# Broodstock Management of Marine Fish in RAS Tanks

**Ambarish P. Gop, Ritesh Ranjan., Santhosh B., Surya S. and M. K. Anil**

*ICAR-Central Marine Fisheries Research Institute, Kochi*

*Email: Ambarish.gop@icar.gov.in*

## Introduction

Marine fishes maintained in captive conditions are often susceptible to diseases due to accumulation of ammonia in water, necessitating effective disease prevention measures. In most land-based broodstock development systems, a flow-through mechanism is employed, with a 200-300% water exchange rate to maintain the various physicochemical parameters of water quality. This approach incurs substantial costs associated with water procurement and exposes the broodstock to fluctuating water quality, as well as various parasites and microbial pathogens. These factors can delay or impede broodstock maturation and breeding. Consequently, there is a growing emphasis on completing the entire production cycle of commercially important fish within recirculating aquaculture systems (RAS). RAS address the challenges of sourcing live broodstock from the wild, mitigating high costs, ensuring biosecurity, and reducing the impact on marine ecosystems. Recirculating Aquaculture Systems (RAS) offer an optimal platform for the precise manipulation of environmental parameters critical to maturation processes, including temperature, photoperiod, nutrition and various water quality metrics.

Moreover, RAS facilitate detailed observation of fish behavior and enable the implementation of diverse husbandry practices. This system has the potential of advanced filtration technologies, coupled with optimized facility management strategies, to mitigate disease risks and enhance biosecurity. By addressing water quality concerns and minimizing energy consumption, the proposed system aims to streamline maintenance efforts while promoting environmental sustainability.

This facility explores the application of advanced filtration systems and efficient facility management practices to improve the health and biosecurity of marine fishes, particularly in captive tank-like conditions where occurrence of mortality are prevalent due to sudden increases in ammonia levels. The facility has the efficacy of various filtration methods, including cartridge filters, UV filters, protein skimmer and sand filters, in mitigating disease risks by enhancing water quality. Additionally, the recirculation facilities and enhanced system efficiency contributes to reduced energy consumption for water quality management and feed waste removal, thereby facilitating easier maintenance by a single operator and minimizing carbon footprint. Recirculating aquaculture systems (RAS) enable the continuous filtration and recirculation of water, reducing the need for frequent water exchanges and minimizing resource consumption. By optimizing water flow and circulation patterns, RAS improve oxygenation and nutrient distribution within tank environments, enhancing fish health and ecosystem. It will also help to reduce the water exchange and thereby the stress in fish. Implementation of energy-efficient equipment and automation technologies reduces energy consumption associated with water quality management and waste removal processes. By optimizing system performance and minimizing energy usage, facility operators can achieve greater operational efficiency and environmental sustainability.

A typical RAS facility with 10 tanks designed for maturation and spawning of marine fish described here (Fig.1).

