CMFRI

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Lecture Notes

Part 1

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PELAGIC FISHERIES OF INDIA

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Introduction

The pelagic fishes live most part of their life in the surface or subsurface waters. This group exhibits rich species diversity and abundance in the Indian EEZ. Though 240 species constitute the pelagic fisheries along the Indian coast, it is only about 60 species belonging to 8 groups support major fisheries (Table1). During the last decade, pelagic finfishes contributed to 46-56% (average: 51%) of the total marine fish production, of which almost 70% was fished from within the 50 m depth zone (Table 2). Small pelagics such as the Indian oil sardine, Indian mackerel and Bombay duck contributed 26% of the total marine fish landings (1990-2005). The dependence of a large number of artisanal fishers and the coastal population on the pelagic fisheries underlines the socioeconomic importance of these low value fishes. Besides these, large growing pelagic fishes such as tunas, billfishes, seerfishes and pelagic sharks are high unit value fishes contributing significantly to the export earnings of the country.

Unique biological characteristics

The pelagics (except pelagic sharks) are characterized by certain unique combination of biological features, which include formation of large schools, feeding on plankton or nekton, fast growth rate and short life span (0.5-4 years). Most of them are either continuous spawners or have prolonged spawning periods with high fecundity. Many of them are migratory and generally show shoaling behaviour. The most prominent feature of the pelagic fisheries is their extreme annual fluctuations.

Mode of exploitation

Canoes, Pablo type boats, catamarans, trawlers and purseseiners are used in the exploitation of pelagic resources. The gears used are purse seine, ring seine, shoreseine, boatseine, gillnet, drift gillnet, hooks & line, troll line, pole & line and *dol* net. Considerable quantities of pelagic fishes are also landed by pair trawls and high-opening fish trawl nets operated from the shrimp trawlers as well as gillnets of various mesh sizes operated from motorized/mechanized crafts.

Production trends

A comparison of the average annual production of major pelagic finfish groups from the initial stages of mechanization in 1960s through the 80s to 1994, shows an increasing trend with respect to all the groups. Compared to 1960s, the production almost doubled or even trebled with respect to many groups in the 1980s, but since late 1990s catches have stabilized (Fig.1). The increased production in the early eighties could be attributed mainly to the introduction of purseseine fishing, while that of the late eighties and nineties to the motorisation of country crafts, introduction of innovative gears like ringseine and commencement of stay-over fishing. Substantial increase was noticed in the case of anchovies, Bombay-duck, tunas and billfishes till 1992 and that of ribbonfishes and mackerel till 1993-94 while oil sardine and mackerel showed only marginal increase.

The average annual pelagic fish landings (1990–2005) is given in Table 3. Region wise, the southwest coast (Goa, Karnataka and Kerala) is most productive (41%) followed by the northwest (Gujarat and Maharashtra 25%), southeast (Tamil Nadu, Pondicherry and Andhra Pradesh 23%) and northeast (West Bengal and Orissa 11%). The trend of exploitation of pelagic stocks by the non-mechanised (traditional), motorised traditional and mechanised sectors is given in Table 4.

Status of pelagic fishery resources

The landing pattern of the pelagics can be categorized as follows: (a) fisheries which have fluctuated very widely (oil sardine, Bombay duck and Indian mackerel); (b) fisheries which have increased the landings fairly consistently (lesser sardines, *Hilsa* spp., whitebaits, *Thryssa* spp. *Coilia dussumieri*, carangids and ribbonfishes); and (c) the only pelagic fishery which has declined (unicorn cod *Bregmaceros mclellandi*).

