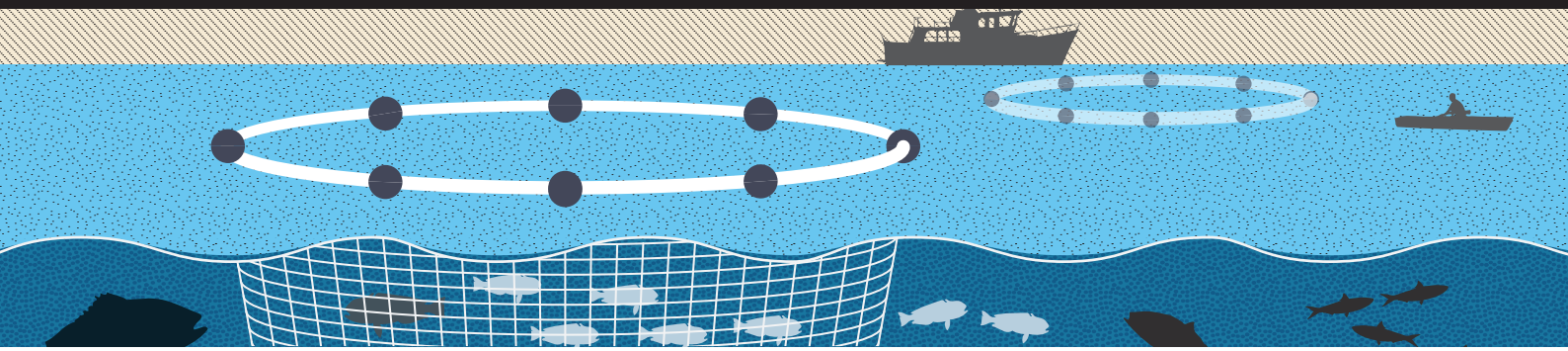

MARICULTURE AND FOOD PRODUCTION

SUSTAINING THE PROMISE

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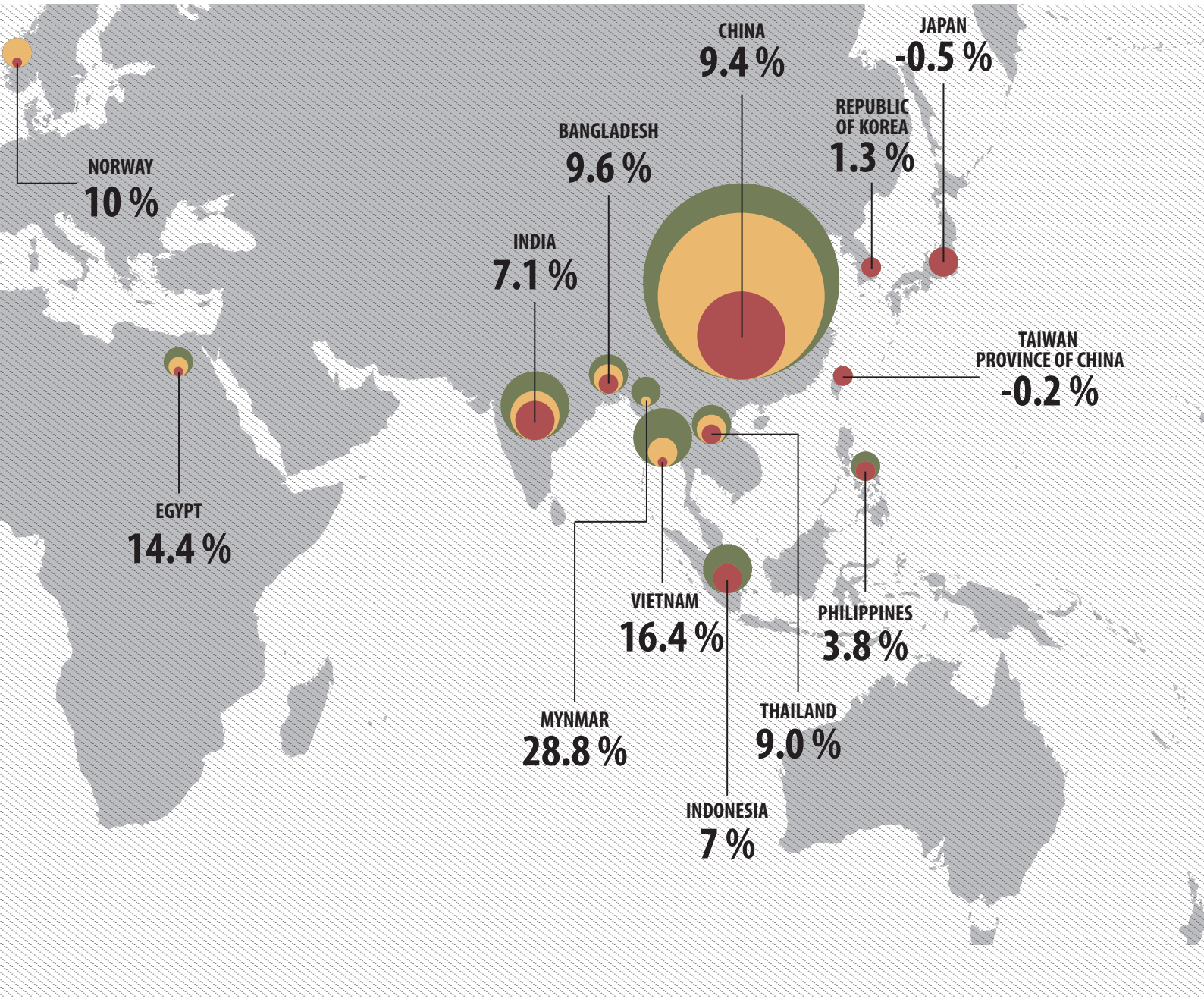
Feeding the world with dwindling stocks