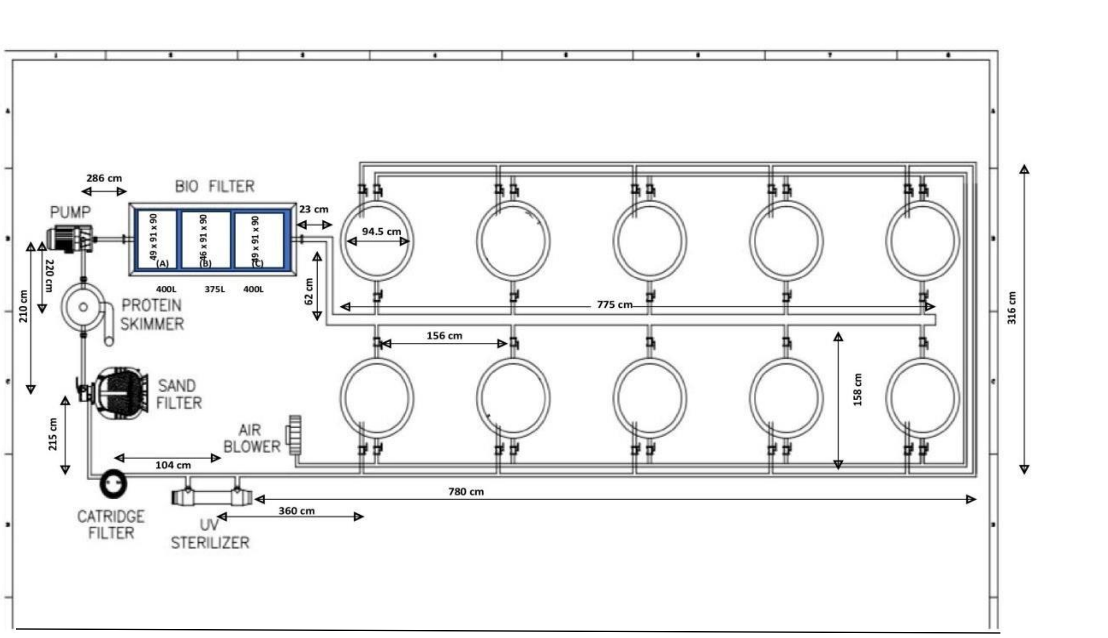


Fig.1. Schematic diagram of RAS with 10 tanks

The facility configured with a flow through system connecting 10 tanks via a single drainage pipe, supplemented with two overhead tanks for keeping seawater and fresh water, as needed for rearing marine species for breeding and seed production purposes.

## 1. Broodstock tank

The system can be designed to accommodate the broodstock of 1 kg/ m3 (Ranjan *et al.*, 2019) with minimal capital and operational cost involvement. Tank capacity can be decided based on the species and space availability. The tank should be designed with a slope towards the central drainage system which is to facilitate the complete removal of the waste along with water. If we need, another surface drainage (provided at 20 cm below from top of the tank) can be fitted to facilitate the egg collection from the surface during spawning and for circulating the surface water.

## 2. Suspended solid waste removal system

Rapid sand filters can be use for removal of suspended solids. The rapid sand filter (RSF) filled with 350 kg of white sand of 2 mm particle size can be used to remove the solid waste of more than 60 µm particle. RSF is attached with multiport valve, and the main function of the valve includes filter, backwash, rinse and recirculation. Depending on the need, the valve position can be changed.

## 3. Foam fractionation system

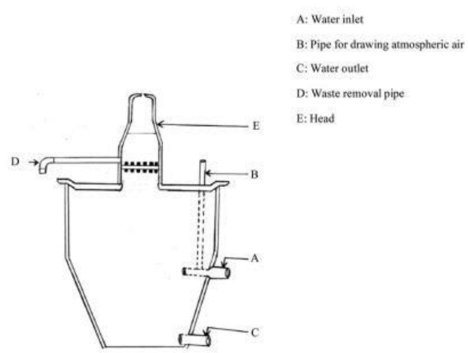


Fig.2. Schematic diagram of protein skimmer

Protein skimmer of required quantity (based on the capacity of broodstock tank) can be used for skimming the water to remove dissolved organic waste. The skimmer is conical in shape with a flat bottom and a head at the top with inlet at middle and outlet at bottom. A pipe provision for drawing atmospheric air is provided at the surface of the main unit, and this venturi pipe is connected to the inside of inlet. The head of the skimmer is provided with a number of pores at the bottom, through which the protein waste formed from the main unit is carried to the head and then removed through a single hole provided at the side of the head.

**4. Cartridge filter**

Cartridge filter, with a pore size of ≤15μm, can be used to remove particulate matter and debris from the recirculating water. Cartridge filters utilize a physical filtration mechanism to trap suspended solids, organic matter and other debris present in the water. The cartridge itself is typically made of pleated or wound filter media, offering a large surface area for efficient particle capture. As water flows through the cartridge, particles are trapped within the filter media, allowing clean water to pass through. Cartridge filters are commonly integrated into the water recirculation loop of RAS systems, often positioned after solids removal processes such as settling tanks or drum filters. They serve as a secondary filtration stage, capturing finer particles that may have bypassed earlier filtration stages.