Indian oil sardine

The Indian oil sardine is a very important pelagic fish species which contribute to about 15% of the total marine fish production in the country. The oil sardine fishery has been most strikingly characterized by wide fluctuations in the annual landings from the very early years of exploitation. The resuscitation of the oil sardine stock after an ever-lowest landing of 47,000t in 1994 was manifest from the heavy recruitment that followed, which culminated to a highest production of 4.04 lakh tonnes in 2003. Since late 80s it has become an established fishery on the east coast with the average (1985 to 1996) annual landings of the oil sardine on the west coast being 128,282 t (86%) and the east coast 21,262 t (14%). Till the close of 1970s, artisanal fishing gears mainly boat and beach seines, cast nets and small meshed gill nets were the major gears operated along the southwest coast. With the introduction of mass harvesting gears like purse seines in the late 70s and ring seines in the late 80s along with a steady rise in the motorization of the traditional fishing crafts, many of these traditional fishing methods have become redundant. Along the east coast mainly boat seines, gillnets and bag nets dominate.

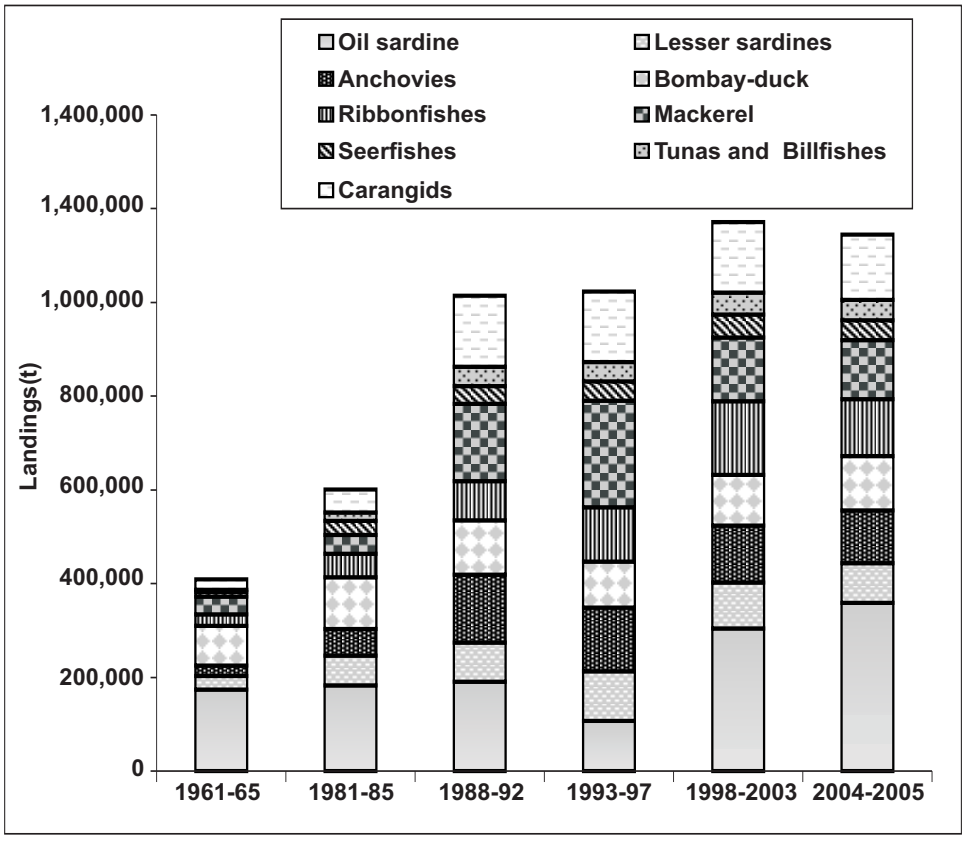

Fig. 1. Trend in major pelagic landings (in t) in India

Table 1. Details of major families of pelagic fishes and species/groups

Family	Group/species	Number of species
Clupeidae	Oil sardine*	1
	Lesser sardines* (including rainbow sardines)	14
	Hilsa spp. & other shad	15
	Whitebaits*	24
	Thryssa and *Thrissocles* spp.	10
	Wolf herrings	2
	Other clupeids	40
Scombridae	Coastal tunas	5
	Oceanic tunas	3
	Seerfishes & wahoo	5
	Mackerels*	3
Trichiuridae	Ribbonfishes*	8
Carangidae*	Round scads	2
	Golden scads	6
	Hardtail scad (or horse mackerel)	1
	Jacks	17
	Black pomfret	1
	Others	19
Harpodontidae	Bombay-duck*	2
Stromateidae	Pomfrets	2
Coryphaenidae	Dolphinfishes	2
Rachycentridae	Cobia	1
Mugildae	Mullets	22
Sphyraenidae	Barracudas	7
Exocoetidae	Flying fishes	10
Bregmacerotidae	Unicorn cod	1
	Others	19
	Total pelagics	242

*Annual catches exceed 1 lakh tons

Table 2. Growth in pelagic fish production from 1950 to 2005

Source: Pillai and Pillai (2000)

Period	Production (tonnes)		Relative growth (%)	
	Pelagics	Overall	Pelagics	Overall
1950-59	362,548	618,501	-	-
1960-69	527,211	814,721	+ 45	+ 31
1970-79	643,142	1,243,707	+ 22	+ 27
1980-89	819,093	1,579,836	+ 27	+ 27
1990-99	1,116,792	2,258,874	+ 36	+ 43
2000-05	1,326,055	2,516,608	+19	+11

