Indian J. Fish., 71 (1): 12-28, 2024 doi:10.21077/ijf.2024.71.1.131154-02

Available online at: epubs.icar.org.in/index.php/IJF

Pelagic fisheries of India - An overview

Prathibha Rohit*, E. M. Abdussamad, A. Margaret Muthu Rethinam, U. Ganga, Shubhadeep Ghosh, K. M. Rajesh, K. P. Said Koya, K. Mohammed Koya, C. Anulekshmi, Ajay D. Nakhawa, S. Surya, Subal Kumar Roul, P. Abdul Azeez, R. Vinoth Kumar, H. M. Manas, J. Jayasankar, K. G. Mini and Somy Kuriakose

ICAR-Central Marine Fisheries Research Institute, Ernakulam North P. O., Kochi - 682 018, Kerala, India

Abstract

The annual pelagic fish landings of the country comprising diverse species, increased from 0.3 million t in 1950 to >3 million t in 2021, marking a tenfold increase. The pelagic resources consistently constituted over half of the total marine fish landings. Major contributors to the pelagic landings are sardines, mackerels, tunas, carangids, ribbonfishes, Bombayduck, codlets, billfishes and barracudas. The west coast of India accounts for 60% of total pelagic landings with the south-west coast comprising of Kerala, Karnataka and Goa sustaining vast shoals of small pelagic fishes thriving in the nutrient-rich upwelled waters. The pelagic fishes play a crucial role in the marine ecosystem, functioning as both prey and predator. Furthermore, the small pelagic fishes serve as sources of protein-rich food for coastal populations, and the large pelagic species command lucrative market prices both in the domestic and export markets. Continuous monitoring of the landings of pelagic fishes is essential for recommending suitable management plans for the optimal and sustainable exploitation of the available pelagic resources in Indian waters. This paper attempts to provide an overview of the marine pelagic fisheries of India, based on analysis of the fish landings data across various sectors spanning the period from 1985 to 2021.

*Correspondence e-mail:
prathibharohit@gmail.com

Keywords:
Marine fish landings, Pelagic fishes, Sustainable exploitation, State-wise contribution, Trends

Received : 07.12.2022
Accepted : 28.03.2024

Introduction

India, a tropical country with a long coastline stretching over 8,129 km, a continental shelf spanning 0.5 million km^2 and an exclusive economic zone (EEZ) covering 2.02 million km^2, is endowed with rich marine biodiversity. Since 1960, India consistently ranked among the the top ten fish-producing countries globally, fluctuating between the 6th and the 8th positions. With rapid progress in mechanisation and the developing indigenous R&D capacity spearheaded by both central and state governments through successive five-year plans, the total fish production in India increased from 0.73 million t in 1950 to 2.87 million t in 1984 and further to 14.16 million t by 2019-20, recording an increase of about 19 times over 1950 and a compounded annual growth rate (CAGR) of about 4%. Currently (2019-2020), India, with an annual production of 14.16 million t, is the second largest producer of fish and second largest aquaculture producer in the world next to China, accounting for 7.56% of global production (with inland and marine sectors contributing to 13 and 4.4% respectively). Additionally, the fisheries sector contributes about 1.24% to the country's Gross Value Added (GVA) and over 7.28% to the agricultural GVA.

The estimated potential for marine fish production in India stands at 5.31 million t (CMFRI-FSI-DOF, 2020; DoF, 2020). Over the years, the annual marine fish landings have seen a significant increase ranging from 0.06 million t during the 1950's to 3 million t in 2021 and the 3 million t in 2021, accounted for 26% of the country's total fish production. Marine fish production has undergone remarkable growth since the pre-independence era, evolving from a subsistence level fishing activity in to a highly evolved commercial activity with the involvement of diverse types of crafts and gears and supported by various allied activities. The sector provides livelihood opportunities to 3.77 million people (Banerji, 1973; George *et al*, 1977; Pillai,

1992; Devaraj *et al*., 1997; Pillai and Pillai, 2000; CMFRI-FSI-DOF, 2020) and also is an important revenue generator through exports. A consistent, positive relative decadal growth has been observed in the total annual marine fish production over the past six decades. However, during 2020 -2021 the impact of the total lockdown for all fishing and related activities in the wake of the Covid-19 pandemic has negatively impacted growth of the pelagic fisheries (Table 1). Recognising the potential of the fisheries sector, the state as well as the central governments are making all efforts for overall improvement of the fisheries sector. The Government of India has introduced a flagship scheme, Pradhan Mantri Matsya Sampada Yojana (PMMSY) through the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, to bring about Blue Revolution through sustainable and responsible development of the fisheries sector in India at an estimated investment of ₹20,050 crores. PMMSY is being implemented in all the states and union territories (UTs) for a period of 5 years from FY 2020-21 to FY 2024-25, as a part of the Aatma Nirbhar Bharat Package (DoF, 2022). PMMSY aims to enhance fish production to 22 million t and fisheries export earnings to ₹1,00,000 crore by 2024-25, doubling of incomes of fishers and fish farmers, reducing post-harvest losses from 20-25% to about 10% and generation of additional 55 lakhs direct and indirect gainful employment opportunities in the fisheries and allied sectors.

The pelagic fishes comprise the smaller-sized fishes with a maximum length of 35 cm or less and the large-sized fishes which attain a total length of 2- 3 m and more. The small pelagics are a diverse group of fishes mostly occupying the surface waters generally, are plankton feeders constituting the grazers in the marine food web and mostly follow the 'r' selection strategy of short life span, rapid growth, early maturity, high fecundity and often with a prolonged spawning period. These fishes attain a maximum length of not more than 35 cm and form huge concentrations in the highly productive coastal upwelling areas of the continental shelf and are harvested by the seines, gill nets and the trawls. Pelagic fishes are the most dominant group in the marine ecosystems globally, with a wide distribution from the shallow seas to the open oceans. Many pelagic fishes have the capacity to move vertically through the water column and tolerate the unique temperatures, oxygen concentrations and light levels of these zones. In addition, they have several morphological and physiological adaptations to swim continuously for extended periods while searching for prey or favourable oceanographic conditions as well as the capacity for rapid bursts of speed for feeding or escaping (Cushing, 2001; Bernal, 2011; Stephenson and Smedbol, 2019). Most species support huge fisheries significantly contributing to the exploited fisheries of the region accounting for approximately 20-25% of the total annual world fisheries catch (ICES, 2015; FAO, 2020).

The pelagic fish resources form an integral part of the marine food web with the smaller planktivorous species as grazers and also an important prey of larger fishes (also used as bait to catch larger carnivores), while the large pelagics, the apex predators play a vital role in sustaining the balance in the marine ecosystem (Cushing, 2001). Most of the pelagic fishes contribute significantly in providing the much-needed affordable protein source to the diets of coastal population, a considerable part of the marine domestic and export trade, the supporting industries of fishmeal, surimi, and fish processing plants and related industries. This paper presents an overview of the pelagic fish resources of India and also provides insights in to the general trends in marine fish production of the country, based on analysis of the landings data by different sectors for the period 1985-2021.

Materials and methods

The present study is based on the database made available by the National Marine Living Resources Data Centre (NMLRDC) of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi, along with field observations by the scientists. The fish landings data from various sectors for the period from 1985 to 2021 were analysed to examine production trends and the species composition of the major pelagic groups. The information on the biological characteristics of dominant species was mostly gathered from published works. Total production, average production and growth rates were calculated using MS-Excel.

Results and discussion

Overview of pelagic fisheries in India

The pelagic resources have always formed more than half of the total marine fish landings, dictating the general trend of the marine capture fisheries production of the country mainly through their sheer bulk catches. Due to their wide distribution in different ecological niches, they are harvested by multiple gear types such as seines, gillnets and trawls. The annual marine fish landings of the country revealed an increasing trend over the years since 1985 with the contribution of the pelagic group to the total fish landings

Table 1. Growth in the average annual total marine fish and pelagics production in India through seven decades from 1950 to 2020

Period	Production (kg)		Relative growth	
	Pelagics	Total marine fish	Pelagics	Total marine fish
1950-59	362548	618501		
1960-69	527211	814721	45.4	31.7
1970-79	643142	1243707	22.0	52.7
1980-89	819093	1579836	27.4	27.0
1990-99	1167316	2357693	42.5	49.2
2000-09	1396074	2690662	19.6	14.1
2010-19	1910222	3667783	36.8	36.3
2020-21 (two years)	1577825	2954984	-17.4	-19.4

fluctuating over the years, but mostly forming more than 50% of the total marine fish landings (Fig. 1).

