NO. 249, July - September 2021 ISSN 0254-380X

MFiS

Marine Fisheries Information Service Technical & Extension Series

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Marine Fisheries Information Service
Technical & Extension Series

Mar. Fish. Infor. Serv., T & E Ser., No. 249, 2021

Published by

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Director
ICAR - Central Marine Fisheries Research Institute, Kochi

Marine crab landings at Cochin Fisheries Harbour

Photo credit: Josileen Jose

Marine Fisheries Information Service Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers and transfer of technology from laboratory to the field.

MFIS

Marine Fisheries Information Service
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From the Editorial Board

Warm greetings to all our esteemed readers

The marine fisheries sector in India contributes 29% of the total fish production in India, but more importantly, provides livelihoods and nutritional security to a vast number of people. Capture fisheries and mariculture enterprises provide seafood that reportedly accounts for 17% of global production of edible meat. Rising human population, upward incomes and preferences among meat consumers increasingly shifting towards healthier seafood, point to the growing importance of the seas in the future. In recent years, extreme weather events spurred by the global climate change phenomenon have increased the challenges facing the coastal community and highlighted the need for fisheries management interventions based on principles of sustainability, resource efficiency and good governance. Against this background, the present issue of MFIS tries to capture the various aspects of marine fisheries in India, covering different fishery resources and regions along the vast Indian coastline.

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Trends in marine crab fishery of India

Jose Josileen[1]*, A. P. Dineshbabu[2], P. T. Sarada[3], Gyanaranjan Dash[4], Indira Divipala[5], Rajan Kumar[6], Raj Kumar[7], K. N. Saleela[8], S. Lakshmi Pillai[1], Rekha Devi Chakraborthy[1], N. Ragesh[1], L. Sreesanth[1], Sindhu K. Augustine[1] and T. V. Sathianandan[1]

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Abstract

The overall production of marine crabs in India during 1975-2020 was around 1.61 million tonnes, accounting an average of 9.6% in the total crustacean landings. The overall trend of the fishery indicated an increase at the national level, recording a maximum landing of 57354 tonnes (t) during 2018 and the lowest record of 14202 t during 1978. Bulk of the estimated landings (59%) were from Tamil Nadu and Gujarat with the three portunid crabs *Portunus sanguinolentus, Portunus pelagicus* and *Charybdis feriata* dominating in the fishery during 2007-2020. Status of the marine crab fishery in the different maritime states with landing trends, gear-wise contribution, species composition and bionomics are also presented.

Key words: Marine crabs, India, maritime states, landings, bionomics

Introduction

Crabs constitute an important resource in the marine fishery in India and contributed an overall average of 9.6% to the total crustacean landings during 1975-2020. Many species of crabs are exploited along the east and west coasts of India, mainly in trawls as a by-catch and as a targeted resource in gillnet in some regions. While making a comparison between east and west coasts of India, east coast was found more productive contributing 56.7% to the marine crab landings. The overall trend of the fishery showed increase at national level, recording a maximum landing of 57354 tonnes during 2018 and the lowest, 14202 tonnes during 1978. Otherwise, the scenario varied between maritime states, for instance earlier years (2008-2012), state of Gujarat was leading in crab production, later the position was taken over by Tamil Nadu with very clear dominance. It is very evident from the national data on species wise production of marine crabs (2007-2020) and at present in overall production Gujarat is in second position followed by Andhra Pradesh & Kerala. The marine crab landings and effort data used for the analysis were obtained from the National Marine Fishery Resources Data centre (NMFDC) of ICAR-CMFRI (Figs. 1- 3 & Table 1).

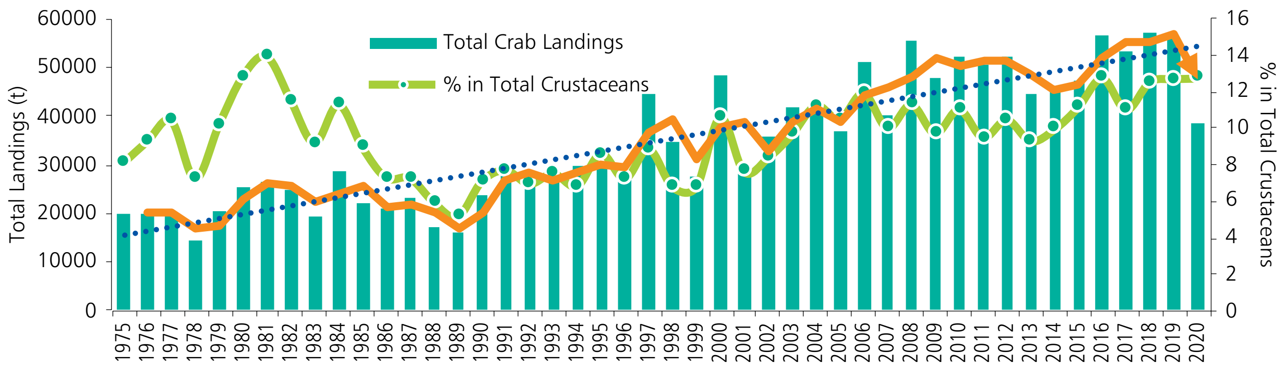

Fig. 1. Marine crab landings in India during 1975–2020.

Table 1. State-wise trend in overall crab landings of India during 2007- 2020

States	Coastal length (km)	Coastal districts	Total (t)	Rank	Percentage	Overall trend
Tamil Nadu	1076	13	233164001	1	33.31	Decreasing
Gujarat	1600	15	179602878	2	25.66	almost steady
Andhra Pradesh	974	9	76795955	3	11.00	Decreasing
Kerala	590	9	51622213	4	7.37	Increasing
Karnataka	300	3	41839864	5	6.00	Increasing
Odisha	480	6	36941425	6	5.28	Increasing
West Bengal	158	4	36762107	7	5.25	Decreasing
Maharashtra	720	7	15153865	8	2.16	Increasing
Puducherry	45	4	12953456	9	1.85	Increasing
Daman & Diu	21	2	10496116	10	1.50	Decreasing
Goa	104	2	4681290	11	0.67	Increasing

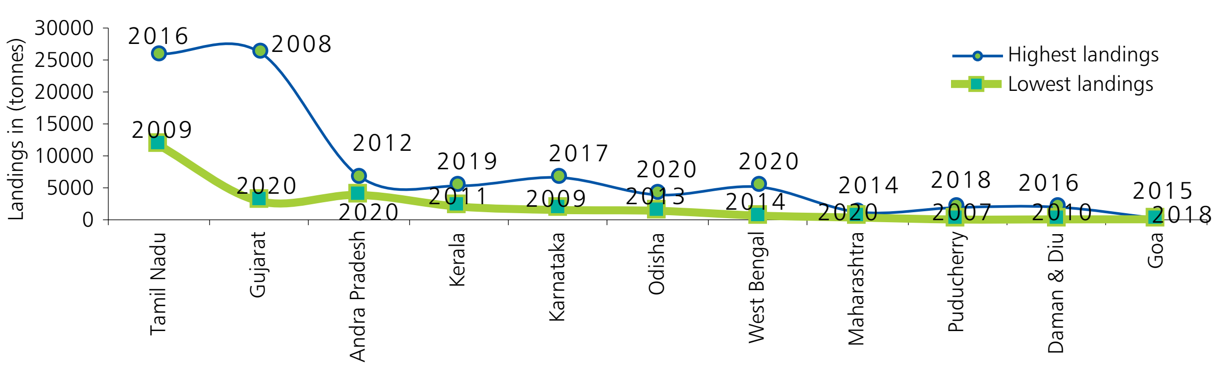

Fig.2. Statewise trend of highs and lows in annual crab landings (2007-2020)

