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Molluscan resources and management strategies*

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Since the dawn of human civilization molluscs have a tremendous impact on Indian tradition and economy. In India, molluscs have been in great demand as ornaments, currency, as popular panacea for illnesses and as mascot for ward off evil spirits in olden days. Now, molluscs have assumed greater significance in our industrial, technological and aesthetic aspects of life, in addition to edible utility. Several species of gastropods and bivalves are traditionally fished for food and shell from time immemorial. The exploitation of cephalopods began recently and became large scale operation after the introduction of mechanized trawling. About 80,000 – 1,00,000 species of molluscs are recorded from the world over and a total of 3271 species are recorded from India. They are represented in 220 families and 591 genera and the spectrum comprise of 1900 gastropods, 1100 bivalves 210 cephalopods 41 polyplacophores and 20 scaphopods (edible and ornamental) and 14 species of cephalopods are exploited on commercial basis in India. The exploitation status of important groups are given below.

CEPHALOPODS

Altogether eighty species of cephalopods are known and only a dozen species contribute to the fishery. Cephalopods comprise the squids, cuttle fishes and octopus and are exclusively marine. They have emerged as valuable resources in recent times due to their high demand in the export market.

Cephalopods make up only a small proportion (nearly 3%) of the world capture fisheries landings, but there have been substantial increases during the last three decades. According to the FAO, the total world landing of cephalopods was 1.6 million tones in 1982 and 3.77 million tones in the year 2004.

The production of cephalopods increased from a mere 94 t in 1961 to 3,36,032 t in 2006 along the Indian coast. However, the increase in production was not consistent and showed the following four phases during the four decades; (i) sharp increase from 94 t in 1961 to 10,786 t in 1976; (ii) marginal increase from 10,786 to in 1976 to 20,407 t in 1984; (iii) again sharp increase from 20,407 t in 1984 to 1,16,753 t in 1995; and (iv) stagnation at around 1,10,000 t during 1996-2000. By 2006 the total cephalopod landing is increased up to 13,6032 t. Concurrent with this growth in production, the contribution by the cephalopods to all India marine fish production rose from 0.1% in 1972 to 4% in 1992.

Cephalopods are landed in all the maritime states in India and the production increased during 1961-1995. Kerala ranked first accounting for 37.70% of the total cephalopod landings followed by Maharashtra (28.98%), Tamilnadu (13.8%) and Gujarat (13.65%) during 1992. Region-wise analysis shows that there is an increase in the production from 83 to1,00,246 t along the west coast (1995) where as the increase was from 11 t to 16,507 t. along the east coast. Cephalopods are not targeted fishery along Indian coast except for small production coming from jigging. Cephalopods are mostly caught as by-catch of shrimp trawlers. Lesser quantities are caught in hook and line, boat seine and purse seine.

Squids and cuttle fishes are the major groups contributing 52 and 48% respectively to the cephalopod fishery. Octopus are landed in negligible quantities viz. 16 t/year. *Loligo duvaucelli, Sepia pharaonis* and *Sepia aculeata* are the three main species contrtibuting 42, 22 and 20% respectively to the cephalopod landing of the country.

The Indian squid, *Loligo duvaucelli* is landed in all along the coast and Kerala accounts for 38% of this species, followed by Gujarat (22%) and Maharashtra (20%). Other squids with commercial importance but with restricted distribution are *Loligo uyi, Loliolus investigatoris* and *Sepioteuthis lessoniana*. They contribute about 6% of the total cephalopod landings. Bulk of the catch (87%) is landed by the trawlers which operates within 50m depth. The average catch per trawl unit per day was highest (96.9 Kg) in Maharashtra and lowest (0.4 kg) in Orissa.

Potential Yield of Cephalopods :

Various resources survey and estimations are available on the cephalopod resources of Indian Exclusive Economic Zone, continental shelf, neritc and oceanic sector. A brief summary is presented in Table 1.