Marine fish stocks in many parts of the world have been exploited beyond recovery, but this has done little to slacken an increasing global demand for sea food. These markets compel producers throughout the world to fish out even smaller sizes, effectively endangering reproducing populations of several commercial species. Sustainability and equity in fisheries has frequently been sacrificed in favour of meeting this growing desire for seafood. Declining wild fish catch, increasing input costs of fishing operations, and the unrelenting demand for marine products has prompted an interest in aquaculture. Consequently, recent years have seen economies, particularly in the tropics like India, embarking on nation-wide aquaculture development programmes. India currently ranks second in world aquaculture production (see figure on Pages 2-3), with an estimated production of 3,791,921 tonnes per annum. The origins of aquaculture date back more than 4,000 years[1]. There is evidence that Egyptians cultured fish as early as 2500 BC[2]. The Chinese have a rich tradition of aquaculture practices that can be traced back to 2000 BC. Contemporary practices in this field are a result of the refinement and the adaptation of these ancient experiments with aquaculture.

The tradition of aquaculture in India can be traced back to 300 BC, and certain practices involving the integration of paddy and fish farming techniques are seen in their more traditional manifestations even today in Kerala and West Bengal. Even though these traditional production methods were considered low-technology, produced lesser quantities, and were often low cost and less intensive, these traditional forms of fish production were practised by poorer farmers unlike the huge enterprises that later entered this sector. These traditional forms also exerted a gentler pressure on ecosystems, and maintained biodiversity values.

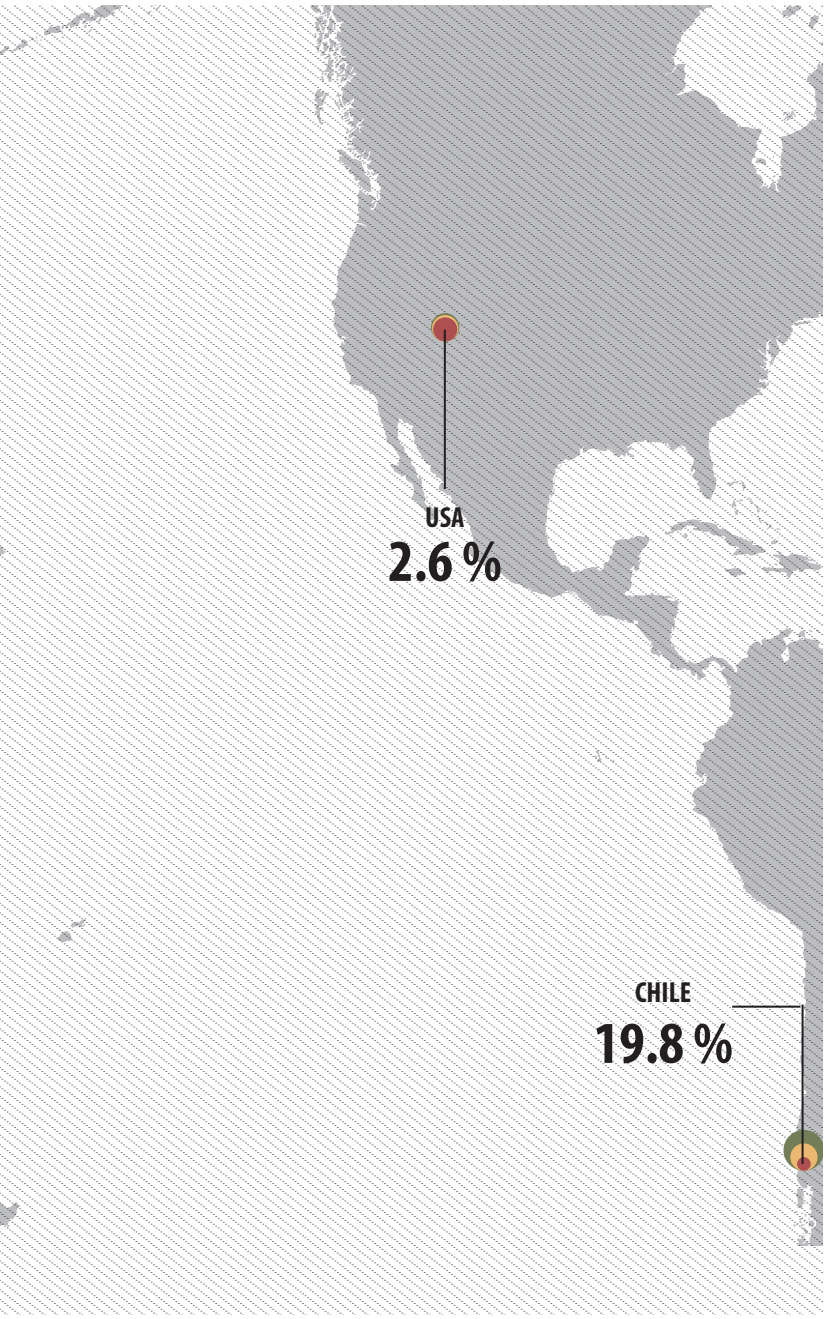
Industrialisation of the aquaculture sector from 1900 to 1970 led to 'improved' technologies that facilitated the transport of fish, information flow, artificial feed production, breeding and hatchery technology, and processing and storage technology. This transformation from low to high technology and investment is encouraged primarily from the view of supplementing dwindling wild stocks to feed a global market.

Modern day aquaculture rationalises its operations at large scales by accessing metaphors and rhetoric of fighting global poverty and food shortage in developing and under-developed economies[3,4].