Species composition

Edible crabs landed in India belong to the family Portunidae and around 61% of the landings were recorded by three species of marine crabs *Portunus sanguinolentus* (28.2%), *Portunus pelagicus* (25%) and *Charybdis feriata* (7.7%). Major species recorded in different states during 2007-2020 and their fishery trends are presented (Table 2, Figs. 4 – 6). In Gujarat, *P. sanguinolentus* has recently emerged as the dominant species followed by *P. pelagicus*, pushing down *C. feriata* to the third position. Similarly in Tamil Nadu, the hitherto dominating species *Portunus pelagicus* (30.7%) has been overtaken by *P. sanguinolentus* (33.3%) with a marginal increase registered in the landings. The other important edible species included in the fishery in appreciable quantities were *Charybdis lucifera*, *Charybdis*

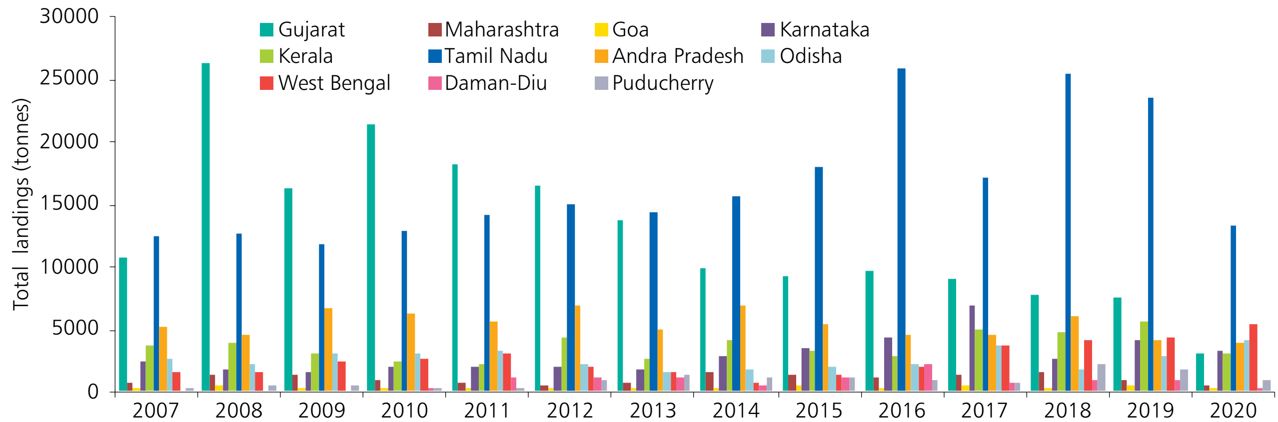

Fig. 3. State-wise estimates of marine crab landings during 2007-2020

Table 2. Major species recorded in the marine crab landings of different maritime states during 2007-2020

State	Major species in Overall landings (2007-2020)	Dominant species (2018-2020)
Gujarat	*C. feriata, P. sanguinolentus & P. pelagicus*	*P. sanguinolentus*
Maharashtra	*P. sanguinolentus, C. feriata & P. pelagicus*	*P. sanguinolentus*
Goa	*P. sanguinolentus, P. pelagicus & C. feriata*	*P. sanguinolentus*
Karnataka	*P. pelagicus, P. sanguinolentus & C. feriata*	*P. pelagicus*
Kerala	*P. sanguinolentus, C. feriata & P. pelagicus*	*P. sanguinolentus*
Tamil Nadu	*P. pelagicus, P. sanguinolentus & C. natator*	*P. sanguinolentus*
Andhra Pradesh	*P. sanguinolentus & P. pelagicus*	*P. sanguinolentus*
Odisha	*P. sanguinolentus, P. pelagicus & C. feriata*	*P. sanguinolentus*
West Bengal	*P. sanguinolentus, P. pelagicus & C. feriata*	*P. sanguinolentus*
Daman-Diu	*C. feriata, & P. sanguinolentus*	*C. feriata*
Puducherry	*P. sanguinolentus & P. pelagicus*	*P. sanguinolentus*

**Note: Species names are provided as following the World Register of Marine Species (WoRMS).*

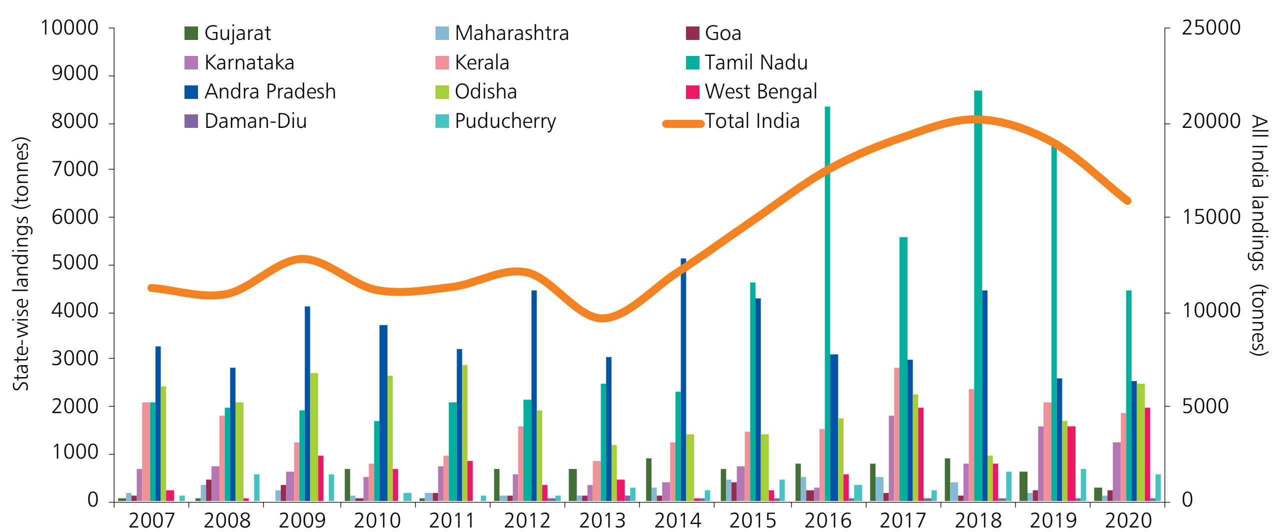

Fig 4. State-wise *Portunus sanguinolentus* landings in India (2007-2020)

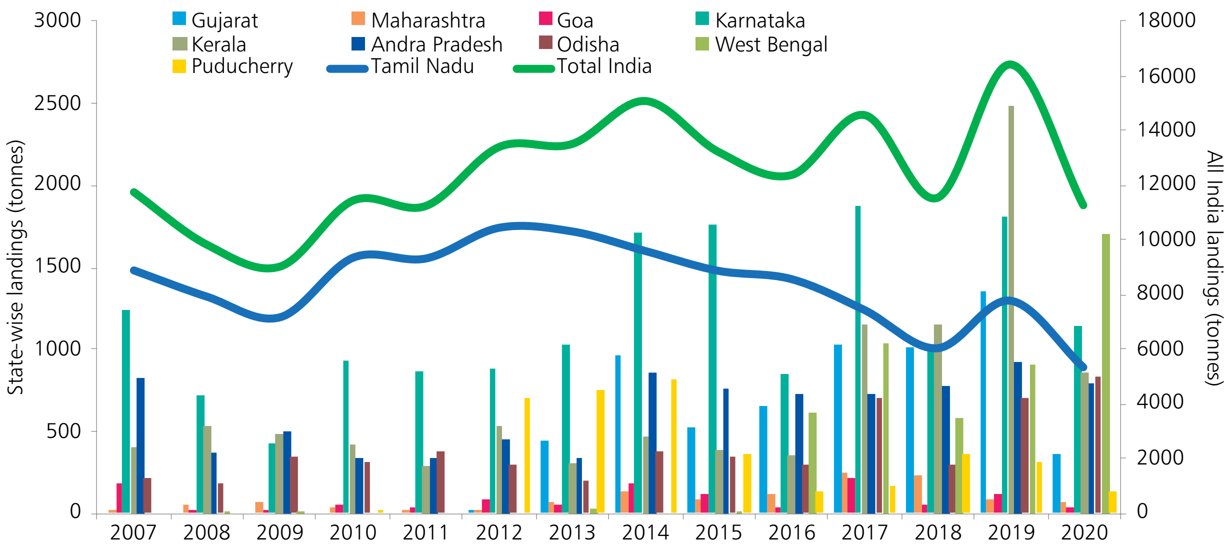

Fig 5. State-wise *Portunus pelagicus* landings in India (2007-2020)