Table 1 Estimated potential yield of cephalopods

Author	Year	Estimated potential yield	Sector/Zone
George *et al.*	1977	1,80,000 t	EEZ
Chikuni	1983	50,000-1,00,000t	Bay of Bengal
Chikuni	1983	1,00,000– 1,50,000 t	Eastern Arabian Sea
Silas	1985	50,000 t	Oceanic sector
Silas	1985	25,000-50,000 t	Neritic sector
Sudharashan	1990	20,600 t	50-300 m depth
Philip and Somavanshi	1991	49,100 t	Cuttlefish alone from the continental shelf
CMFRI	2002	92,604 t	

BIVALVES

The commercially important bivalves along the Indian coast are the clams, mussels, edible oysters and pearl oyster. The bivalves were exploited for shell, meat, industrial purposes and for the pearl. The edible bivalves and ornamental shell became more popular and the average quantity of bivalve products exported per annum was 580 t during 1995-1999. The average annual production of bivalves during 1996-2000 was estimated as 1.52 lakhs tones. Clams and cockles form 73.8%, followed by oysters (12.5%), mussels (7.5%) and windowpane oysters (6.2%). The state-wise production of bivalves is given in Table 2.

Clams :

Among the exploited bivalve molluscan resources of India clams are widely distributed and abundant. They form subsistence fisheries all along the Indian coast and fished by men, women and children from the inter tidal region to about 4m depth. They are hand picked or collected by hand dredges.

The commercially exploited clams are *Villorita cyprinoides, Meretrix meretrix, M. casta, Paphia malabarica, Katelysia opima* and *Anandara granosa*. In the Andaman and Nicobar giant clams, *Tridacna maxima, T. squamos, T. crocea and Hippopus hippopus occur*. The former two species have been reported from Lakshadweep also. The Kerala State stands far ahead of all maritime states in clam production with a catch of 32927 t which accounts for 72.5% of the estimated 45,412 t clam landings. The Ashtamudi and Vembanad lakes are the important production centers in Kerala. Karnataka ranks the second with 6592 t forming 14.5% of the clam production.

Table 2 Details of bivalve fishery in the maritime states

State & main landing centers	Commercially Important bivalve resources	Av. landings (t) (1996-00)
Kerala (Vembanad and Ashtamudi Lakes)	Vc, Pm, Mc, Mo, Cm, Sc, Pv, Pi	58763
Karnataka, Mulky, Udayavara	Mc, Vc, Pm, Cm, Sc, Pv	12,750
Goa (Nauxim Bay, Zuari, Mandovi estuaries)	Mc, Vc, Pm, Cm, Sc, Pv	1,637
Maharashtra (Ratnagiri)	Pm, Mc, Gb, Cg, Cr, Sc	2,035
Gujarat (Gulf of Kutch)	Cg, Cr, Sc, Pp, Pf	4,202
Tamilnadu & Pondicherry	Mc, Mm, Cm, Sc, Pv, Pf, Pi	2,098
Andhra Pradesh (Kakinada Bay)	Ag, Gb, Mc, Mm, Pm, Cm, Pv, Pp	70,705
Andaman & Nicobar Is.	Tc, Tm, Pmar, Pv, Pm	Na
Lakshadweep	Tc, Tm	Na

Ag- *Anadara granosa*, Cg- *Crassostrea gryphoides*, Cm- *C. madrasensis*, Cr- *C. rivularis*, Gb- *Gelonia bengalensis*, Mc- *Meretrix casta*, Mo- *Marcia opima*, Mm-*Meretrix meretrix*, Pf- *Pinctada fucata*, Pi- *Perna indica*, Pv- *P. viridis*, Pm- *Paphia malabarica*, Pp- *Placenta placenta*, Pmar- *Pinctada margaritifera*, Sc- *Saccostrea cucullata*, Tc- *Tridacna crocea*, Tm- *T. maxima*, Vc- *Villorita cyprinoides*.

The extent of clam bed in Ashtamudi lake was estimated at 1200.78 ha and it is dominated by *Paphia malabarica*, *Villorita cyprinoides* and *Meretrix casta*. About 61255 t. to of clam was estimated as the standing stock of Ashtamudi lake. The estimated biomass of *V. cyprinoides* is 36945 t. *P malabarica*, 22672 t and *M. casta* is 1638 t (Appukuttan *et al.*, 1989)

In the Kakinada bay during March-May 1983, the standing stock of blood clam (*A. granosa*) has been estimated at 6895 t and that of *M. meretrix* at 1082 t.

The consumption of the clams is generally limited to coastal communities. Export of frozen clam meat began in 1981 and in 1991, 1231.8 t valued Rs. 37.4 million was exported to 18 countries. Also 3 t of dehydrated clam meat valued Rs. 8.72 million was exported in 1991.