Table 3. Average landings of pelagic fishes (t) and their percentage contribution during 1990–2006

Groups	Catch (t)	%
Oilsardine	236214	18.60
Mackerel	162540	12.80
Carangids	141169	11.11
Ribbonfish	135749	10.69
Anchovies	115013	9.05
Bombay duck	111302	8.76
Lesser sardine	96780	7.62
Other pelagic	77310	6.09
Other clupeids	47328	3.73
Tunas & billfishes	47271	3.72
Seerfish	44015	3.46
Hilsa	26066	2.05
Wolfherring	15284	1.20
Barracuda	14258	1.12
Total pelagics	1270299	

Source: CMFRI

Table 4. Sector- wise effort, catch & catch/hr of pelagic groups in respect of non-motorized (traditional), motorized and mechanised units in India during 1999-2005

	Mechanized	Motorized	Non-motorized(traditional)
Total catch (t)	763994	550911	227498
Effort (AFH)(hr)	17435308	17697995	10961736
Effort (Units)	1076745	4102995	3015025
% contribution	49.5	35.7	14.8
Catch/hour (kg)	44	32	22

Source: Pillai, 2006.

The lesser sardines comprise several species of *Sardinella* contribute to a lucrative fishery along the southeast and southwest coasts. The dominant species contributing the fishery are *Sardinella albella, S. gibbosa S. fimbriata, S. sirm and S. dayi.* The traditional, motorized and mechanized crafts employ a variety of seines, gill nets and trawls to exploit the lesser sardines .

Anchovies

The anchovies constituted by five genera *viz. Stolephorus, Coilia, Setipinna, Thryssa* and *Thryssina* constitute seasonal fisheries mostly along the coasts of Andhra Pradesh, Tamil Nadu, Kerala, Karnataka and Maharashtra. Among anchovies, whitebaits (*Stolephorus* and *Encrassicholina* spp.) are dominant contributing 48% (average 1985 –2003) followed by *Coilia dussumieri* (24%), *Thryssa* (26%) and *Setipinna* (2%).

The Indian mackerel

The mackerel fishery comprises a single species viz., *R.. kanagurta.* However, *R. brachysoma* and *R. faughni* also are reported to occur in the catches along the east coast. Till the 1980s exploitation of the resource in the upwelling areas of the southwest coast of India was mainly restricted to the post-monsoon period by traditional crafts using small surface gears like shore-seine, boat-seine and gillnets made of

cotton or hemp up to 20-m depth. With the introduction of motorization and purse seine and ring seines in the early eighties, the indigenous fishery has undergone a major upheaval with heavy catches of juveniles even during the monsoon period. This large scale exploitation of the juveniles is the key factor which limits the yield from the mackerel stock. Under the present length at first capture (140 mm), maximum sustainable yield from the resource is 2.2 lakh tonnes.