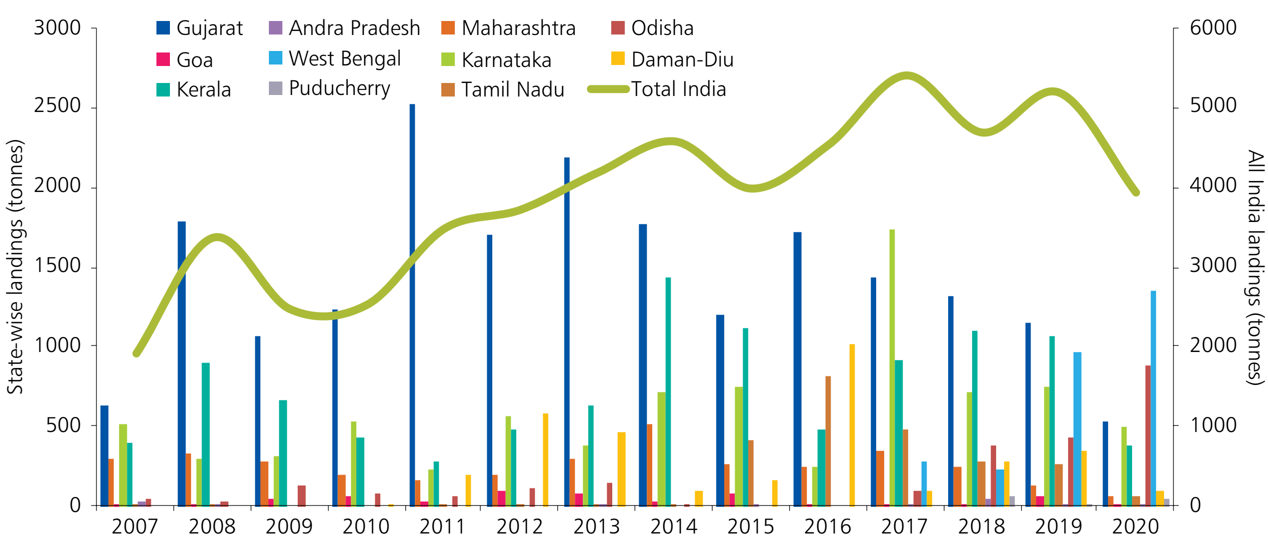

Fig. 6. State-wise *Charybdis feriata* landings in India (2007-2020)

natator, *Charybdis smithii*, *Charybdis annulata*, *Portunus gladiator* (revised as *Monomia gladiator*), *Podophthalmus vigil*, *Scylla serrata* and *Scylla olivacea*.

State-wise landings

Gujarat contributed 25.7 % of the overall crab landings in India, recording highest and lowest landings in 2008 and 2020 respectively (Fig. 7). January to March is the most productive period for the landings of crabs, and contributed 37.8 to 47.8% of annual crab landings during 2018-2020. Till recently, the dominant species recorded was *Charybdis feriata.* However, during 2018-2020 *P. sanguinolentus* emerged as the most dominant species followed by *P. pelagicus* and pushing down *C. feriata* to the third position. Another important observation was that the non-edible crab, *Charybdis hoplites* landed in enormous quantities encompassing bulk of the *Charybdis* spp. (50.4%) in total landings. Crabs were mainly landed in trawls (Multi-day 81% & Single-day 4%) followed by mechanised dol nets (6%). In multi-day trawls the catch per unit effort (CPUE) varied between 31-374 kg and the catch per hour (CPH) between 0.3- 6.0 Kg (Figs. 8 & 9).

During 2007-2020 period the overall trend of total crab landings in Maharashtra was stable and contributed 2.2

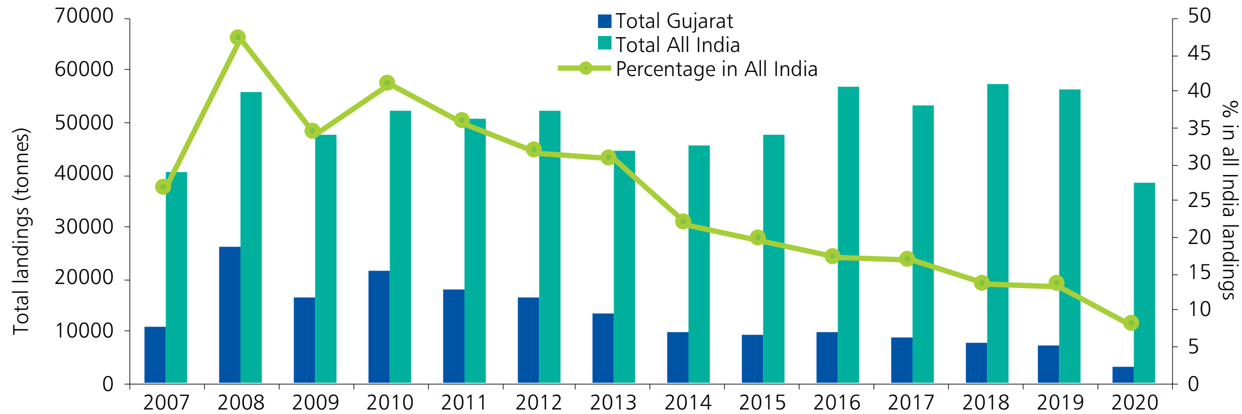

Fig. 7. Annual marine crab landings in Gujarat (2007-2020)

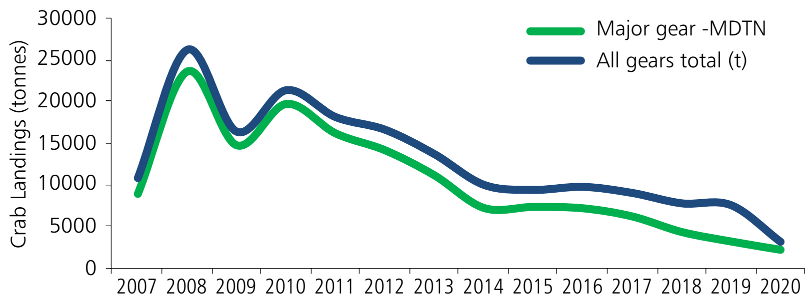

Fig. 8. Gear-wise contribution of marine crab landings in Gujarat (2007-2020)

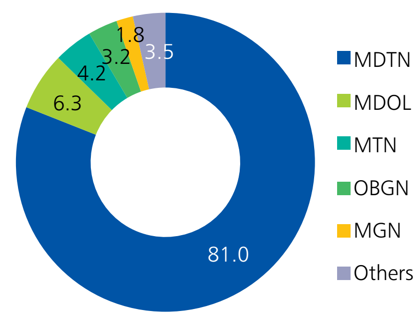

Fig. 9. Percentage contribution of different gears to marine crab landings in Gujarat (2007-2020)

% of the overall crab landings in India, with the highest and lowest landings in 2014 and 2020 respectively. *P. sanguinolentus* was the dominant species throughout the period (Fig.10). 71% of the crab landing of the state was recorded in trawls (Multiday-60% & Single day 11%) and mechanised dol nets (17%). In multi-day trawls the CPUE varied between 5.0-17.0 kg and the CPH between 0.1-0.21 kg (Figs. 11&12)

The share of Goa in overall crab landings during 2007-2020 was very meagre and status of the fishery recorded a slightly declining trend over the period. The highest and lowest landings were noted in 2015 and 2018 respectively and the bulk of the landing was contributed by *P. sanguinolentus* in all years (Fig.13). Maximum crabs were landed in Multiday trawls (44.3%) and Single day (40.2%) trawls followed by the gillnets (10.5%) (Figs. 14 & 15).

