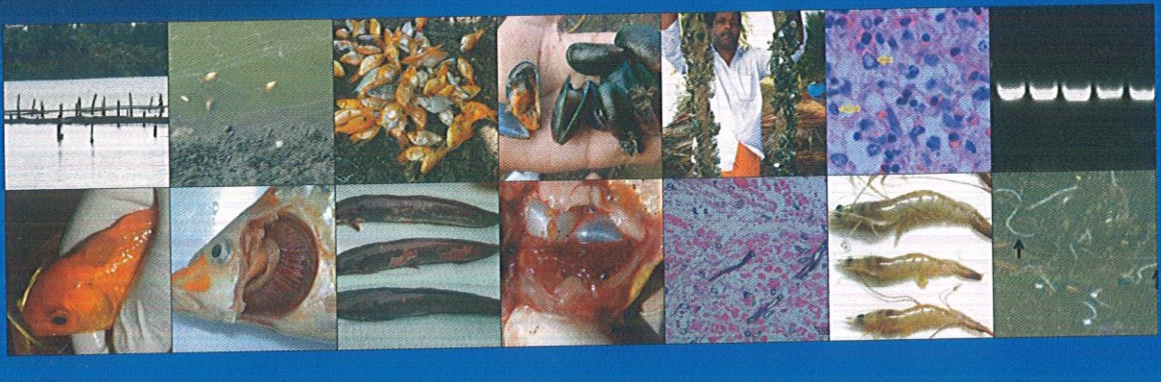
ISAAHE

International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture

April 20-21, 2017

ICAR-National Bureau of Fish Genetic Resources, Lucknow, India



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ASIAN FISHERIES SOCIETY
FOUNDED 1984
Indian Branch

ABCS

ISAAHE Book
Published by
Aquatic Biodiversity Conservation Society (ABCS), Lucknow, India

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Citation:
ISAAHE (2017). International Symposium Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture,
April 20-21, 2017, Lucknow, India,
Pp 208

© ISBN: **978-93-85338-02-1**
ICAR-National Bureau of Fish Genetic Resources
Canal Ring Road, P.O. Dilkusha, Lucknow-226 002, India

Perspectives in Marine Aquatic Resources and Health Management

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Aquatic resources are now regarded as major contributors to provisioning services that include health-food supply and pharmaceutical products. There are tremendous opportunities to advantageously make use of the rich biodiversity; and the provisioning, regulatory, cultural and supporting services of our seas to meet the emerging demands of humankind. Since biodiversity and ecosystem functioning is inextricably linked to human societies, we have to value the services of both, considering the growing costs of biodiversity loss and ecosystem degradation. A greener environment with enhanced ecosystem services will be beneficial to the ecological and human well-being.

Ecosystem Approach to Fisheries Management (EAFM)

It has now been recognized globally that fish and fisheries are only a part of the marine ecosystem which provides us with innumerable goods and services. This paved the way for "Ecosystem Approach to Fisheries Management" which aims at development and management of fisheries while considering the health of the marine ecosystem. India too needs to shift from traditional single species management approach to EAFM for sustainable ecosystems. EAFM addressing ecological and human wellbeing with good governance has proved to be an effective option for sustaining the fisheries in several cases. EAFM involves identifying and prioritizing issues and threats, developing and implementing plans with quality checks and adapting. An EAFM approach would address our concerns regarding production from over-burdened coastal stocks, production from under-utilized off-shore and non-conventional resources, pollution of the seas, overcapitalization of coastal fisheries, biodiversity loss and so on.

An important component of EAFM is regulated and well-managed fisheries. For well –managed fisheries we need an effective management regime that sustains the fish stock while taking care of stakeholder and environmental requirements. Just like any system, an effective management regime will have an input, processing, output and feedback components. The input is the database on fisheries statistics which needs to be strengthened. The processing component is the scientific assessment of fish stocks and ecosystems resulting in advisories on fishery regulations (spatial and temporal controls, gear controls, catch controls) in conjunction with other uses of the ecosystem (mariculture, tourism, biodiversity conservation).The output component is effective implementation of fishery regulations which is the weakest link in our current management regime. The performance of management interventions would be reviewed from time-to-time and adapted accordingly, which would form the feedback component.