Pearl Oysters :

The Indian seas harbour six species of pearl oysters and among these, *Pinctada fucata* and *Pinctada margaritif*era are the two commercially important species. *Pinctada fucata* was dominant in the Gulf of Mannar and Gulf of Kutch and was contributing substantially for the pearl fisheries till early 60s. The latter is distributed in Andaman and Nicobar islands.

In the Gulf of Mannar, between Kanyakumari and Rameswaram there are about 65 pearl banks known as Paars. The paars are located at a distance 12-20 km away from the coast, at 12-25 m

depth. During 1663-1961, 38 pearl fisheries were conducted. The pearl fishery was conducted in India in 1900, 1908, 1926 to 1928 and 1955 to 1961 successfully.

Due to several reasons there have been considerable decline in the fishery of pearl oysters. Shifting of the sand by bottom currents, colonization by the *Modiolus* on the pearl beds, over-fishing, over-crowding, diseases and predation by the gastropods, octopus, crabs and starfish are some of the explanations advanced for the decline of the resources.

In the Gulf of Kutch, there are about 42 important pearl oyster beds known as *Khaddas* in the inter tidal zone at distance ranging from 1 to 5 km from the coast. The total area is about 24,000 ha from Sachana in the east and Ajad in the west. From 1950 to 1967, the average number of oyster fished per season was about 17,000 and the last fishery was held in 1966-67 yielded about 30,000 oysters. The highest value of pearls realized from the fishery was Rs. 61693 during 1943-44. Since 1968, there has been no improvement in the pearl fishery.

The CMFRI has developed the hatchery technology in 1981 for the spat production. To enhance the natural production, sea ranching was done in the Gulf of Mannar. During 1985-1990, a total of 1,025 300 spat of *P. fucata* has been sea ranched in 17 occasions. The average size of the spat ranged from 1.5 to 5.7mm.

Windowpane Oysters :

Among the commercially exploited bivalves in India, the Windowpane oyster *(Placenta placenta)* occupies a prime position next to the clams in production. It occurs in soft muddy bottom in shallow bays, estuaries and backwater. It is reported to occur in Gulf of Kutch, Nauxim Bay (Goa) and Kakinada Bay. The oysters are handpicked at low tide without any diving aids.

In the Gulf of Kutch, Pindara bay is an important production center. The annual yield is 60 million oysters. The standing stock at Goomara, Poshetra and Raida have been estimated at 9,1.2 and 0.1 million windowpane oysters respectively (Varghese, 1976). The natural pearls from the oysters are collected and used in the indigenous pharmaceutical preparations. The shell accounts for 85% of whole weight and is used for lime based industries.

The Nauxim bay in Goa supports a minor fishery yielding 8,000-10,000 oysters/day throughout the year except the monsoon season. The annual production is estimated at 100 t. The oyster meat is consumed locally and the pearls are not used.

Narasimham (2005) studied the windowpane fishery in Kakinda Bay. It occurs 40km^2 area and the population density is low at 2-15 oyster/km^2. The annual production is 50,000 t. The oysters are fished here for the shell only and the meat and pearls are discarded. The standing stock has been estimated at 12420 t in 1983.

In Tuticorin Bay, the windospane fishery is done mainly for the extraction of the pearl. But in Vellapatti Village, the exploitation is solely for the shells. During 2000, 150 tonnes of windowpane oysters were exploited and during 2001, about 60 tonnes of oysters were fished. The live windowpane oysters were purchased at the rate of 1.90/Kg from the fishers and Rs.2.00/Kg to traders.

Edible Oysters :

Out of the seven species of edible oysters reported from India. *Crassostrea madrasensis, C. rivularis, C. gryphoides* and *Saccostrea cucculata* are commercially important. C. rivularis occurs along the Gujarat and Maharashtra coast. *C. gryphoides* is distributed along the north Karnataka, Goa, Maharashtra and Gujarat coast and is regularly exploited from several creeks and backwaters in Maharashtra. *S. cucculata* is found on the rocky substratum in marine environment in shallow coastal and intertidal areas throughout the mainland coast of India and also in the Andamans and Lakshadweep islands. At Worli and Bandra near Bombay 8.75 ha beds of this species have an estimated standing stock of 335.2 t of oysters.

