Integration of seaweed (*Kappaphycus alvarezii*) and pearl oyster (*Pinctada fucata*) along with Asian seabass (*Lates calcarifer*) in open sea floating cage off Andhra Pradesh coast

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Introduction

Aquaculture is growing very fast and its growth is expected to continue and it is necessary to supply fish for the ever growing population of our country. In India, fish production and consumption is considered to be important and needs to be promoted. As capture fisheries have almost become stagnant, diversification of aquaculture is highly necessary. Considering the limited scope of freshwater aquaculture and the availability of vast coastline, open sea cage culture gained importance in the present day mariculture practice. Open sea floating cage culture is an alternative sustainable practice for rearing fish and shellfish species and polyculture along with seaweeds may also improve profitability and sustainability. Open sea cage culture is an aquaculture production system where high density of fish is cultured in floating cages. Floating cages are widely used in commercial aquaculture and individual cage units of desired shapes and sizes can be tailored to suit the needs.

The release of NO_3 and PO_4 from the high density of fish stock and due to heavy feeding from the nearby areas of the cage and to utilize this form of nitrogen and phosphorus as the source of nutrient for the cultivation of valuable sea weed, the study has been conducted to see the possibility of co-cultivating sea weed *Kappaphycus alvarezii* and Asian seabass *Lates calcarifer* in open sea floating cage in Bay of Bengal off Visakhapatnam coast in Andhra Pradesh. Cage culture is an alternative sustainable practice for rearing fish and shellfish species and polyculture along with seaweeds and pearl producing oysters may also increase production. In this experiment, at the open sea cage demonstration project site at Visakhapatnam co-cultivation of Asian seabass (*Lates calcarifer*), the seaweed (*Kappaphycus alvarezii*) and the marine pearl producing oyster (*Pinctada fucata*) was undertaken in the floating cage. It was carried out in an offshore area near the Visakhapatnam Regional Centre of Central Marine Fisheries Research Institute, off Andhra Pradesh coast, Bay of Bengal, India.

Basics of the integrated system

Integrated cage culture with sea weed, oysters and fish is a method of raising animals and weeds needs a floating

cage which permits a good water exchange and waste removal into the surrounding water. Adequate water circulation is essential to make the nutrients available for the growth of the sea weed. However, the following criteria need to be given attention.

Site selection

Appropriate site selection is important for successful enclosure aquaculture. Sheltered, weed-free, shallow bays (6-10 m deep) are the ideal locations for installing cages. The sites should have adequate circulation of water, with wind and wave action within moderate limits. Excessive turbulence may lead to wastage of fish energy for stabilizing themselves, loss of feed and growth of weed also may not be proper. The other major considerations are that the water should be pollution-free, availability of seed in the vicinity, easy accessibility to the site and a ready market for fish and the weed. Flowing waters with a slow current of 1.0 to 9.0 m per minute are considered ideal for cage siting. It is desirable to install cages a little away from the shore to prevent poaching and crab menace but within the limit of reach by the persons who monitor daily the activities.

Species selection

Selection of species for cage culture should be based on factors like the local demands and availability of quality seed, fast growth rate, adaptability to the stresses in enclosures due to crowded conditions, ready acceptance of trash fish feeds and good market demand. Seaweed is opted at places where it can be disposed off as fast as possible.

Cage Materials, mooring and anchoring

The cage should be durable and strong, but light weight and allow complete exchange of water volume every 30 to 60 seconds by using a minimum of 13-mm square mesh size. There should be a free passage of fish wastes and should be inexpensive and readily available. It should have a proper net to hold the crop as well as to protect from the predators. The outer ring should have been supported with cat walk for daily observation of the fish, weed and the oysters. Proper care must be taken with regard to floating system and buoyancy, a good service system for collars and fittings and a good mooring system and a proper anchorage to hold the cage. A mooring system must be powerful enough to resist the worst possible combination of the forces of currents, wind and waves without moving or breaking up.

Cage positioning

Positioning of the cage for good growth of fish and weed should be done in open areas with good water circulation, but protected from strong currents and high waves. It should be away from still or stagnant water where poor water quality may stress or kill fish and improper growth of the weed. It must be placed at least above 1 m above the bottom sediments.