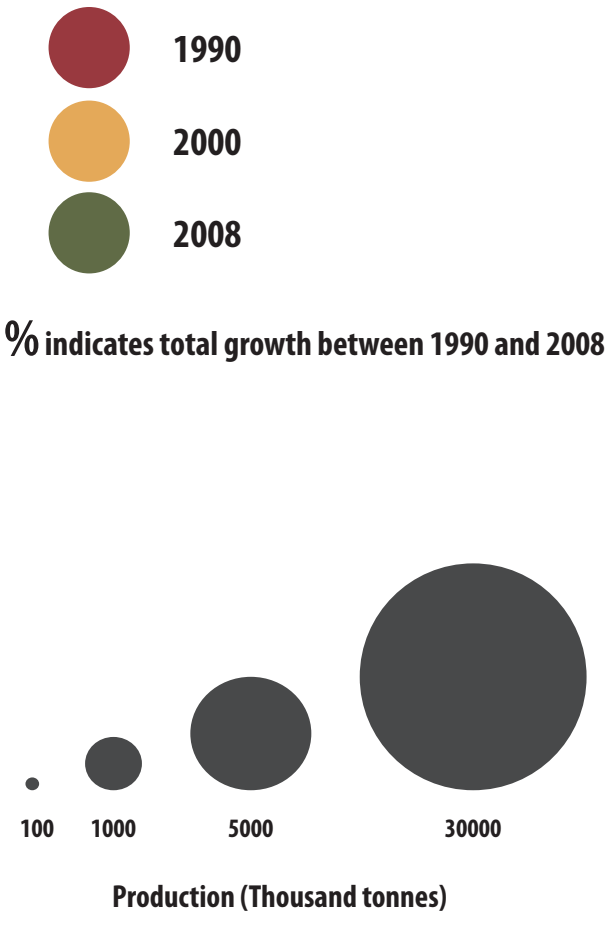


The preface of the 2008-2009 Annual Report of the Indian Coastal Aquaculture Authority states "Coastal aquaculture is one of the important economic activities which contributes to employment, poverty alleviation, community development, reduction of over-exploitation of natural resources and food security."

Did modern aquaculture deliver the goods? Are the promises of employment generation, reduced pressure on wild fish stocks, and improved food security of the poor discernible? There is little evidence to show that all these benefits indeed materialised. The experiences with aquaculture tells a contrary story.



TRENDS IN AQUACULTURE PRODUCTION BY THE TOP 15 PRODUCERS OF THE WORLD



	Production (Thousand tonnes)			Average annual rate of growth (%)		
	1990	2000	2008	1990-2000	2000-2008	1990-2008
China	6,482	21,522	32,736	12.7	5.4	9.4
India	1,017	1,943	3,479	6.7	7.6	7.1
Vietnam	160	499	2,462	12.0	22.1	16.4
Indonesia	500	789	1,690	4.7	10.0	7.0
Thailand	292	738	1,374	9.7	8.1	9.0
Bangladesh	193	657	1,006	13.1	5.5	9.6
Norway	151	491	844	12.6	7.0	10.0
Chile	32	392	843	28.3	10.1	19.8
Philippines	380	394	741	0.4	8.2	3.8
Japan	804	763	732	-0.5	-0.5	-0.5
Egypt	62	340	694	18.6	9.3	14.4
Myanmar	7	99	675	30.2	27.1	28.8
United States of America	315	456	500	3.8	1.2	2.6
Republic of Korea	377	293	474	-2.5	6.2	1.3
Taiwan Province of China	333	244	324	-3.1	3.6	-0.2

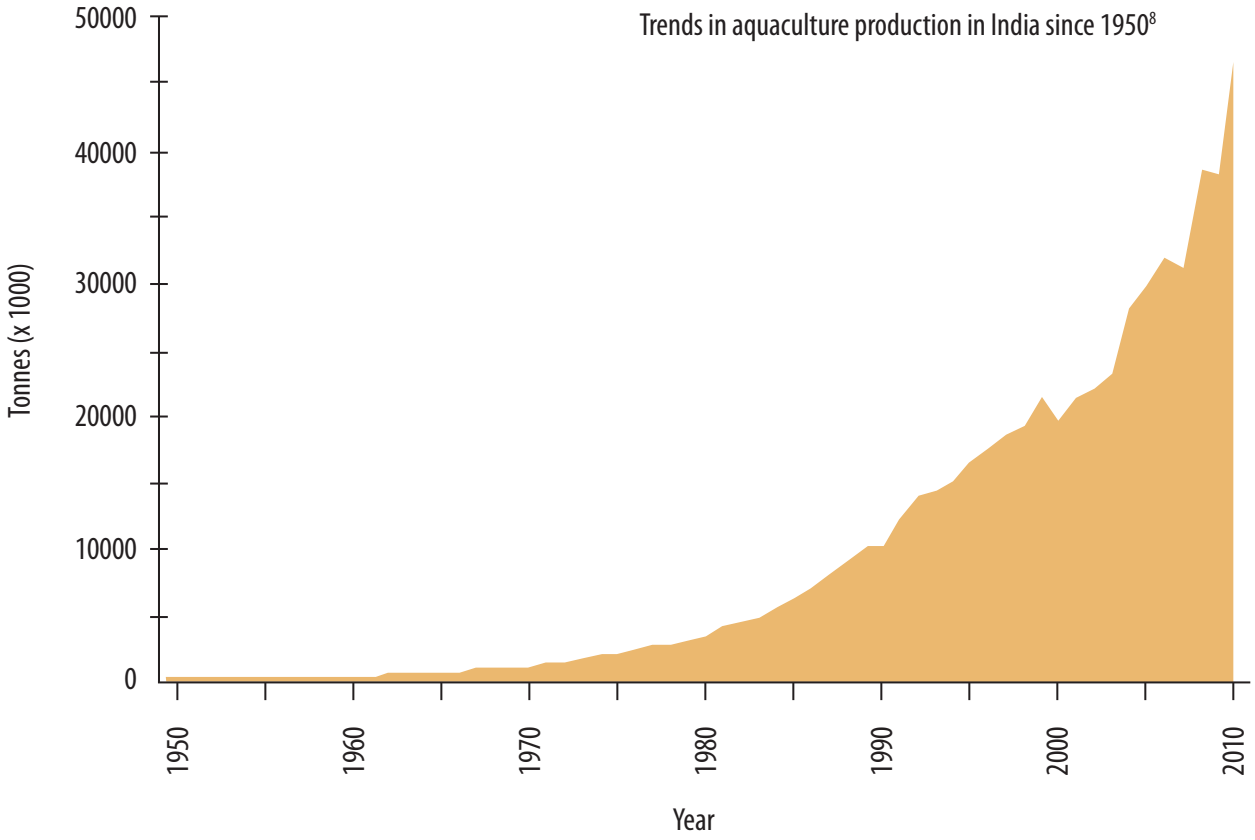
Trends in aquaculture production by the top 15 producers of the world[5]