Between the period 2010-2021 the west coast contributed nearly 60% of the total (Fig. 2) with the group's contribution to the total catch ranging from 35 to 86% in the different maritime states (Fig. 3). Though, Goa registered the highest proportion of pelagics in the total marine fish catch; Kerala followed by Tamil Nadu, Karnataka and Gujarat contributed majorly to the total pelagic landings of the country (Table 2).

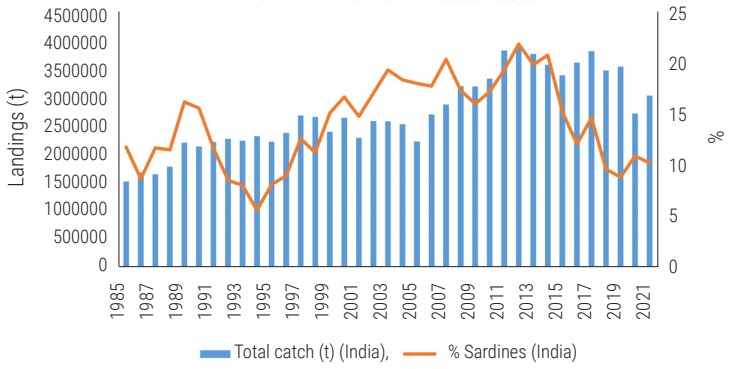


Fig. 1. Trends in total marine fish landings of India and contribution of pelagic fishes during 1985-2021

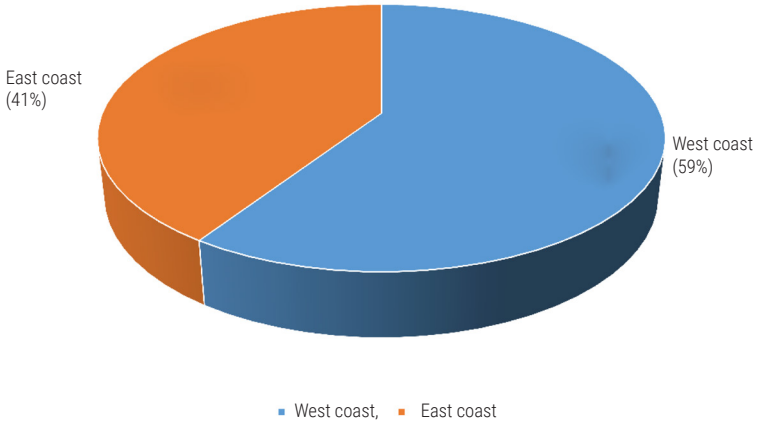
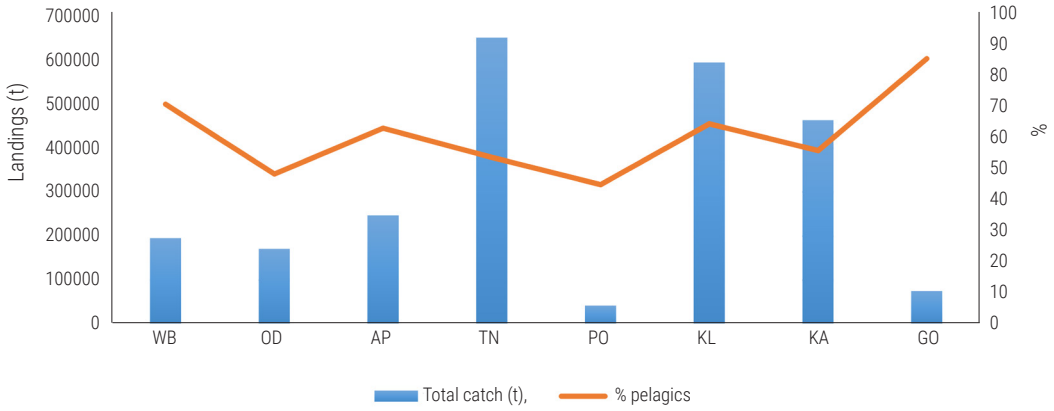


Fig. 2. Contribution (%) of the east and west coasts of India to total pelagic fish landings



(WB-West Bengal, OD - Odhisha, AP - Andhra Pradesh, TN - Tamil Nadu, PO - Puducherry, KL - Kerala, KA - Karnataka, GO - Goa, MH - Maharashtra, GJ - Gujarat, DD - Daman and Diu)

Fig. 3. Annual contribution of pelagic resources to the total marine fish landings (1985-2021) in various maritime states of India

Table 2. Total marine fish landings and contribution of pelagic fishes (average 2010 to 2021)

Maritime stae/UT	Total marine fish landings (t)	Pelagics (t)	% Pelagics to total	% of total Pelagics
West Bengal	195580	139538	71.3	7.6
Odisha	171415	83422	48.7	4.5
Andhra Pradesh	247356	157133	63.5	8.5
Tamil Nadu	650666	352099	54.1	19.1
Puducherry	42795	19370	45.3	1.0
Kerala	594132	386110	65.0	20.9
Karnataka	463420	261108	56.3	14.1
Goa	75683	65165	86.1	3.5
Maharashtra	271176	110398	40.7	6.0
Gujarat	699602	244357	34.9	13.2
Daman and Diu	66845	27851	41.7	1.5
Total	3478669	1846551	53.1	100.0

Several gear types deployed from the mechanised, motorised, and non-mechanised crafts exploited the pelagic fishes (Fig. 4). The seines, specifically designed to harvest the schooling fishes from near shore as well as offshore waters, are more popular along the west coast and include the shore seines, boat seines (ring seines) and the purse seines. The gillnets (monofilament as well as polypropylene), a passive gear, are also popular with mesh size as well as the depth of operation varying with the fish species and its size targeted. The small gill nets widely used all along the Indian coast and the islands are deployed by individuals while the larger ones are operated either from non-mechanised, motorised, or mechanised units. The trawls which were originally designed to exploit the bottom-dwelling fishes and shrimps have evolved extensively over the years and are now operated to catch both the bottom as well as the column and surface-dwelling fishes. The pelagic trawls thus land huge quantities of pelagic fishes such as scombroids, clupeids, ribbonfish and carangids in recent times (Fig. 5). The other gears that harvest the pelagic fishes include the lines (long lines, troll lines and the hand lines and the pole and line) and bagnets. While the long lines and the troll line mostly target the tuna and tuna-like fishes, the smaller hand lines usually landed smaller tunas and carangids. The pole and lines are operated mostly in the Lakshadweep islands and target the skipjack and smaller-sized yellowfin tuna, bigeye tuna and other miscellaneous pelagic fishes. The gears used in different states to harvest the pelagics are provided in Table 3.

Major groups constituting the pelagic fishes

Fishes included under the families Clupeidae (sardines, shads and sprats), Scombridae (mackerels and tunas), Carangidae (jacks, scads, trevallies, pompanos, amberjacks, queenfishes and runners) (Abdussamad *et al*., 2013; Rohit, 2022), Engraulidae (anchovies), Sphyraenidae (barracudas) and Trichiuridae (ribbonfish) and represented by several species formed the major component of the pelagic fisheries of the country. In addition, some single species such as the Indian oil sardine (*Sardinella longiceps* - Clupeidae), Indian mackerel (*Rastrelliger kanagurta* - Scombridae), Large head hairtail (*Trichiurus lepturus* - Trichiuridae), Bombayduck (*Harpadon nehereus* - Synodontidae), unicorn cod (*Bregmaceros mcclellandi* - Bregmacerotidae), Cobia (*Rachycentron canadum* - Rachycentridae) made significant contributions to the total pelagic as well as total fish landings

The pelagic fishes include the small sized fast growing and short lived diverse groups such the sardines, engraulids, shads, anchovies and some species of mackerels generally are nearshore dwellers. The large pelagics which include diverse groups, occupy the surface and columnar waters, are mostly carnivores, and form the apex predators in the marine food web. Compared to the small pelagics, the large pelagics (tunas, billfishes, seerfishes, dolphinfish, rainbow runners and barracudas) occupy the open oceanic waters and are known to migrate across the seas and oceans for considerable distances. They have a longer life span ranging from 8-15 years and depending on the species, attain length of up to 3 m and have high fecundity. They are harvested mainly by gill nets, lines (long lines, troll lines, pole and line) and large meshed purse seines.