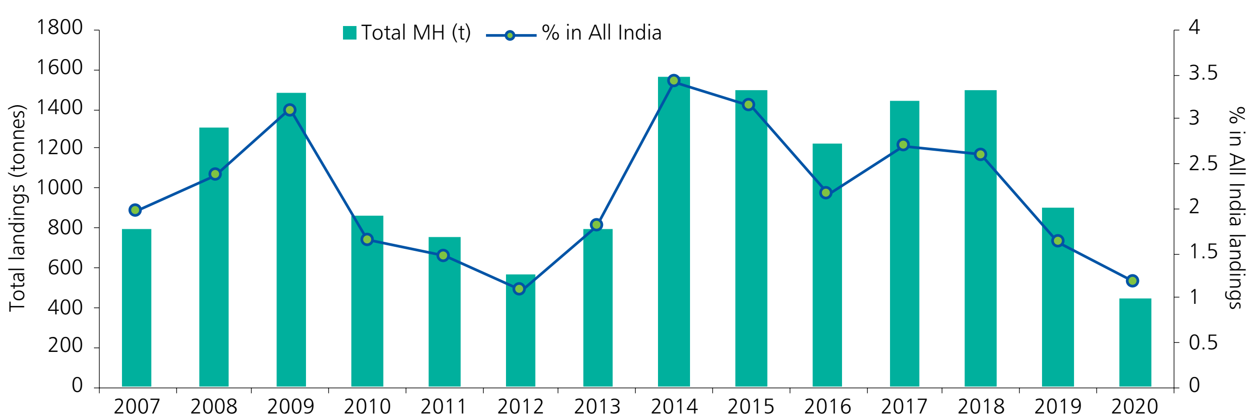

Fig. 10. Annual marine crab landings in Maharashtra (2007-2020).

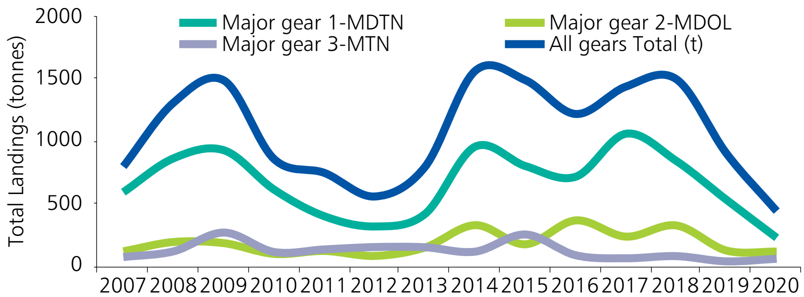

Fig. 11. Contribution of major gears to marine crab landings in Maharashtra (2007-2020).

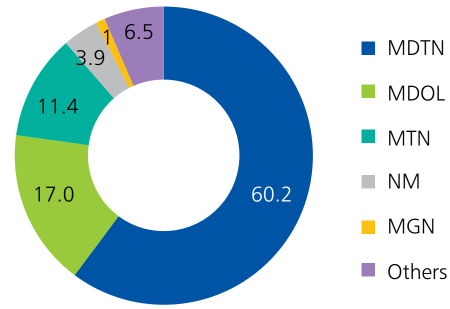

Fig. 12. Percentage contribution of different gears to marine crab landings in Maharashtra (2007-2020).

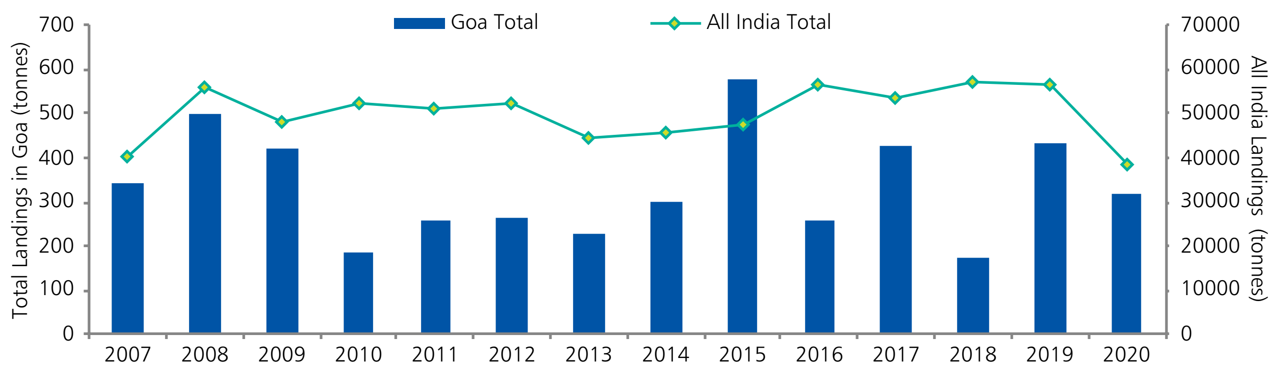

Fig. 13. Annual marine crab landings in Goa (2007-2020)

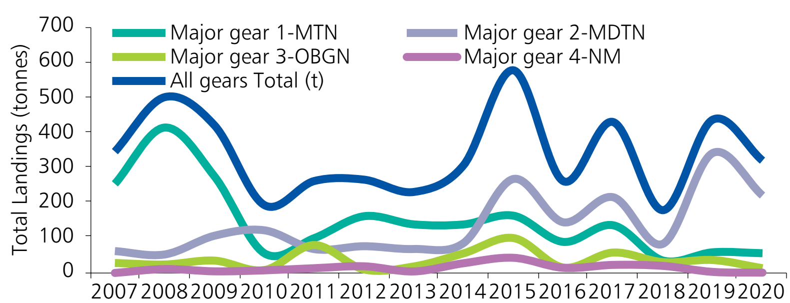

Fig. 14. Gear-wise contribution of marine crab landings in Goa (2007-2020)

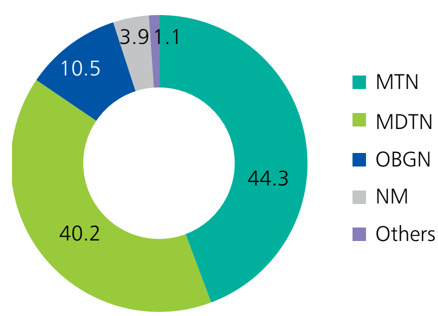

Fig. 15. Percentage contribution of different gears to marine crab landings in Goa (2007-2020)

Karnataka contributed 6% of the overall crab landings in India, recording highest and lowest landings in 2017 and 2009 respectively. The state ranked 5th in overall landings and *Portunus pelagicus* was the dominant species throughout the reporting period. The overall trend showed a steady increase (Fig. 16). Bulk of the crab landings in the state were contributed by Multi-day trawls (60%) Single-day trawls (30%) and the rest by other gears. Annual CPUE and CPH in multiday trawls varied between 17.6–187.3 kg and 0.2–1.8 kg and in single day trawls between 8.0–21.8 and 1.1- 3.5 kg respectively (Figs. 17 & 18).

In Kerala the overall trend of total crab landings during 2007-2020, recorded increase and contributed 7.4 % of the overall crab landings in India, with the highest and lowest landings in 2019 and 2011 respectively. *P. sanguinolentus* (46.6%) was the dominant species (Fig. 19) with major contribution by trawls (Multi-day 52% & Single-day 27.3%) accounting for nearly 80% of the crab landing of the state. Annual CPUE and CPH in multiday trawls varied between 8.1–43.3 kg and 0.3–5.5 kg and in single day trawls between 6.1 – 17.5 & 1.0- 11.8 kg respectively (Figs. 20 & 21).