C. madrasensis is the mainstay of oyster fisheries of India. Dense populations are found and exploited along the east coast of India and also along the coast of Kerala, Karnataka and Maharashtra. It inhabits backwaters, creeks, bays and lagoons from the intertidal region to 17m depth. Meat forms 5-10% of the total shell weight.

The studies conducted by CMFRI revealed that in 11 water bodies in Andhra Pradesh the standing stock of oysters was about 1450 t, in Tamil nadu, 21 water bodies have about 23,000 t and in Kerala in 13 water bodies at about 4,000 t. The current annual production of oysters is about 2,000 t. and another 800 t by farming.

Mussels :

Along the Indian coast two species of mussels viz., the green mussel, *Perna viridis* and the brown mussle, *Perna indica* are commercially important. The former is found in small beds at several places along the east coast and extensively along the Kerala coast from Kollam to Kasaragod. It is also found in Karnataka, Goa, Maharashtra and the Gulf of Kutch along the west coast and also in Andamans. *Perna viridis* occurs from the intertidal zone to a depth of 15m. *P. indica* has restricted distribution and is found in the south west coast from Varkkala north Quilon to Kanyakumari and from there to Thiruchendur along the south-east coast.

Kerala state is aptly called as the "Mussel fishery zone of India" since extensive beds of both mussel species occur in the state. They account for the bulk of mussel production in the country. In the major green mussel landing centers in Calicut-Cannanore area about 325 full time and 336 part time divers and 340 canoes were deployed. The green mussel production from this area has been estimated at 3043, 3074 and 2579 t during 1981-82,. 1982-83 and 1983-84 respectively. The catch per unit effort varied from 44.3 to 60.5 Kg/canoe. The standing stock of the mussel has been estimated at 15887 t in 555 ha of mussel beds. The density varies from 2.25 to 4.5 Kg/m^2. In the Majali-Bhatkal are of Karnataka during 1982-83, a total of 36.5 t green mussel were landed. The standing stock from 5 ha mussel bed in this area has been estimated at 206 t. Appukkuttan *et al.* (2001) estimated anextent of 50675 m^2 of mussel bed with 178 t of biomass in Karnataka. In Kerala, the estimated extent of mussel bed was 5665300m^2 with 7954 t mussel biomass.

The important fishing centers of *P. indica* are located between Kovalam and Muttom in the southern part of south-west coast of India. The annual production is estimated at 500 t and the standing stock was estimated at 1586 t. The population density of the mussel is 5-8 Kg/m^2. The production by farming is 10,060 t (2006)

Exploitation of Shell Deposits :

The sub-fossil deposits, also called lime shell are exploited for industrial purposes. The annual production from Karnataka estuaries is 62,000 t. Vembanad lake in Kerala 148,000 t, Pulicat lake in Tamilnadu 57,000 t, Vaigai estuary in Tamilnadu 5500 t and from other sources 5500 t with a total of 278,000 t. The estimated reserve of lime shell in Karnataka estuaries is 2135700 t, suggesting vast scope to step up production.

GASTROPODS

The shell of the sacred chank, *Xancus pyrum* (Linnaeus) is extensively used in the bangle industry in West Bengal and exploited from time immemorial. The major resource occur in the Gulf of Mannar along the Ramanathapuram-Tuticorin coast. They are incidentally caught in bottom trawling along Tanjavur-Chingelpet coast, and in hook and lines along Vizhinjam coast. The average annual production in numbers shows that the catch from the Tuticorin coast as 877000, Ramanathapuram 300 000, Tanjavur-Chingelpet coast 40,000 Quilon-Vizhinjam coast 22,000, Gulf of Kutch 12,000 and Andaman and Nicobar Islands 5000. The overall production comes to 1,256,000 numbers. Devaraj & Ravichandran (1988) estimated the annual stock in the Gulf of Mannar at 2 million chanks and in the intertidal zone of the Gulf of Kutch at 25,000 chanks.

During 2003, about 116 tonnes of sacred chank were landed along the southeast coast mainly at Rameswaram, Mandapam, Keelakarai and Tuticorin. *Babylonia sp. Conus sp. Bursa sp.and Murex sp* were landed from Kakinada Bay and Thangaithittu (Pondicherry) and the annual landing came up to 893 t.