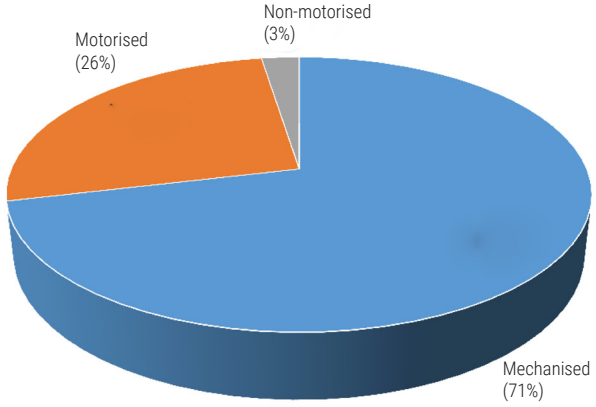


Fig. 4. Contribution of different fishing sectors to the pelagic fish landings of India

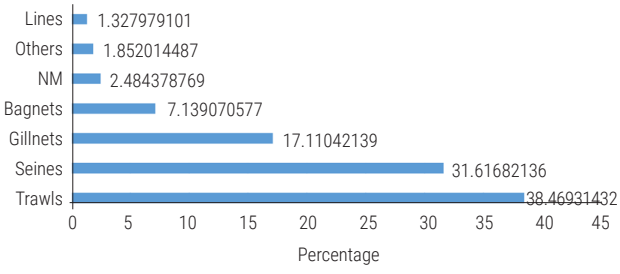


Fig. 5. Gear-wise contribution to total pelagic fish landings in India

Table 3. Contribution of different gears to total pelagic fish landing by maritime states and UTs of India

Major gear category	Seines						Gillnets		Trawls			Bagnets				Lines		Others		NM
Gears/State	MPS	MRS	OBBS	OBPS	OBRS	OBSS	MGN	OBGN	MDTN	MTN	OBTN	MBN	MDOL	OBBN	OBDOL	MHL	OBHL	MOTHS	OBOTHS	NM
West Bengal	0.0	0.0	0.0	0.0	0.0	0.6	35.4	4.8	36.9	0.0	0.0	9.2	0.0	8.7	0.0	0.0	0.0	3.5	0.1	0.7
Odisha	0.0	0.0	0.0	0.0	6.0	0.1	3.3	24.1	54.6	3.2	0.0	0.0	0.0	0.2	0.0	0.1	1.9	0.1	0.0	6.5
Andhra Pradesh	0.0	0.0	0.4	0.1	27.0	0.5	0.9	22.4	26.6	0.5	0.4	0.0	0.0	0.0	0.0	0.1	4.3	0.0	0.2	16.5
Tamil Nadu	0.1	6.4	0.1	0.4	8.2	0.1	3.7	17.4	10.0	47.3	0.2	0.0	0.0	1.2	0.0	0.1	1.4	2.3	0.3	0.7
Puducherry	1.5	0.1	0.0	0.9	13.7	0.0	2.5	10.0	60.9	4.2	0.0	0.0	0.0	0.3	0.0	0.0	0.3	5.5	0.0	0.1
Kerala	0.9	34.9	3.2	0.0	25.1	0.1	0.6	9.0	17.3	1.0	0.1	0.0	0.0	0.0	0.0	0.5	2.1	3.5	0.5	1.2
Karnataka	39.7	0.0	0.0	0.0	7.9	0.2	0.1	5.1	44.2	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Goa	89.1	0.0	0.0	4.6	0.2	0.1	0.0	1.5	2.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.1
Maharashtra	36.9	0.0	0.0	0.8	0.9	0.1	11.7	2.6	23.3	3.9	0.0	0.0	17.0	0.0	1.5	0.0	0.0	0.0	0.0	1.1
Gujarat	36.9	0.0	0.0	0.8	0.9	0.1	11.7	2.6	23.3	3.9	0.0	0.0	17.0	0.0	1.5	0.0	0.0	0.0	0.0	1.1
Daman and Diu	0.2	0.0	0.0	0.0	0.0	0.0	19.7	11.9	66.2	0.5	0.0	0.0	1.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0

MPS - Mechanised Purse Seine, MRS - Mechanised Ring Seine, OBBS – Out-Board motorised Boat Seine, OBPS – Out-Board motorised Purse Seine, OBRS – Out-Board motorised Ring Seine, OBSS – Out-Board motorised Shore Seine, MGN - Mechanised Gill Net, OBGN – Out-Board motorised gill Net, MDTN - Multi-Day Trawl Net, MTN - Mechanised Trawl Net, OBTN – Out-Board motorised Trawl Net. MBN - Mechanised Bag Net, MDOL - Mechanised Dol Net, OBBN - Out-Board motorised Bag Net, OBDOL - Out-Board motorised Dol Net, MHL - Mechanised Hook and Line, OBHL - Out-Board motorised Hook and Line, MOTH - Mechanised Others, OBOTH - Out Board motorised Others, NM - Non-Mechanised.

Sardines

The sardines comprising mainly the Indian oil sardine (*Sardinella longiceps*), lesser sardines (*Sardinella gibbosa*, *S. albella*, *S.brachysoma*, *S. fimbriata*, *S. jussieu*, *Amblygaster sirm*), rainbow sardine (*Dussumieria* spp.) and white sardine (*Escualosa thoracata*) form the bulk of the clupeid fisheries. The annual landings of sardines along the Indian coast during 1985 to 2021 period fluctuated over the years and the annual landings ranged between 1,30,666 t (1994) and 8,66,660 t (2012) forming 6 to 22% of the total fish landings. The west coast of India generally recorded higher landings of sardines over the years as compared to the east coast and contributed 61% of the total sardines landed. Annually the sardines formed 2 to 24% of the total landings with an average of 13% from 1985 to 2021. Along the east 5coast, the sardines formed 11-25% of the total fish landings with an overall contribution of 17% during the study period. The Indian oil sardine *Sardinella longiceps* is the most important single species of sardine that is landed along the Indian coast. This species formed <1% to 13% of the total fish landings of the country with an average of 7% during the study period. Along the west coast, the oil sardine formed <1% to 24% of the total landings with an overall contribution of 12%. Along the east coast, the oil sardine contributed <1 to 10% annually with an overall contribution of 7% (Fig. 6). While the oil sardine is a highly preferred food fish along the south-west coast, the lesser sardines are preferred along the south-west coast. The sardines have a short life span of around 3 years, attain a length of 20-22 cm and relatively early sexual maturity with absolute fecundity ranging from 50-80 thousand. Various aspects of the fishery and biology of oil sardine have been studied and the reasons for the steep fluctuations observed in the annual landings too have been elucidated (Balan and Reghu, 1979; Rohit *et al*., 2018; Hamza *et al*., 2020, Akash *et al*., 2021).

Engraulids

The engraulids are another consortium of several small pelagic species (most do not attain a total length of 20 cm) and are characterised by a large mouth, with the upper jaw extending well behind the eye and the jaw articulation well behind the eye, snout extending beyond the tip of the lower jaw and mostly with translucent body (Nelson, 1994). They play an important and significant role in the marine ecosystem as plankton grazers and serve as a good food source for predatory fish, as well as marine mammals and birds (PSMFC, 1996). These fishes of the Engraulidae family include whitebaits (*Stolephorus* spp., *Encrasicholina* spp.), golden anchovy (*Coilia dussumieri)*, Thryssa (*Thryssa* spp.) and hairfin anchovy (*Setipinna* spp.) (Menon and George, 1975; Rao, 1988a,b; Luther *et al*., 1992; Rohit *et al*., 1992; Gopakumar and Pillai, 2000; Khan, 2000: Khan, 2003; Jayaprakash, 2003). The whitebaits (*Stolephorus* spp. and *Encrasicholina* spp.) dominated at a national level. However, the contribution of these species in the maritime states varied. While whitebaits dominated in most states (Andhra Pradesh, Tamil Nadu, Puducherry, Kerala, and Karnataka), *Coilia* sp. was dominant in West Bengal, Maharashtra and Gujarat and *Thryssa* spp. in Odisha, Goa as well as in Daman and Diu.

