics, coldwater marine and freshwater aquaculture.
Aquaculture Science and Pathology Department, University of Rhode Island, Kingston, Rhode Island 02881	1. M.Sc. and Ph.D.; 2. –; 3. –; 4. M.Sc. in fisheries science, advanced aquaculture systems and fish nutrition. Ph.D. in marine pathology (including virology).
Fisheries Research Laboratory, Southern Illinois University, Carbondale, Illinois 62901	1. M.Sc., Ph.D.; 2. –; 3. –; 4. Freshwater aquaculture including *Macrobrachium* and tilapia studies; encourages overseas students.

Appendix V (Cont.)

University/Institution	Program and Course Details 1. Higher degree program level; 2. Other aquaculture courses (type, duration); 3. Willing to offer special short courses/individual training on request; 4. Specialization and other comments.
Department of Forestry, Wildlife and Fisheries, University of Tennessee, P.O. Box 1701, Knoxville, Tennessee 37901	1. M.Sc., Ph.D.; 2. –; 3. –; 4. M.Sc. in fisheries and wildlife; Ph.D. in aquatic biology or ecology; courses have some aquaculture bias.
Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, Texas 77843	1. Master of Agriculture, M.Sc., Ph.D.; 2. Yes; 3. Yes; 4. A wide range of programs and topics on freshwater and marine systems (tilapias and crustaceans); encourages overseas students; fields training staff in developing countries; requests information on training needs from developing countries.
College of William and Mary, Virginia Institute of Marine Science, School of Marine Science, Gloucester Point, Virginia 23602	1. –; 2. + (2-3 week bivalve culture course); 3. –; 4. The bivalve culture course is run at the Eastern Shore Laboratory; overseas trainees can opt for longer stays.
College of Fisheries, University of Washington, Seattle, Washington 98195	1. M.Sc., Ph.D.; 2. –; 3. –; 4. A wide range of topics in coldwater aquaculture including fish nutrition, biochemistry, hatchery and culture systems.

[1]This table omits opportunities in Australia, Austria, Belgium, Czechoslovakia, Denmark, Eire, Finland, East and West Germany, Greece, Iceland, Hong Kong, Italy, Japan, South Korea, Kuwait, Norway, Poland, Portugal, Singapore, Spain, Sweden, Switzerland, Yugoslavia and the USSR–all of which have aquaculture industries and research programs and therefore associated training needs/opportunities. This list also omits universities and institutions with training interests in the aquatic sciences but not concentrating on aquaculture *per se* (e.g., in the U.K., Aberdeen, Bangor, East Anglia and Liverpool universities) and government institutions which have no regular involvement in training foreign students.

[2]The following universities and institutions also list some research and training interests in aquaculture in their literature: Colorado State, Connecticut, Cornell, Duke, Florida, Guam, Houston, Kansas State, Louisiana State, Maine, Massachusetts, Massachusetts Institute of Technology, Miami, Mississippi State, National Marine Fisheries Service Centers (La Jolla, Miami, Woods Hole, Seattle), New Hampshire, North Carolina State, Purdue, Rutgers, South Carolina, South Carolina Marine Resources Research Institute, State University of New York, U.S. Fish and Wildlife Service Laboratories (Reservoir Research Program, Fayetteville, Arkansas; Great Lakes Fishery, Ann Arbor, Michigan; Southeast Cultural Laboratory, Marion, Alabama; National Fishery Research Center, Seattle, Washington; Fish Farming Experiment Station, Stuttgart, Arkansas; Fish Control Laboratories; La Grosse, Wisconsin; Tunison Laboratory of Fish Nutrition, Cortland, N.Y.; National Fisheries Research and Development Center, Wellsboro, Pennsylvania; National Fisheries Research Laboratory, Gainsville, Florida; Eastern Fish Disease Laboratory, Kearneysville, West Virginia; National Fish and Wildlife Health Laboratory, Madison, Wisconsin; National Fish Laboratory, Washington, D.C.), and Woods Hole Oceanographic Institution.