Water quality considerations

A good water area without any pollution is desired for the culture of fish or shellfish and sea weed. Biofouling caused by organisms that attach themselves to the cage and restrict water exchange. Area away from marine biofouling organisms include algae, oysters, clams, and barnacles is suited or else cleaning at regular intervals are required to facilitate a good culture activity.

Security considerations

Cages should be placed where they can be easily monitored if poaching is a serious consideration.

Methods applied

Experimental circular grow-out cage (15 m diameter and 6 m deep) with floating frames was used for the purpose. Fingerlings of 80-95 mm average length which were reared and acclimatized in 5 ton capacity FRP tanks at the mariculture hatchery of the regional centre were transferred to the grow-out cage and reared at a suitable density. In order to test the use of available space in the outer ring of the floating cage, thalli of the seaweed *K. alvarezii* were grown in nets tied with plastic rope to the HDPE outer ring

of the cage. Simultaneously, epoxy coated iron boxes (2 x 2 x 0.5 ft) with plastic net covering were used to grow the spat of *P. fucata* were attached to the outer ring of the cage. The spats which were bred and grown in the mariculture hatchery of the centre were used to stock in the boxes with the average initial DVM 45 mm, AVM 38 mm and cup width 13 mm and an average weight of 6.22 gm. Regarding management, fish was fed only with trash fish available at the Visakhapatnam fishing harbour at different rates as per the biomass and no other management was undertaken for the oysters and the seaweed. Sea weed brought from Mandapam area of Ramanathapuram district of Tamilnadu and it was grown in the mariculture hatchery of Regional Centre of Central Marine Fisheries Research Institute, Visakhapatnam, Andhra Pradesh. It was cut it in to fragments of 30 g each and allowed to grow further, in the 1 ton FRP tanks with 30 ppt salinity and about 30% water exchange everyday. Further, it was grown in offshore area of Lawson's Bay at Visakhapatnam stocked in plastic net pouch of 0.5x05 ft. and the growth was recorded and compared with onshore culture conditions. After sufficient amount has been harvested it was re stocked in plastic net pouch of 2.0x2.0 ft. the outer floating frame of the open sea floating cage in square plastic rope nets of (2x2 ft) size in which 150 gms. of sea weed were stocked. Growth of oysters, seaweed and fish yield reached remarkable production rates with the increment in case of fish about 212.5 %, in case of oysters with 28.8 % in DVM, 23.68 % in AVM, 61.53 % in cup width and 296.62 % in weight and in case of seaweed the increment was 456.66 %.

Advantages and disadvantage

Advantages:

- Use of existing coastal water bodies with possibility of making maximum use with greatest economy with lower capital cost investment as compared to land-based farms.
- With its technical simplicity open sea floating cage farms can be established or expanded which further helps to reduce the pressures on land resources.
- Easier stock management and monitoring compared with pond culture and it shows the possibilities of combining several types of culture within one water body.
- Easy for daily observation of the stock allows for better management.

Disadvantages:

- Stock is vulnerable to external environmental hazards like cyclones and currents and the water quality problems like algal blooms and biofouling organisms. Rapid fouling of cage walls requires frequent cleaning of net.
- Back up food store hatchery and processing are necessary to overcome feeding in the fishing ban timings.
- Feed losses possible through cage walls due to water currents and sometimes the small fish enter cages and compete for food.
- Security management is must to avoid poaching as the high density of crop is in confinement.

Conclusion

With the results presented, it can be concluded that in open sea floating cages, the cultivation of fish, sea weed and oysters either pearl producing or edible, provides a reasonable solution to cultivate species that are economically valuable and increase profitability without much investment. In the present study, the conditions of oysters and the seaweed were very healthy and no negative interferences could be observed in co-culturing fish, oyster and seaweed in the same cage indicating the treatments and harvests remaining independent. Further improvement with regard to designing of the system can be done when battery of open sea floating fish cages are tagged to each other with sea weeds and oysters attached to the outer floating frames. It provides scope for further research to incorporate with species that could grow well and also act as an efficient biofilter for this integrated system.