Tunas and bill fishes

Tuna production along the mainland coast fluctuated between 30,285 t (1987) and 54,007 t (2000) with an annual average production of 41,443t forming 3.6% of the total pelagic fish production.Of the 8 major species of tunas occurring along the Indian coast, five are coastal/neretic and three are oceanic and migratory. The commonly occurring coastal tuna species are *Euthynnus affinis* (little tuna)*, Auxis thazard* (frigate tuna)*, A.rochei* (bullet tuna)*, Sarda orientalis* (oriental bonito), *Thunnus tonggol* (long tail tuna) while oceanic species include *Katsuwonus pelamis* (skipjack tuna)*,T. albacares* (yellowfin tuna) and *T. obesus* (bigeye). Four genera of billfishes *Istiophorus*, *Makaira* and *Tetrapturus* (family Istiophoridae) and *Xiphias* (family Xiphilidae) occur in the Indian seas and occur as by-catch in the gillnet/hook and line fishery for tunas. Drift gill nets, purseseine and the hooks and line are popular for tuna fishing by mainland fishermen while pole and line and troll lines are operated in Lakshadweep seas targeting skipjack and yellowfin tuna.

Seerfishes

The annual seerfish catch showed an increasing trend during the past five decades with fluctuations ranging from a mere 4505 t in 1953 to an all time peak of 54,998 t in 2003 with the increase along the west coast being remarkable. They contribute just 1.85% of the marine fish production but owing to high unit value are major sources of income for gill net and hooks and line fishermen. Out of the four species *viz*., the king seer (*Scomberomorus commerson*), the spotted seer (*S.guttatus),* streaked seer (*S.lineolatus)* and the wahoo *(Acanthocybium solandri*), the fishery is sustained by the first two species.

Carangids

Carangids have emerged as one of the important pelagic fish groups landed by the mechanized sector and the average annual production (1985-2003) was 133,000 t which constituted 4% of the total marine fish production. There are 46 species of carangids occurring along the Indian coast but commercial fisheries comprise mainly of horse mackerel *(Megalaspis cordyla)*, round scads (*Decapterus dayi, D.macrosoma),*, selar scads (*Selar crumenophthalmus*), queenfishes (*Carangoides* spp.), trevallies *(Caranx para, C.carangus, Selaroides leptolepis)*, leatherjackets (*Scomberoides* spp.) and pompanos (*Trachinotus* spp.). The fisheries are mostly seasonal coinciding with the monsoon and largely from 60 –80 m depths along the mainland coast and 20 - 40 m in Andaman seas. Exploitation is done by a variety of gears such as trawl nets, drift and bottom-set gill nets, hooks and line, shore seines, ringseines and purseseines.

Ribbonfishes

The ribbonfishes, (hair-tail or cutlass) are widely distributed along the Indian coast and form major pelagic fishery resources of the Indian seas. The average ribbonfish production in the 60s was 28,171 t, which increased to 65,360 t during the 80s to 120,461t during 1990s. The average production during 2001-2005 was 159,352 t (Fig.7). *Trichiurus lepturus* is the dominant species (>95%) in the fishery. Species such as *T. russelli, Lepturacanthus savala, L.gangeticus, Eupleurogrammus muticus and E. glossodon* have also been recorded in the Indian waters. The major gears are trawls (70%) followed by the bagnets, gillnets and the purseseines. Nearly 64% of the ribbonfish landed annually in India are exported in frozen form to China, Japan and other southeast Asian countries, the remaining being either routed for the domestic fresh fish market or sun-dried. The development of export market has led to targeted fishing for ribbonfishes and to a certain degree of unsustainable exploitation especially on the east coast, as evidenced from increasing

component of juvenile ribbonfishes in trawl landings.