Table 2. Selected aquaculture higher degree programs and other courses in the developing countries of Asia.

University/Institution	Program and Course Details 1. Higher degree program level; 2. Other aquaculture courses (type, duration); 3. Willing to offer special short courses/individual training on request; 4. Specialization and other comments.
Asia and the Pacific Region	
Network of Aquaculture Centres in Asia (NACA), Regional Head Office, National Inland Fisheries Institute, Bangkhen, Bangkok 9, Thailand	1. Master of Aquaculture or Diploma in Aquaculture; 2. Yes (various; see comments); 3. Yes (individual and courses); 4. Activities of national lead centers within NACA are listed below; NACA's main training course is a 12-month course for senior aquaculturists based at the Philippine lead center–see page 00.
FAO/UNDP South China Sea Fisheries Development and Coordinating Programme, P.O. Box 1184, MCC, Metro Manila, Philippines	1. No; 2. Yes (various); 3. –; 4. This program has offered a variety of courses, e.g., small-scale pen and cage culture for finfish, Laguna, Philippines, 26-31 October 1981 and Aberdeen, Hong Kong, 1-13 November 1981; seabass spawning and larval rearing, June 1-21, 1982, in Songkhla, Thailand in cooperation with the Department of Fisheries, Ministry of Agriculture and Cooperatives, Thailand (see p. 00).

Appendix V (Cont.)

University/Institution	Program and Course Details 1. Higher degree program level; 2. Other aquaculture courses (type, duration); 3. Willing to offer special short courses/individual training on request; 4. Specialization and other comments.
People's Republic of China	
Asian-Pacific Regional Research and Training Center for Integrated Farming, Wuxi, Jiangsu Province	1. –; 2. Yes (4-month courses, 2/year); 3. –; 4. Integrated farming and freshwater pond aquaculture; highly practical courses; Wuxi is the China lead center for NACA.
Pearl River Institute, Kuangzhow (Canton)	1. –; 2. Yes (content unknown); 3. –; 4. Inland fisheries and freshwater aquaculture; has undertaken training for FAO.
India	
Indian Council for Agricultural Research (ICAR), Krishi Bhavan, New Delhi 110001	1. Yes (various; see comments); 2. Yes (various; see comments); 3. Yes; 4. ICAR is the umbrella research organization over all government aquaculture research and training centers; coordinates/approves all training programs at centers listed individually.
Central Inland Fisheries Institute, Barrackpore 743101, West Bengal	1. No; 2. Yes (various); 3. Yes (individual or courses); 4. Freshwater aquaculture, especially composite culture of carps.
Central Institute of Fisheries Education, Versova, Bombay 40061	1. Yes (various certificates and diplomas); 2. Yes (various; 9-10 months); 3. –; 4. Freshwater and pond aquaculture; culture of carps.
Freshwater Aquaculture Research and Training Center, Dhauli, Bhubaneswar, Orissa	1. No; 2. No (no fixed courses); 3. Yes (individual or courses); 4. Freshwater pond aquaculture; all aspects of carp culture; the Indian lead center of NACA.
Centre of Advanced Studies in Mariculture, Central Marine Fisheries Institute, Cochin 682019	1. M.Sc. through the University of Cochin; 2. –; 3. –; 4. M.Sc. in mariculture; has details of other marine and brackishwater training.
Indonesia	
Biotrop, P.O. Box 17, Bogor	1. –; 2. Yes (short (6 week) and longer (10 month) courses); 3. Yes (individual); 4. Freshwater biology and associated laboratory skills; pathology, bioassay, water quality, etc.
Malaysia	
Universiti Pertanian Malaysia, Serdang, Selangor	1. M.Sc. in Resource Economics in June 1983; 2. –; 3. –; 4. Fisheries and aquaculture economics.
Philippines	
Central Luzon State University, College of Fisheries/Freshwater Aquaculture Center, Muñoz, Nueva Ecija	1. M.Sc., M.P.S. (Master of Professional Studies); 2. Yes (various); 3. Yes (individual or courses); 4. Freshwater pond aquaculture, especially integrated farming and tilapias, rice-fish culture; Master's degree either by thesis or non-thesis.
Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC), Tigbauan, Iloilo	1. M.Sc. through university links; 2. Yes (various); 3. Yes (individual or courses); 4. Freshwater, brackishwater and marine aquaculture especially milkfish, penaeid prawns and tilapias; short courses differ annually according to demand; the Philippine lead center of NACA.
University of the Philippines in the Visayas, Iloilo City	1. M.Sc., Master of Aquaculture, Diploma in Aquaculture; 2. Yes; 3. –; 4. Brackishwater finfish and crustacean culture training through the Brackishwater Aquaculture Center, Iloilo City; currently developing a new campus.
Thailand	
Asian Institute of Technology, Division of Agricultural and Food Engineering, P.O. Box 2754, Bangkok	1. M.Sc., Diplomas; 2. –; 3. –; 4. Exceptionally well situated for graduate training in freshwater aquaculture, particularly engineering and waste utilization; takes students from all Asian countries.
National Inland Fisheries Institute, Kasetsart University Campus, Bangkhen, Bangkok 9	1. ? (through university links); 2. Yes (various); 3. –; 4. Freshwater aquaculture; the Thailand lead center for NACA.

