Training Manual on Modern Technology for Seabass Production

Prepared by

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Ministry of Commerce
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Assisted by

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1. Introduction

Presently, Aquaculture production in the coastal region of Bangladesh depends largely on the production of Black Tiger Shrimp while some other species like Asian Seabass (*Lates calcarifer*) are also produced following traditional practices using trash and live fishes as feed. A planned strategy to produce Seabass, as is done in many Asia-Pacific Countries, using modern production methods involving, among others, breeding process to produce fingerlings in hatcheries and use of formulated feed, can open up new opportunities for farmers in the coastal region to produce an additional species which is indigenous to the region and comparatively less susceptible to diseases compared to Black Tiger Shrimp. This species may have considerable good returns for the farmers who do also need to adapt their production practices to cope with adverse impact of climate change- rising of sea-level and increasing salinity.

The present manual has been prepared with main focus on modern Seabass production process with the active support and assistance from the Business Promotion Council of the Ministry of Commerce with a view to helping interested stakeholders in Bangladesh who would like to undertake Seabass production both for domestic consumption and potential export to the international markets. The manual outlines in detail the breeding technology for Seabass production and other important aspects of Seabass production with special focus on breeding technology of the species appropriate for hatcheries.

2. The structure of the Manual

The manual has been so structured to include in depth details on the following important aspects of the general characteristics of Seabass and various stages of its production.

1. **Biology of Seabass Production**
2. **Requirements for the Production of Seabass Seeds in Hatcheries**
3. **Hatchery Production of Seabass**
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5. **Grow-out of Seabass**
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6. **Nutritional/ Feeding Aspect of Seabass Production**

3. Biology of Asian Seabass (*Lates calcarifer*)

The Asian Seabass (*Lates calcarifer*) is a euryhaline species that can tolerate a wide range of environmental salinity ranges (0 – 35‰). It is widely distributed in the Indo-West pacific region, from the Arabian Gulf to China, Taiwan, the Philippines, the Indonesian archipelago, Papua New Guinea, and Australia. Seabass supports important commercial and recreational fisheries throughout its entire distribution range, and has developed into a mature aquaculture industry. The aquaculture industry of this species is well established in Thailand, Malaysia, Singapore, Indonesia, Hong Kong, Taiwan, the Philippines and Australia. Thailand is well known for its Seabass culture as it was here that culture techniques were first developed -in the 1970's. Culture of this fish has been fairly widespread since then.

Seabass has a complex life history. Seabass attains sexual maturity at two to three years of age. The fish mature initially as males and participate in one or more spawning cycles before undergoing a sexual reversion (protandry or protandric hermaphroditism), becoming functional females by the next breeding season. Usually, fish less than 80 cm in length are males and those greater than 100 cm are females. The broodstock are ready to spawn at the end of their third year when their body weight reaches 3.5 kg. For male spawners, maturing age is 2-4 years and for females 3-4 years. In captivity, barramundi have often exhibited a very short male phase becoming functional females when they reach 50 – 60 cm in length. The reasons for this have been variously attributed to the captive environment, increased and more regular feeding or hormone treatments used during the spawning season. Interestingly, in Queensland and the Northern Territory, male fish held under conditions of constant temperature and monthly, year-round spawning, have often shown delayed sex change.

Even though Seabass can live in either fresh or salt water, their eggs and early-stage larvae will only survive in sea water (salinities between 22 – 40‰). For this reason, breeding takes place in river mouths and bays near areas of suitable nursery habitat. Areas such as mangrove swamps and low-lying land that becomes flooded during spring tides and monsoonal rains provide ideal habitat for juvenile barramundi.

Seabass

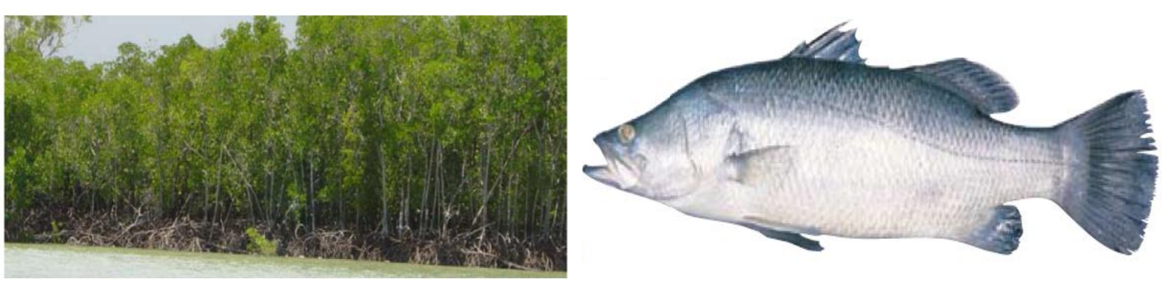

Figure-1: Mangroves is the Main Natural Breeding Ground for Seabass

In general, Seabass is an opportunistic predator throughout its life cycle. Fish less than 4 cm feed on "microscrustacea" almost exclusively; 30-cm fish have diets of "macrocrustacea" such as shrimps and fish; larger individuals predominantly prey on fishes. In captivity, Seabass accepts pelleted rations. Spawning of Seabass takes place at night around the time of the slack tide and appears to be related to the lunar cycle. The nights following full and new moons are the periods of greatest spawning activity. Each female may release many millions of eggs (the highest reported number is 40 million, although 6 – 8 million is more common) as she swims in tandem with one or more males that release a cloud of sperm to fertilize the eggs in the water. The actual release of the eggs lasts only a few seconds and the males immediately ‘pirouette’ around the female’s tail, releasing their sperm. The eggs are capable of being fertilized for only the first few minutes before they ‘water harden’. Once fertilized, the eggs drift in the current for 12 – 15 hours until the larvae hatch. The larvae of Seabass live on their yolk sac for the first 36 – 40 hours and then feed on microscopic zooplankton. They continue to feed on plankton for a number of weeks, moving on to larger prey as they grow rapidly. This species is cannibalistic and many of the juveniles may end up being eaten by other individuals not much larger than themselves. The surviving juveniles may remain in their nursery habitat for most of the wet season. As water levels in the nursery swamps begin to fall, most of the young fish will move upstream into fresh water and stay there for two to three years until they mature. Fingerlings ranging from 10-20 cm are found at the beginning of the rainy season from the previous year's fry. The subsequent supply during rainy season consists of mixed sizes but small sizes of 2-5 cm are quite dominant. However, sea bass fry collected from natural sources are usually big enough (size of 10-15 cm) for stocking in grow-out ponds and cages.