The Top Shell and Turban Shell :

The top shell, *Trochus niloticus*, and turban shell, *Turbo marmoratus* occur in Andaman and Nicobar Island groups. These ornamental molluscs fetch lucrative price. The annual production

ranges from 400 to 600 t for top shell and 100 to 150 t for turban shell. The top and turban shell fishery is banned since both the species are coming under scheduled one and schedule IV of Wildlife (Protection Act) 1972.

Whelks :

The species *Babylonia* is widely distributed in the Indo-Pacific region. In India this species is well represented on the Indian peninsula at places such as Gulf of Mannar, Phomphuhar, Nagapatanam, Madras and waters around Andaman and Nicobar Islands, *Babylonia* are commonly known as 'Whelk', 'Spiral Babylon' and 'puravumuttai chank' (Dove egg shell) in local parlance and 'Baigae' in trade. The total quantity of whelk trade during 1993-94 was 300 tonnes and in increased to 500-600 tonnes during 1995-96. *Babylonia* is a much sought after species and it fetch a good foreign exchange. It has been important food species in Indo-pacific region. Annual landing of whelk during 2001 was 295 tonnes. It increased to 442 t in 2002, whereas a decrease is observed in 2003 as 327 t.

ORNAMENTAL MOLLUSCS

Several ornamental gastropods and bivalves with trade value are distributed in the Gulf of Mannar, palk Bay, Gulf of Kutch, Andaman and Nicobar islands and Lakshadweep. The important shells are *Xancus Pyrum, Chicoreus sp. Babylonia, Cyprea, Conus, Cassis, Cymatium, Cymbium, Drupa, Fistularia, Hemifusus, Lambis, Murex, Natica, Nerita, Oliva, Pyrene, Strombus, Tonna, Tibia, Dentalium sp. Umbonium* etc. They are regularly collected, cleaned and marketed and form the basic material for the shell craft articles. The annual production is estimated at 600 t in 1989, a total of 7.2 t ornamental shells valued at Rs. 0464 million were exported.

Majority of the ornamental shells are landed as by-catch of the trawlers and used in the shell trade. Approximately 70 species are used in the ornamental shell trade. Approximately 70 species of gastropods are used in the trade at present. The rate gastropods collected include - *Conus milneedwardsii* (endangered), *C. bengalensis. C. miles, C. striatus* and *C. geographus* from the family Conidae; *Strombus listeri* and *S. plicatus sibbaldi* (both endangered) from the genus *Strombus* and *Lambis crocea, L. truncate* and *L. scropius* (three endangered) from the genus *Lambis* of the family strombidae, *Cypracassis rufa, Charonis tritonis, Trochus niloticus* and *Turbo marmoratus* (all endangered). The species of *Tridacn*a from Andaman and Nicobar islands are endangered.

Estimated *Xancus pyrum* landings were 4.2 lakh numbers caught by 52 divers during 2003-04. In addition to this there was 2 lakh numbers of elephant chank *Chicoreus ramosus* caught during this year. Species- wise landings of ornamental mollusks in India are not available from various maritime states.

CONSERVATION AND MANAGEMENT STRATEGIES

At the moment marine molluscs appears to be least endangered or mostly exploited at optimum level. Commercial exploitation especially trawling account for higher fishing pressure leading to greater reduction of molluscan population in time wild. Other sources of depletion are pollution and environmental hazards especially in the intertidal areas in mainland and Islands. Very little is known about the magnitude of destruction caused by these sources from Indian waters.

Conservation of cephalopods is not an immediate priority. Eventhen squid and cuttle fish spawning grounds are now a days indiscriminately destroyed by trawling and man made activities. This may affect the recruitment process in coming years. It is suggested that prohibition in the destructive type of fishing for juveniles and eggs of cephalopods is to be imposed to protect this resources. At present cephalopod exploitation has corssed the estimated potential yield and there is no sign of depletion of the stock. The cephalopods production has reached all time high of 1,36032 t in 2006. This is higher than the estimated potential. The reason can be attributed to that while estimating the potential yield of cephalopod resources available in columnar oceanic and pelagic zones were not taken into consideration. The present exploitation extends trawling beyond 50m depths.

