PRAWN POND ENGINEERING

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Techniques employed in the cultivation of sugpo in ponds is still basically traditional and is in fact patterned after that for bangus culture. Most prawn ponds are converted bangus ponds where they are used for monoculture or polyculture with bangus. The stocking of ponds with sugpo fry depends on the seasonal nature of fry collection. The sugpo fry are collected from known breeding grounds in estuaries and bays during season an are stocked in the ponds until they grow to marketable size.

Engineering concepts and principles have only been recently employed in the design of aquaculture facilities to increase production in both the hatchery and pond culture operations. One has only to examine the culture of prawns in Japan to conclude that applying these concepts is indeed rewarding.

The main operations involved in prawn culture are outlined in Figure 1. The enclosed dotted area in the diagram shows the operations where pond engineering principles may be applied.

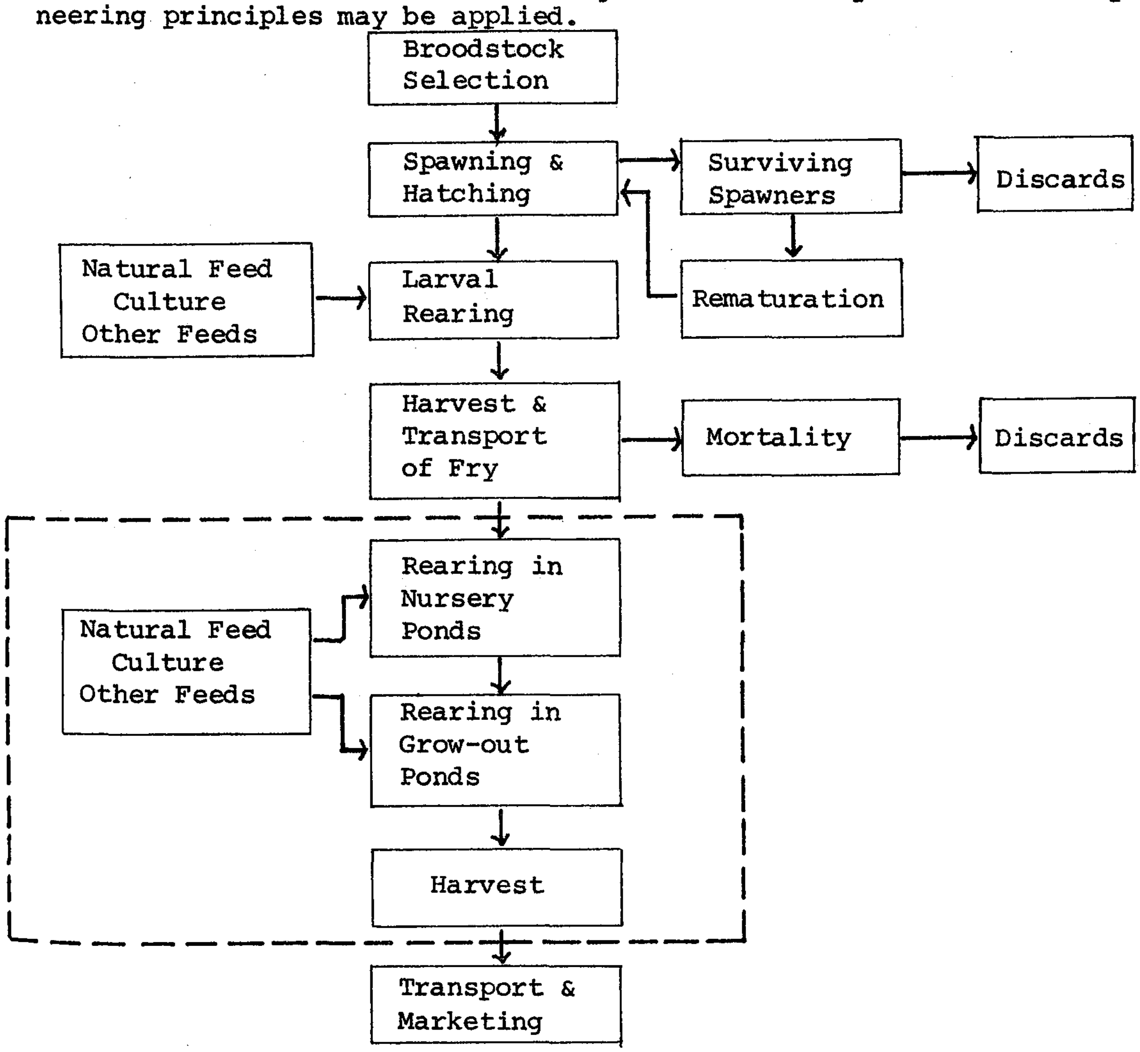


Fig. 1 The Prawn Culture Process

This paper reviews briefly the engineering principles and concepts, materials of construction, design and construction techniques of pond systems adequate for use in the cultivation of prawns.

Pond System Layout and Design

1. Pond Engineering

Pond engineering is principally concerned with water supply, the application and storage of water, the design and construction of pond structures and equipment, and the drainage problems associated with it. It is also concerned with the biological factors involved in the proper cultivation of the cultured species.

2. Site Selection

The greater and more detailed knowledge of the pond site there is, the more effectively and efficiently a pond system can be designed and developed. The criteria usually employed in evaluating prospective pond sites are as follows:

Water source (fresh and salt water)
Topography (elevation, soil type, etc.)
Road and market accessibility
Fry source
Availability of electric power
Availability of technical manpower

3. Biological Considerations

The biological factors which influence the design and construction of prawn ponds are:

Salinity: 10-20 ppt

Stocking rates

With transfer

Nursery pond: 20-30 sugpo fry/sq m

Grow-out pond:
Monoculture - 5 to 2 sugpo juveniles/sq m
Polyculture - 5 to 1 sugpo juveniles/sq m
.05 to .1 bangus fingerlings/sq m

Without transfer

Nursery/grow-out pond:
Monoculture - 1 to 3 sugpo fry/sq m
Polyculture - 1 to 2 sugpo fry/sq m
.04 to .06 bangus fingerlings/sq m

Water depth
- Nursery pond: 20-60 cm
- Grow-out pond: 30-110 cm

pH: 7 to 9
Dissolved oxygen: 5 to 10 ppm
Temperature: 20°to 35°C
Toxic metabolites
Predation and cannibalism
Fertilization

4. Layout Considerations

The general engineering considerations which affect the planning and layout of a prawn pond system are:

Water source

- Surface water (salt and fresh water)
- Ground water (wells and springs)
- Precipitation
- Floodwater

Interrelationship between the major components of the system for easy access and circulation

Layout types

- Conventional type
- Progressive type
- Radiating type

Local materials and labor
Economics

5. Pond System Structures

The development of a pond system consists of the design and construction of several structures, equipment and appurtenances. These structures and equipment may be classified and grouped as follows:

Protection structures: breakers, jetties, barriers
Water measurement structures: orifices, weirs, measuring flumes
Water conveyance structures: canals, flumes, drops, flexible tubings
Water impounding structures: earth dams, nursery ponds, grow-out ponds, reservoir ponds, sump ponds
Pumps and wells
Other equipment and accessories

Pond Structures and Equipment in the Philippines

1. Protection Structures

Shore protection structures are employed to protect aquaculture facilities along the shore. In a pond system, they usually consist of breakers, jetties and barriers. The sizes and types of the structures vary according to the conditions for which are constructed.