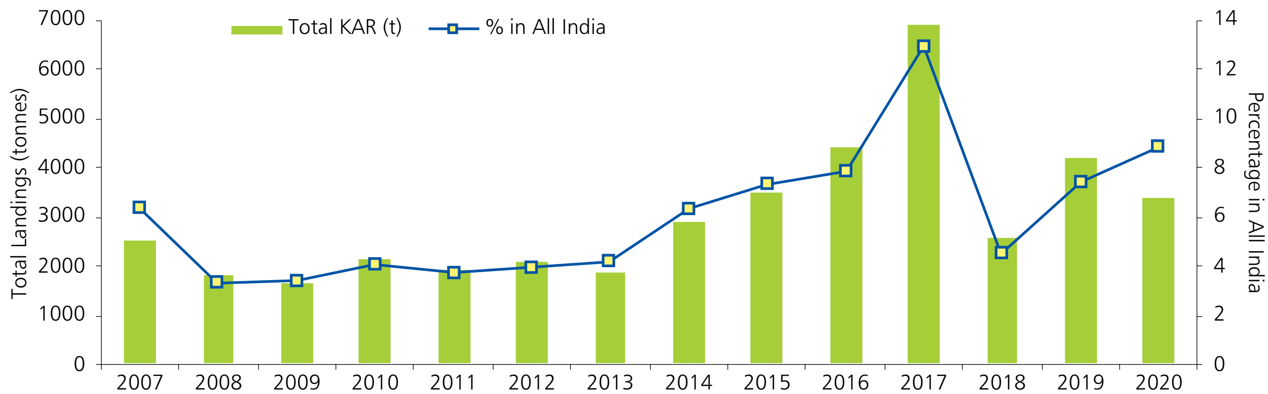

Fig. 16. Annual marine crab landings in Karnataka (2007-2020).

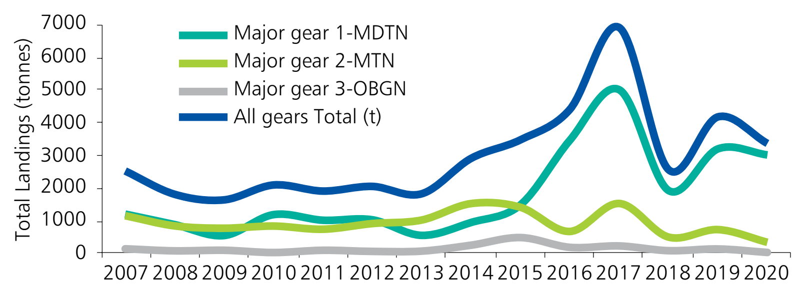

Fig. 17. Gear-wise contribution of marine crab landings in Karnataka (2007-2020)

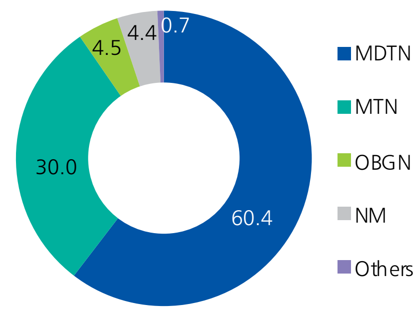

Fig. 18. Percentage contribution of different gears to marine crab landings in Karnataka (2007-2020)

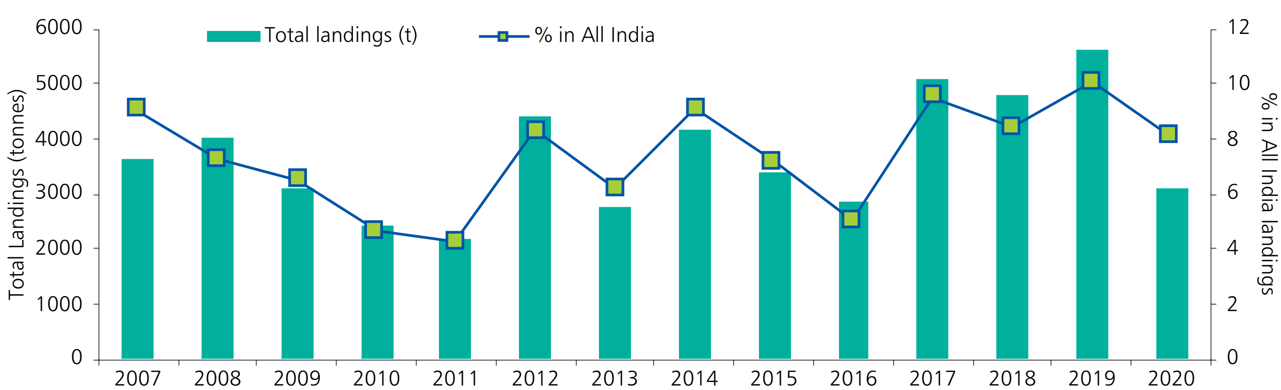

Fig. 19. Annual marine crab landings in Kerala (2007-2020)

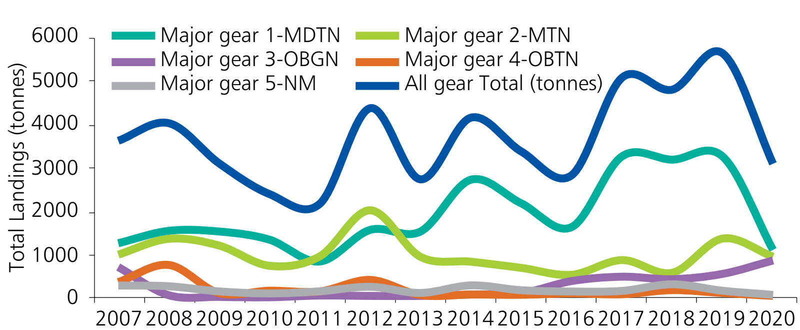

Fig. 20. Gear-wise contribution of marine crab landings in Kerala (2007-2020)

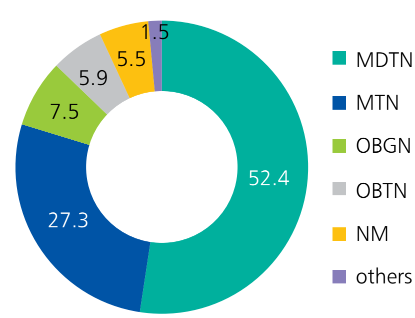

Fig. 21. Percentage contribution of different gears to marine crab landings in Kerala (2007-2020)

During 2007-2020, Tamil Nadu ranked first in the country contributing 33.3% in overall marine crab landings, recording an increasing trend over the period. The state registered the highest and lowest landings in 2016 and 2009 respectively. *P. pelagicus* was the dominant species in overall landings, however, in recent years *P. sanguinolentus* has shown dominance (Fig. 22). Unlike in other maritime states, crabs were mainly landed in gillnets (44%), single-day trawls (34.6%) and multi-day trawls (15.6%). The annual CPUE in gillnets, single-day and multi-day trawls varied between 2.5–8.1 kg, 7.6–51.9 kg and 18.3–279.5 kg respectively with CPH between 0.53–1.1 kg, 0.71–4.4 kg and 0.77–3.1kg respectively (Figs. 23 & 24).