Among bivalves, clam resource contribute the maximum quantity and the estuaries of Kerala

and Karnataka have rich clam resources and there is considerable scope for increased production. The major problems facing clam fisheries are over-exploitation and exploitation of undersized clams. Pollution and environmental changes also affect the recruitment and stock position.

Large scale exploitation of undersized *Villorita cyprinoids* from Vembanad and *Paphia malabarica* from Ashtamudi are examples of depletion of stock of these species. The mining of sub-fossil deposits of bivalve shells from river beds in Kalinadi and Vembanad damages the natural habitat due to environmental changes. To replenish the stock of calms in various estuaries it is suggested to impose ban on clam fishing when spawning and spat settlement occur. Mesh size regulation for fishing clams to be strictly imposed. The meat count of clams exported to be restricted to less than 1400 nos /kg. Strict vigilance on exploitation of undersized clams from natural beds. Practice relaying of seed clam and sea ranching of hatchery produced seed for increased production in natural beds. Establishment of clam sanctuaries or clam park in estuaries is suggested for replenishment of stock. It is desirable to demarcate the area for sub-fossil dredging through detailed geological investigation and ecological observations.

Edible Oyster fishery is of sustenance nature and there is no possibility of over exploitation at present. Farming activities are being taken up in most of the southern states and possibility of increased production through farming is very bright.

Mussel production from the wild is steadily increasing in recent years from Kanyakumari-Vizhinjam area and Calicut – Thellichery area. The production through farming also showed a phenomenal increase from 2 t in 1997 to 10,060 t in 2006. The farming activity is spreading to Karnataka , Goa, Maharashtra and Tamilnadu and the production may increase many fold in coming years.

Gaint clams *Tridacna* spp. are endangered animals and are protected under Wildlife (Protection) Act 1972. Pearl oyster fishing has been discontinued from 1968 onwards in both Gulf of Mannar and Gulf of Kutch due to non-existence of harvestable sized pearl beds. The Central Marine Fisheries Research Institute has made attempts to replenish the stock through sea ranching of hatchery produced pearl oyster seed with positive results. Large scale organized attempt is required to replenish the stocks in Gulf of Mannar.

The licensing system for fishing of chanks by conventional divers exists in Tamilnadu and Kerala. The presence of juvenile chanks and egg masses in trawl catches is increasing now a days causing large-scale destruction to potential stock. Restrictions in the exploitation of juvenile chanks and trawling over chank beds are to be imposed as conservation measures. Hatchery technique for chank seed production has been evolved recently and sea ranching of chank seed in chank beds will also replenish the stock..

Whelk production is increasing in recent years due to the greater export demand. At present there is no fishing for under sized whelks, but the fishing pressure is increasing year by year. Mesh size regulation and sea ranching of seed whelks are suggested for replenishment of stock.

At least 70-100 species of gastropods and bivalves are used as ornamental shells in shell handicraft trade. Many of them are being exploited from the intertidal areas of mainland and islands. It is felt that restrictions in the collection of under sized shells, rare groups, declaration of protected areas and ban on collection during spawning season are to be imposed to sustain the stock for exploitation. We may have to think about quota system for many of these species, especially cowries *Conus* spp *Strombus* spp. *Murex* spp. *Chicoreus* sp. etc. for conserving these resources.

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farming already discussed elsewhere.

CULTURE OF TROUTS

While practicing organic aquaculture of trouts in pond farms, atleast 15% of the production area should retain natural vegetation. Inlet and outlet of the farm shall be protected suitably for entry of wild fishes into the farm as well as prevention of the cultured stock from escaping. When farming is done in net cages they should be secured by means of firm anchoring. The net material used should withstand damage. The water quality of intake water bodies (in the case of pond farms) or the surrounding lake or sea regions (in the case of net cages) should not get deteriorated from the effluents generated from the farming operation. The water let out of the pond farms should be allowed to pass through properly designed sedimentation ponds and / or filtering plants. The settled particulate organic matter (products of metabolism, feed residues etc.) should be removed and put to adequate re-use. The proper functioning of the installation should be evaluated during every quarterly analysis. In the case of net cages, the sea bottom below the net cages should be regularly inspected for organic deposits caused by feed remnants and fish excrements. Installation of so called "lift-up" systems is recommended for net cages in order to facilitate the removal of organic deposits. The outflow of nutrients from the farm should be kept at minimum through proper feed by determining the feed conversion ratio (FCR). Insufficient feed conversion is an indicator for increased nutrient discharge and proper adjustments has to be done in the feeding schedule. Wild trout and salmon feed exclusively on other animals. Hence for their culture, a feed prepared from fishes is inevitable.