Engineering analysis

The structures are designed for wave and wind action. The engineering formulas commonly used are the Stevenson formula, the Molitor formula, the Gaillard formula, etc. These formulas are quite outdated and may be used only to establish preliminary designs. The design must be checked and modifed properly by applying the more advanced analytical methods and verified by model tests.

Breakwaters

Breakwaters commonly employed are: (a) rubble-mound breakwater, (b) wooden-type breakwater formed by driving two lines of mangrove piles and filling the space between them with branches of trees, and (c) a buffer zone of mangrove trees.

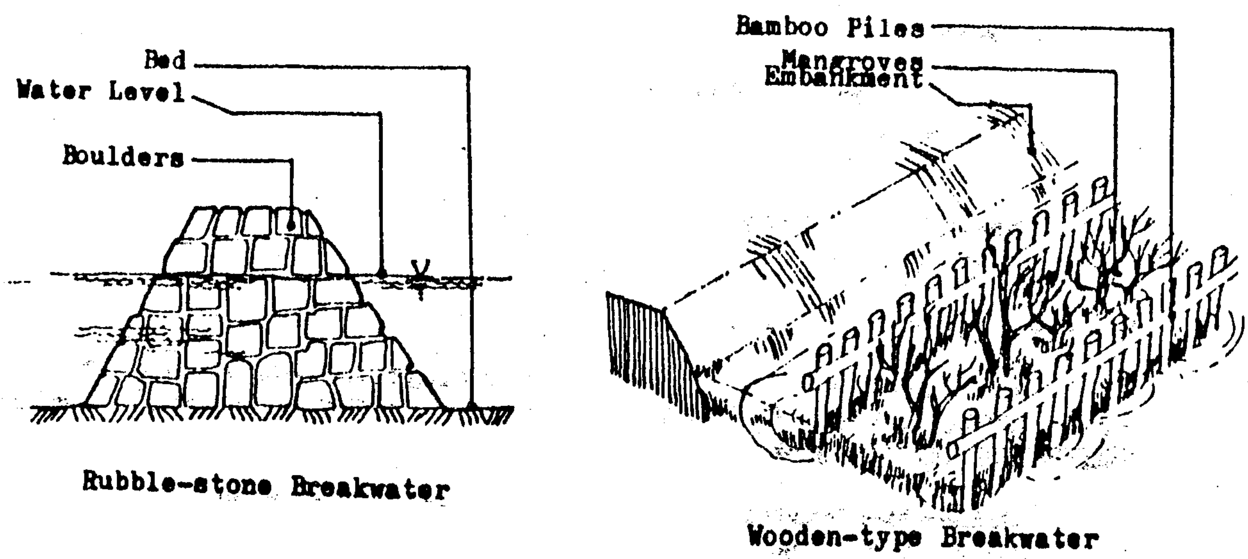


Fig. 2 Breakwaters

Jetties

Bamboo jetties arranged in a zigzag pattern prevent scouring at river bends. Coconut trunks are also used intead of bamboos. The spaces between the river bank and jetties are filled with twigs and branches.

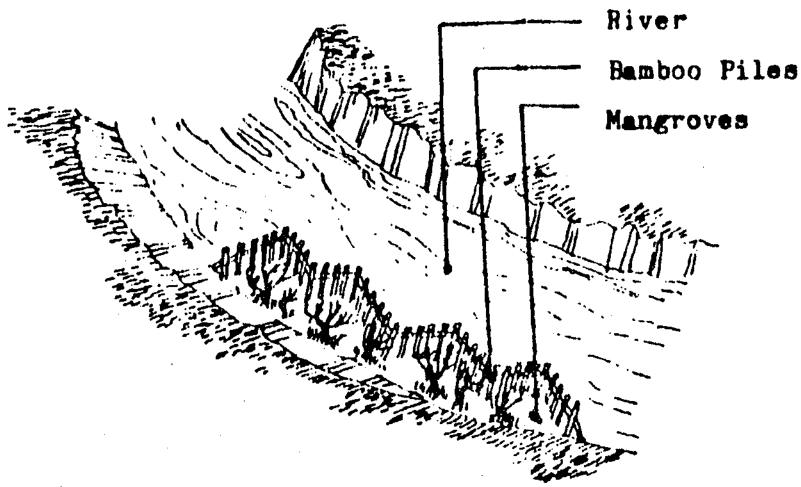


Fig. 3 Bamboo Jetties

Embankment protection structures

Embankment are protected against internal waves by the following: (a) bamboo wave breakers, (b) worn-out tires arranged side by side along the embankment, (c) riprapping of embankment, and (d) growing of creeping or close-growing grasses on embankment.

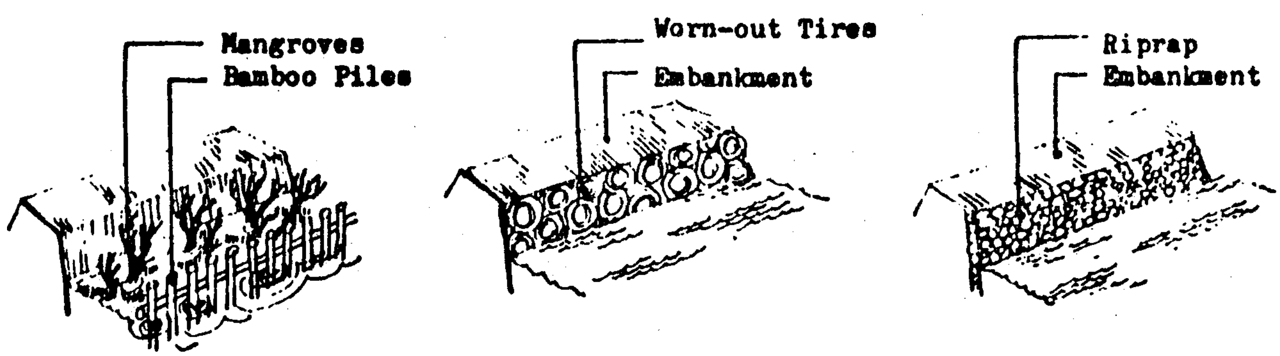


Fig. 4 Embankment Protection Schemes

Screened barriers

Bamboo or nylon screens are installed at the mouth of the main gates to preven clogging of the gates by floating debris.