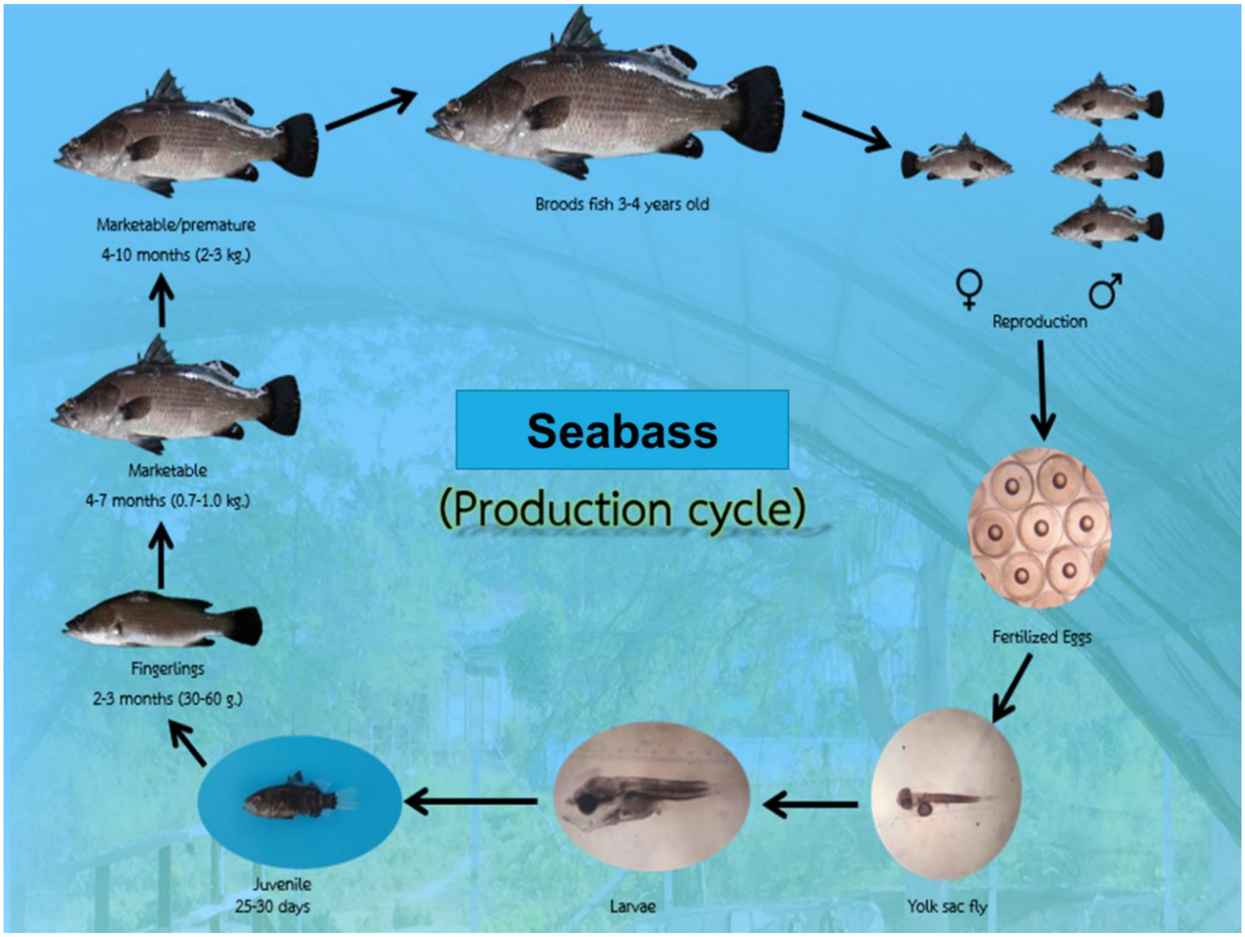

Figure-2: Life Cycle of Seabass

4. Requirements for the Production of Seabass Seeds in Hatcheries

The required important facilities for the Seabass hatcheries ideally should include the following:

a. Broodstock holding tanks
b. Maturation tanks
c. Spawning tanks
d. Egg incubation tanks
e. Artemia hatching tanks
f. Live feeds (Algae and Rotifers culture tanks)
g. Larvae rearing tanks

The saline water for the above can be drawn from a bore-well in the inter-tidal area or from open seawater. Water drawn should be stored in reservoirs and filtered through bio-filters, rapid sand filters and ultra-violet filters to maintain the required water quality. The broodstocks are the most important inputs for the hatcheries. The source of broodstocks can be either from wild or the rearing ponds/cages. Brood fish ranges in size from 2.02 to 10.0 kg. Smaller size for males and larger ones for female which can be induced to mature and spawn within 6 months. Transportation of broods should be handled with great care so that they are not damaged or harmed. They can be carried using open or closed containers sealed with soft materials lined rubber-foam mattress materials and proper oxygenation. Before transporting the fishes into the broodstock tanks, of appropriate size with PVC inlet and outlet, they should be acclimatized in the hatching tanks for 2-3 days.

5. Hatchery Production of Seabass

Hatchery production starts with the spawning of captive breeding fish or ‘broodstock’ and is completed when the small fish or ‘fingerlings’ are 20 – 25 mm long and are feeding on formulated diets. Broods of Seabass require large, fibreglass, seawater tanks. The main breeding fish are kept in circular tanks (>30,000 L), operated on a re-circulating sea water system. Suitable water temperature and salinity is considered as 30°C and 30‰, respectively.