The inherent strength of EAFM is that it considers the entire gamut of services provided by marine ecosystems. To effectively know the worth of a marine ecosystem, we need to value its services, both tangible and intangible. So far no work has been carried out in India on marine ecosystem valuation. A move towards EAFM gives us a seminal opportunity to work towards ecosystem valuation and to assess how various management interventions will affect ecosystem economics.

Ocean Health Index

It is common knowledge now that the oceans provide innumerable goods and services that are essential for human and terrestrial health. Thus efforts are now being made to study and understand the ocean as a whole taking into account all its tangible and intangible assets. However, this is not an easy task and we need good tools to assess the health of the oceans. The Ocean Health Index is the first assessment tool that scientifically measures key elements from all dimensions of the ocean's health — biological, physical, economic and social — to assess how sustainably people are using the ocean. This OH Index allows us to not only understand the oceans but also to prepare suitable strategies for improving the health of oceans. The OH Index deals with measurements of food provisioning services, traditional fishing opportunities, non-food products, carbon sequestration, livelihoods and economies of coastal communities, tourism and recreation value, aesthetic value and biodiversity assessment of marine ecosystems

Application of biotechnology in mariculture

The potential applications of biotechnology in mariculture include induced breeding, cryopreservation of gametes and gene banking, marker assisted genetic improvement, chromosome manipulations (especially polyploidy, in bivalves), health management like development of diagnostic, vaccines and probiotics. Functional genomics studies such as nutrigenomics offers better understanding of feed utilisation, effect of feed ingredients on growth, immunity, reproduction etc. and offers a tool for better feed formulation. The area of modern biotechnology which will probably have the most significant impact on genetic improvement of aquacultured species is transgenesis. Transgenesis offers an excellent opportunity for modifying or improving the traits like growth and efficiency of food conversion, resistance to pathogens,

tolerance to environmental variables, commercially significant flesh characteristics, colour variants of ornamental species, control of reproductive activity and also in producing novel biopharmaceuticals. We will also be utilizing the microbial biodiversity of the oceans via bio-prospecting for bioactive compounds and bio-molecules..

Disease problems in mariculture and their mitigation

Disease outbreaks are the main setback in the development of mariculture programmes. Diseases caused by viral, bacterial and parasitic pathogens result in serious economic losses to the industry.

In India, the most common bacterial disease encountered in mariculture practices is Vibriosis which causes severe economic loss both in hatchery and grow-out farming. Vibriosis is the disease caused by any of the several species of Vibrio like *V. alginolyticus*, *V. harveyi*, *V. anguillarum*, etc which are the normal inhabitants of marine ecosystem. Stress induced by husbandry practices like high stocking density, increased water temperature, etc predispose the fish to infection. Similarly, disease caused by *Photobacterium damselae* ssp. *damselae* which also inhabits the marine environment causes disease when water temperature raises. Due to the limitations in use of antibiotics due to environmental concerns especially in cage or pond farming, more focus is being shed on development of alternate therapeutics and vaccines.

Among the viruses, viral nervous necrosis or viral encephalopathy and myopathy caused by betanodavirus is a serious concern especially in young ones. This virus infects most of the farmed fishes causing severe mortality. The economic loss due to the virus is chiefly due to mortality and spread of infection both vertically and horizontally.

Parasites affect the profitability of the farm by causing mortality and growth retardation. Among the parasites of farmed marine fin fish, acanthocephalan and monogenean flukes like *Gyrodactylus* and *Pseudorhabdosynochus* are noteworthy.