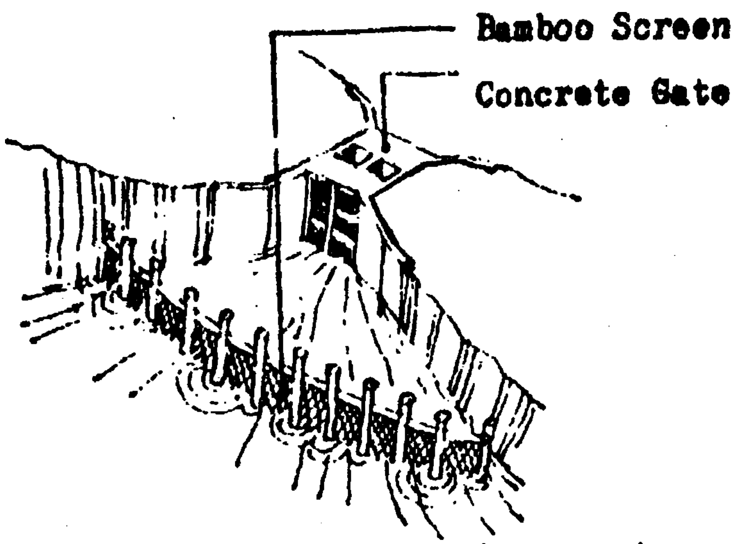


Fig. 5 Bamboo Barrier

2. Water Measurement Structures

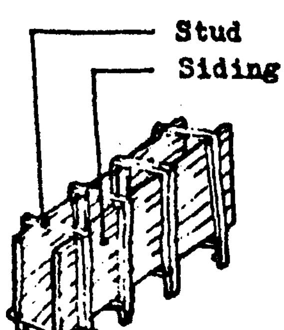
The only type of water measurement structure employed in pond systems is the sluice gate. However, their main function is to admit water to the ponds rather than to measure the flow of water.

Engineering analysis

The flow through a sluice gate is determined by the following formulas: (a) $Q = CA\sqrt{2gh}$ if it acts as a submerged orifice, and (b) the Francis formula if it acts as a weir.

Gates

Water sluice gates are either made of poured concrete, CHB with concrete frame, adobe, stone or lumber. Single, double and triple gates are generally used.



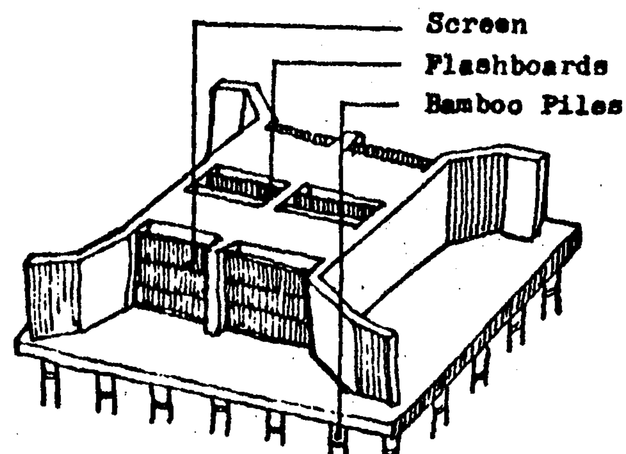


Fig. 6 Gates

3. Water Conveyance Structures

Water in rivers and ponds are conveyed either in open or closed conuits. The most common structures employed in the conveyance of water to ponds are canals, flumes and tubes.

Engineering analysis

The formulas used in the analysis and design are the continuity equation, the Bernoulli equation and the Manning formula.

Canals

The most common type of conveyance channel used is the earth canal. The sides of the canals have slopes varying from 1:3 to 1:1. To overcome seepage losses, low velocities and erosion, the canals are lined either at the sides, at the beds or both. The materials used for lining are concrete, rock masonry, brick and natural clay of low permeability.

Flumes

Flumes are used for crossing natural depressions or for conveying water above dike level. They are constructed either of wood, metal or concrete.

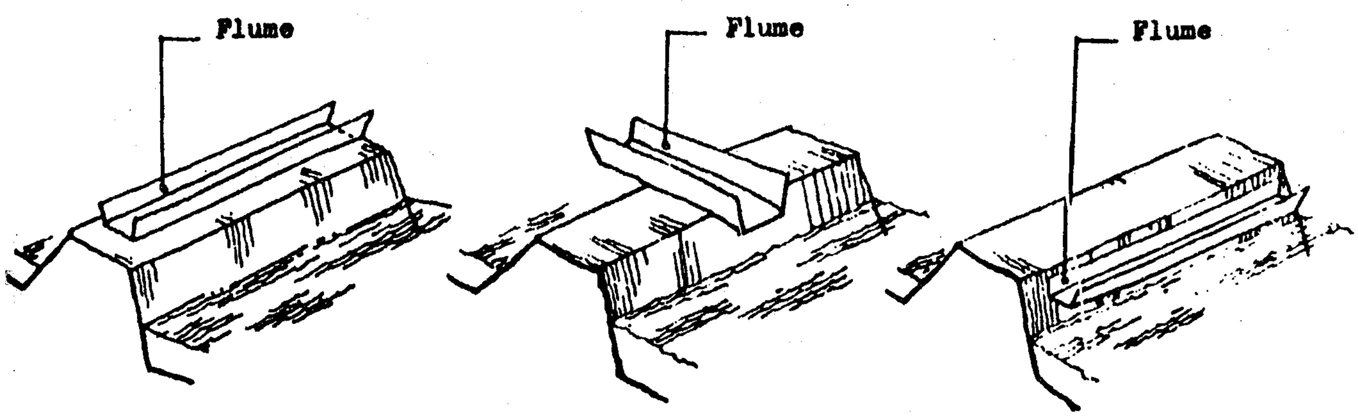


Fig. 7 Some Applications of Flumes

Flexible tubings

Tubing made of rubber or plastic is also used to convey water. The tubing is generally flexible so that it will lie flat when no water is in the rope.

4. Water Impounding Structure

The water impounding structures generally used in a prawn pond system are the earth dams, nursery ponds, grow-out ponds, reservoir ponds, sump ponds.

Engineering analysis

The design of impounding structures is essentially the design of embankments or levees. The procedure consists of determining the height of the embankment, its slopes, its stability and the seepage flow associated with the design.