Note: Data exclude aquatic plants. Data for 2008 contain provisional data of some countries.

CONVENTION ON BIOLOGICAL DIVERSITY AND MARICULTURE

The Convention on Biological Diversity 1993 identifies mariculture as a rapidly developing industry in the food production sector and as a mechanism to facilitate the economic development of local communities. The Convention, however, also recognises the potential impacts of the industry if carried out on an industrial scale. In particular, the CBD highlights the use of nutrients and antibiotics, the disposal of mariculture wastes, accidental releases of alien species or living modified organisms, transmission of diseases to wild stocks, and the displacement of local and indigenous communities as priority concerns.

At the 4th CBD Conference of the Parties (COP) in Montreal, Canada 1999 an Ad Hoc Technical Expert Group on Mariculture was established to assist the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) in helping implement Programme Element 4 (Mariculture) of the Programme of Work on marine and coastal biological diversity. The Technical Expert Group on Mariculture and SBSTTA 8 put forth a set of recommendations during the 7th CBD COP[6]. The working group put together detailed recommendations[7] of specific methods and practices to avoid adverse biodiversity-related effects. In addition, a number of research priorities were also identified.



EXPERIENCES OF FARMING SHRIMP

The history of the shrimp aquaculture industry in India flags several concerns for enthusiasts interested in promoting related activities such as mariculture. It highlights the need for a meaningful regulatory framework and the need to prioritise environmental and social concerns while designing interventions. Prior to the industrialisation of aquaculture in India a traditional system of shrimp farming was practised in the coastal stretches of states like Karnataka, Kerala, and West Bengal, where tide-fed farms were used for the extensive culture of various brackish water species dominated by shrimp. In some cases shrimp harvesting was alternated with paddy cultivation (usually a salt-resistant variety). However, these time-tested sustainable practices found little space in the vision of a modern aquaculture tasked with feeding a global population of consumers. The unfolding of events related to shrimp aquaculture in India are presented in the adjoining table highlighting the ironies of this sector, and its social and ecological fallout.

Historical events	Outcome/s	Impacts
In 1973, the All India Coordinated Research Project (AICRP) on 'Brackishwater Fish Farming' was initiated by the Indian Council for Agricultural Research (ICAR).	Dedicated research units and programmes emerged in the Central Marine Fisheries Research Institute (CMFRI) which promoted the concept of selective stocking and supplementary feeding as improved technological interventions to achieve higher production results.	The demand for wild fish products increased in order to prepare the feed necessary for fish farms that followed these practices.

In 1979, the Marine Products Export Development Authority (MPEDA) set up its aquaculture wing. In addition, the Ministry of Agriculture provided substantial support to promote and develop the aquaculture industry.	By the 1980s, MPEDA had introduced the idea of intensive and semi-intensive shrimp farming as the idea of a modern aquaculture unit. 100% export units came up with MPEDA's support.	Aquaculture became more high-tech and investment-heavy, with little support for traditional aquaculture practices. The scale of ecological impacts increased, and exacerbated social equity issues. Later neither MPEDA nor any other Government authority had much control on they way the industry developed.
Between the 1980s and mid 2000, due to its high demand and value in the international market, *Penaeus monodon* farming was promoted throughout the coastal states of India and subsidies, loans and technologies were provided with substantial government support.[9]	Shrimp farming gains popularity across all coastal states of India. Aquaculture is equated with shrimp farming and further, becomes synonymous with intensive and semi-intensive technology and capital dependent practices.	The industry grew at a rapid pace with little regulatory or monitoring mechanisms in place. Laws such as the Water Act (1974) or even the Environment (Protection) Act, 1986 were unable to address this problem in their existing form. The indiscriminate expansion leads to the degradation of coastal ecosystem health (particularly in mangrove ecosystems), salinity ingress, social conflict and unrest.
White Spot Syndrome (WSS) disease outbreak was noticed first during 1994, and by 2000 spread to nearly all the coastal states of India.	There was little collaborative effort to stem the spread of the disease. Indiscriminate use of antibiotics leads to a crash in the export value and demand for shrimp from India. Investment costs suddenly increased and there are fears that the disease may have spread to wild populations.	This led to the virtual decimation of the *Penaus monodon* farming industry. Many farmers incurred substantial losses and the shrimp production in India came down substantially (from approximately 50,000 kg/ha in 1993 to a few thousand kg/ha in 2001).
In the mid- to late-1990s, the substantial social-ecological impacts of the shrimp industry led to campaigns and protests such as the Campaign Against the Shrimp Industry (CASI).	Individuals and organisations from various coastal states, particularly Tamil Nadu, protested against the shrimp farming industry. The Supreme Court judgement led to the formation of the Aquaculture Authority under the Environment (Protection) Act, 1986 under section 3(3).	In a significant judgement, the Supreme Court of India passed a verdict (known popularly as the Jagannath judgement)[5] in December 1996 banning shrimp farming activities within the jurisdiction of the Coastal Regulation Zone (CRZ),except extensive and improved extensive methods and banning conversion of agricultural lands, salt pans, mangroves, wetlands, and common village property land for shrimp culture purposes.
The Aquaculture Authority of India is replaced by the Coastal Aquaculture Authority Act, 2005.	The law contains detailed guidelines for coastal aquaculture. Curiously, this law makes reference to the Coastal Regulation Zone Notification 1991, stating that the ban on aquaculture in this law is reversed. In effect it negates the provisions of the Jagannath judgement.	Reports of poor implementation of the guidelines' positive features of this law makes its implementation challenging. It also re-introduces the idea of coastal aquaculture once again albeit under a system of guidelines which are practically voluntary in nature and unmonitored.