Andhra Pradesh was contributing 11% of the total crab production with overall status showing a declining trend and the highest and lowest landings recorded in 2012 and 2020 respectively. (Fig. 25). The major species in the landing was *P. sanguinolentus* in all the years and was recorded in multi-day trawls (62%) and gillnets (19%). The annual CPUE in multi-day trawls and gillnets recorded between 58.1- 134.4 kg and 0.93- 5.6 kg respectively while annual CPH was

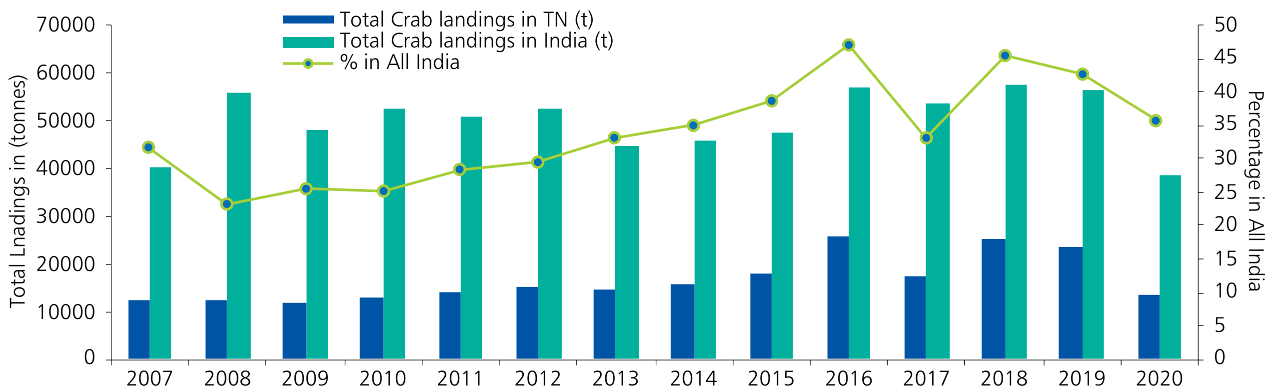

Fig. 22. Annual marine crab landings in Tamil Nadu (2007-2020)

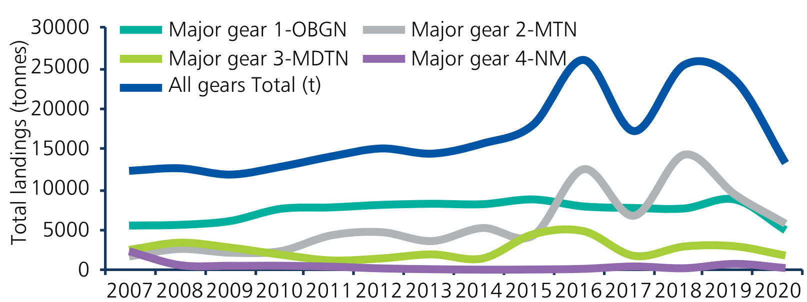

Fig. 23. Gear-wise contribution of marine crab landings in Tamil Nadu (2007-2020)

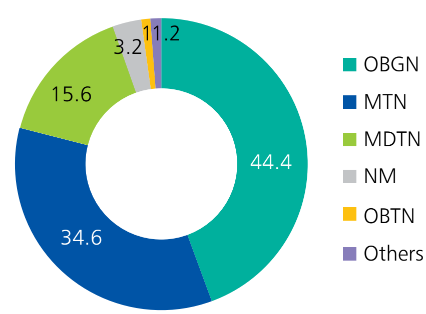

Fig. 24. Percentage contribution of different gears to marine crab landings in Tamil Nadu (2007-2020)

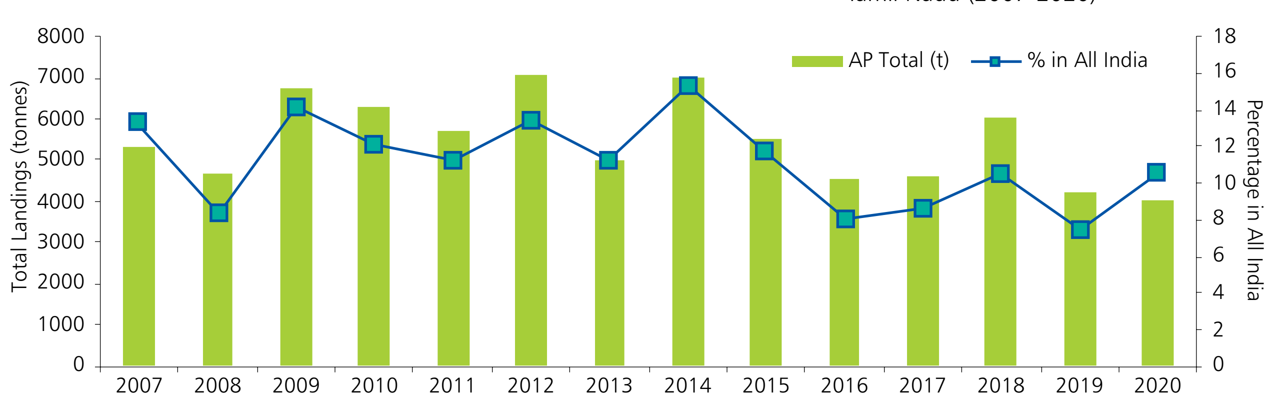

Fig. 25. Annual marine crab landings in Andhra Pradesh (2007-2020)

between 0.69–1.3 kg and 0.22–1.2 kg respectively (Figs. 26 & 27).

In Odisha the overall trend of total crab landings showed increase and the state contributed 5.28% of the overall crab landings in India, with highest and lowest landings in 2020 and 2014 respectively (Fig. 28). *P. sanguinolentus* was the dominant species throughout the period. Crabs were mainly landed in multi-day trawls (67%), gillnets (12%) and single-day trawls (11.8%). The annual CPUE in multi-day trawls, gillnets and single-day trawls ranged between 45.6 – 127.5 kg, 0.8-3.7 kg and 18.2 – 91.4 kg respectively and annual CPH between 0.7–1.3 kg, 0.16–0.6 kg and 0.94 – 14.4 kg respectively (Figs. 29 & 30).

West Bengal contributed 5.25% of the overall crab landings in India, recording highest and lowest landings in 2020 and 2014 respectively. The overall trend showed a steady increase (Fig. 31). *P. sanguinolentus* was the dominant species throughout the period and mainly landed in multi-day trawls (51%), followed by motorised and mechanised bag nets contributing 26% and 15.2% respectively. The annual CPUE in multi-day trawls, motorised and mechanised bagnets ranged between 6.3-157.6 kg,

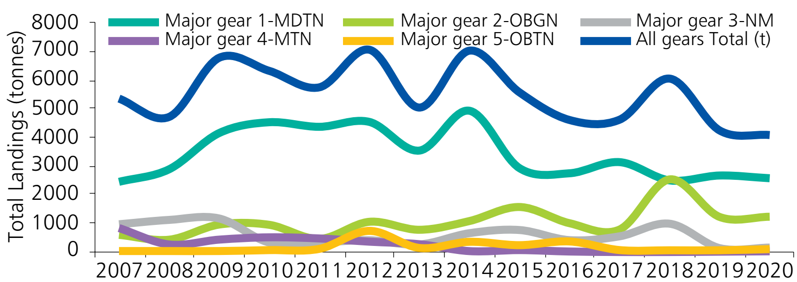

Fig. 26. Gear-wise contribution of marine crab landings in Andhra Pradesh (2007-2020)

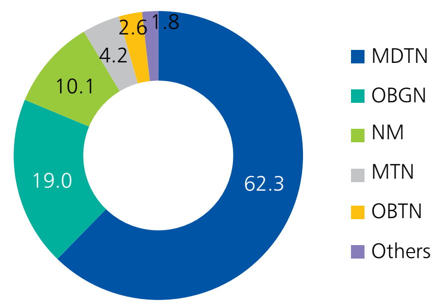

Fig. 27. Percentage contribution of different gears to marine crab landings in Andhra Pradesh (2007-2020).

