Chapter 16

Techniques of Integrated Multi-Trophic Aquaculture (IMTA)

Johnson Belevendran
ICAR - Central Marine Fisheries Research Institute, Mandapam

Introduction

The fish catch or harvest from marine capture fisheries is in a stagnation phase over the last few years, which has led to reduction in fish catch. The demand for seafood is increasing over the years. In this context, one of the options for additional seafood production is the farming of fishes in the sea cages and coastal saline ponds. The Central Marine Fisheries Research Institute (CMFRI) has developed breeding, seed production and farming technologies for commercially important marine finfishes. As a result of the initiative taken by the CMFRI, many groups are adopting cage farming in the coastal region of Tamil Nadu, Karnataka, Andhra Pradesh, Kerala, Goa, Maharashtra, Odisha and Gujarat states. One of the anticipated issues while expanding the sea cage farming is the environmental degradation and consequent disease problems. In this context, the idea of bio-mitigation along with increased biomass production can be achieved by integrating different groups of commercially important aquatic species which are having varied feeding habits. This concept is known as Integrated Multi-Trophic Aquaculture (IMTA) which is gaining importance at global level.

What is IMTA?

IMTA is a form of aqua farming that utilizes the ecosystem services provided by organisms of low trophic levels (e.g. shellfish and seaweed) raised in appropriate ratio to mitigate the effects of organisms of high trophic levels (e.g. fish) (White 2007, Troell *et al.,* 2003). Integrated Multi Trophic Aquaculture (IMTA) is the practice which combines in appropriate proportions the cultivation of fed aquaculture species (E.g. fin fish / shrimp) with organic extractive aquaculture species (e.g. shell / herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweed) to create balanced systems for environmental stability (bio-mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

IMTA has been successfully adopted in Chile, USA, Canada, Europe and many Asian countries. It was reported by Chopin (2006) that under the IMTA systems in the Bay of Fundy, 'Kelp and mussel productions increased by 46 and 50%, respectively, when cultivated in proximity to salmon sites.

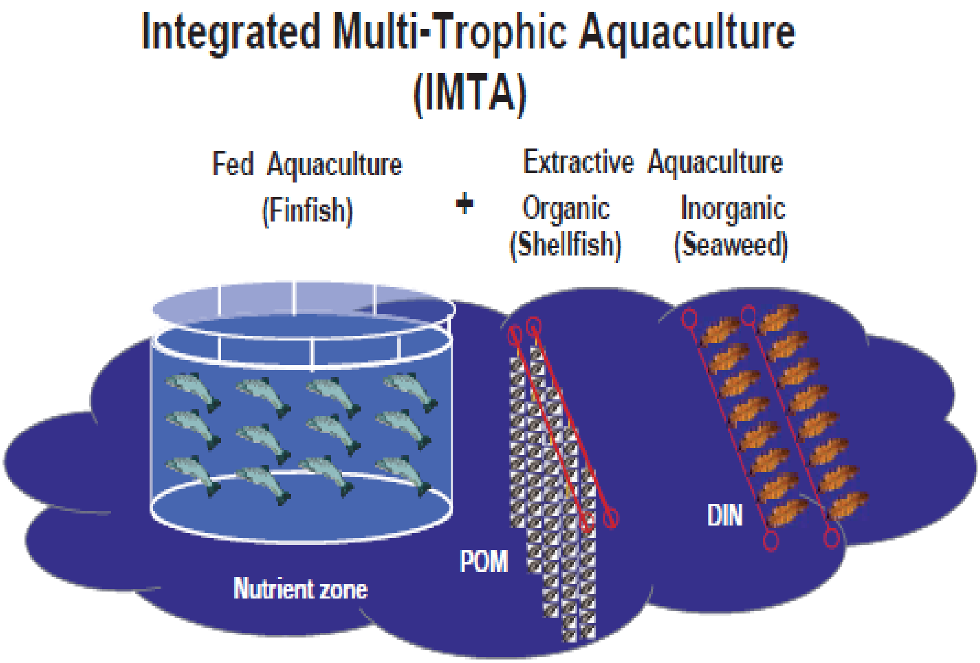

Figure 1. Integrated Multitrophic Aquaculture systems
POM: Particulate Organic Matter; DIN: Dissolved Inorganic Nutrients Source: Chopin, 2006

CMFRI has successfully conducted demonstration of Integrated Multi Trophic Aquaculture (IMTA) under participatory mode with a fishermen group at Munaikadu (Palk Bay), Ramanathapuram district, Tamil Nadu by integrating seaweed *Kappaphycus alvarezii* with cage farming of Cobia (*Rachycentron canadum*).

IMTA Design

A total of 16 bamboo rafts (12× 12 feet) with 75 kg of seaweed per raft were integrated for a span of 4 cycles along with one of the cobia cages. A GI cage of 6 m diameter and 3.5 m depth with 750 cobia fingerlings was integrated with the above seaweed raft system. One complete cycle of seaweed extends for an average of 45 days duration and four such cycles were performed in a row. As a control, a separate set of rafts of the same number were grown in a distant location without any integration with the cages.