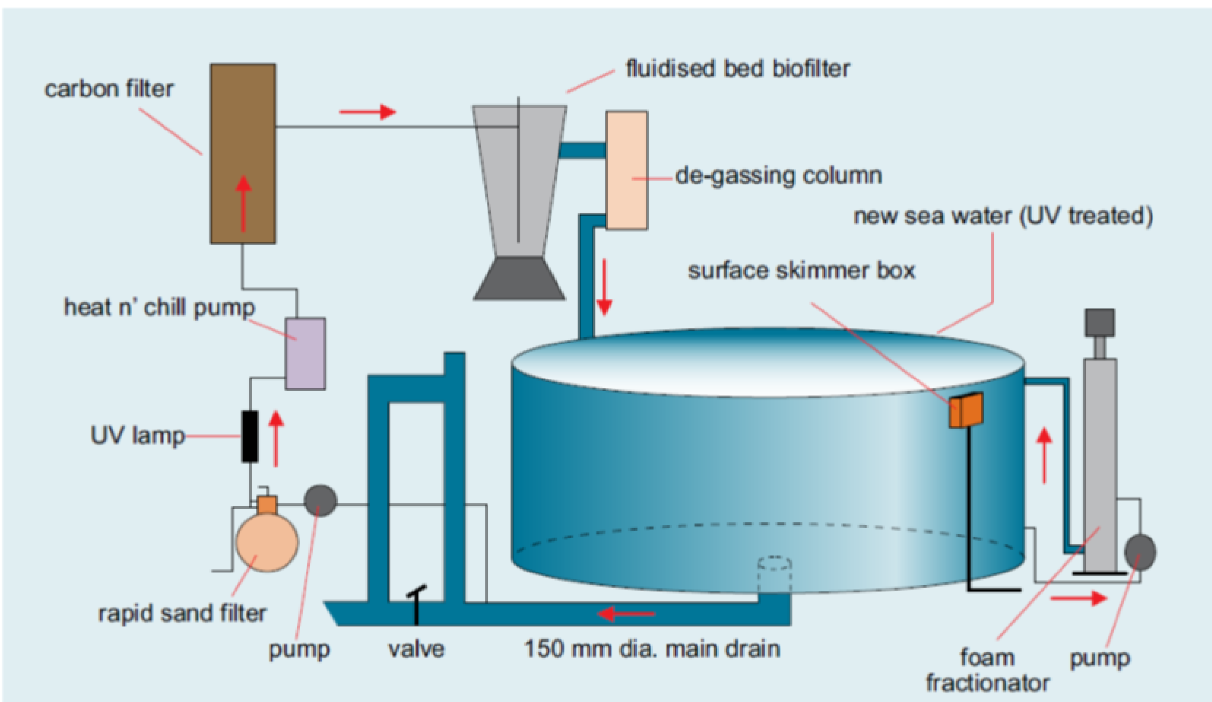

Figure-3: Hatchery Production of Seabass

Broodstock of Seabass are fed with high quality diet consisting of freshly thawed whole mullet, sardines, squids and poilychaetes occasionaly or other small fishes once a day in the morning at 2% of their body weight. The excess food which settles down at the bottom of the tank is removed by siphoning. The size of the feed is usually 10 – 20 cm per piece. The fish are fed three days a week and tank cleaning is undertaken on the non-feeding days. For better performance, broodstock can be fed with high quality formulated feed (50% protein content) and also with vitamin mix.

5.1. Spawning and Induced Breeding

The hormone used for inducing spawning of female Seabass is Luteinising Hormone Releasing Hormone analogue (LHRHa). It may be administered to the fish either by injection in liquid form or by implantation of a slow releasing cholesterol pellet. The dose rate administered to females is in the range of 50 – 100 µg per kg body weight, with the lower end of the range being favored. Male fish, if induced, normally receive 25 µg per kg.

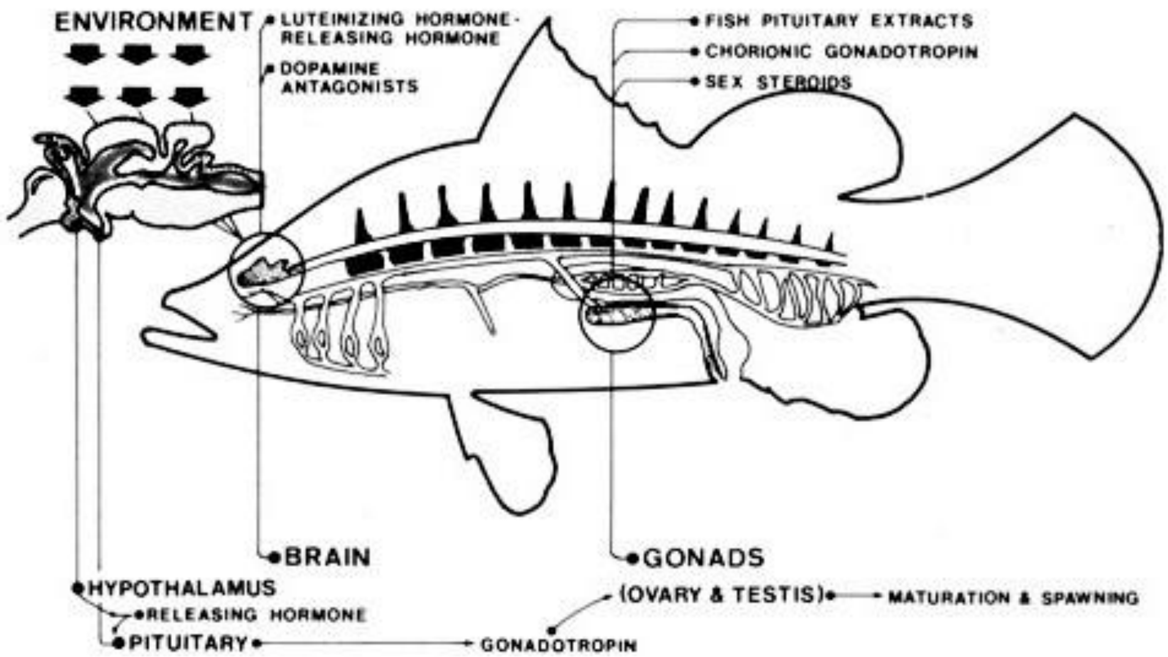

Figure-4: Levels of exogenous intervention in the hypothalamus-pituitary-gonad axis leading to gonadal maturation and spawning