A perusal of the landings of engraulids in the country from 1985 to 2021 period revealed they contributed 4 to 9% of the total landings and 7 to 18% of the total pelagic landings of the country (Fig. 7). Overall, from 1985 to 2021 period, the engraulids contributed 5%

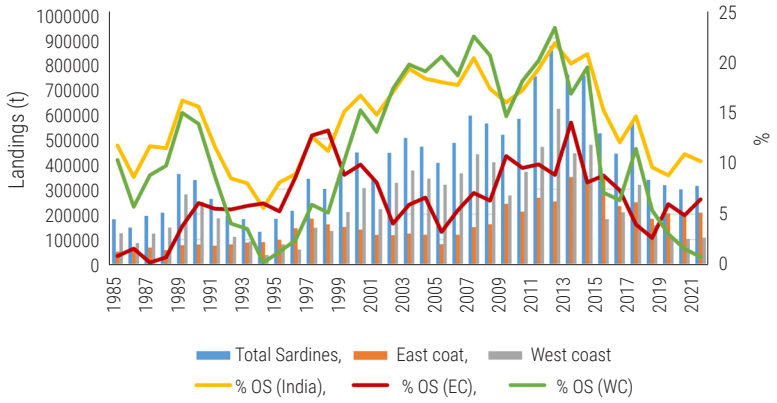


Fig. 6. Coast-wise contribution of sardines to total marine fish landings in India

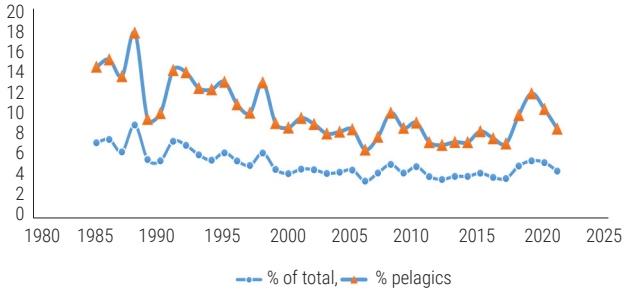


Fig. 7. Contribution of engraulids to total marine fish landings and total pelagic landings during 1985-2021

of the total fish landings. The west coast was more productive and contributed 61% of the total engraulids landed. Kerala (28%) followed by Gujarat (14.8) and Tamil Nadu (14.4%) were the lead states contributing to the total landings of engraulids (Fig. 8). The contribution of the different groups to the total engraulid landings varied with annual and seasonal fluctuations. Overall, the whitebaits dominated contributing 45% of the total engraulid landings, followed by *Thryssa* spp. (28 %), *Coilia* spp. (21%) and *Setipinna* spp. (6%). While *Thryssa* spp. contributed to the fishery in all the coastal states, the whitebaits formed a major constituent of the engraulid landings in the southern states (Kerala, Karnataka, Tamil Nadu and Andhra Pradesh) and the golden anchovy formed a significant part of the Engraulid landings in the northern states (Gujarat, Maharashtra, Daman and Diu, West Bengal and Odisha). The state-wise contribution of the major groups to the total Engraulid landings is given in Fig. 9.

Unicorn cod

The unicorn cod, also known as the spotted codlet was represented by a single species *Bregmaceros mcclellandi* under the family Bregmacerotidae. The species has a very limited distributional range along the Indian coast and formed a part of the landings only along the Gujarat and Maharashtra coasts (Rao, 1973; Reghu *et al*., 1996) between 10°29'N - 75°30'E near the south-west and at a pocket in Andaman waters. It is a small-sized fish attaining a maximum total length of 9.6 mm (Kaviarasu *et al*., 2016). The landing of the spotted codlet was monitored from 1985-2022 and the landings ranged from a mere 11 t in 2021 to a high of 1,492 t in 1991. Landings of codlet were mainly restricted to Maharashtra and a certain extent to Gujarat. Typical of small pelagics, the landings have recorded high fluctuation over the years and have registered a steep decline since 2012 (Fig. 10). The species was mainly exploited by the dol nets with the highest landings in the October - December period and the lowest in the months of June to September. Menon *et al*. (1996) reported that Bregmacerotidae formed about 2.4% of the total fish biomass. The biology of the species has been studied and the fish matured when it attained a total length of 36-40 mm and the

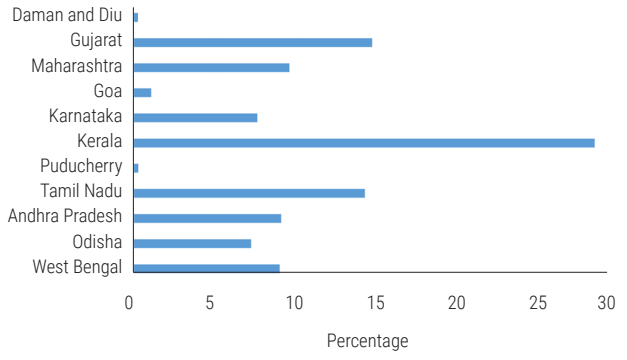


Fig. 8. Contribution of different maritime states to the total engraulid landings

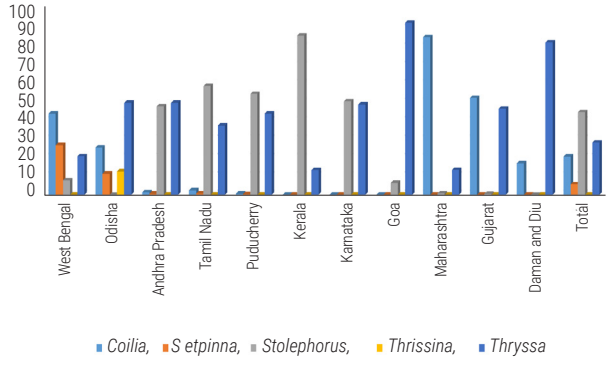


Fig. 9. State-wise and specie-wise composition of engraulid landings in India

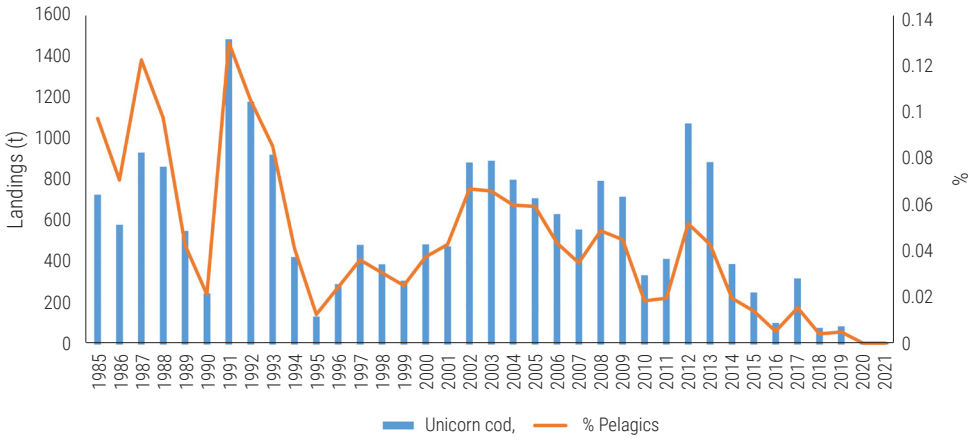


Fig. 10. Landings of unicorn cod along the Indian coast during 1985-2021

fecundity ranged from 530-980 in fishes of 42-50 mm in total length. The food items included zoobenthos (ostracods) and zooplankton (copepods, euphausiids, chaetognaths, decapod larvae).