Bombay-duck

Bombay-duck constitutes a fishery of high magnitude along the northwest coast and are conspicuously absent on the southwest and southeast coasts. They form a seasonal fishery on the northeast coast (West Bengal, Orissa and the northern part of Andhra Pradesh). The gillnets, boatseines and trawls are also employed in this fishery. Though *Harpadon nehereus* was the sole contributor along the northwest coast, another species *H. squamosus* has been recently recorded off Kakinada on the northeast coast.The Bombay duck is highly perishable because of its high water content, and hence needs speedy disposal. The bulk of the catch is sun-dried and sold in the interior markets while a small portion is converted into manure. Laminated Bombay duck are in good demand in some foreign markets.

Pomfrets

Pomfrets belonging to the family Stromateidae, comprises silver pomfret (*Pampus argenteus*) and the Chinese pomfret (*P.chinensis*) which form about 2% of all India marine fish landings. They are highly relished table fishes and command high unit value in internal and export markets. Landings are mainly from Gujarat and Maharashtra on the northwest and Orissa on the northeast coasts. On the northwest coast the principal gear exploiting the adult pomfrets are drift gillnets (140-155 mm mesh size) while the *dol* net essentially exploits the juveniles.As the fishery on the northwest coast collapsed during the 1990s, restriction of *dol* net operations to minimise recruitment overfishing and regulation of gillnets to minimise growth overfishing were recommended as management measures to be urgently implemented. Recently, the CMFRI recommended minimum legal weight (MLW) of 300 g for export of pomfrets have been implemented by DAH D&F, Ministry of Agriculture, Govt. of India which can go a long way in ensuring the sustainability of the fishery.

Other pelagics

The Hilsa shad (*Hilsa ilisha*) form a prominent fishery in the northeast coast.The barracudas (seapikes) fishery in India comprises four species, *Sphyraena obtusata, S.barracuda, S.jello* and *S.forsteri*. The unicorn cod (*Bregmoceros mcclellandi*) fishery is observed on the northwest coast but catches are dwindling.The flyingfish fishery is seasonal and limited to the Coromandel coast in Tamil Nadu supported mainly by the species *Hirundichthys coramandelensis*. **C**lupeids such as the wolfherring (*Chirocentrus dorab*), Rainbow sardine (*Dussumiera* spp.), *Escualosa, Ilisha, Nematalosa, Opisthopterus, Pellona, Reconda, Dorosoma, Chanos* etc. form minor fisheries constituting about 1.6 % of the total all India landings. The mullets (*Mugil* spp.) form a fishery mainly in the northwest region, which contributed an annual average of 6056 t during 1999-2005.

Research priorities in the management of pelagic fisheries

Impact of environment on pelagic fisheries

There is strong evidence that annual variations in the year class strength of pelagic fishes in upwelling areas are governed mainly by oceanographic factors such as upwelling intensity, offshore water transport and water column stability and each year the success of pelagic fisheries is a delicate balance between physical oceanographic factors and effects of fishing on the stock.

Seawater temperature, dissolved oxygen levels, salinity, phytoplankton and zooplankton concentrations play a vital role in controlling the distribution and abundance of pelagic fishery resources. The global warming phenomenon has been observed to have significant impact on the change in distribution and abundance patterns of the pelagics like oil sardine and mackerel along the Indian coast as manifest in their movement towards more northern latitudes in recent years. Parameters like Sea Surface Temperature (SST) and phytoplankton pigments (Chlorophyll *a*) obtained from satellites and available with agencies

like the Indian National Centre for Ocean Information Services (INCOIS) are used in prediction of Potential Fishing Zones (PFZ) for the benefit of the fishermen. Thus, fishery environment data has become crucial to addressing productivity of fishing grounds, annual/long term fluctuations in fish catches and making fishery forecasts and has to be further researched to find practical solutions for fisheries management purposes.