Construction of embankments

Three methods are employed in the construction of embankments - the line system, the sliding system and the raft system.

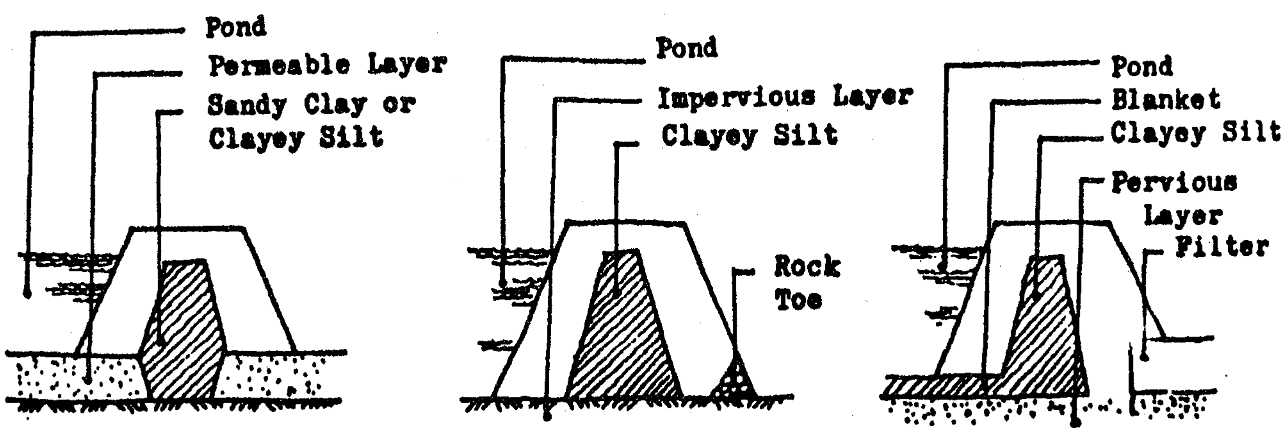


Fig. 8 Embankment Sections*

Nursery ponds

The usual shape of nursery ponds are rectangular and square. The compartment size ranges from 500 to 1500 sq m. Its orientation depends on the prevailing wind direction. The depth is usually 60 cm. It is provided with an aeration system and provisions for easy drainage are made.

*Diagrams taken from R.G. Hechanova's paper entitled, Practical Applications of the Basic Principles of Hydraulic and Soil Mechanics in Aquaculture Engineering.

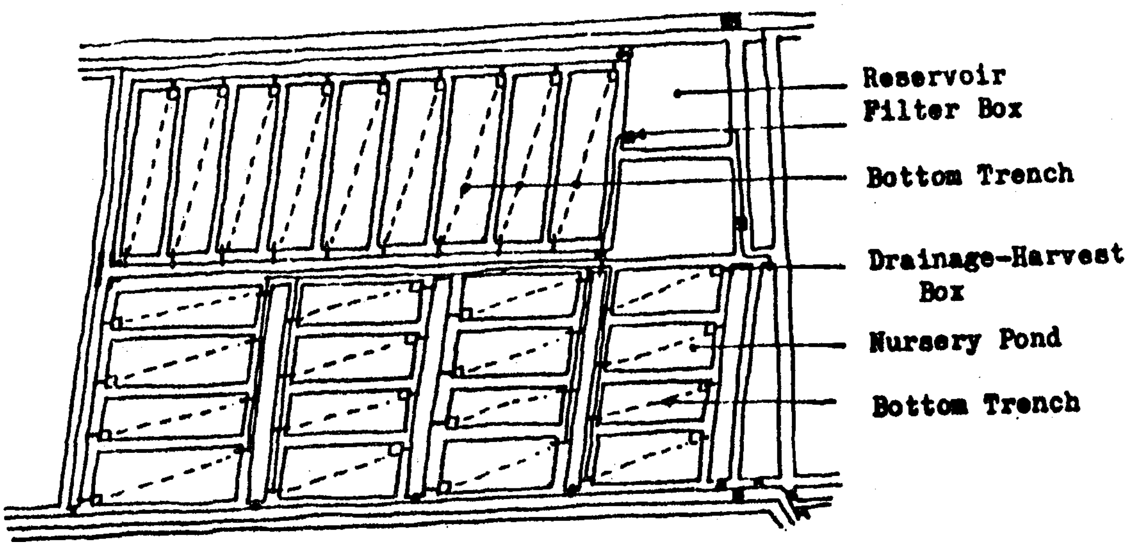
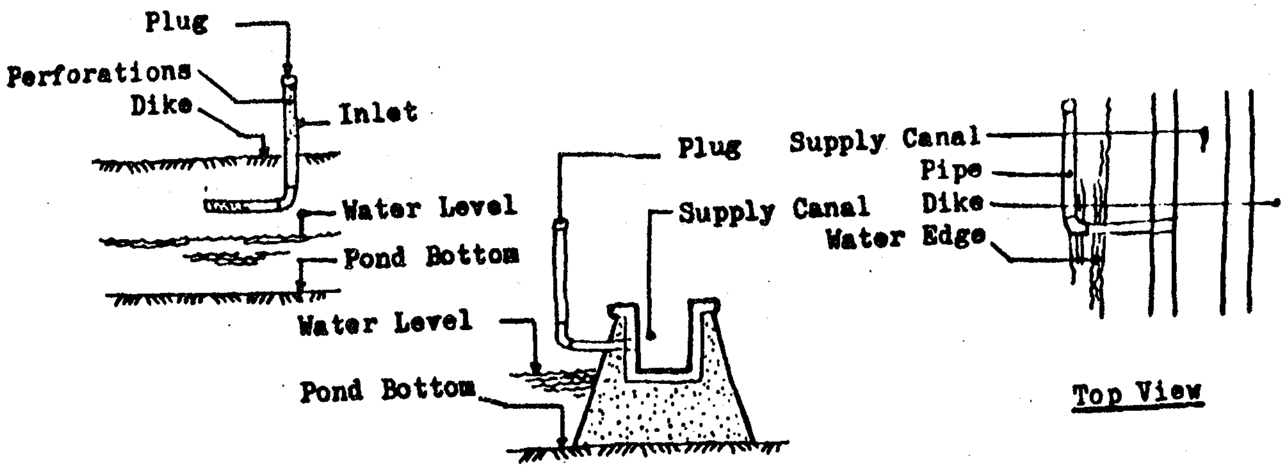


Fig. 9 A Nursery Pond System*



Vertical Position*

Fig. 10 Inlet Pipe

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*Diagrams taken from paper by F.D. Apud and M.A. Sheik entitled, Design and Construction of a Prawn Nursery Pond System.