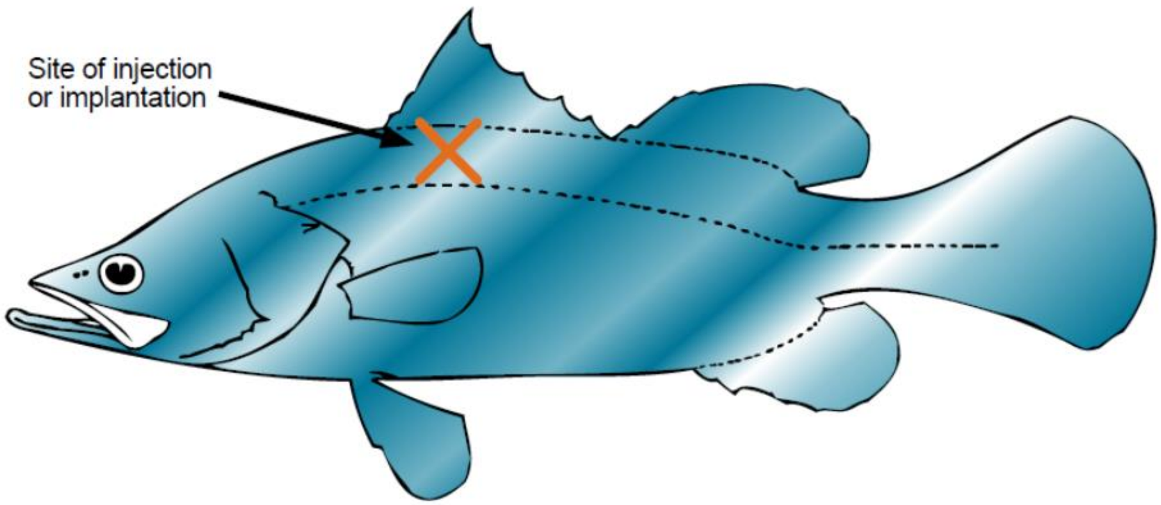

Figure-5: Site of Injection for Induced Breeding of Seabass

Female fish are examined first and are selected for spawning on the basis of a sample of oocytes removed from the ovary by cannulation. The cannula is gently inserted through the genital opening for a distance of 6 – 8 cm and the plunger on the syringe is withdrawn slightly. As the plunger is withdrawn the cannula is pulled back out from the fish. If a sample of oocytes is not obtained the process may be repeated but no more than three to four times. The oocyte sample is examined under a microscope for size and shape. Suitable oocytes are greater than 400 µm in diameter, are separate from each other and spherical in shape.

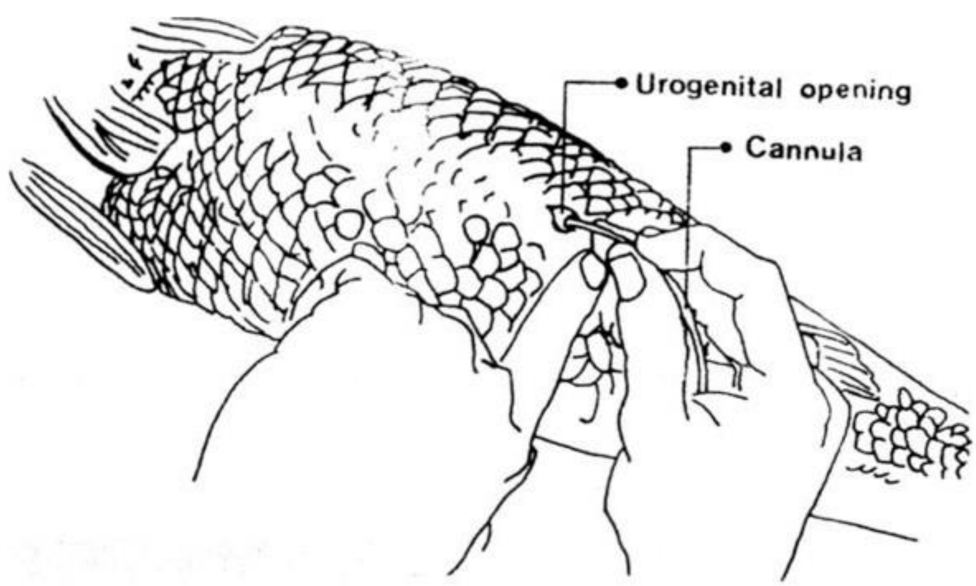

Figure-6: Sampling for sex determination. A cannula is inserted into the urogenital opening to obtain egg or sperm sample.

If the female contains suitable oocytes she is induced straight away, otherwise another female is caught and examined. Once induced, the female is usually transferred to a separate spawning tank. Male fish are also examined by cannulation. Providing the cannula withdraws a small sample of sperm, and the sperm swims actively when mixed with a drop of saline water, the fish is considered suitable for spawning.

5.2. Egg Collection, Evaluation and Disinfection

Fishes spawn in the fiberglass tanks. Two tanks are normally used and each has a slot cut in the tank wall for skimming the water surface. The buoyant fertilized eggs are carried through the skimmer by an overflow of water and are trapped in a 250 µm net suspended in a water-filled collecting basin. One female is usually paired with two to three males. On some occasions the induced female is left to spawn with all available males in the main holding tank. In this case eggs are airlifted into floating cages fitted with 250 µm mesh nets.

