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COURSE MANUAL

Winter School

on

Mariculture Technologies: Principles and Practices to augment the Seafood Production in India

ICAR - Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
Mandapam Regional Centre, Marine Fisheries P.O.
Mandapam Camp, Ramanathapuram District. Tamil Nadu, India.

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06-26 November, 2019

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Mariculture Technologies: Principles and Practices to augment the Seafood Production in India

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Marine Biodiversity Perspectives on Mariculture

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Introduction

Oceans cover about 70% of the planet's surface and hold an abundance of biodiversity with marine and coastal environments being home to 97% of all species on earth. Life in the sea is roughly 1000 times older than the genus Homo. Oceans, marine ecosystems and their biodiversity are vital for life on earth. They play a key role in global nutrient recycling and climate regulation and provide humans with a wide range of resources and services.

Capture versus Culture

Fishery products are important for local food production in developing countries, as 72.4% of all capture harvest (by mass, including only animals) and 92.3% of all culture harvest occurs in developing countries (Diana 1993). FAO estimates that 75% of world fish stocks are over-fished and a recent scientific study concludes that unless we take immediate action, we risk witnessing the collapse of our entire fishery by 2050. The International Food Policy Research Institute (Delgado et al. 2003) forecasts that the annual increase in seafood consumption will be about 1.5 kilograms (kg) per person in 2020, which would make the demand for seafood products considerably higher than it is now—more than 10 million metric tons of additional seafood would be consumed each year (assuming no increase in the human population). Over this same time, harvest from natural fish stocks will probably remain static or decline (Wijkstrom 2003, FAO 2007) As a result, the development of indigenous food production systems for local consumption as well as for export should be a priority means for achieving higher living standards in many countries. Aquaculture (both marine and freshwater) is probably the fastest growing food-producing sector in the world. It now accounts for approximately 50% of the world's food-fish and it is estimated that given projected population growth over the next two decades, an additional 40 million tonnes of aquatic food will be required by 2030 to maintain current per capita consumption (FAO, 2007).

Mariculture as an option

Mariculture is the cultivation of marine organisms, animals and plants, in their natural habitats (*i.e.* seawater) for commercial purposes. Both aquaculture and capture fisheries have caused much public concern about their sustainability and influence on the environment . All forms of mariculture, regardless of physical structure or economic motivation, affect biodiversity at genetic, species and ecosystem levels. At the ecosystem level, both goods and services functions can be affected, with widespread consequences and knock-on long-term effects. Therefore, the interconnected nature of aquatic communities requires that impacts on aquatic ecosystems should be considered in a holistic manner, both in the short and long terms. Some aquaculture practices are harmful

to biodiversity, and environmental groups have cited this potential damage as reason to call for reductions or even elimination of some types of aquaculture. Some of these claims arise because it is difficult to compare the impacts of aquaculture with impacts from other land or water uses. It is also difficult to compare the sustainability of seafood (farmed or caught) with traditional agriculture commodities. No food production system now in use is truly sustainable from an energy and biodiversity perspective—all food production systems generate wastes, require energy, use water, and change land cover. (Goldburg and Triplett 1997, Goldburg and Naylor 2005). While mariculture output is still dwarfed by the tonnage of farmed freshwater organisms, it is growing globally, and its practices have important implications for marine and coastal biodiversity on the level of genes, species and ecosystems. However, mariculture provides good quality food and is comparatively more efficient than many other food production forms. Humans consume less than 1% of terrestrial primary organic matter production, which totals about 132 billion tons, and less than 0.02% of the 82 billion tons of the primary production of the oceans (assuming that the fish caught are secondary consumers). Because of better feed conversion ratios, fish can replace terrestrial animals generally at about half the level of feed inputs. In other words, a hundred kilos of feed can produce thirty kilos of fish or fifteen kilos of pork. In this sense, mariculture is a more efficient user of primary productivity than is the farming of livestock (SCBD, 2014).