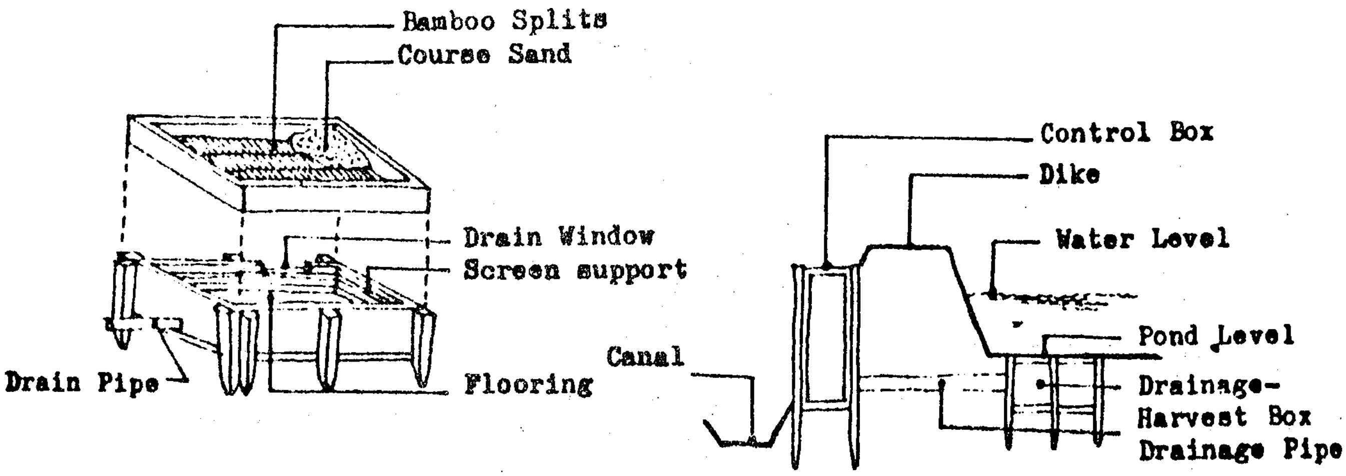

Fig. 11 Drainage-Harvest Box*

Grow-out ponds

The common size for grow-out ponds is 1 hectare. The shape is rectangular and the depth is usually 1.20 m. Other features are similar to that of the nursery ponds.

Reservoir ponds

Reservoir ponds are rectangular in shpae. Their sizes are deterdmined to supply approximately three days replenishment of nursery and grow-out ponds. Water depth ranges from 1.6 to 1.8 m. The base is usually 6 m and the crown width is 2 m. The bottom of the pond is at least 10 cm above the highest bottom elevation of nursery and grow-out ponds. Reservoir ponds for the nursery ponds are equipped with filters.

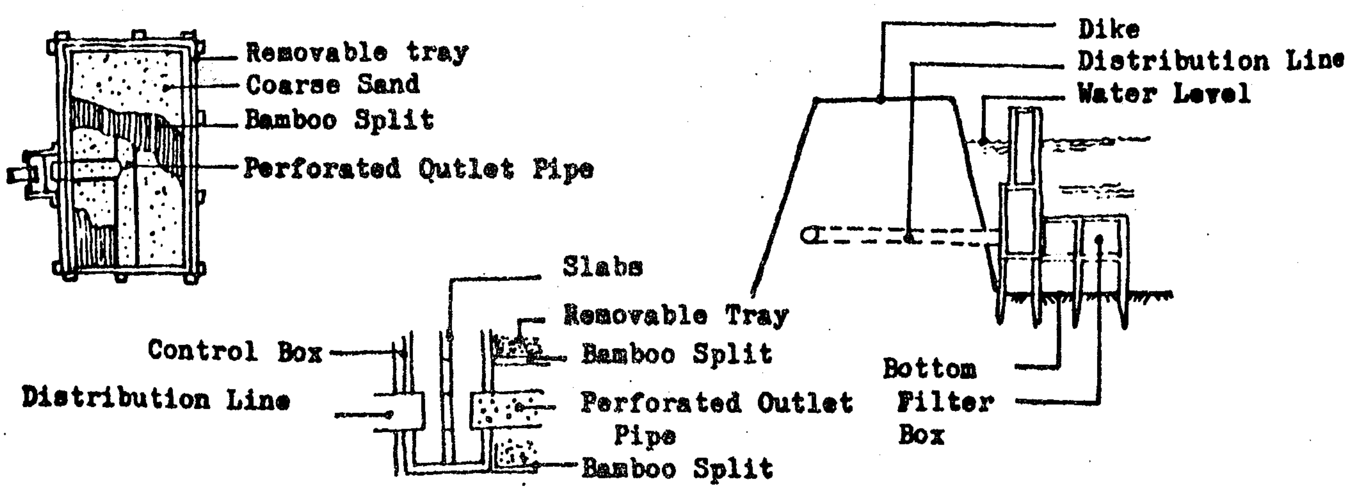

Fig. 12 Filtration Box*

*Diagram taken from paper by F.D. Apud and M.A. Sheik entitled, Design and Construction of a Prawn Nursery Pond System.

Sump ponds

Sump ponds are reservoir ponds for drainage wayer to be deposited prior to their being released to their points of disposal. Sump ponds are also utilized as harvesting ponds.

5. Pumps and Wells

Wells

Two types of wells commongly used are the shallow well and the deep well. Deep wells are usually preferred because of lesser danger of contamination. The formulas used in determining discharges of wells are the Darcy formula for confined wells and the Dupuit formula for unconfined wells.

Pumps

Four basic designs of pumps are generally used. These are (a) radial type (b) Francis type (c) mixed flow type and (d) axial flow type. The characteristics of these pumps are shown in Fig. 13. Typical pump installation are shown in Figs. 14 to 16.

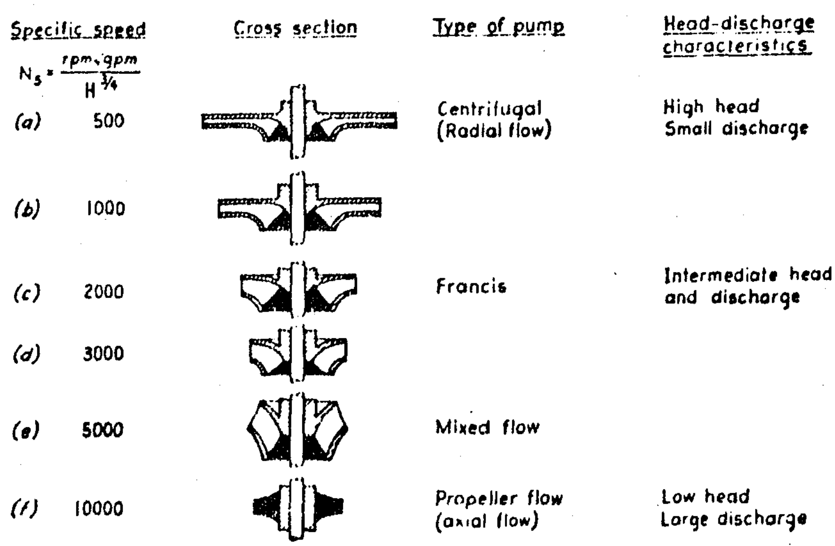

Fig. 13 Pump Characteristics*

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*Chart taken from Irrigation Principles and Practices by W.O. Israelsen and V.E. Hansen.