The eggs can stay in the collection net for several hours but it is better to use them as soon as possible. Eggs are scooped up with a 150 µm soft, mesh net and immediately transferred to a basin of sea water at the same salinity and temperature as the spawning tank. A sample of eggs is examined microscopically for quality, size and egg development stage. High quality eggs have a high fertilization rate, are between 800 and 850 µm in diameter and have a single oil droplet. Another indicator of egg quality is that they should float strongly in a beaker of sea water. Weakly floating or sunken eggs are usually discarded. Suitable eggs are taken into the hatchery, rinsed with filtered sea water and treated in a bath of ozonated sea water before being transferred to hatching tank (1000 L is preferable). The hatching tank is supplied with filtered, UV-treated sea water at a flow rate of about five liter per minute. Gentle aeration is supplied and the central outlet of the tank is screened by a 250 µm mesh net to prevent any loss of eggs. Up to 2,000,000 eggs can be placed in to a 1,000 L tank (2,000 eggs per L). Suitable temperature for hatching and larval rearing is 28 – 30°C. The procedure for collecting spawned eggs from tanks or cages is as follows:

- Check for the presence of spawned eggs in the tank by examining water samples collected with a glass container. Fertilized Seabass eggs float and are normally transparent.
- If eggs are present, collect the eggs with a soft and fine-mesh seine net (mesh size of about 0.4-0.5 mm). Concentrate the eggs in the middle of the seine net and gently scoop out eggs with a small bowl.
- Collect the remaining eggs, securely place at the outlet canal a wooden box with a fine-mesh screen bottom.
- While the tank is gradually being drained, gently scoop out eggs from the wooden box and transfer them to a 15 L pail containing aerated fresh seawater. This procedure minimizes impact-related stress and mortalities during draining and collection of eggs.
- Screen out any debris mixed with the collected eggs.
- Rapidly but gently transfer eggs to a fiber glass tank containing 250 L of aerated fresh seawater.

- Spawners are returned to the spawning tank after refilling with seawater.

Fertilized eggs are to be incubated in fiberglass tanks at a density of 1,200 eggs/L or less. Provide gentle aeration to keep the eggs suspended in the water column. Hatching will occur approximately 14 hours after fertilization at 28 – 30°C and 30 – 35‰.

Two to three hours after the larvae hatch, the water and air flow to the tank are stopped, and the water in the tank gently swirled. This helps the egg shells settle into the center of the conical based tanks, from which they can be siphoned to waste. After swirling the shells are left to settle for fifteen to twenty minutes. After siphoning the air flow and water flow to the tank are resumed. The larvae are kept in these incubation tanks until they are either packed for shipment to other farms or stocked into larval rearing tanks.

The culture of larvae or larviculture, is defined as the period from hatching until the fish metamorphose into their final 'fish' shape and eat (wean onto) a formulated diet. For the Asian Seabass, the larviculture phase is generally completed once the fish reach a size of 15 – 20 mm (3 – 4 weeks). Ideally the first two weeks of the larviculture must be done at salinities ranging between 25 – 35% and a water temperature range of 27°C to 31°C.

The larvae need to kept under controlled conditions in either flow through or re-circulating saltwater systems. The larvae are fed a diet of zooplankton, usually Rotifers and Artemia, for the first two to three weeks and are then weaned on to a formulated diet. The intensive culture system imitates a small food chain. Pure strains of microalgae are fed to zooplankton cultures. The plankton is in turn, harvested and fed to the fish larvae. Because of the high concentration of animals in a relatively small volume, the whole process is very dependent on adherence to a strict hygiene and management routine.

Live foods (algae, Rotifers and Artemia) are grown in batch culture and larvae are to be kept in small (1,000 – 10000 L) tanks. New sea water is added regularly to control water quality in the larval tanks. The larvae in this system are fed several times throughout the day by harvesting zooplankton from the batch cultures. The nutritional quality (particularly the essential marine oil content) of the harvested zooplankton is boosted by using one of a number of commercially available products. After boosting, the zooplankton is thoroughly rinsed to remove oily residue and to reduce bacterial contamination and then the feed is added in the required quantity to the larval tanks.