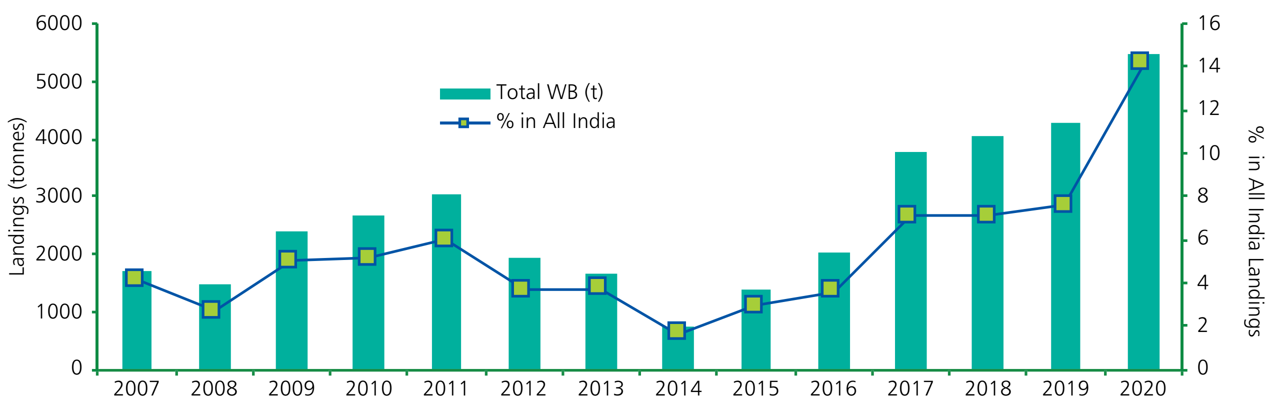

Fig. 28. Annual marine crab landings in Odisha (2007-2020)

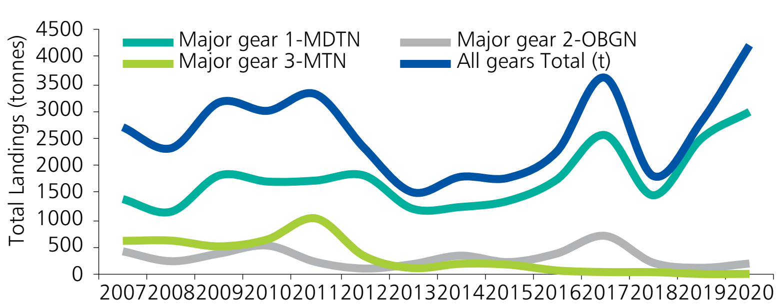

Fig. 29. Gear-wise contribution of marine crab landings in Odisha (2007-2020)

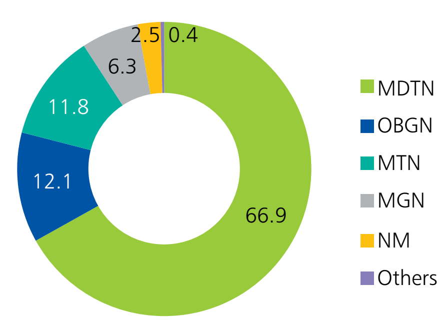

Fig. 30. Percentage contribution of different gears to marine crab landings in Odisha (2007-2020)

3.3 -16.7 kg ans 7.4 -107.4 kg respectively and CPH between 0.10–1.3 kg, 0.51 – 2.5 kg and 0.61 – 4.6 kg respectively (Figs. 32 & 33).

Union Territory of Puducherry contributed 1.85% of the overall crab landings in India, recording highest and lowest crab landings in 2018 and 2007 respectively (Fig. 34). The dominant species was *P. sanguinolentus* and gear-wise landings indicated dominance of multi-day trawls (Multiday-60%, gillnets-16% and Single day 14%) similar to other maritime states. The annual CPUE in multi-day trawls, gillnets and single-day trawls ranged between 9.5-124.3 kg, 0.3-11.8 kg and 2.7-116.5 kg respectively and annual CPH between 0.44- 2.7 kg, 0.11–3.9 kg and 0.3-10.4 kg respectively (Figs. 35 & 36).

During the 2010-2020, the overall crab landings in Daman & Diu exhibited a slightly declining trend and contributed 1.5% of the overall crab landings in India with highest and lowest landings recorded in 2016 and

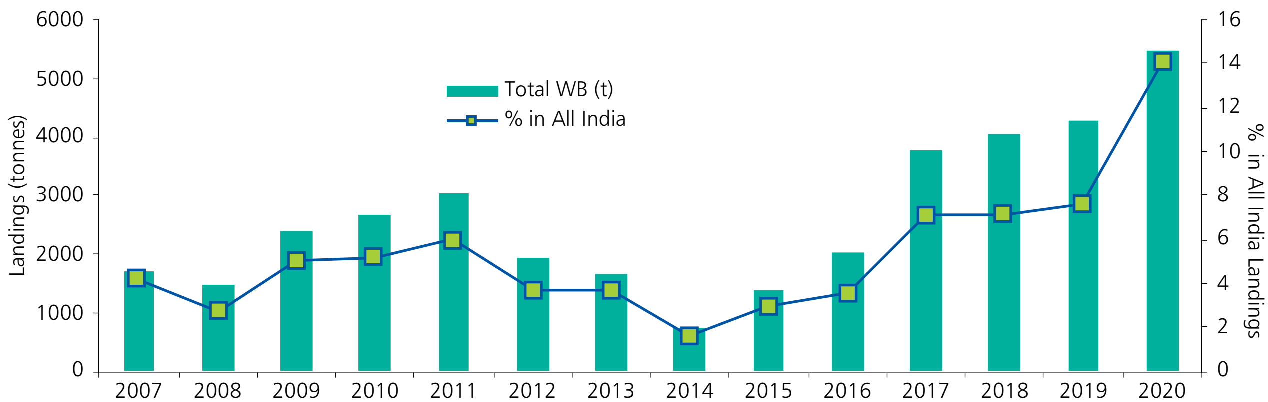

Fig. 31. Annual marine crab landings in West Bengal (2007-2020).

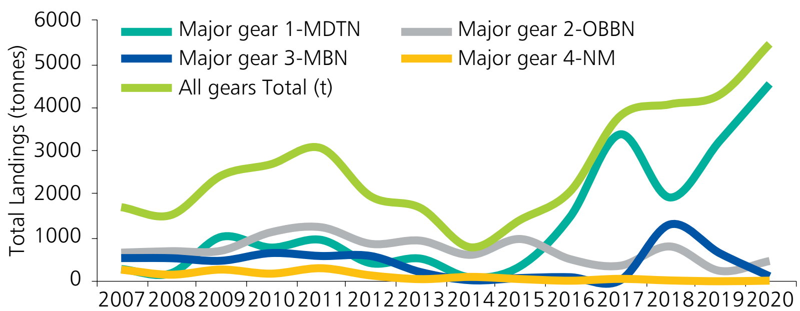

Fig. 32. Gear-wise contribution of marine crab landings in West Bengal (2007-2020)

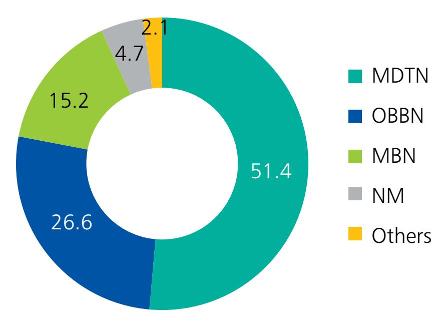

Fig. 33. Percentage contribution of different gears to marine crab landings in West Bengal (2007-2020)