Introduction of *Litopenaeus vannamei* (earlier known as *Penaeus vannamei*) in India.	*Litopenaeus vannamei* has replaced *Penaeus monodon* as the preferred aquaculture product. Despite fears about disease and pathogen transmissions, farms are known to practice extremely high stocking intensities. The regulatory mechanism has failed to prevent this situation from arising.	*Litopenaeus vannamei* appears to be going the *Penaeus monodon* way, and imports of this species have been banned in certain countries due to the detection of a range of pathogens in this species and the high rate of transmission of disease from this species. A positive aspect is the Government insisting on introduction of only Specific Pathogen Free (SPF) *Litopenaeus vannamei* broodstock for hatchery production. However, stringent monitoring is needed to reduce risks of pathogen introductions.

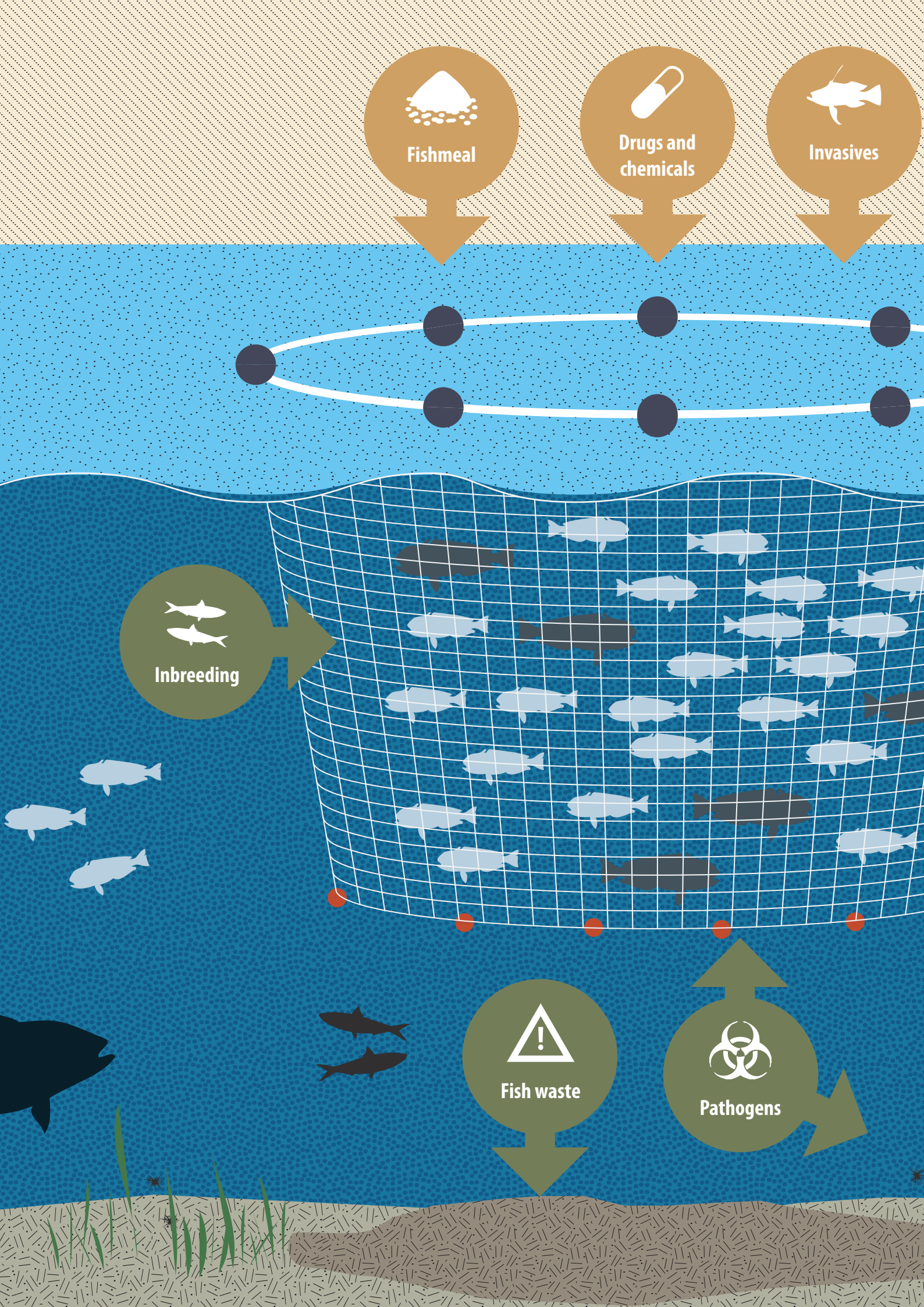
APPROACHING MARICULTURE

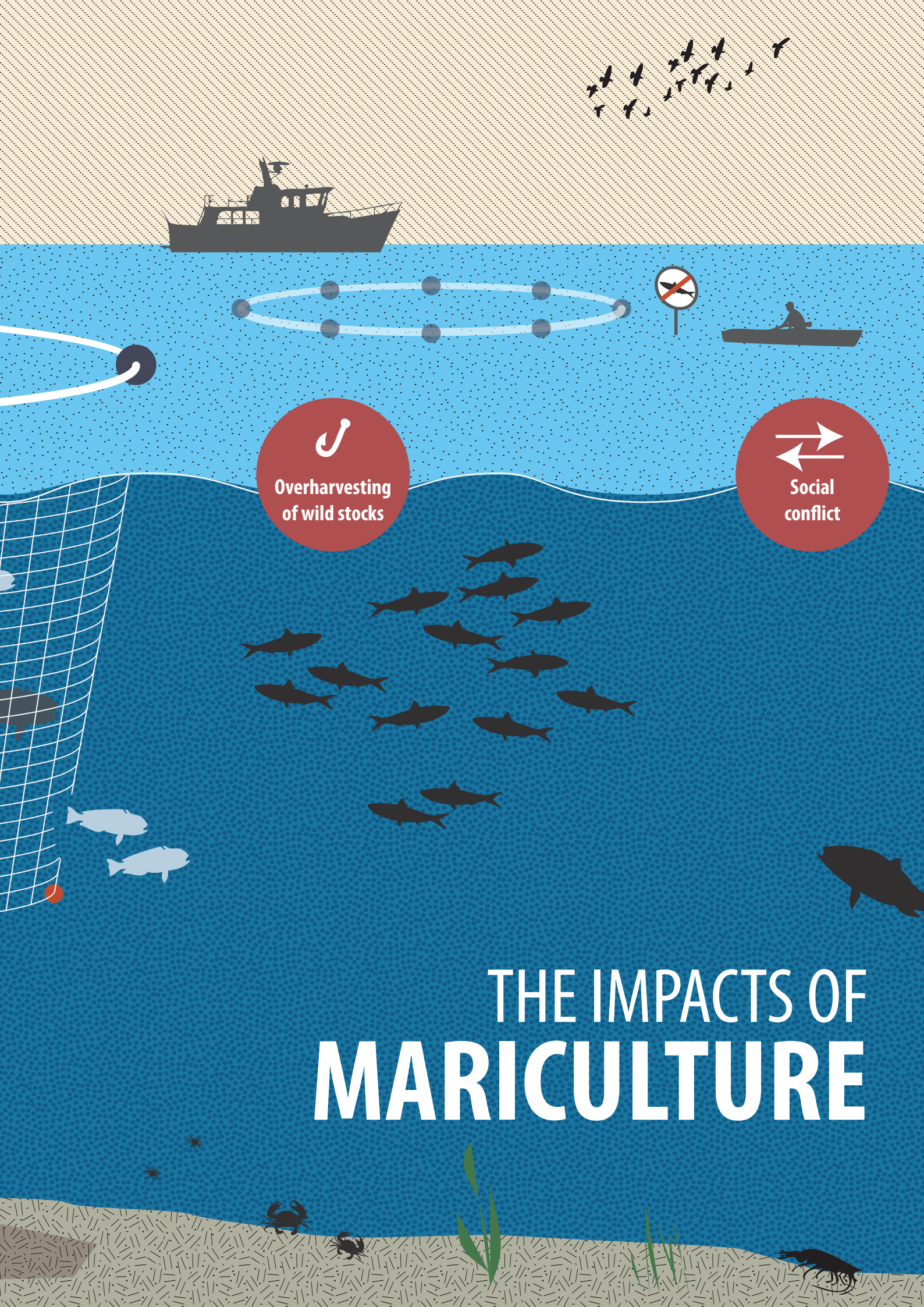
With coastal aquaculture—particularly shrimp farming—becoming increasingly unpopular, the food production sectors in India are now exploring options of promoting mariculture. The Twelfth Five Year Plan of India identifies mariculture as a potential food production sector that needs to be developed and supported on a large scale[10].

Mariculture and its introduction must be viewed against the backdrop of shrimp aquaculture in countries like India. What can we learn from the experiences of modern aquaculture? Understanding and adopting mariculture demands an interdisciplinary perspective which places the ecological and social on an equal footing with the technical and economic, while addressing the food security questions in developing countries.