Generic impacts of mariculture on Marine biodiversity

Mariculture can affect different parts of the marine environment. The generic environmental impacts of mariculture activities are illustrated in Figure 1

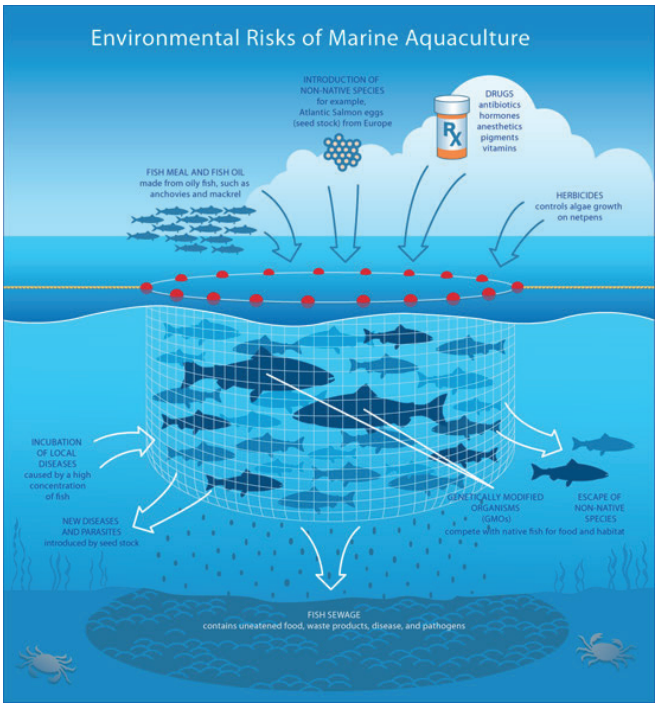

Fig.1 Impacts of Mariculture activities

i) Escapement of aquatic crops and their potential hazard as invasive species.

Probably the most important aspect of aquaculture as an influence on Biodiversity is the negative impact of introducing new species or modified genotypes. General attributes of successful invasive species include characteristics such as a widely distributed original range, a broad environmental tolerance, high genetic variability, short generation time, rapid growth, and early sexual maturation (Ricciardi and Rasmussen 1998).

ii) The relationships among effluents, eutrophication of water bodies, and changes in the fauna of receiving waters.

The waters in which wastes from cage or pond culture are placed have a large influence on the impact of those wastes. Studies have shown that in more oligotrophic marine waters, aquaculture effluents increase local biodiversity. For example, a study of 43 Chilean fish farms found negative effects on benthic invertebrates in the fallout zone (Soto and Norambuena 2004); in contrast, diversity and production of pelagic fishes in the surrounding waters increased.

iii) Other resource use, such as fish meal and its concomitant overexploitation of fish stocks

Fish meal and fish oil in prepared feeds have a negative impact on biodiversity. Fish meal is a limited resource, because fish meal is composed of many captured species, overexploitation results in declining biodiversity (Delgado *et al.* 2003). Fish meal commonly comes from small pelagic species of fish, whose harvest can also reduce food for production for larger predatory fishes at sea. For these reasons, the use of fish meal in aquaculture must be considered a negative impact of the industry (Naylor *et al.* 2000).

iv) Disease or parasite transfer from captive to wild stocks.

The transmission of diseases or parasites from farmed animals to wild fish stocks is yet another aspect affect marine biodiversity. These problems, combined with concerns about antibiotic resistance that could develop from use of antibiotics in culture, have been suspected for a long time. However, evidence from several sources, as well as adherence to the precautionary principle, indicates that we should remain cautious about the impact of aquaculture on disease and parasite transfer. Antibiotic and hormone use, which may influence aquatic species near aquaculture facilities.

Some effects of aquaculture on biodiversity may be positive. For example: Production of fish can reduce pressure on wild stocks, which may already be overexploited, Stocking organisms from aquaculture systems may help to enhance depleted stocks with limited reproductive success.

Worm *et al.* (2006) carried out a meta-analysis of published studies to identify whether the level of marine diversity had an effect on ecosystem services such as productivity, resource use, nutrient cycling, ecosystem stability, and therefore whether marine

degradation was harming the ability of ecosystems to provide services. The study found that increased diversity at either a genetic or species level led to enhanced ecosystem services and stability (ability to withstand recurring perturbations). In some cases, primary and secondary productivity were increased by 78% to 80% in diverse ecosystems when compared to monocultures.