Bombayduck

The Bombayduck is yet another important pelagic resource which contributed significantly to the total marine fish landings of the county and is highly valued in the domestic market in fresh and more in the dried form. The commercial fishery, supported mainly by a single species, *Harpadon nehereus* (Kurian, 2003), exhibits a discontinuous distribution pattern limited within the northern latitude of 18^{0}N and 22^{0}N (north-west coast - Gujarat, Maharashtra and north-east coast, West Bengal, Odisha) (Fig. 11). Despite its limited latitudinal distribution, the quantum of landing along the coast makes Bombayduck an important fishery to reckon with. The fish forms massive shoals in the nearshore as well as deeper mid water areas in the Indian EEZ (Bapat, 1970; Deshmukh and Kurian, 1980; Khan, 1986; Khan *et al*., 1992, Balli *et al*., 2006; Ghosh, 2014; Fofandi and Rohit, 2020; Vase *et al*., 2021) and formed 2.3-7.4% of the total landings of the country and 4.3-14.8% of the pelagic landings during 1985-2021 (Fig. 12). However, detailed studies have indicated regional variations in distribution which could be due to hidden diversity (Zhu *et al*., 2014; Ganga *et al*., 2016; Yang *et al*., 2021; Wang *et al*., 2021) and is exploited mainly by stationary bag nets (dol nets) and the pelagic trawl nets.

Ribbonfish

The ribbonfish also known as cutlass fish is an integral part of the marine fish landings of the country. Though, several species are reported from the Indian coast (Silas and James, 1960; James,

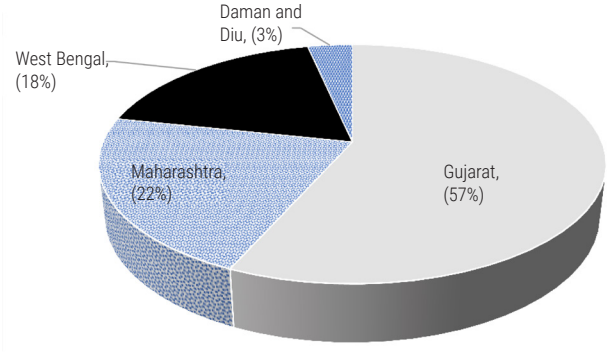


Fig. 12. State-wise contribution (%) to the Bombayduck landings in India

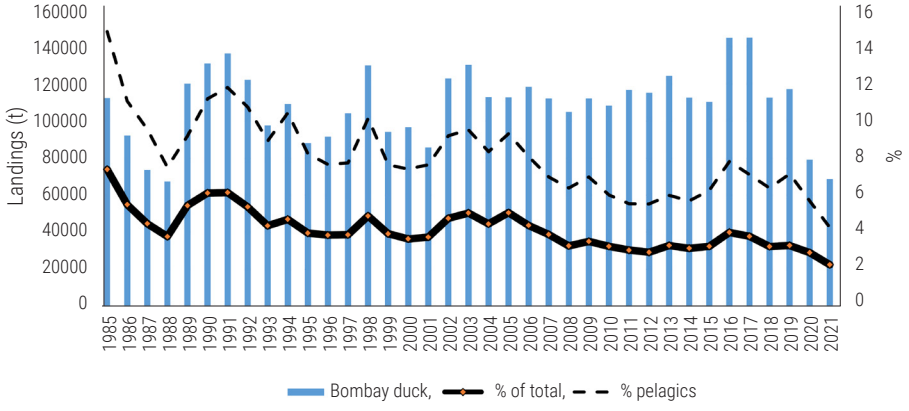


Fig. 11. Bombayduck landings and its contribution to the marine fish landings during 1985-2021

1967a,b, 1973; Silas and Rajagopalan, 1975; Rao *et al.,* 1977; Sastry, 1980; Narasimham 1983; Rohit *et al*., 2015; Udupa *et al*., 2022), the commercial fishery is supported by the widely distributed largehead hairtail, *Trichiurus lepturus* (Chakraborty *et al.,* 1997; Abdurahiman *et al.,* 2004). This species formed a fishery all along the Indian mainland and was harvested mainly by the pelagic trawls and to a very small extent by other gears such as seines and the gill nets. The average annual landings during 1985-2021 were estimated at 149628 t forming 5% of the total landings and 10.6% of the total pelagics. The annual landings varied from 65,150 to 2,35,045 t forming 2.9-8.7% of the total landings and 5-16% of the total pelagic resources (Fig. 13). Being a fishery of great relevance to the Indian coast with good demand in the domestic as well as export markets, the fishery, biology, stock assessment as well as the impact of climate on the stock has been extensively reported (Udupa *et al*., 2022). The west coast of India has been more productive with respect to the quantum landed and contributed 77.3% of the total ribbonfish landings during 1985-2021. Gujarat followed by Maharashtra, Kerala and Karnataka are the main states that contributed significantly to the ribbonfish landings (Fig. 14).

Mackerels

The mackerels are a vast group that includes some of the most prominent pelagic fishes which significantly contribute to the total landings of the country and meet the food requirement of fish eaters within the country as well as on a global scale. They include fishes from several genera from Scombridae (*Rastrelliger* spp., *Scomberomorus* spp., *Scomber* sp., *Acanthocybium* sp.), Gempylidae (snake mackerels) and Carangidae (jack mackerels, horse mackerels). In this overview, data on species under the family Scombridae (*Rastrelliger* spp., *Scomberomorus* spp. and *Acanthocybium* sp.) only is used. The mackerels generally have streamlined bodies and are slim and fast swimmers. The size varies from the smaller Indian mackerel (less than 0.5 m in total length) to the large-sized Wahoo and seerfishes (over a meter in total length). They are harvested by all types of gears (seines, trawls, gillnets, lines and other indigenous gears). The smaller fishes forage on the zooplankton and are in turn foraged by larger predators including birds along the food web. Most of the larger mackerels are apex species. The annual trends in the landings of mackerels from 1985 to 2021 are given in Fig. 15. Among the maritime states, Kerala contributed the maximum (27.5%) to the total mackerel landings followed by Karnataka (20.7%) (Fig. 16).

Of these, the Indian mackerel (*Rastrelliger kanagurta*) is the most important in terms of bulk landings and with a pan-India distribution. It comprised 80.1% of the total mackerels landed by weight, followed by the narrow barred Spanish mackerel (*Scomberomorus commerson*) with a contribution of 12.7% and the Indo-Pacific mackerel (*S. guttatus*) with a contribution of 7%. The contribution of other species to the total mackerel landings was minimal (Fig. 17). The composition of the mackerel landings in the maritime states differed in the maritime states. While the Indian mackerel (*R. kanagurta*) was the dominant fish in most states except Gujarat and Daman and Diu, the Indo-Pacific king mackerel (*S. guttatus*) dominated in Gujarat, the narrow barred Spanish mackerel dominated in Daman and Diu and contributed significantly in West Bengal (Fig. 18). The various mackerel species harvested by multiple gears such as seines (purse seines, boat seines, and shore seines), gill nets and trawls are valued both in the domestic and international markets. The stock delineation using truss morphometrics and the impact of climate variables on Indian mackerel fisheries was reported (Remya *et al*., 2014, Sajna *et al*., 2021).

Carangids

A diverse array of fishes occupying several niches in the marine system and with varying size, colour and shape but grouped by the presence of general morphological characters such as the presence of two dorsal fins, two detached pre-anal spines, slim pectoral fins, often sickle-shaped and scutes on the body (Abdussamad *et al*., 2007). The group includes the scads, jacks, trevallies, runners, pompanos, queenfishes and pilotfishes under

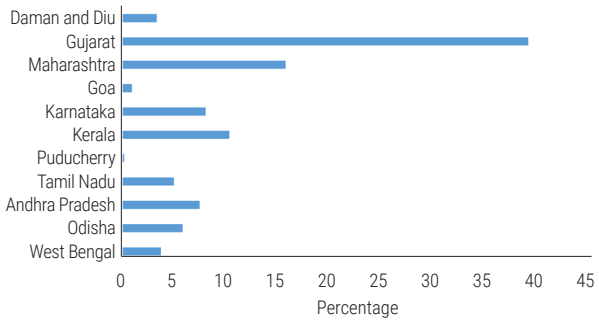


Fig. 14. Contribution to the total ribbonfish landings by various maritime states