While practicing farming of salmons in cages, the principle route of contamination is through the feed administered, due to restriction of natural food. Hence the insistence on organically grown or high quality natural ingredients in the feed in organic aquaculture may help to lower the risk of contamination through feeds(Develin & Donaldson, 1992). But since cage farming is practiced in open waters, which may also contain high levels of pollutants continuous monitoring of the water quality is necessitated (Avnimelech *et al.*, 1994). Astaxanthin, a carotenoid pigment should be provided through the diet since it is needed for a number of biological function including immune response and protection against oxidation of essential polyunsaturated fatty acids (Bell *et al.*, 2000). Natural astaxanthin extracted from algae or yeasts are preferred in organic aquaculture and are incorporated in the diet.

A serious problem in organic salmon production is the sea lice infection. The sea lice *Lepeophtheirus salmonis* is a copepod (crustacaea) ectoparasite, feed on the mucus and skin of the host fishes (Bjorn & Finstad, 2000). High numbers of sea lice kill the host and both wild and farmed stocks are affected. Several chemicals are used to treat sea lice infections but some of them were reported to have an impact on marine ecosystems (Collier & Pinn 1998). Low stocking densities and high flow rates at the production site diminish the risks of infections (Mac Kinnon, 1997). In Europe 'cleaner fishes' (Wrasses) are being used, but concern have been raised on the effect on natural stocks by harvesting cleaner wrasses for sea lice control. Coho and Chinook salmon are more resistant to sea lice.Farming of fishes in net cages in open waters has been the cause of concern which include escape of farmed species into open waters, release of untreated effluents and exposure to chemical drift. These problems are considered to be limitations to organic certification.

Certified organic aquaculture production is estimated to increase 240 fold from 5000 metric tones in 2000 to 1.2 million metric tons by 2030, equivalent to 0.6 percent of the total estimated aquaculture production (Tacon and Deborah 2002). While total world aquaculture production is expected to increase 4 fold from 45 million metric tons in 2000 to over 194 million metric tons by 2030, with the sector growing at an average APR of 5% per year. These estimates are primarily based on the existing organic aquaculture production levels form developed countries and the assumption that the major nutrients for certified farmed aquatic products will be Europe and North America in the west and Australia, Japan, New Zealand and Singapore in the East. Both these

estimates may change, if developing countries also adopt certified organic aquaculture production methods. At present certified organic aquaculture production in the developing countries has been restricted to the limited experimental production of organic shrimp within a few selected countries (Eucador, Vietnam and Indonesia) developed by approved organic certifiers. Though the production of certified organic aquaculture products within developing countries are still in its infancy, these countries together is seen to have produced over 90.3% of the total global aquaculture production 1999. But in contrast to the developed countries where thrust is given to the production of high value carnivorous species, the majority of finfish production within developed countries was contributed by freshwater filter feeding species (silver carp, big head carp and catla) and omnivorous/ herbivorous species (grass carp, common carp, nile tilapia, rohu etc.). Hence if organic production is to be spread widely and grow into major activity with more local demand, species feeding low on the aquatic feed chain should be targeted for production.

Organic aquaculture has not taken roots in India so far, inspite of the wide potentiality in the country. Most of the aquaculture products certified as organic (Tea, Coffee, Spices etc.) are getting exported to Europe and U.S.A. Deliberations has been made in Ind-Aqua 2007 held at Chennai regarding the certification of organic aquaculture in the country. It is understood that SIPPO in collaboration with MPEDA has plans to take up organic certification of aquaculture products on the lines of Naturland, Aqua-Gap and Europe- Gap Standards by accredited certification agencies in India.(Vinod & Basavaraja 2007) NACA too came forward in collaboration with MPEDA for production of aqua products based on 'best management practices' (BMP), where the inputs strictly prohibited by organic farming are not permitted. The contract signed between SIPPO and MPEDA may help the confirmation of the farmers in getting their aqua products certified and find markets in Europe, USA etc.

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