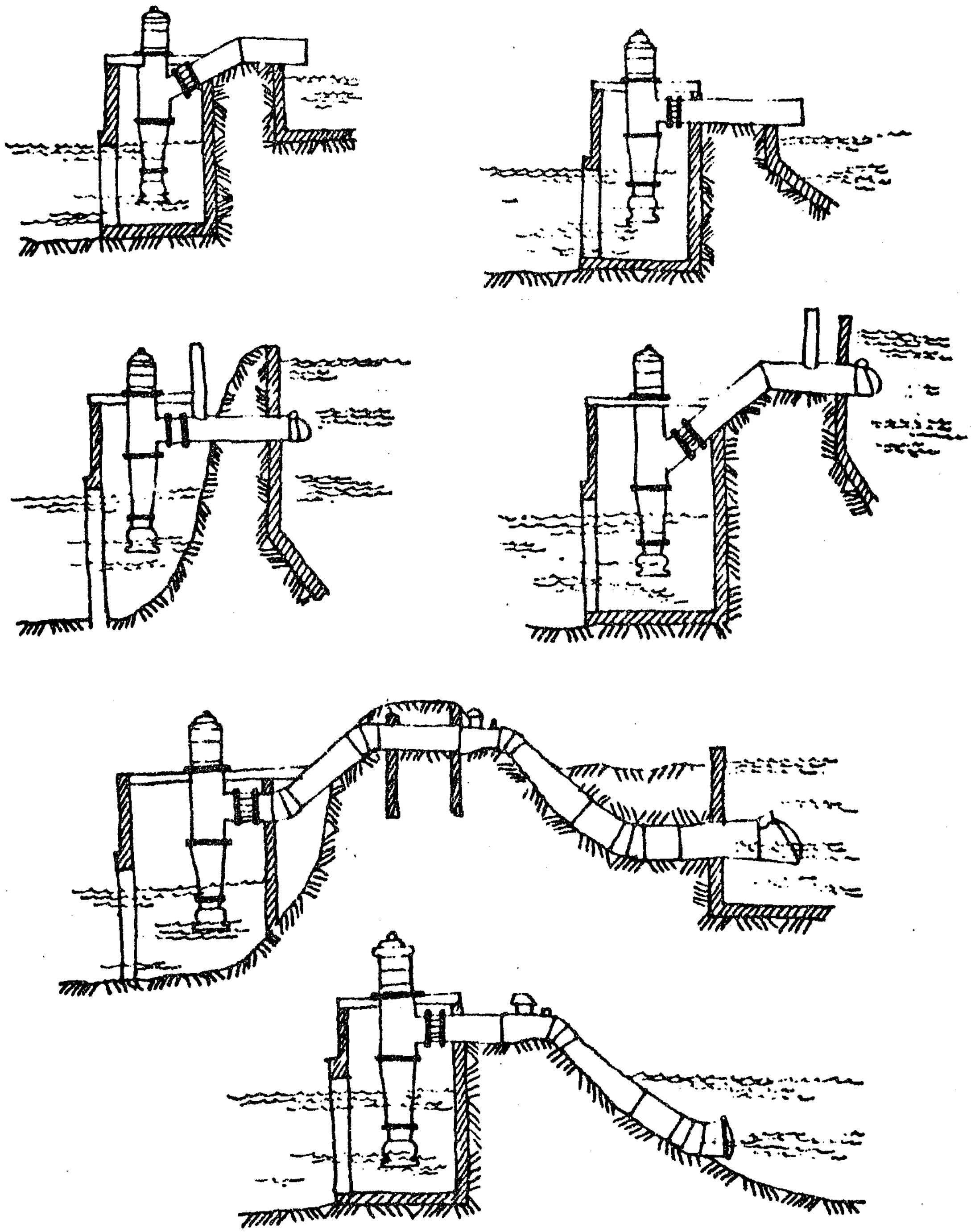

Fig. 14 Pump Installations*

*Diagrams taken from T.J. Jamandre's paper entitled, Pumps for Brackishwater Aquaculture.