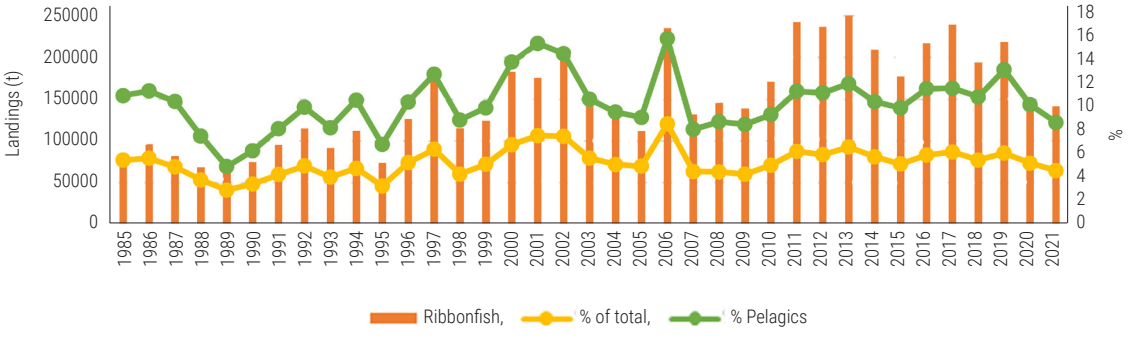


Fig. 13. Annual landing trends of ribbonfish and its contribution to the marine fish landings in India

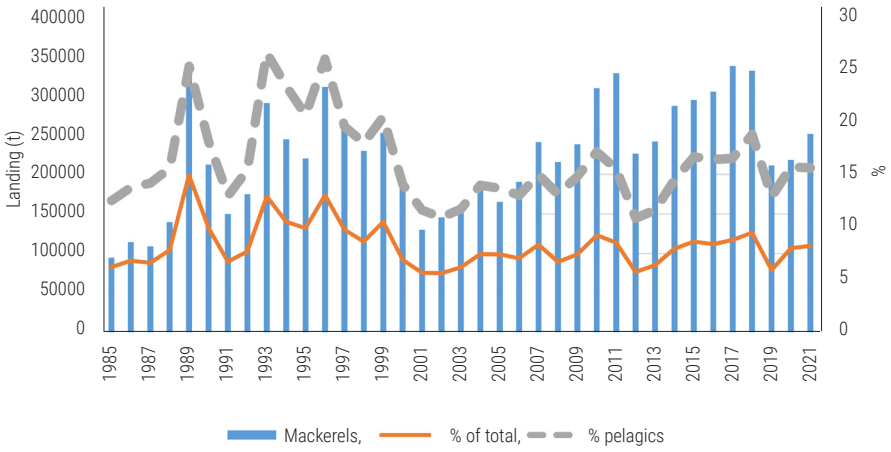


Fig. 15. Trend of mackerel landings in India during 1985 -2021

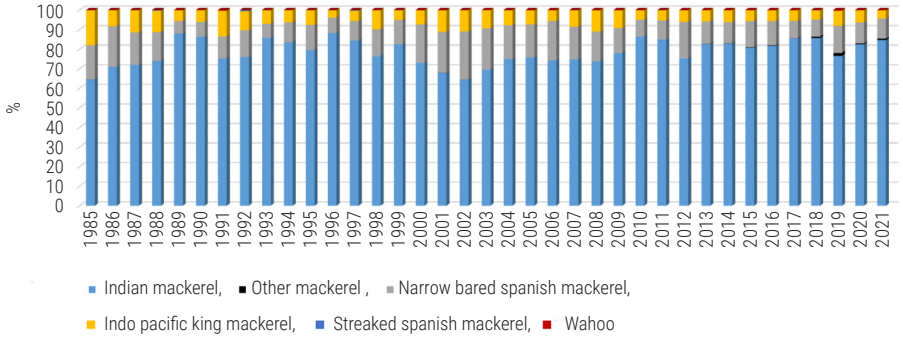


Fig. 16. Group-wise contribution to the mackerel fishery in India during 1985 - 2021

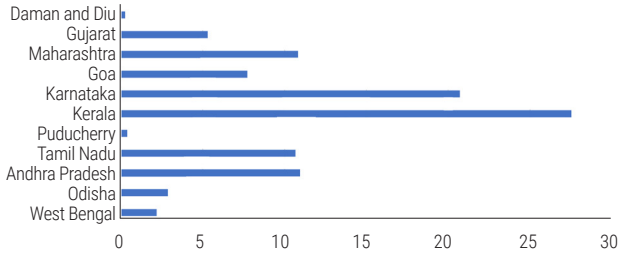


Fig. 17. State-wise contribution (%) to the total mackerel landings in India

several genera and contributed 4.2-14.8% of the total marine fish landings of the country and 8.5-28.0% of the total pelagics landed (Fig. 19). The seines (shore seines, boat seines, purse seines), trawls, gillnets, hooks and line and several small traditional gears, harvest these groups. Most of the carangids are valued for their good taste both in the domestic market as well and a few species are also being hatchery-reared and cultured in ponds/cages. Over the years (1985-2021), the landings of carangids have registered a steady increase with minor annual fluctuations. However, the major groups contributing to the total carangid landings did record annual

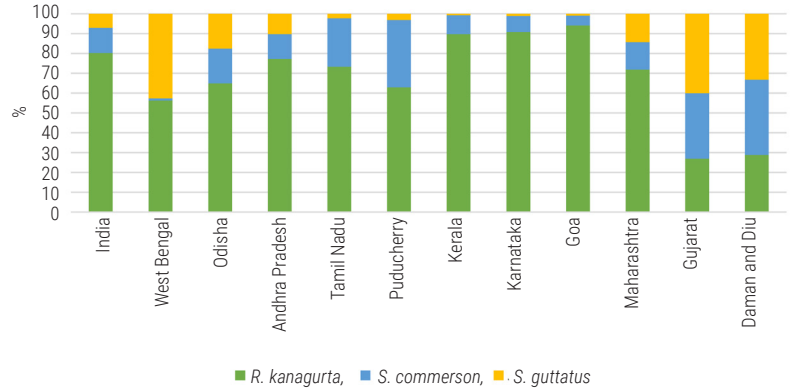


Fig. 18. Species-wise contribution (%) to mackerel landings in India

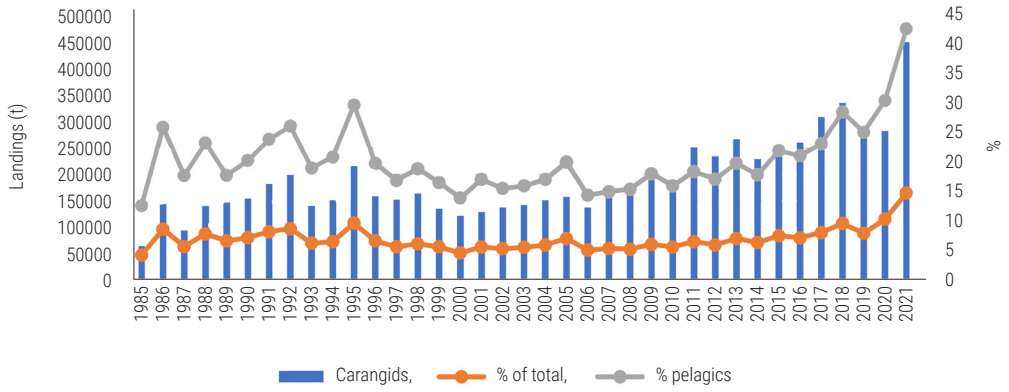


Fig. 19. Carangids landings in India (1985 – 2021) and percentage contribution to total marine fish landings and landings of pelagics

and seasonal changes. The scads, horse mackerel, leather jackets and the pomfrets were the major group of fishes that contributed in significant quantity to the total carangids. The scads have emerged as the most dominant fish followed by the horse mackerel and the black pomfrets (Fig. 20). The carangids are exploited all along the Indian coast, with the highest landings made in Kerala followed by Tamil Nadu and Karnataka (Fig. 21). The scads were the most dominant group in all maritime states except in West Bengal and Odisha, where the horse mackerel was followed by black pomfrets (Fig. 22). The fishery, biology and population characteristics of several carangid species have been reported (Randy, 2000).