Development and practice of proper management system is a must in any farming venture. Stocking of healthy, disease free animals and adoption of prophylactic methods is a must for sustainable aquaculture. Research aimed at understanding the innate and acquired immune system of fish and host- pathogen interactions should merit importance to develop strategies for prophylaxis, therapeutics and metaphylaxis. CMFRI is working on development of various molecular diagnostic tools for detecting several bacterial and viral pathogens as well as parasites of maricultured species. A highly specific and sensitive RT-LAMP (Reverse Transcriptase-Loop Mediated Isothermal Amplification) technique has been developed for detecting betanodavirus in infected fish. Bivalve farming in marine and esturine environment has proved to be a sustainable farming system in India. Bivalve molluscs are filter feeders and do not require any external feed inputs, thereby minimizing the major input costs as well as the environmental impacts. Estuaries and backwaters serve as ideal locations for bivalve farming. Recently, an internationally notified pathogen, *Perkinsus olseni* has been reported from farmed and wild bivalves. Changes in the climatic pattern – rise in temperature increases the pathogenicity of *P. olseni,* causing 60-80% mortalities in farmed mussels in the northern region of Kerala. Role of increased aquaculture activities, translocation of infected stock/seed for consumption/trade could spread the disease easily. Since the farming is practiced in open waters, there is little scope for containment/treatment of the disease. Adopting better management practices, self-imposed restrictions on culture density/frequency, screening of seeds for pathogens prior to stocking and development of early diagnostic systems are advised to resolve the disease issues and reduce crop losses. LAMP based diagnostic has also been developed for detecting *Perkinsus* Sp. infection in bivalves and also for detecting WSSV in crustaceans. A nested PCR assay for the detection of Perkinsus infestation in bivalves. Profiling study on the Indian edible oyster *Crassostrea madrasensis* for the presence of *Perkinsus spp* revealed the presence of *P. beihaiensis* for the first time in *C. madrasensis* populations from the Indian subcontinent and south Asia. Development of DNA based as well as recombinant based vaccines against Betanodavirus and vibriosis is also progressing in the division. Betanodavirus antigen as well as various vibrio antigens have been cloned, recombinantly expressed and purified for development of subunit vaccines and also DNA vaccine constructs prepared using the same antigenic genes for developing recombinant as well as DNA based vaccine against viral nervous necrosis and vibriosis in fish. Various vibrio antigens have been cloned, recombinantly expressed and purified for development of subunit vaccines against vibriosis in fish. Genes for tolerance against fluctuations in temperature, salinity and acidity have been isolated from various stress tolerant microalgae using suppression subtractive hybridization technique. The isolated genes have been functionally validated by recombinant expression in *E.coli.* Among the mined genes are some potential candidates for developing transgenic stress tolerant plants.

Adaptation to climate change impacts

Climate change is now recognized as one of the greatest long-term threats to marine ecosystems and fisheries. The implications of climate change are far reaching and hence there is a need to develop and implement management actions to increase the resilience of marine systems. The action plan should comprise of the following key elements:

(i) Targeted science: Address critical knowledge gaps about climate change impacts; identify thresholds, improve monitoring, and evaluate strategies; and translate information into active management responses;

(ii) A resilient coastal ecosystem: Minimize impacts through local management actions; adapt existing management to incorporate climate change considerations; and maximize resilience by protecting vulnerable ecosystems and species;

(iii) Adaptation of industries and communities: Identify risks and resilience of fisheries industries and communities; maximize resilience by planning regulations, policies and guidelines and assist in adaptation responses;

(iv) Reduced climate footprints: Increase knowledge and involvement of stakeholders; and work with organizations and individuals to reduce their climate footprint.