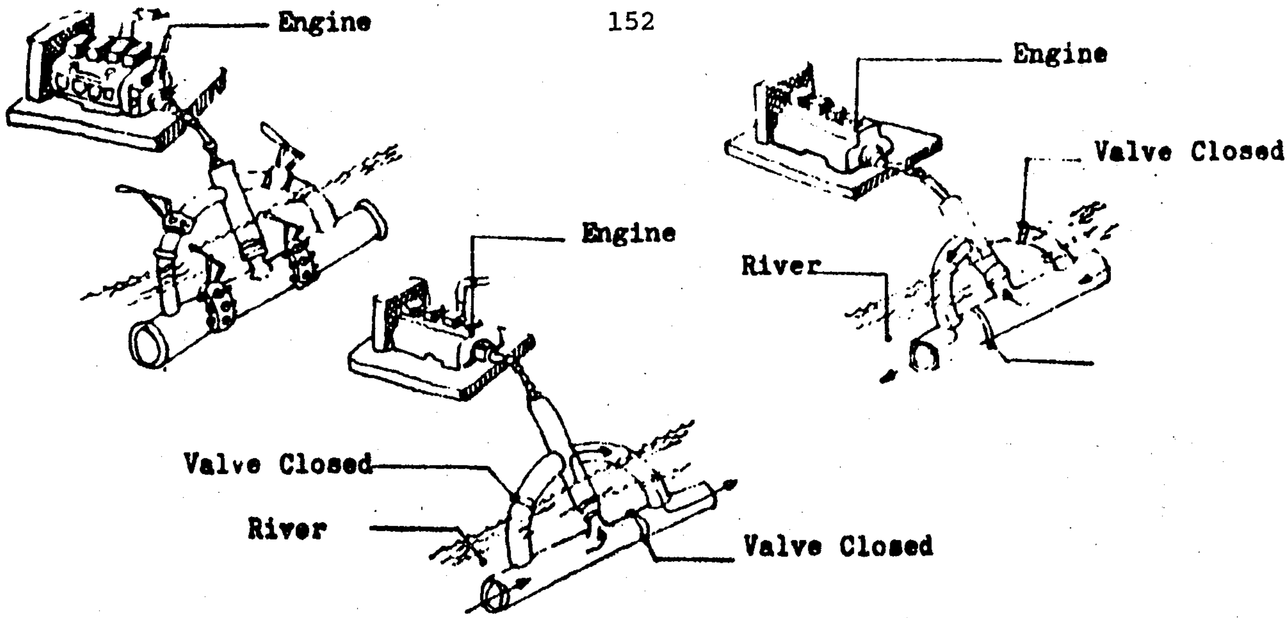

Fig. 15 Watering and Dewatering Ponds*

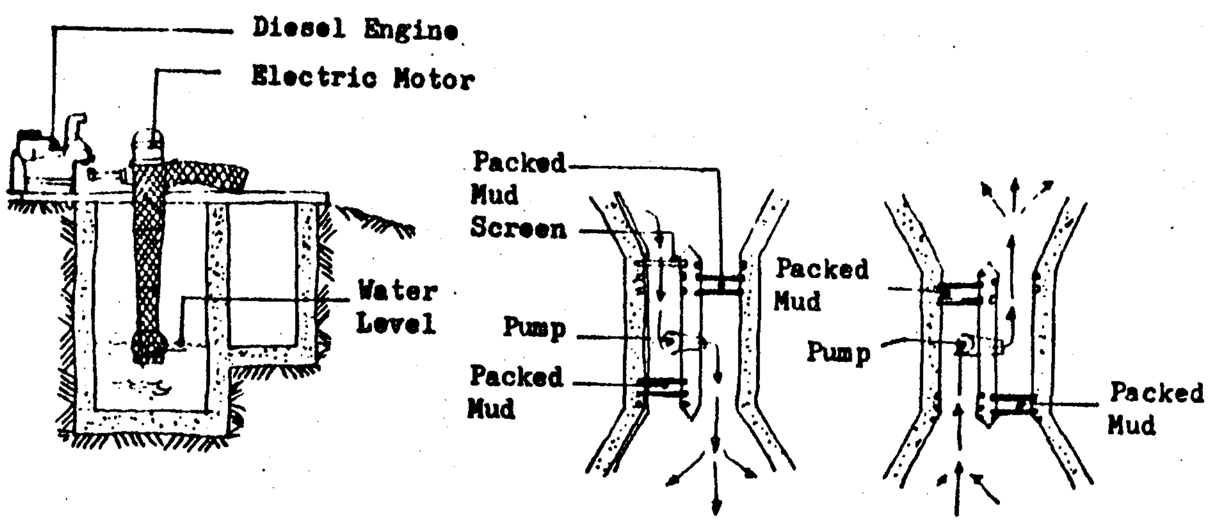

Fig. 16 Main Tidal Gate Pump Installation*

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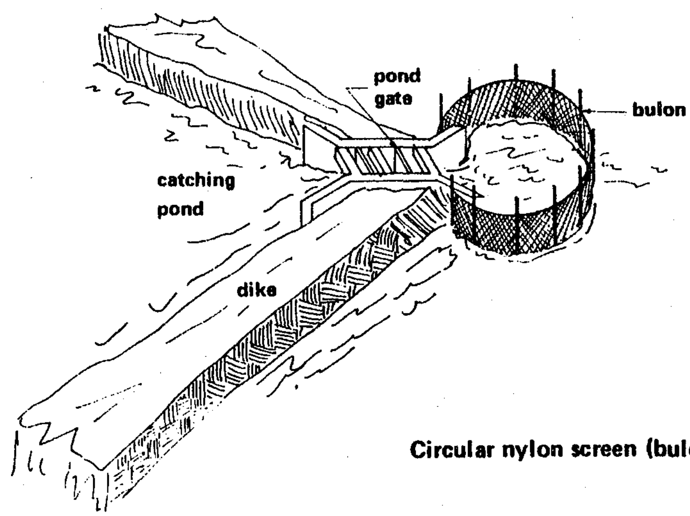
*Diagrams Taken from T.J. Jamandre's paper entitled, Pumps for Brackishwater Aquaculture.

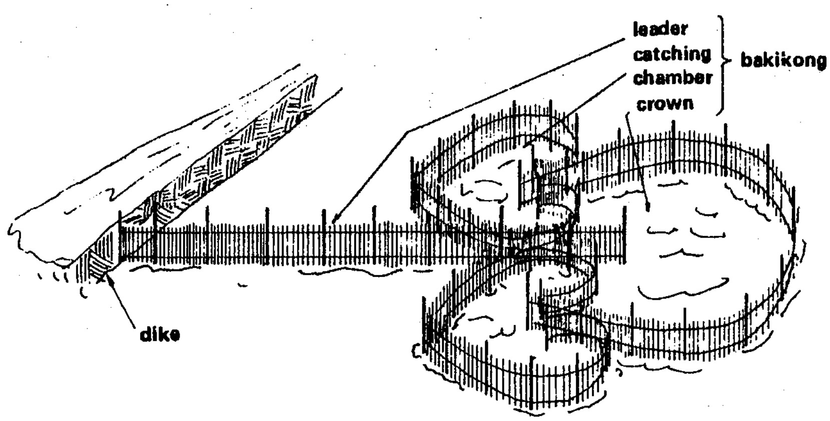
6. Other Equipment and Accessories

Tidal gauges
Aerators
Electric motors and diesel engines
Trapping gears

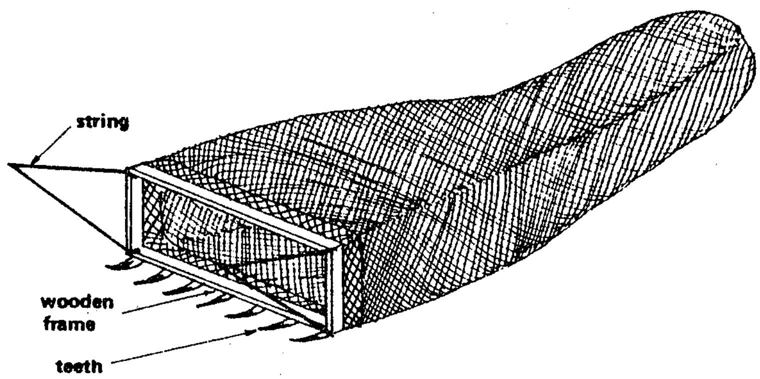
The commonly employed trapping and catching devices for prawns are the following: (a) bulon or nylon screen trap for use in draining ponds, (b) bakikong, lumpot and bagnet for harvesting juveniles and full-grown prawns, (c) shrimp cage and suspension net for carrying prawns, and (d) seine, scissor and dredge nets for catching remaining prawns in ponds.