Tunas

The tunas are the most promising oceanic resources in the Indian fisheries sector. With an estimated potential of 18,35,32 t of tunas from the coastal waters and 1,01,986 t from the oceanic waters of the Indian EEZ and with the average annual yield of 54,663 t during the 1985-2021 period, only around 19% of the total estimated potential is exploited from the Indian waters. Tunas are a major group included under the family Scombridae and with an average contribution of 2% of the total marine fish landings of the country and 3.9% of the pelagic landings during 1985-2021 are yet another

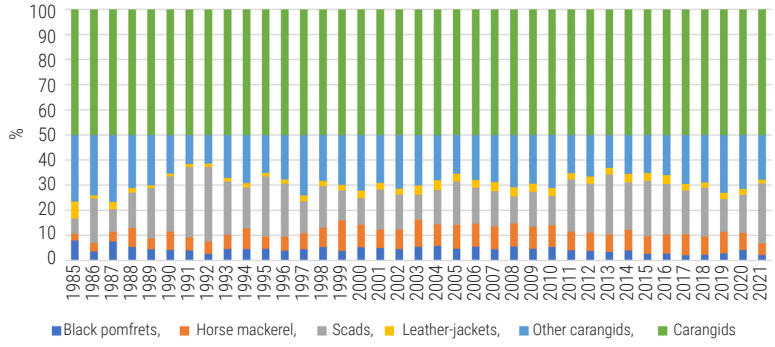


Fig. 20. Species-wise composition of carangid landings in India during 1985 - 2021

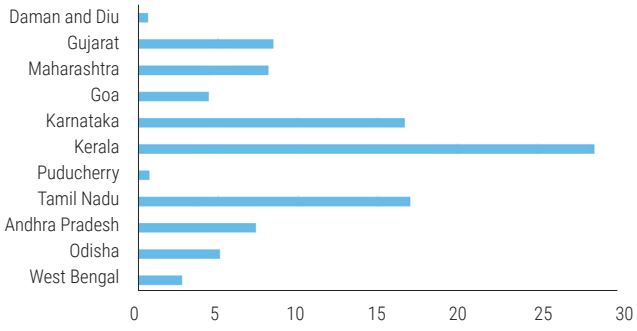


Fig. 21. State-wise contribution (%) to the total carangid landings in India

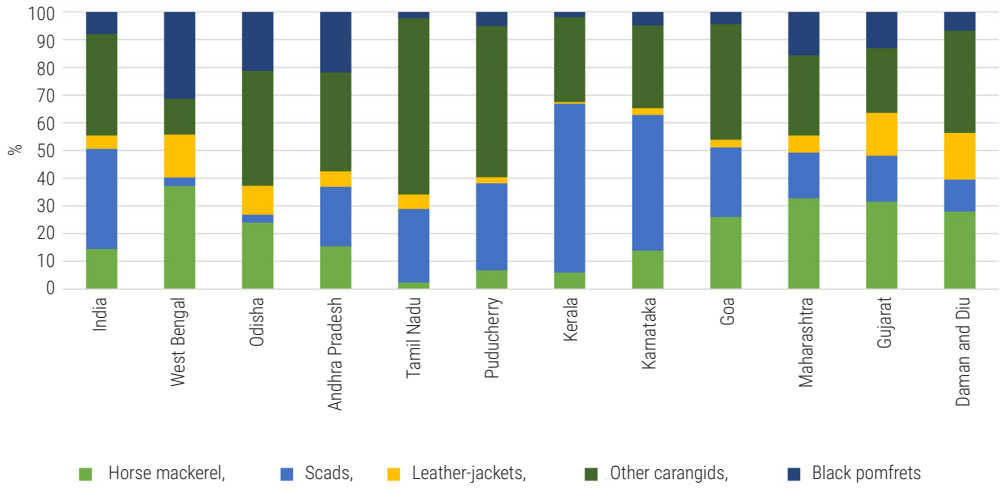


Fig. 22. Group-wise contribution to the total carangid landings in the various maritime states of India

important pelagic resource of the country (Fig. 23). Fig. 24 depicts the state-wise contribution to the tuna landings in India, with Kerala showing the highest contribution (32%). Five species of neritic tunas (*Euthynnus affinis, Auxis thazard, A. rochei, Thunnus tonggol, Sarda orientalis*) and four oceanic tunas (*Thunnus albacares, Katsuwonus pelamis, Thunnus obesus* and *Gymnosarda unicolor*) contribute to the tuna fishery of the country (Fig. 25). The tunas are mainly exploited by the gillnets, longlines, troll lines and the smaller neritic tunas also by purse seines. All species have a good domestic demand in specific areas and a couple of neritic tunas (*E. affinis, T. tonggol*) and oceanic species (*T. albacares, T. obesus* and *K. pelamis*) in various forms have a good demand in the export market. Being a resource of great importance as a source of food with good economic returns, most species have been extensively studied (Pillai *et al*., 1993; Somvanshi *et al.*, 1999; Abdussamad, 2012; Abdussamad *et al.*, 2008; 2012 a, b; Rao and Rohit, 2008; Rohit and Rammohan, 2009; Rohit *et al*., 2010; Rohit *et al.*, 2012a, b; Ghosh *et al*., 2012; 2023; Joshi *et al*., 2012; Koya *et al*., 2012; 2013; Sivadas *et al*., 2012; Jasmine *et al.,* 2013; Pillai and Satheeshkumar, 2014; Mohammed Koya *et al*., 2018). Studies on the movement of yellowfin tunas, optimum temperature and depth preference by deploying pop-up satellite tags were reported by Kumar *et al.* (2020).

Billfishes and other large pelagics

The billfishes, barracudas, halfbeaks and fullbeaks, leather jackets as well as drift fishes are fishes forming part of the pelagic group. The annual landings of billfishes ranged from 977 t in 1985 to 16,815 t in 2016 with an average 5,589 t during 1985-2021 (Fig. 26) forming a meagre part of the total landings. The landings of the billfishes increased over the years with the expansion of the fishing grounds and enhanced fishing capacity. Kerala topped the maritime states with an average contribution of 38% followed by Tamil Nadu and Andhra Pradesh (Fig. 27). Several studies on the fishery, movement and environmental studies on bill fish species have been reported from the Indian, Atlantic and Pacific oceans (Block *et al*., 1992; Chang *et al*., 2012; Bruno *et al*., 2014; Bruno *et al*.,

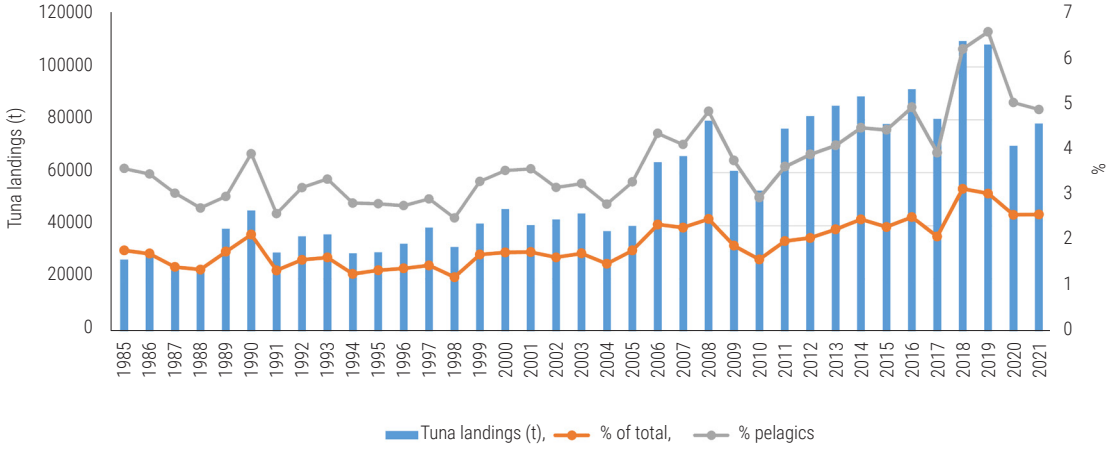


Fig. 23. Annual tuna landings in India (1985 – 2021) and its contribution to total marine fish and pelagics landings