Appendix VI - France Aquaculture

France Aquaculture is a limited company with capital of 1,000,000 F.

1. Officials:	Director General Secretary General	Jacques Perrot Rene le Marchand
	Headquarters Address	66 Avenue Iena, 75.116 Paris, France
	Telephone (1) 72.35.528	
2. Project Planning Department:	Director	Michel Girin
	Address	BP 337, 29273 Brest Cedex, France
	Telephone (98) 49.17.93	
	Telex 940627 F	

3. France Aquaculture Section in the Centre National pour L'Exploitation des Océans/Centre Océanologique du Pacifique (CNEXO/COP)

CNEXO/COP	Director	Bruno Chaumel de Varagne
CNEXO/COP	Aquaculture Program Manager	Alain Michel
	Address	CNEXO-COP, BP 7004, Taravao, Tahiti, French Polynesia
	Telephone 7.12.74	
	Telex OCEANEX 294 FP	

Appendix VII

The International Center for Living Aquatic Resources Management (ICLARM)

ICLARM is an autonomous, non-profit, international, scientific and technical center similar in many ways to the international agricultural research centers. It has been organized to conduct, stimulate and accelerate research on all aspects of fisheries and other living aquatic resources.

The Center was incorporated in Manila on 20 January 1977 (after a two-year formative period in Honolulu) and its operational base was established in Manila in March 1977. ICLARM is an operational organization, not a granting or funding entity. Its program of work is aimed at resolving critical technical and socio-economic constraints to increased production, improved resource management, and equitable distribution of benefits in economically developing countries. It pursues these objectives in the fields of aquaculture, traditional fisheries, resource development and management, fisheries affairs, and education and training through cooperative research with institutions in developing and developed countries.

ICLARM policy is set by a Board of Trustees. Board members are drawn from the international community and serve in their personal capacities. Direction of ICLARM, under the policies set by the Board, is the responsibility of the Director General. Advice on programs is received by the Director General from a Program Advisory Committee. This Committee is composed of outstanding scientists, also drawn from the international community, who serve in their personal capacities.

The ICLARM core staff consists of internationally recruited scientists drawn from the areas of aquaculture, fishery biology, population dynamics, economics, anthropology, and international law. The ICLARM permanent core staff is to remain small, reaching a total of about 12 professionals. Provision is also made for interns, consultants and visiting fellows.

The core program and permanent core staff are supported by governments and private foundations. In addition to the core program, special projects relevant to the ICLARM terms of reference are undertaken on behalf of governments, world and regional banks, and other regional and international agencies.