Circular nylon screen (bulon)



Bamboo shrimp trap (bakikong)



Dredge net

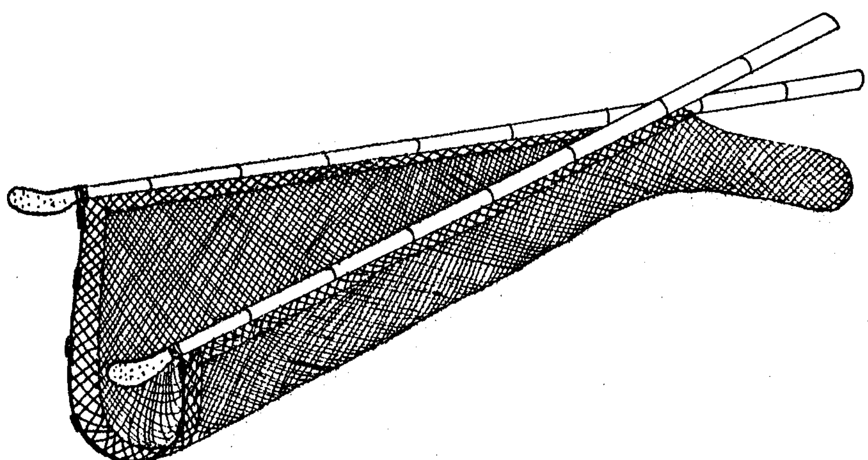
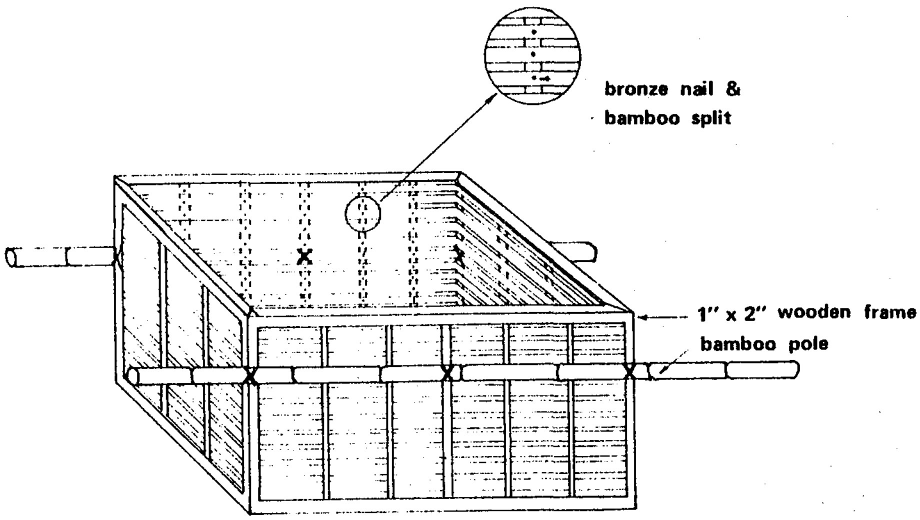
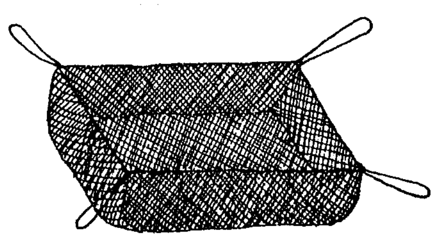

Scissors net

Fig. 17 Commonly Used Trapping Devices*

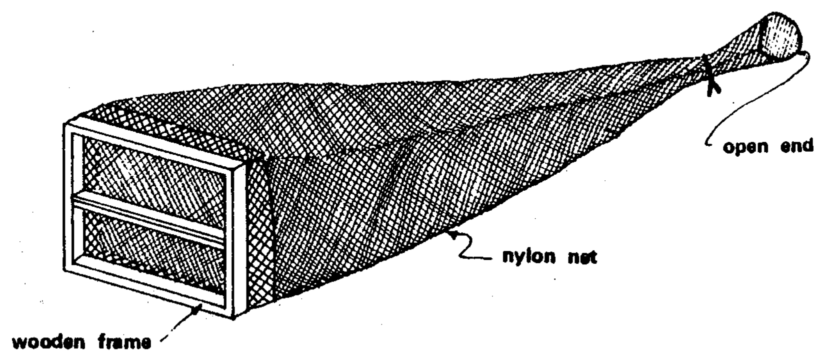
*Diagrams taken from Manual of Pond Operations: Sugpo Pond Culture, by J. H. Primavera and F. D. Apud.



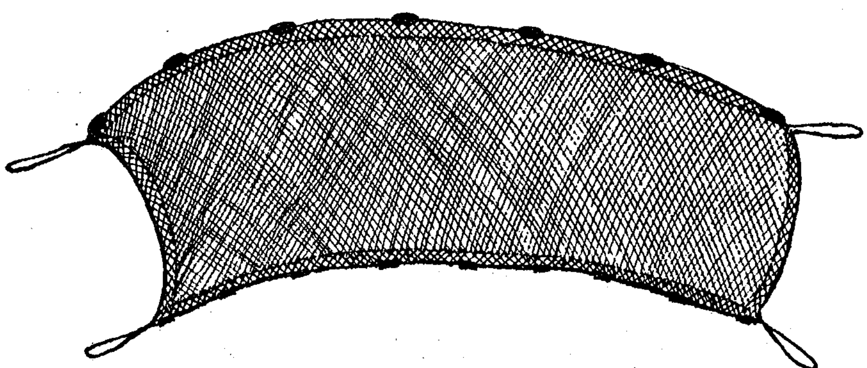
Bamboo cage for transport of juvenile or adult sugpo.



Suspension net (bitinan)



Bagnet (lumpot) attached to wooden frame



Seine net

Conclusion and Recommendations

Conclusion

The subjects of water flow, levees and embankments, foundations, and hydraulic structures are well advanced in the field of hydraulics, soil mechanics and foundation engineering. However, these developments have not been fully applied in pond layout, design and construction. One reason is the fact that these topics are highly complex and technical. There is a need for translating these concepts and principles into more simplified forms. There is also a need to develop low-cost pond structures using indigenous materials which are appropriate for use in the rural areas.

Recommendations

Preparation of a handbook on pond layout, design and construction for laymen with engineering principles and concepts presented in the simplest forms.

Use of water measurement structures such as the parshall and trapezoidal flumes.

Design, development and fabrication of cheap, durable and portable gates and flumes.

Improved methods of embankment stabilization using low-cost materials such as clay, soil-cement, bamboos, etc.

Improved drainage methods for pond systems.

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