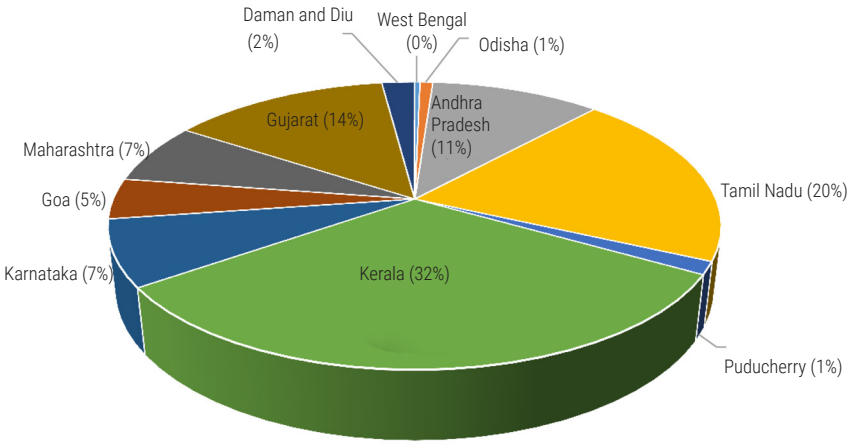


Fig. 24. State-wise contribution (%) to the tuna landings in India

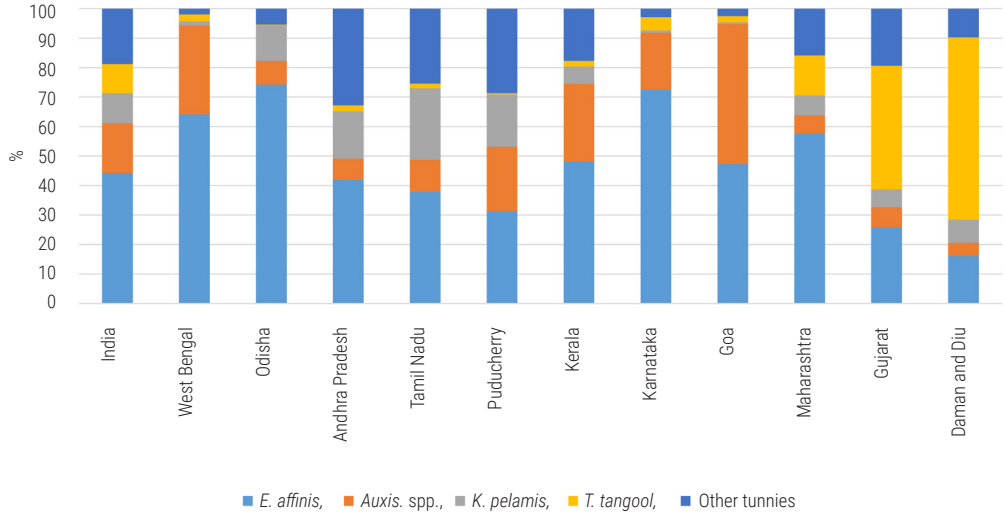


Fig. 25. Species-wise composition (%) of the total tuna landings in the various maritime states of India

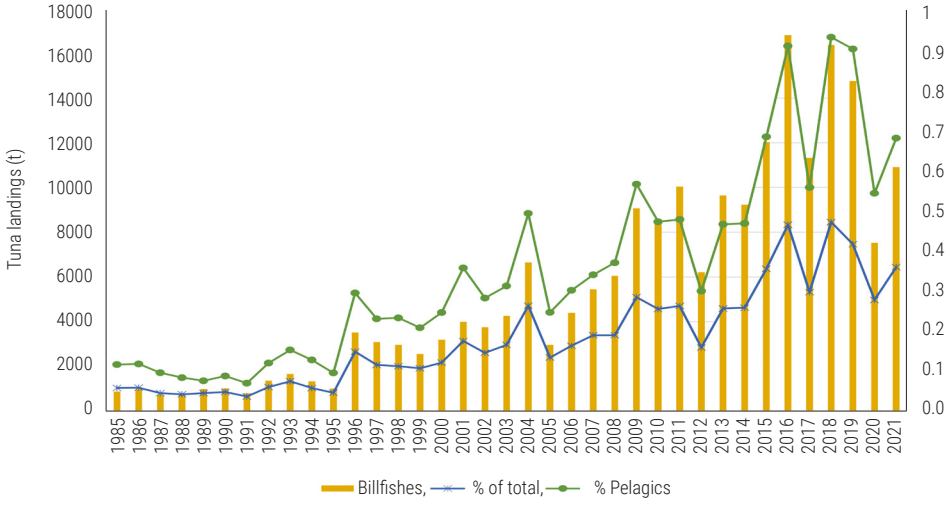


Fig. 26. Annual landings of billfishes in India during 1985 – 2021 and its percentage contribution to total marine fish and pelagics landings

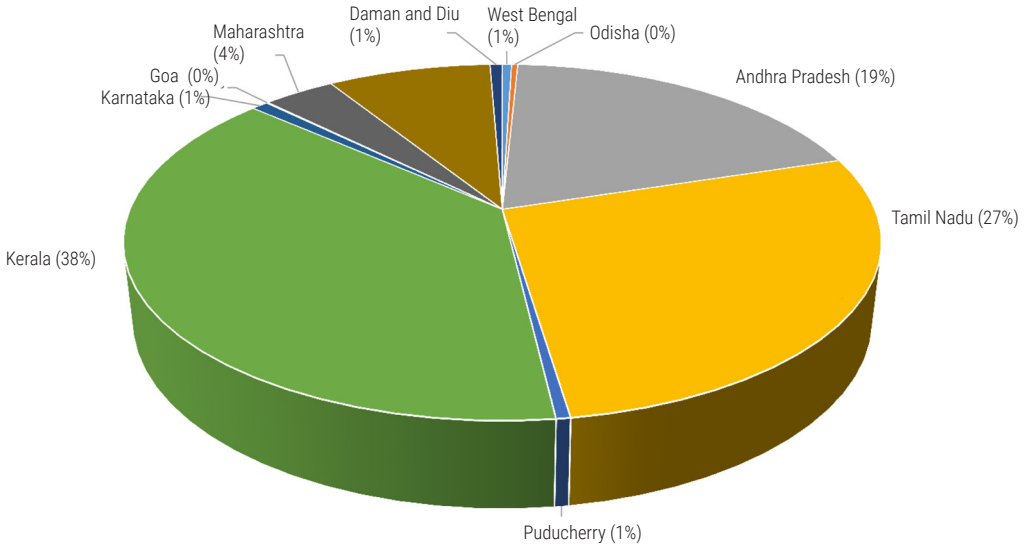


Fig. 27. Percentage contribution by various maritime states to the total bill fish landings in India

2018; Rathnasuriya *et al*., 2016; Bandaranayake *et al*., 2018). However, except for reports on the species distribution and basic information on the fishery (Varghese *et al*., 2005; Varghese *et al*., 2013; Bishnupada and Ansy, 2014), detailed reports on the distribution, species composition and environmental preferences of billfishes landed along the Indian coast are very recent. The catch is monitored and studies on the fishery, biology and stock structure of these species too have been reported by Somvanshi *et al*. (1999), Ganga *et al*. (2008; 2012) and Surya *et al*. (2021; 2022; 2023a,b) .

The pelagic fish resources comprising of diverse groups of fishes and occupying various niches are undeniably the most important component of the biological life of the oceans. They play a vital role in maintaining the ecological balance of the marine environment and their sheer bulk makes it a group to reckon with and they generally dictate the trends in marine fish production. Despite, their vulnerability to short-term and long-term climate change events resulting in seasonal, annual, and decadal fluctuations, the pelagic fishes with their ability to move away from the unfavourable area and combined with their inherent biological characteristics of rapid growth, high fecundity, and moderate to high resilience, continue to dominate the total marine fish production of the country. Several pelagic fishes are considered keystone species, some are important sources of protein-rich food and yet others do fetch a good price in the domestic and export markets. The present production of the pelagic groups especially the oceanic and the mesopelagic species (Mathew *et al*., 1993), which have very good export and industrial utility, is much lower than the estimated potential. Fishers have to be actively encouraged to take up the various schemes provided by the government and trap these resources. The fishery of the pelagic fishes needs to be monitored on a regular basis along with the impact of short- term and long-term climate changes on both the small as well as large pelagics along the Indian coast has to be studied in detail so as to propose suitable measures to manage the fishery. Such studies would definitely throw more light on the sharp fluctuations inherent to most pelagic fisheries. The influence of environmental factors on the growth and reproduction of small pelagic fishes is well known and reported by several researchers and holds the key to these fluctuations and AI as well as remote sensed data will throw more light on suitable habitats that influence the fishery. Continued and focused research on these lines will definitely bring out a suitable model to predict the fishery of the pelagic resources.

Acknowledgments

The authors wish to thank the Director, ICAR-CMFRI, Kochi for the encouragement and facilities provided for completing the work.

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