**5. Biological filter**

A reinforced concrete cement tank or a FRP tank of required capacity can be used as biological-filter tank, which was filled with bio-balls and oyster shells for developing bacteria involved in nitrification process. The tank should be constructed at a slightly raised level (0.5 m) so that the water from the biological filter tank falls directly to broodstock tank. It should be with three compartments, with partitions facilitating the flow of water from one compartment to the other serially. The first compartment was packed with a sponge filter, bio-balls and coral rubbles in such a way that incoming water gets first filtered by the sponge. Filter sponge has to be cleaned with seawater twice a week. The next two compartments are packed with moving bed biofilm reactor (MBBR) media which is aerated and kept fluidized for efficient bio-filtration. The out-let was provided at the bottom of the biological filter tank with s, from which water fell freely into the broodstock tank by gravity.

**6. UV filter**

In a Recirculating Aquaculture System (RAS), UV filters serve as guardians of water quality, employing ultraviolet (UV) light to combat harmful microorganisms. Positioned within the water recirculation loop, these filters harness the germicidal properties of UV-C light to neutralize bacteria, viruses and algae, thereby preventing disease outbreaks and promoting a healthy aquatic environment. The UV lamp, encased in a protective quartz sleeve within the UV chamber, emits a steady stream of UV light, which disrupts the DNA of pathogens, rendering them unable to reproduce or pose a threat to fish and other aquatic species.

This continuous sterilization process not only enhances water quality but also reduces reliance on chemical treatments, fostering a more sustainable aquaculture operation.

Fig.3. Filtration system

## Working operation of RAS

The RAS system was designed to run with a single centrifugal pump of 3 HP capacity. This pump draws the water from the broodstock tank and drives it to the RSF, thereafter to protein skimmer, biological filter and finally back to broodstock tank. Thus, at a time, the system is operated by a single motor, but to reduce the working load, two electric pumps can be used to run alternatively. A portion of the pumped water (around 40 %) passes through the skimmer and then the skimmed water to the biofilm developed in the bio-balls and shells and are released through outlet pipe at the bottom of the tank. Bio-balls and oyster shells can be used for providing sufficient surface area for attachment of bacteria and for maximizing the contact with the passing water for nitrification process. Remaining portion of the water (around 60 %) can be passing through the rapid sand filter, cartridge filter and UV filter.

## Broodstock management of silver pompano in RAS

Proper care should be given to broodstock in captivity (here RAS) to get successful spawning. The viability of the larvae is very much dependent on broodstock nutrition. The nutritional components in the diet, the feed intake rate or the feeding period can all affect spawning, egg and larval quality (Gopakumar *et al.*, 2012). Improper care may lead to disease outbreaks and mortality in maturation tanks.

In the case of maturation of wild caught silver pompano in RAS, the male and female broodstock of above 1.5 Kg is an ideal size for successful captive breeding and hatchery production of good quality larvae. Stocked fishes were fed once daily at the rate of 5 % of their body weight with fresh cleaned sardines and anchovies. Fresh squid was given every day along with vitamin C and vitamin E tablets once a week (Anil *et al.*, 2019).

**Water quality requirements**

Seawater to be used in the facility should enter a storage tank where it should be treated with hypochlorite solution. Water quality requirements in the maturation tank system are a temperature of 27–29 ºC, salinity of 27–32 ppt, ammonia of ≤ 0.02 and a pH of 7.8–8.5, permitting adequate feeding of the broodstock while maintaining optimal and stable water quality.

**Feeding**

Wild-caught pompano brooders can be trained to accept and maintain on trash fish, squid meat and formulated feed for over four years. Newly collected pompano should not be fed until all therapeutic treatments are completed. This delay assures the fish will be hungry when feed is first offered and prevents habituating fish to ignore feed by presenting it to them when stress or disease agents impede their appetites (Kohler, 1997). Initially fishes are fed with squid and trash fish by hand feeding. After a period of one month, mix squid meat (better to keep the formulated feed inside the end portion of squid) with formulated feed and train them to accept it.