Mariculture is a sector of aquaculture that involves the rearing of aquatic organisms under controlled or semi-controlled conditions in coastal and offshore waters. The sector has received comparatively little attention. With its diverse coastal and marine ecosystems, India is viewed as a fertile ground for expanding mariculture, and addressing multiple challenges faced by the seafood industry. Various research institutes in India have achieved breakthroughs and have successfully cultured some organisms in pilot trials. However, the policy and regulatory framework that must guide the development of this industry is yet to take shape. The future of mariculture, its scale of operation, direction, growth, and impacts must be understood and foreseen through multidisciplinary frameworks. Regulation of this activity must be designed bearing its ramifications for both social and ecological communities. Some important questions that need to be addressed before promoting mariculture on a large scale are:

1. How do we ensure that the promotion of mariculture meets the food security needs of poor coastal communities?
2. How do we combine ecological and social goals while framing the mariculture development plans at various scales?
3. In what manner can we operationalise the precautionary principle in mariculture development?
4. Drawing from the experiences of shrimp aquaculture, what elements must be incorporated into the design of a regulatory framework for mariculture?


Fishmeal
Drugs and chemicals
Invasives
Inbreeding
Fish waste
Pathogens


Overharvesting of wild stocks
Social conflict
THE IMPACTS OF
MARICULTURE

Mariculture development in India

Modern scientific experiments with mariculture research, and promotion trials began in India in the late 1970s and 1980s. Mariculture has been tried and tested in various fields (details below) with varying degrees of success. The table provides an account of these along with their present status and a brief assessment of these endeavours.