5.3. Larval Rearing

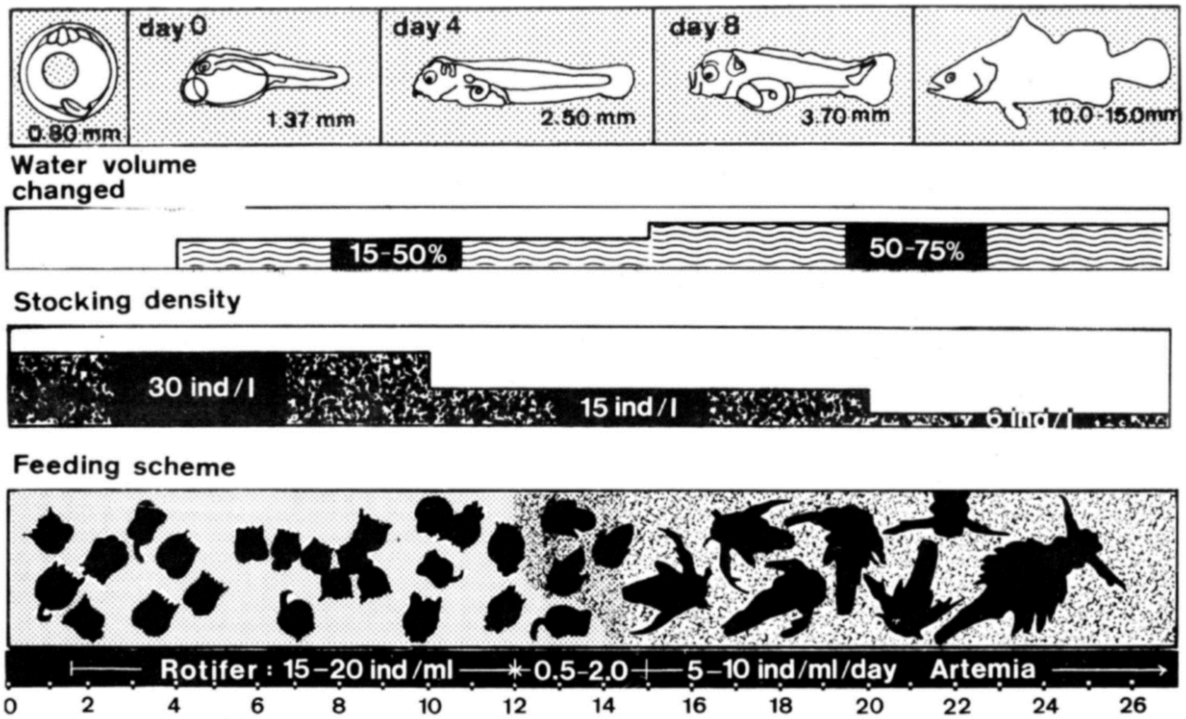

Figure-7: Flow-diagram of Larval Rearing of Seabass

Upon hatching, transfer larvae from the incubation tank to the larval rearing tank. Stock larvae at an initial density of 30 ind./L. Higher densities, e.g., more than 90 ind./L, may be adopted based on production targets (in terms of fry size and number of individuals harvested) and level of capitalization. Reduce the density to 15 ind./L when larvae reach 10 days old and further to 6 ind./L when 20 days old.

Seabass begin to feed 50 h after hatching at 28°C. However, it is advisable to introduce the larval feed at an earlier time. If larvae are unable to feed 60 h after hatching, irreversible starvation will occur and at least 50% of them will die. Larvae should be weaned gradually to each new food type. This is done by increasing daily the proportion of the new food type while gradually reducing that of the preceding food. This is necessary to train the fish to recognize and accept the new feed particle. If weaning is done properly, feed wastage and fish mortality due to starvation are minimized.

Larval rearing of Seabass is largely dependent on the use of live food organisms, e.g., rotifer (*Brachionus plicatilis*), Artemia (newly hatched nauplii, enriched nauplii, subadult or adult biomass), and the freshwater *cladoceran* Moina.

Phytoplankton culture: Algal species used in seabass hatchery are Chlorella sp., *Tetraselmis sp*. and *Isochrysis sp*. All stages of the phytoplankton culture procedure are conducted in the phycology lab or algal room, except for large scale culture (more than 1 ton per tank) which are done outdoor.

Rotifer culture: Rotifer is one of the most important feeds required for early stages of seabass larvae. It is rich in nutrient and small in size for the larvae to consume. In the larval rearing of seabass, rotifers in rearing water should be maintained at a density of 3–5 ml for at least 10 days. Rotifer are usually reared either in concrete of fiberglass tanks. The size of the culture tank ranges from 1 ton to 50-ton tanks. The tanks are initially filled with Chlorella culture at a density of > 100,000 cell/ml. It is then inoculated with rotifer from another culture tank to a density of 10 rotifer/ml. Since the rotifer feeds on the algae, daily addition of the algae is necessary. Normally, rotifer production reaches a peak density of between 100–200 ml in about 7–8 days. After 2 days of feeding with algae, rotifer can also be fed with marine yeast as a substitute diet. Harvest of rotifer from mass culture tanks are done after a period of 7–8 days. While some are used directly as larval feed, a portion must be saved for future inoculation of other tanks. The hatchery should maintain pure stock (inoculum) of algae throughout the year. Sub-culture should be started each month so that larger cultures can be started as required.

Approximately 36 h after hatching of eggs, add rotifers to the rearing tanks at 15-20 ind./ml until larvae reach day 12. Maintain this density by daily addition of rotifers. Also add 60 liters of *Chlorella* in peak bloom to attain a density of 1-3 x 105 cells/ml. *Chlorella* is added to maintain water quality and serves as food for rotifers. From day 12 to 15, gradually reduce rotifer density until it is totally removed by day 15. Wean larvae to newly hatched Artemia nauplii over a 3-day period (day 12 to 14), although weaning may be done as early as day 8 or later depending on food availability and production target. During weaning, provide Artemia at increasing densities of 0.5 to 2.0 ind./ml/day. On days 15 to 17, increase Artemia density to 5-10 ind./ml/day. Feed larval fish with enriched Artemia nauplii from day 18 to 23 at a density of 5-10 ind/ml/day. This is important because Seabass exhibits higher survival rate during metamorphosis when fed enriched Artemia. As the larvae grow bigger, they ingest larger feed particles. They are fed subadult or adult Artemia biomass at 1 ind./ml or higher. As a partial or a complete replacement of Artemia, the freshwater cladoceran (*Moina macrocopa*) may be fed to Seabass larvae. Fed partially or as a complete replacement of Artemia, Moina can be fed to 17- to 20-day old larvae at a feeding rate of not less than 1 ind./ml. Moina are first sieved to obtain small adults and neonates for feeding to 17-day old larvae.

Starting on the 4^{th} until the 14^{th} day of culture, drain and replace daily 15-50% of the total water. On the 15th day, when feeding level with newly hatched Artemia nauplii is maximum, change daily 50-75% of water. Once feeding with non-live feed begins, change 100% of water daily. During water exchange, drain water in the rearing tank using a siphon with its inlet covered with plankton net. This is to prevent larvae from being drained. Refill tanks to its original volume with new seawater. In addition, siphon off feces and other debris found at the tank bottom every morning from the 3^{rd} day until harvest.

6. Nursery of Seabass

The nursery phase for Seabass can be defined as the growth period between 15 mm and 100–120 mm in length. It encompasses the completion of the process of weaning the fish from a live food diet onto formulated feeds and it is also the stage at which there may be a problem with cannibalism. Cannibalism is a significant cause of mortality in juvenile Seabass and is particularly a problem in fish up to 150 mm in size. Juvenile Seabass are capable of eating and/or causing mortal injuries to fish up to 75% of their own body length. Cannibalism is promoted by two main factors.

- Rapidly growing juvenile fish have a high energy requirement. If the need for energy is not satisfied by supplemental feeding the fish may look for extra energy sources such as other fish in the tank. Seabass is also naturally aggressive and look to strike at other fish within close proximity to themselves.
- The widely differing growth rates within the same age class of Seabass means that some fish quickly reach the size where they are capable of capturing and ingesting other, smaller fish. It is believed that larger fish are also more aggressive and successful at feeding when supplementary food is added. This then gives the larger fish a further growth advantage. It does not take long for a thousand or more cannibals, each eating at least two small fish per day, to have a significant impact on the numbers of fish in the nursery tanks. The two main ways to control cannibalism are:

a. **Regular grading:** During the early nursery stage (20–35 mm) the fish need to be graded every three to four days. Larger fish (50–100 mm) need to be graded weekly. This is the single most effective method for reducing cannibalism.