Blue carbon: A win-win situation for India

Carbon dioxide is a greenhouse gas emitted from anthropogenic and natural sources, which is now modifying the atmosphere and terrestrial and ocean systems. Increasingly, carbon will be regulated and priced under national (e.g. emissions trading schemes) and international agreements (*e.g.,* Copenhagen Agreements). One of the primary natural processes that reduces carbon levels is 'Blue Carbon'. The term 'Blue Carbon' describes the natural processes by which atmospheric carbon is captured and stored (sequestered) by marine environments. 'Carbon sequestration' means carbon storage that is unlikely to be reintroduced to the atmosphere for more than some period of time (say 100 years). Coastal wetlands have the potential to sequester carbon in the tissues of plants and sediments, just as trees on land sequester carbon. Carbon sequestration and storage in seagrass, mangrove and wetland ecosystems is considered to be extremely high (rates of up to 5 times those of tropical forests) and turnover is low in undisturbed systems. And yet these ecosystems are the ones facing the greatest challenge from humans. India is blessed with large areas of mangroves and coastal wetlands which give us a distinct advantage in a carbon-led economy. However in order to utilize the economic benefits arising from 'Blue Carbon' we need to conserve these sensitive ecosystems and propagate them in the years to come. Additionally a viable market needs to be created for carbon trading (as on land – called the Green Economy), although significant efforts are required to develop this into reality, including science background and policy reform.

Better Management Practices (BMP) and Ecosystem Approach to

Aquaculture (EAA)

Developing bio-secure brood bank for high value finfish breeding and seed production programmes deserves prime attention. The broodstock tanks with continuous bio-filtration system can be used to develop and maintain brood stocks of high value marine finfish like cobia, pompano, groupers, snappers, breams, etc. Establishment of a few marine finfish broodbank is needed to provide fertilized eggs/newly hatched larvae to the hatcheries where further rearing and seed production can be carried out. A recirculation aquaculture system with components such as drum filter, fluidized-bed bioreactor, protein skimmer, UV sterilizer and egg collection facility, is inevitable for healthy maintenance of the marine finfish broodstock. The system will serve to develop the broodstock into spawners through photo-thermal conditioning. Thus the safety of the spawners and year-round controlled spawning are ensured in this system. Hence, recirculation units have to be established to ensure year-round seed production of the required species. The application of recirculation aquaculture technology for growing fish in high densities under controlled conditions is a future opportunity. This approach to fish production minimizes the use of water and land and can be potentially expanded to locations that are normally unsuitable for seafood production. The development of cost-effective grow-out feeds and appropriate health management practices also require prime attention.

Another immense opportunity for India is to augment marine ornamental fish production. On a global level, marine ornamental fish trade has emerged as a multi-million dollar enterprise. There is scope to develop breeding and seed production technologies for a number of species which have high market demand, and develop trade for hatchery produced marine ornamentals in India. The techniques for breeding more than a dozen species of ornamental fishes have already been developed by CMFRI and research focus is needed to develop technologies for more species since the trade is based on diverse species. Parallel to this, establishment of small-scale ornamental fish hatcheries can lead to income generation for rural communities. By formulating appropriate policy regulations and guidelines for wild collection of species as exemplified by the international agencies like the Global Marine Aquarium Database (GMAD) and Marine Aquarium Council (MAC), and developing commercial production of selected species through available hatchery technologies, India has the capacity to emerge as one of the major source countries for marine ornamental fish trade.

For sustainable mariculture in the country, the mariculture practices should aim at optimum production and maintain a 'green environment'. The lessons learnt from the shrimp farming is an eye opener as intensive shrimp farming resulted in environmental deterioration and consequent disease problems which called for a need

for 'Better Management Practices' and species diversification. A green environment necessitates the need to adopt Ecosystem Approach to Aquaculture (EAA) by taking into account the knowledge and uncertainties of biotic, abiotic and human components of the ecosystem including their interactions, within the ecologically and operationally meaningful boundaries. In many areas, there is lack of diagnostic support for mariculture. The farmers should be educated on the negative environmental impacts that will in turn affect their production. In this regard, establishment of SPR and SPF brood facilities can go a long way to avoid the environmental health hazards to farmed fish species. An SPF certification is therefore essential. Finally, carrying capacity assessments are essential before any species is farmed either in the sea or land. This is particularly relevant while expanding sea cage farming in the country. The total number of cages in a given area, stocking density of fish per cage, and feeding intensities should be taken into consideration.

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