Nature and practice	Current status	Problems encountered
Pearl oyster culture: Pearl oyster farming and hatchery technology was developed by Central Marine Fisheries Research Institute (CMFRI) in the 1970s and 1980s.	Attempts were made to take up village-level culture activities in the Gulf of Mannar, by the M.S. Swaminathan Research Foundation. Technologies were developed for Mabe and Akoya pearl production.	Could not be established on a large scale. Economic viability hinged on regular and reliable market supply of high quality pearls, which the community-based enterprise was unable to fulfill. Project funding was short-lived.
Oyster farming: Techniques of farming the edible oyster *Crassostrea madrasensis* have been developed and evolved since the 1970s by CMFRI.	For more than a decade now, oyster farming has been undertaken by local communities, especially women's groups, along the Kerala coast.	Method of hatchery production of oyster seed even though developed has not yet become commercially viable.
Mussel culture: The technology of seeding ropes with spats collected from the wild, was developed in the 1980s.	Continuous efforts by CMFRI enabled many women's Self-Help Groups (SHGs) in Kerala to take up mussel culture from 1996 onwards. Various coastal state governments (particularly Kerala, Karnataka, and Maharashtra) have supported mussel farming. The common cultured varieties are *Perna virdis* and *Perna indica*. The production of mussels in India from mariculture in 2006 was recorded at 10,600 tonnes. At least 3,000 women self-help group members derive incomes from mussel culture.	The major limitation is that the hatchery technology for seed production has not been commercialised yet. Hence there is a heavy dependence on wild seed, which is in short supply. Mussels need to be grown in pollution free water. Being filter feeders they are known to accumulate both biological and chemical pollutants which are passed on to consumers.
Finfish culture: Cage culture of many commercially important finfishes has been promoted and experimented by the CMFRI and Rajiv Gandhi Centre for Aquaculture (RGCA) promoted by MPEDA in India.	Finfish mariculture is yet to be undertaken at a commercial scale.	Rajiv Gandhi Centre for Aquaculture (RGCA) mentions the main constraint in developing finfish mariculture as limited availability of high quality pelletised feed and lack of proper allotting/leasing policy for water area.

Seaweed culture: The culture of agar-yielding red seaweed, *Kappaphycus alvarezii*, *Gracilaria ediulis*, and *Geldiella acerosa* is promoted by Central Salt and Marine Chemical Research Institute (CSMCRI) and CMFRI since 1964. The vegetative propagation of seaweeds on nylon ropes has been standardised in the Palk Bay area.	The commercial production of seaweeds took many more years to take off when the company, Pepsi Foods Limited, promoted the culture of the exotic species *Kappaphycus alverzii* through women's SHGs. Later, agencies like the Aquaculture Foundation of India also supported the venture. The yield is reported to be economically viable.	*K. alvarezii* is an introduced exotic species and is a well-known biological invasive in many parts of the world. Reports suggest that *K. alverzii* has invaded the coral reef ecosystems of the Gulf of Mannar Marine National Park, and is increasingly becoming a threat to local biodiversity. There is a need for transparent and stringent procedures to prevent the willful or unintentional introduction of alien invasive species. These must be accompanied by detailed environment impact assessments applying precautionary measures to mitigate adverse impacts in the face of uncertainties. Local varieties should be promoted in mariculture experiments and programmes.
Crustacean culture: Wild lobster and crab fattening technology has been developed.	Lobster fattening is now followed by some fishers, mainly in Kanyakumari in Tamil Nadu and Bhavanagar in Gujarat. The mud crab *Scylla serrata* are fattened in ponds along many parts of the coast. Crab fattening often accompanies mangrove conservation programmes.	The exploitation of juvenile lobsters from their nursery habitats has been found to be detrimental to the health of the resource in the long run. In spite of advanced research in the breeding of lobsters, commercial hatchery production is yet to be developed. RGCA claims to have shown commercial viability of mud crab seed production.

ADDRESSING IMPACTS OF MARICULTURE

One of the most critical aspects of promoting aquaculture, specifically mariculture, in biodiversity-rich areas in the tropics will be its impacts on the environment and ecosystems. There are several studies that highlight the impacts of mariculture on the health, services, and functioning of adjoining ecosystems and species[11]. Developing countries hoping to formulate regulatory mechanisms must incorporate these aspects into their assessment and monitoring procedures. Based on case studies from countries where mariculture has been carried out on a large scale, the table below presents potential ways of addressing certain negative outcomes of mariculture activities.

Possible impacts of mariculture	Potential ways to address concerns
Unplanned and unregulated mariculture can create conflicts over the protection and use of coastal commons.	Since marine areas are often covered by tenural arrangements under common property regimes, plans for the use of such spaces and ecosystems must respect existing arrangements and address the present and future needs of other users of the same system. These arrangements must be developed and guided by local communities.
Over-harvesting of wild populations to meet stocking needs.	The promotion of mariculture should be undertaken for species with well-established hatchery production technology. Strong regulation and monitoring of the extraction of seeds from wild stock should be the norm.
Continuous inbreeding could reduce hybrid vigour and result in poor genetic quality of the cultured stock. These effects could spread to wild stocks if cultured stocks escape or if such specimen are used for sea ranching.	Selective breeding of disease resistant animals on a regular basis could address this problem. Mechanisms should be put in place to minimise the escape of farmed fish into the wild.
Introduction of pathogens during intensive culture by way of broodstock or seeds can affect both cultured stocks and wild stocks.	Strict regulation in intensification of culture, a strong monitoring and quarantine regime, stringent certification and licensing methods.
Intensive culture of finfishes in cages, crustaceans or even molluscs could lead to accumulation of organic wastes from unconsumed feed or faecal matter. This could increase the organic load, resulting in depletion of oxygen.	Regulations must address the question of intensity and scale, e.g., number of cages, distance between cages, and stocking density. Use of feed with very high feed conversion ratio, and effective feeding mechanisms that minimise wastes. Polyculture of finfishes, seaweeds, and molluscans could help recycle nutrients and organic wastes to some extent.