   In the rearing of seabass fry under confined conditions, the competition among the individuals for feed and space results in uneven growth of the fish especially if the stock is poorly managed. Heavy mortalities will also occur due to cannibalism and stress on small or weaker fry. Since seabass is a voracious carnivore, proper grading should be done to avoid cannibalism. The graded fish must be reared separately.

   Cannibalism in seabass larvae is distinctly rampant from the time the larvae start to feed on Artemia (day 10 larvae). Grading is usually done a week after the fish started to feed on Artemia and every week thereafter. Grading trays used are normally made of plastic basin with many holes bored through the bottom, or made of netting with a wooden frame (Fig. 19). Each tray has a specific hole or mesh size to allow specific size of fish to pass through. The size of the hole/mesh of netting in each vessel varies from 0.3–10 mm.

   Fish are placed in the trays which are floated in the newly prepared larval rearing tank. The smaller size fish can pass through the hole to the new tank. The remaining fish in the vessel are transferred into another tank and likewise graded with the use of a bigger hole or mesh tray. This procedure sorts out fish to several sizes and simplifies management.

b. **Maintaining optimal feeding:** If the fish are fed regularly and effectively it reduces the number of fish that are hungry and may decrease the number of 'strikes' they make on their tank mates.

7. Grow-out of Seabass

The grow-out phase for fish production can be defined as the growth of fish greater than 100 mm in length. Depending on the final market size, grow-out can be as short as three months for an entrée size fish of 250 grams or up to 18 months for a fish of more than 3 kg suitable for filleting.

7.1. Pond Culture

Earthen brackish water ponds are the traditional method used for Seabass culture in much of South-East Asia. Prior to the development of hatcheries, farmers used to collect wild fry and grow them in impoundments. There was little attempt made to regulate the numbers of fish grown and there was certainly no effort to grade them. The returns to the farmers were unpredictable using this method. Following the development of hatchery technology, the process of pond culture was made much more predictable. A known number of fish of a similar size could be stocked into a pond and the pond water conditions carefully regulated to achieve maximum return. Careful attention to design is the key to successful fish culture in ponds. Design of the ponds must take into consideration the following factors:

- Suitable soil type: The soil must be capable of retaining water. If it is not, then the pond may have to be lined either with compacted clay or with a synthetic liner. Both of these add to the cost of construction.
- The pond must be located near a water supply, either fresh, brackish or marine. The water should be available cheaply and not have to be pumped large distances or up too great a height.
- Location and size of the water inlet: Each pond must have its own water inlet. It is poor management to have the discharge water for one pond being the inlet water of another. The water inlet must be of sufficient capacity to be able to exchange the water in the pond rapidly if needed.
- Location and size of the water outlet: Each pond must have its own water outlet, preferably on the opposite side to the water inlet. The outlet must be of sufficient size so that the pond can be drained quickly if needed. One type of pond outlet is the water gate or ‘monk’ design.
- The pond must be designed for easy removal of the fish. The usual method is for the incorporation of a collection sump and drainage channel in the pond base or immediately outside the pond wall.
- The pond walls must be designed to minimize the chances of erosion or collapse when subjected to heavy monsoonal rainfall or tidal wash.
- The pond base must be carefully sloped so that the pond can be drained totally and the fish concentrated in the harvest sump.
- The pond must be located near a source of electricity for the operation of aerators, pumps etc.

- If the pond is marine, then it is advisable (although rarely practical) to have a source of fresh water available which can be used to control salinity or treat the fish therapeutically.
- The pond may have to be protected from predators, e.g. birds.

The main advantages of ponds for Seabass grow-out include:

- In areas where high tidal fluctuations and strong water currents make the placement of floating cages difficult, pump ashore, land-based farms are a viable alternative.
- Large volume ponds may also help reduce the incidence of cannibalism because they offer the smaller fish an improved chance of escape.
- To a large extent, earthen ponds are also able to be serviced, irrespective of the weather. Conditions of high wave action caused by storms or strong winds, which can make servicing cage farms impractical or dangerous, do not generally apply to pond farms.
- Chances of fish escapes are much reduced in ponds compared to cages.
- Usually, better control over water quality compared to cages.
- Less labor required than for cages, particularly true in areas that require regular cage cleaning.
- Disease management can be easier than for cages.

The disadvantages of grow-out ponds are:

- It may be difficult to monitor the fish because of turbid pond conditions. The farmer may be in doubt as to the actual number of fish surviving and their health status.
- Uneaten feeds and fish wastes may accumulate and if the ponds are not managed carefully, toxic conditions can develop quickly.
- Capture of the fish for grading, moving or slaughter may be more difficult than in cages. In the ponds the fish are spread over a wide area and, unless the pond is very well designed, the efficient capture of the fish can be problematic.
- Ponds can be more expensive to construct than cages.
- There may be a high cost of operation, especially with regard to aeration and water pumping.
- Large ponds are difficult to screen from predators such as birds.
- Marine ponds may need a large supply of fresh water to balance salinities during the dry months of the year.
- Water quality in ponds may change suddenly (e.g. the algal bloom in the ponds may crash on days of high humidity or after heavy rain) causing oxygen problems for the fish.

7.2. Cage Culture

Cage culture is the preferred culture method of Seabass in Thailand, Hong Kong, Malaysia, Singapore and Indonesia. In South-East Asia, cage culture is usually simpler and more profitable than pond culture. Traditional Asian cage farming uses either simple fixed or floating cages. Fixed cages are made by fastening a cage net to four wooden poles or stakes installed at its four corners. Fixed cages are usually set in shallow bays with narrow tidal fluctuation. In South-East Asia floating cages are made from timber, bamboo or steel walkways mounted on some sort of floatation from which the small cage net is hung. Floating cages are normally used in relatively deep, sheltered areas that are subjected to moderate tidal flushing.