Figure 2. Seaweed rafts (16 Nos.) integrated with cobia cage

Economic stability

In one crop of 45 days the seaweed rafts integrated with cobia cage gave a better average yield of 260 kg per raft while the same was 150 kg per raft for the rafts which were not integrated. An addition of 110 kgs of seaweed/ raft was achieved due to the integration with cobia cage farming.

The total seaweed production of the integrated rafts after 4 cycles was 1280 kg, while that of non-integrated rafts was only 576 kg. So, an additional yield of 704 kg of seaweed was achieved due to the integration with cobia cage farming. Although the operational costs of rafts in either case were the same, there was an additional revenue generation/additional net profit of Rs. 26,400 realized with an increased profit margin of 41 per cent through integration of seaweed rafts with cobia cages.

Figure 3. Comparison of seaweed rafts -both integrated (with cobia cage) and non-integrated

Table 1. Comparison of cost and returns of seaweed cultivation with and without IMTA (16 rafts/ one cage/4 cycle)

Particulars	With IMTA	Without IMTA	Difference
Dried seaweed production (for 4 cycle, 16 rafts)	1280 kg	576 kg	+704
Price of dried seaweed (Rs. per kg)	37.50	37.50	
Revenue (Rs.)	48,000	21,600	+26,400
Costs (Rs.)	16,000	16,000	
Net Profit (Rs.)	**32,000**	**5,600**	**+26,400**
Profit Margin (%)	**67**	**26**	**+41**

Moreover there was an increased number (average 90-100 nos.) of newly emerged apical portion/tips in a bunch of harvested seaweed from the rafts integrated with the cobia cages, whereas the same was less (average 30- 40 nos) from the rafts which were not integrated. The bunches having more numbers of newly emerged apical portion/tips, when used for replanting, will be ready for harvest within 40 days, whereas the seaweed with less numbers of newly emerged apical portion/tips, if used as seed, will be ready for harvest only after 54 days.

Figure 4. Comparison of a bunch of seaweed taken from integrated and non-integrated raft: More numbers of newly emerged apical portion/tips from integrated rafts

Figure 5. Harvested seaweed *Kappaphycus alvarezii* from the integrated raft

The integration of the cage with seaweed also generated favorable returns for the farmers with respect to the finfish production. In a six month production cycle of cage farming of cobia (along with 4 cycles for the integrated seaweed), an average yield of 1,220 kg was achieved with the integrated system in contrast to the non-integrated one where the cobia yield was only 960 kg. The gross revenue generated from the yield (with an average weight of 2.2 kg/ fish and at the rate of Rs. 290/ kg) was Rs. 3,53,800 for the integrated and Rs. 2,78,400 for the non-integrated cages. So, an additional net operating income of Rs. 75,400 was realized from the integrated cage.

Figure 6. Harvested cage farmed cobia fishes from the integrated cages

Environmental stability

It was found that the organic waste mitigation of integrated system of *Kappaphycus* farming is more efficient than the non-integrated system of farming. Biochemical analysis of water and sediments from the experimental rafts and cages indicated a mutual beneficial effect of seaweeds and cobia in the integrated aquaculture system. The analyses for organic matter load and water quality parameters indicated that the organic wastes from the feed waste and excreta of fish were sequestered by the integrated seaweed. While the sequestration of the organic waste by seaweed acts as a fertilizer for itself, decreased the organic pollution and helps the fish to save and minimize its energy expenditure towards warding off environmental stress, thus helping it to have better growth rate over its counterpart cultured in non-integrated manner.

The total amount of CO_2 sequestered into the cultivated seaweed (*Kappaphycus alvarezii*) in the integrated and non-integrated rafts was estimated to be 223 kg and 100 kg respectively. Hence there is an addition of 123 kg carbon credit due to integration of 16 seaweed rafts (4 cycles) with one cobia cage (one crop).

Table 2. Comparison of carbon sequestration potential of seaweed cultivation with and without IMTA

S.No	Particulars	With IMTA	Without IMTA
1	Fresh seaweed production (for 4 cycle, 16 rafts)	12800 kg	5760 kg
2	Average dry weight percentage of the harvested seaweed (%)	8.75	8.75
3	Average carbon content (%)	19.92	19.92
4	**Total amount of carbon sequestered (1)× (2)× (3)**	**223 kg**	**100 kg**

Conclusion

The innovative farming concept integrated multi-tropic aquaculture (IMTA), introduced by CMFRI can mitigate the potential negative externalities of sea cage farming with simultaneous enhancement in seaweed yield. It also generates additional revenue through increased yields of both cobia and seaweed. This is evident from the increased profit percentages in either case. Many fishermen groups in the Palk Bay region are being benefited through this technology and they are perpetually adopting this technology with their own investment.