Mitigating adverse effects of mariculture on marine and coastal biodiversity

- Environmental impact assessments (EIAs) or similar assessment and monitoring procedures should be made mandatory for mariculture developments with due consideration of scale and nature of the operation, as well as the carrying capacities of the ecosystem on the ecosystem level. Immediate, intermediate and long-term likely impacts on all levels of biodiversity must be addressed;
- Criteria should be developed for when EIAs would be required;
- Criteria should also be developed for application of EIAs on all levels of biodiversity (genes, species, ecosystems);
- Support the implementation of appropriate environmental impact assessment and monitoring programmes for mariculture;
- Global assessment should also be reinforced;
- Regional and international collaboration should be supported to address transboundary biodiversity impacts of mariculture, such as spread of disease and alien species;
- Development of appropriate genetic resource management plans at the hatchery level and in the breeding areas, addressed to biodiversity conservation;
- Development of effective site selection and effluent control methods for mariculture;
- Controlled low cost hatchery and genetically sound reproduction and making it available for widespread use to minimize/avoid seed collection from nature;
- In cases where seed is collected from nature, selective fishing gear should be used to avoid/minimize by-catch;
- Effective measures to prevent the inadvertent release of aquaculture species and fertile polyploids, through methods such as confinement;
- Use of local species in aquaculture;
- Avoiding the use of antibiotics through better husbandry techniques.

Areas in need of future research

There is insufficient information available about the effects of mariculture on biodiversity and its mitigation. Therefore, additional efforts shouldbe developed along three topics: research, monitoring programs, policies and legislation.

i) General research needs:

- Development of research programs to support establishing efficient monitoring programmes
- Development of criteria for judging seriousness of biodiversity effects

- Improvement and transfer of integrated mariculture systems, including polyculture
- Monitoring programmes to detect biodiversity effects
- Research in the impact of escapees on biodiversity

ii) Research related to impacts of mariculture on genetic diversity:

- Development of a genetic resource management plans for broodstock
- Understanding genetic effects of biotechnology developments in aquaculture
- Understanding genetic structure of both the farmed and wild populations, including:
  (i) Effects of genetic pollution from farmed populations on wild populations
  (ii) Maintenance of genetic viability of farmed populations
  (iii) Studies of the genetics of wild populations as potential new candidates for mariculture

iii) Research related to impacts of mariculture on species diversity:

- Support for basic global-scale taxonomic Solutions for sustainable mariculture - avoiding the adverse effects of mariculture on biological diversitystudies, perhaps in conjunction with the Global Taxonomy Initiative (GTI)
- Support for studies aimed at development of responsible aquaculture using native species
- Limiting by-catch of seed collection

iv) Research related to impacts of mariculture and ecosystem diversity:

- Carrying capacity and carrying-capacity models for planning aquaculture, specially stocking rates
- Comprehensive studies should be carried out to quantitatively and qualitatively assess
- effects of mariculture on biodiversity for various aquatic ecosystems, selected by their sensitiveness degree.
- The competitive nature imposed on marine fisheries by capture and culture fisheries
- Improved understanding of the effects of inputs, such as chemicals, hormones, antibiotics and feeds on biodiversity
- Research on impact of diseases in cultured and wild species on biodiversity

v) Research related to impacts of mariculture, socio-economics, culture, policy and legislation:

- Comparative studies at legislation, economic and financial mechanisms of regulations for mariculture activity
- Development of quantitative and qualitative criteria to assess mariculture impacts on the environment according to culture practices

vi) Monitoring programmes

- Support mariculture-related disease monitoring programs at the global level

- Support the transfer of biotechnological diagnostic tools for wide use
- Update of taxonomic database including genetic diversity at the intra-specific level

vii) Policy and Legislation

CMFRI was involved in drafting the mariculture policy for India**.** The goal of a National Policy on Mariculture (NPM), 2018 is to ensure sustainable farmed seafood production for the benefit of food and nutritional security of the Nation and to provide additional livelihood options to the coastal communities for a better living. The overall strategy of NPM is to increase seafood production in a sustainable manner, ensure socio-economic development, enhance food, health and nutritional security and safeguard gender, social equity and environment.

- Recognising that the demand for seafood is increasing year after year.
- Knowing that additional seafood requirement of the country in future years cannot be met by capture fisheries and inland aquaculture alone.
- Recognizing that to enhance the living conditions of coastal fishermen, additional livelihood options are needed.
- Recognising that sea farming sector is still in its infancy in the country.
- Realising that there is an immense potential for sea farming in the country.
- Noting that there are many mariculture technologies developed in the country which can be commercialized.
- Bearing in mind that mariculture has already contributed to substantial seafood production sector in many countries and is growing.
- The NPM has been drafted with the following Vision and Mission for farmed seafood production in the country.

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