Site requirements for grow-out cages:

- Depending on the cage design, the site should usually be sheltered and not overly exposed to prevailing winds or large wave action. Exposed sites require special cages which are usually expensive to manufacture.
- Water depth depends on the depth of the cage, but there must be at least 2 – 4 m clear between the bottom of the cage and the sea floor at low tide.
- Water current should be sufficient to flush away wastes from beneath the cage to prevent localized fouling. In areas of excessive current (over three knots) the cages may need to be specially designed and/ or specially anchored.

Advantages of grow-out cages:

- Can be relatively economical and easy to construct, compared to excavation and plumbing for pond farms.
- Very economical to operate as there is usually no need for mechanical aeration.
- Fish can be held at much higher densities than pond farms.
- The fish can be readily caught for either grading or harvest.
- The system lends itself to automation of feeding, harvesting and grading.
- The cages can be protected to prevent theft of fish by birds.
- If the conditions become unfavorable at a particular site the cages can be towed to a new location.

Disadvantages of grow-out cages:

- Fish totally rely on the addition of formulated feeds for survival and growth. During periods of inclement weather, it can be very difficult to service cages.
- In areas where biofouling is severe, net changes on a weekly basis may be required. This is usually a labor-intensive process and can add significantly to the operating costs of the farm. Solutions to the biofouling problem may include the use of rotating cages or ‘net rocking’ that allow net panels to be sun dried and cleaned in situ.

- Traditionally cage farms required areas of relatively deep, sheltered water. As cage farming technology has developed it is now possible to install cages in more exposed and remote locations but the cost of servicing the cages in these remote locations is high.
- Predators including sharks, crocodiles and man have to be controlled by specially designed nets/ cages and security systems.
- Fish cages may have a high on-going maintenance cost made up of replacement of damaged nets, net cleaning, purchase and maintenance of tender boats, etc.
- Damage to the cages caused by inclement weather other environmental factors (e.g. strong tides) can quickly lead to large losses of fish.
- Growth rates of fish may be slightly slower than in ponds due to extra exertion swimming against current.

8. Nutritional/ Feeding Aspects of Seabass Farming

It is widely reported in the scientific literature that larval marine fish and crustaceans have a high requirement for highly unsaturated fatty acids (HUFA's). Three fatty acids in particular, eicosapentaenoic acid, (EPA or 20:5ω3), docosahexaenoic acid (DHA, 22:6ω3) and arachidonic acid (ARA or 20:4ω6) have been identified as being of special importance for the survival and growth of marine fish larvae. Diets that lack sufficient quantities of these fatty acids, or have them in the incorrect ratio, may decrease survival. Sub-lethal effects of dietary deficiencies may also be observed, such as malformation of the spine, missing gill opercular, jaw deformities and mal-pigmentation of the skin. During larviculture care must be taken to ensure that the diet offered to the fish larvae contains sufficient nutrients to sustain healthy growth and is presented at a density that promotes efficient feeding and limits size variation (cannibalism) within the population of the same batch of fish.

These are usually dry pellets consisting of fish meal, cereals, vitamins, minerals and binders. The actual configuration of the pellets varies with the manufacturer and the specific recipes are usually kept confidential. Apart from availability, pelleted diets have a number of significant advantages over fresh diets.

- Consistency of supply. The pellets can be bought in bulk, and if stored correctly, can last many months with little drop in food quality.
- Consistency of quality. The nutritional quality and standard of the pellet are batch tested in the factory before the pellets are shipped to the farmers. This minimizes, but does not totally eliminate, the problems of poor feed quality.
- Easy to feed. There is no preparation of the pellets required before they are fed to the fish.
- Pellets can be fed to the fish by automatic machines, reducing labor costs.
- Because the feed has been heat treated during the manufacturing process the risk of transmitting disease through the feed has been virtually eliminated.

- The bags of feed are easily stacked for storage.
- The formulation of the diet can be tailored to the species of fish being fed giving consistently high growth rates.

9. Diseases

A spectrum of diseases, pathogens and parasites are known to infect Seabass, some of which are of major biological and economic importance in the production of farmed fish and some of which occur incidentally. From an economic and management viewpoint, prevention is better than cure when it comes to disease in fish. This is especially important under large scale systems of production whereby treatment or control of disease outbreaks may be difficult if not impossible. High water quality standards are paramount to good fish health. An important way to prevent fish diseases is to ensure that the environment is kept as clean as possible.

Feed must be stored correctly to prevent the introduction of infectious agents and to ensure that the nutritional value does not deteriorate. The use of whole or filleted fish from outside the local area is to be discouraged as this may readily introduce microbial organisms into the culture system. Pelleted feed should also be kept cool, ideally at less than 20°C. In the dry season it is usually sufficient to keep the feed in a shaded building. In warm humid conditions, it is necessary to store the feed in an air-conditioned room. If this is not done, pelleted feed can quickly deteriorate. Fats become rancid, vitamins break down and mold can grow on the feed releasing toxins. Feed should not be stored for extended periods and good feed store management should be employed to keep track of stock and ensure that the feed fed to the fish is of the highest quality.

10. Conclusion

The present manual spells out in a step-by-step manner the entire process of modern Seabass production right from the breeding of fingerling stage to the farming level. The manual, in its introductory part, has important details on the life cycle and biology of Asian Seabass. Since assured supply of good seeds are of particular importance for the Seabass production particular attention has been given to provide all the requisite details of good breeding arrangement of Seabass fingerling production. The details in this regard have been presented in a logical step by step manner so as to be easy to follow without missing out important points warranting careful attention. Similar care has been taken to include details on steps to be taken at the nursery phase of the Seabass production and subsequent Seabass production at the grow-out stage. Details have been given both pond and cage cultures of the species. As nutritional/ feeding aspects of Seabass farming and risk of diseases also merit to be given due importance in any production system of specific aquaculture species for good reason the present manual also has important information on these two vital aspects of Seabass production in a holistic presentation meant for all stakeholders.

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