Table1. Feeding schedule maintained in Silver Pompano broodbank in CMFRI, Vizhinjam Regional Centre

| Day of the week | Feed given |
|---|---|
| Sunday | Squid with pellets |
| Monday | Squid and fish |
| Tuesday | Squid with Vitamin C |
| Wednesday | Squid and fish |
| Thursday | Squid with Vitamin E |
| Friday | Squid with pellets |
| Saturday | Squid and fish |

Fig.4. Feeding the Silver Pompano broodstock

**Tagging**

A Passive Integrated Transponder (PIT) tag, also known as a radio frequency device, permanently marks fishes internally. The tag is designed to last throughout the life of the fish providing a reliable, long-term identification method. Passive Integrated Transponder (PIT) tags act as a lifetime barcode for an individual animal, analogous to a Social Security number and provided they can be scanned, are as reliable as a fingerprint (Gibbons & Andrews, 2004). In maturation tanks, PIT tagging can be used to answer questions regarding growth rates and maturation stages.

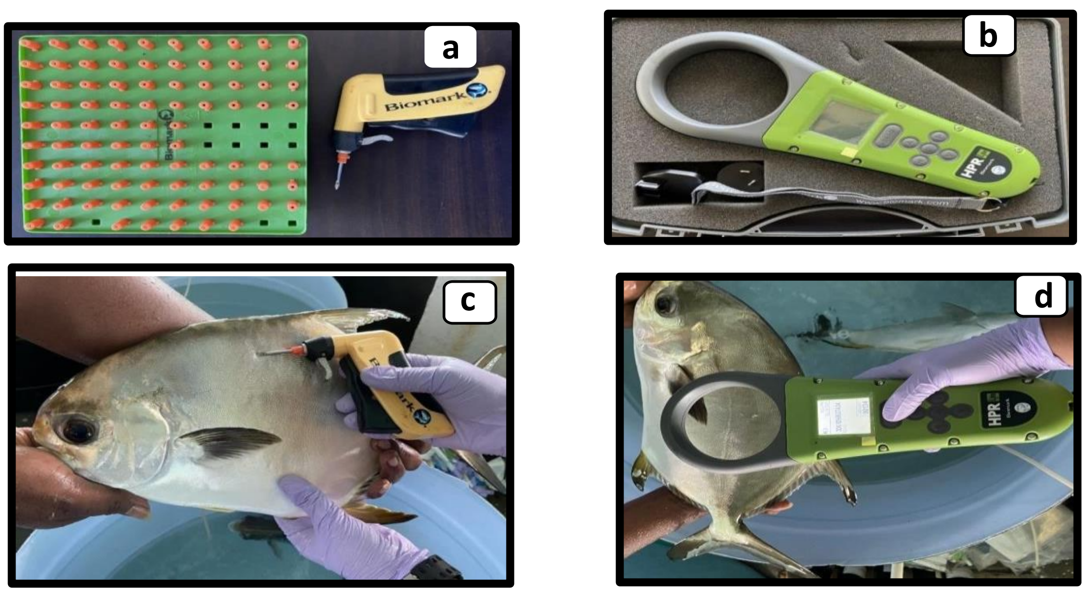


Fig.5. (a) PIT tags and tagging gun (b) PIT tag reader (c) PIT tagging of Pompano brooder fish (d) Reading the PIT tag in pompano brooder fish

Normally, intramuscular insertion is preferential (below the muscular region of dorsal fin) for pompano brooders. In normal cases, pit gag causes no mortality and little incidents of infection. The maturation stages of the fish can be assessed by cannulation of the particular fish and can be recorded in the register of the particular fish. Each tag represents a specific number which can be recorded in a register along with the growth measurements (and maturity stages) of the fish. After a definite period, fish can be recaptured and pit tag reading can be used to identify the particular fish. Various studies confirmed that pit tagging won't cause any serious impact on the survival or growth of the fish in hatchery conditions.

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