Fish migration

Most of the pelagic finfish species move in large shoals and exhibit certain characteristic migratory pattern. While the small pelagics like sardines and anchovies perform migrations along the coast, mackerels, scads and coastal tunas migrate fairly long distances between inshore and offshore waters. Therefore understanding the migratory patterns of pelagics is crucial for planning a successful fishery and its management. Tagging and recovery is the best way to study migration and growth of pelagic fishes for which sophisticated acoustic and telemetric tags have been developed. These allow continuous observations of the behaviour and movements of tagged fish and this information can be gainfully applied for fishing as well as resource management activities.

Fish recruitment dynamics and modelling

Fluctuations in pelagic fish landings are partly due to recruitment variations. Many of the world's greatest fisheries particularly for pelagics like the sardines have collapsed owing to recruitment failure caused by high fishing pressure on the spawning stock. There is also a significant influence of environment in determining the recruitment success of pelagic species every year. Hence time series data on its fishery, fecundity and condition indices are invaluable in developing models to forecast recruitment variations and its impact on fisheries.

Future prospects of pelagic fisheries

The Working Group on the Revalidation of Potential yield of Marine fisheries of the Indian EEZ (Anon., 2000) indicated potential yield of pelagic resources from the Indian EEZ as 1.67 million tonnes of which an average 1.4 million tonnes is harvested mostly from within the 50 m depths. Though a progressive trend is noticeable in production of some pelagics such as carangids and ribbonfishes, many of them, especially the oil sardine, mackerel, Bombay-duck, seerfishes and coastal tunas have reached the optimum level of exploitation in the conventional inshore fishing grounds. The stock assessment studies conducted for 20 species of exploited pelagic finfishes have shown that the present effort expended is close to or in some cases even exceeded the level of MSY and further increase in effort in the coastal sector would be detrimental to sustain the yield and there is not much scope of further increase in production from this inshore zone. However, the potential yield estimates of oceanic resources is 0.24 million t which is mainly constituted by the oceanic tunas (yellowfin, skipjack and bigeye) with lot of export potential especially in value added or *Sashimi* (for yellowfin and big eye tunas) form. Hence there is an urgent need to develop an oceanic pelagic fishery with appropriate infrastructure and policy support from the government and fisheries development agencies. Groups such as whitebaits, carangids, barracudas, billfishes and pelagic sharks are also expected to contribute significantly to the additional yield from beyond the conventional fishing zone. There are also certain imbalances in pelagic fish landings *vis-a vis* their potential, especially on the north east coast of India where demersal fisheries especially shrimp trawling is given more importance which has to be addressed and can lead to increased pelagic fish production for the domestic market as well as export.

With regards to the small pelagics such as oil sardine, mackerel and anchovies, these are fishes with a large domestic market and crucial to the nutritional security of a large coastal population in India. However the unpredictable nature of their fisheries has made their markets highly vulnerable to price fluctuations. A lot of valuable protein rich food is wasted during periods of high production due to a lack of proper cold storage facilities and efficient domestic market network. Infrastructure facilities for storage and transportation of the catches to the interior markets require further strengthening to handle surplus production of pelagics. This aspect has to be looked into along with introduction and popularisation of cost efficient processing

techniques such as improved solar drying and smoking to produce value added products, especially during periods of glut. Considerable knowledge exists in the country on product development for the affluent markets. Small processing plants under community programme could be established in specific locations. High priority should be given to reduce postharvest losses

Also, with the advent of infrastructure facilities such as fishing harbours, mechanized and motorized crafts, fish finding equipments and more efficient gears, it is observed that more than 50% of the pelagic finfish landings along the west coast of India during the months from July to October is constituted of juveniles. This is unsustainable and restrictions on small meshed gears such as ringseines regarding mesh size regulation, minimum legal length at first capture, craft size and horsepower, net size and area /period of operation are required. From the foregoing account, it is clear that the pelagic fisheries is an important contributor to the livelihood and nutritional security of both coastal fishers, consumers and the resources have to be optimally and sustainably harvested.