Most of the finfishes cultured are carnivorous, and the feed ingredients are highly dependent on fish meal. Large quantities of captured pelagic fishes are likely to be diverted for this purpose adding to the problem of over-fishing, or for the availability of these fish to ensure food security of the local communities.	Promote and support existing technologies for reducing the quantity of fish meal and fish oil in mariculture feeds. Decide on appropriate scales of mariculture that do not create shifts in the economics and social aspects of marine fisheries.
Increased instances of diseases and parasite attacks lead to the use of both prescribed and un-prescribed antibiotics and chemicals which pass on their residual effects to consumers as well as other flora and fauna. This leads to the development of antibiotic-resistant pathogens.	Complete ban on the use of antibiotics and chemicals that have bio-accumulative or residual effects. While export markets have stringent regulations on antibiotics, strong regulations need to be developed for domestic markets as well.
Introduction of exotic species like *Penaeus vannamei* or *Kapaphycus alverazii* for commercial aquaculture activities can lead to problems of biological invasions.	The introduction of exotic species should be allowed only after scientific trials are able to establish their benign nature. Systematic impact assessment before according permission for trials and introduction, and continuous and transparent monitoring should be done to establish their impacts on ecosystems.
Many of the mariculture technologies being developed and promoted are capital intensive and are more likely to serve the interests of larger investors rather than the poorer sections of the local community.	The success in propagating mussels, oyster, and seaweed culture among SHGs of women is a good example of low technology, low investment, and highly adaptable techniques for local communities. The focus should be on the development and promotion of such activities rather than promoting large-scale, high-investment projects.

FRAMEWORK FOR REGULATING MARICULTURE IN INDIA

Social equity and access to resources

- Unlike shrimp aquaculture, mariculture in India needs to be introduced in a manner that produces tangible and measurable benefits to the marginalised poor. Mariculture programmes and development schemes at all scales must outline who the intended beneficiaries are.

- All mariculture projects must have detailed impact assessment and mitigation plans that include compensation mechanisms and allocations for potential economic and ecological losses that might be borne by local communities.

- Though some of the mariculture activities can be carried out in offshore waters, culture of most species involves captive/confined culture in productive coastal waters which are fishing grounds particularly for small-scale fishers. Mariculture design plans must respect existing common property regimes in operation in marine spaces and should not undermine the rights of access to fishing grounds or undermine the health of such fishing grounds.

- Local communities should be involved in, and empowered to undertake actions for monitoring health of wild stocks in areas where mariculture is being introduced.

Creation of multidisciplinary regulatory bodies at varying scales

- We recommend the constitution of multidisciplinary bodies, at the national, state, district levels, comprising of experts who can assess, review, and monitor mariculture technologies and practices.

- Such experts can be drawn from a range of disciplines in the natural and social sciences, from local communities, persons with experience from the mariculture industry, and from non-government organisations.

- At the national level, the Coastal Aquaculture Authority of India must reflect such a membership, and its mandate must be revised to accommodate specifically the social and ecological problems associated with mariculture..

Develop appropriate infrastructure for monitoring, enforcing, and implementation

- The structure, infrastructure, and implementation mechanism of the Coastal Aquaculture Authority of India needs assessment, revision, and scaling-up. In its present form, it cannot adequately address the newer challenges posed by sectors of aquaculture such as mariculture.

- Newer regulatory mechanisms and bodies can no longer afford to be top-heavy with a strong government representation and little space for including communities or their concerns.

Make EIA clearance mandatory for projects beyond a certain capacity

- Aquaculture involves the use of ecosystems and its resources in order to produce food. The development of such an industry therefore has strong ecological and environmental implications. The Environment Impact Assessment (EIA) procedures refer to a process of governance whereby the environmental impacts of certain activities can be ascertained in order that decisions can be made about persisting with such activities. Projects may vary substantially in scale, and it may not be feasible to carry out EIAs for all projects. However, EIAs should be mandatory for projects beyond a certain designated scale and for projects of one person/ company that together exceed the designated scale and for individual projects or proponents who cumulatively and collectively exceed these scales.

Maintain transparency in evaluation, clearance, and approval of proposals

- A major concern in India on development projects is the lack of transparency in carrying out feasibility studies (such as EIAs) and socio-ecological assessments. Most assessments are not open to public scrutiny, and exclude the local community. Clearance procedures for aquaculture and mariculture projects must be transparent, where EIAs are made publicly available, and public hearings are conducted for certain types and scales of projects.

- A central role must be assigned to local communities and civil society groups in the processes of designing, assessing, and regulating such projects.

External market influences

- Mariculture in India will invariably target and cater to the foreign market, and export will be a major focus. Invariably, short-term economic benefits could overrun long-term social, ecological, and environmental concerns. It is therefore necessary to establish stringent regulations for licensing, certifying, and promoting large-scale projects that cater to a foreign market.

- Another undesirable outcome of the foreign market influence is the negligence of the local market. There should also be a strong focus on ensuring the promotion and development of a local market for cultured species. If promoted in an appropriate manner, India could become fertile ground for sustainable, small-scale, innovative mariculture ventures. These will have positive impacts on livelihoods and food security at a local scale.

Development of low-cost, innovative technologies, and responsible technology transfer

- Developing technologies that require low capital inputs, are innovative and environmentally safe, and involve minimal technical expertise at future stages of operation are prerequisites for sustainable and pro-poor mariculture activities.

- Secondly, but equally important, is the process of technology transfer. Although research institutes in India have undertaken many trials and experiments in aquaculture technologies for improving poor peoples' livelihoods, they have fallen behind in adopting effective communication and technology transfer capabilities and strategies in relation to users.

- Extension departments of research institutions need to work closely with local community-based organisations and institutions in order to ensure equity in access to the technologies and associated schemes and subsidies. A clear framework that involves multiple stakeholder groups needs to be developed.

- Equally important is the need to develop a feedback mechanism wherein experiences, issues, and concerns in applying the technologies at the ground level can be reviewed and addressed.

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