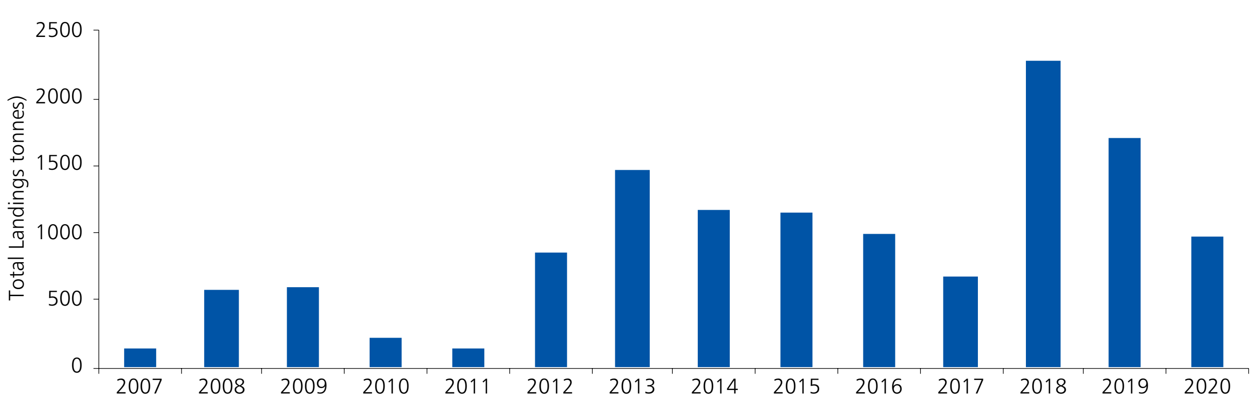

Fig. 34. Annual marine crab landings in Puducherry during 2007-2020

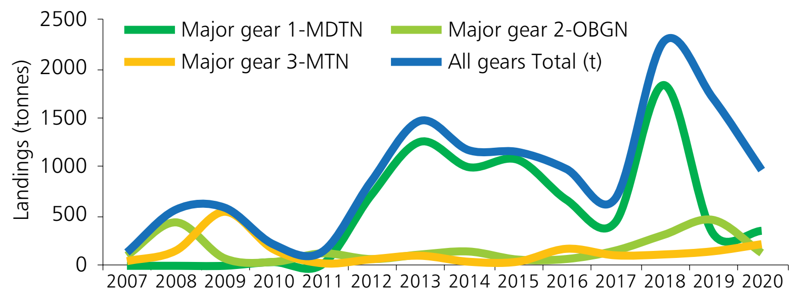

Fig. 35. Gear-wise contribution of marine crab landings in Puducherry (2007-2020)

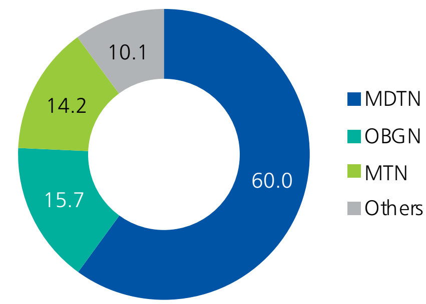

Fig. 36. Percentage contribution of different gears to marine crab landings in Puducherry (2007-2020)

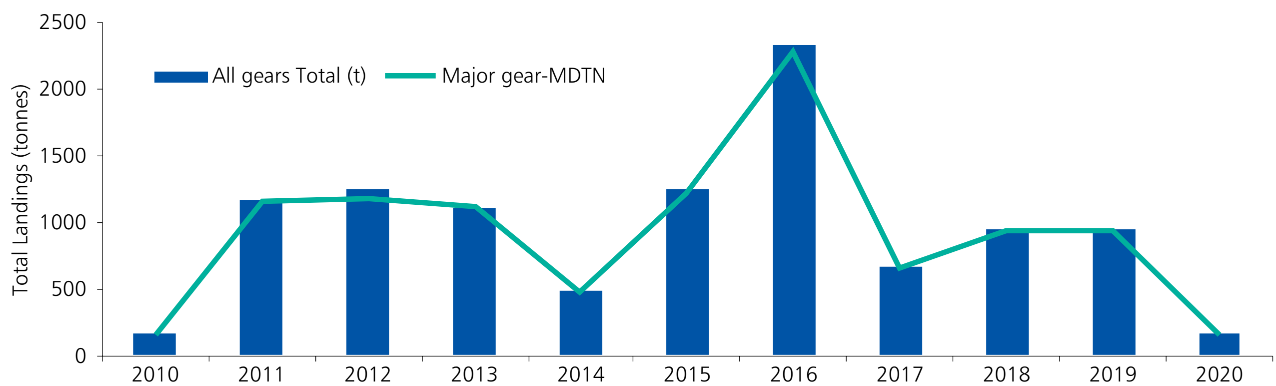

Fig. 37. Annual marine crab landing and gear-wise contribution in Daman-Diu (2007-2020)

2010 respectively. *C. feriata* was the dominant species in overall landings and the bulk of the crab landing was contributed by multi-day trawls (98%) during the period. The annual CPUE and CPH in multi-day trawls ranged between 24.8-360.0 kg and 0.2- 2.72 kg respectively (Fig.37).

Bionomics

The bionomics such as size range, dominant size groups, mean size and sex ratio of three major commercial species viz. *P. sanguinolentus, P. pelagicus* and *C. feriata* in the fishery of different maritime states of the country are presented in Table 3. *P. sanguinolentus* was represented by a size range of 31-203 mm CW (carapace width), *P. pelagicus* 46-230 mm CW and *C. feriata* 31-165 mm CW in overall crab landings in India during 2017-2020. Sizes bigger than the above mentioned were also recorded occasionally in the landings. Landings of *P. pelagicus* from Palk Bay have recorded a maximum size of 250 mm CW, which is very rare with sizes above 200 mm CW forming only 0.24% and 0.3% among male and female crabs respectively. Similarly, in December 2018, a large female *P. sanguinolentus* with 213 mm CW was recorded from Visakhapatnam landing centre. The overall dominant size group in *P. sanguinolentus* ranged between 86-121 mm, in *P. pelagicus* 61-180 mm CW and *C. feriata* 61-115 mm CW. Similarly, the mean sizes of these species also shown wide-range; it varied between 92.3-123.1 mm in *P. sanguinolentus*, 81.2-156.7 mm in *P. pelagicus* and 71.9-101.4 mm in *C. feriata*. Among *P. sanguinolentus,* bigger crabs were landed in Andhra Pradesh and the mean size in males and females were recorded as 126.9 and 122.4 mm CW respectively. Bigger *P. pelagicus* were fished from Palk Bay, Tamil Nadu, recording a mean size of 149.6 mm CW in males and 156.7 mm CW in females. C. *feriata* bigger sized crabs were landed in Gujarat, registering a mean size of 111.4 mm CW in males and 118.7 CW in females. Males of *P. sanguinolentus* were dominating in landings, in all the states. In *P. pelagicus*, females were dominating except in Andhra Pradesh and Chennai region of Tamil Nadu. *C. feriata* landings of east coast recorded a clear domination of females whereas, crab landings along west coast in, Kerala and Karnataka, showed domination of males.

Table 3. Size distribution and sex ratio of major three crab species from different maritime states of India

	Size Range (mm)		Dominant size (mm)		Mean size (mm)		Sex Ratio (%)	
Species/State	Male	Female	Male	Female	Male	Female	Male	Female
Portunus sanguinolentus								
Gujarat	35-175	50-185	95-135	100-145	113.2	117.46	44	56
Maharashtra	78-173	83-163						
Karnataka	51-160	46-145	91-95	91-95	96.5	92.3	47	53
Kerala	46-171	42-152	106-115	96-110	113	107.9	45	55
Tamil Nadu	36-190	31-180	86-121	86-111	95.9	102.9	46	54
Andhra Pradesh	58-203	68-193	108-128	103-123	126.9	122.4	43	57
Odisha	51-186	45-178	126-135	116-125	117	126	44	56
West Bengal	48-189	44-179	121-130	116-120	118	123	41	59
Portunus pelagicus								
Gujarat	85-175	95-185	125-140	135-155	133.5	142.4	42	58
Maharashtra								
Karnataka	46-160	46-160	66-70	61-65	81.2	89.1	44	56
Kerala	55-172	62-182	101-125	101-110	109.4	110.3	40	60
Tamil Nadu (Chennai)	51-170	56-175	81-115	86-115	87.1	96.9	62	38
Tamil Nadu (Palk Bay)	70-230	60-220	141-170	141-180	149.6	156.7	40	60
Andhra Pradesh	83-178	53-163	108-113	113-138	133.5	135.4	56	44
Odisha	61-201	58-194	131-140	121-130	139	122	44	56
West Bengal	62-196	55-191	126-135	116-125	134	127	43	57
Charybdis feriata								
Gujarat	75-165	85-165	100-120	110-125	111.4	118.7	44	56
Maharashtra	63-168	58-138						
Karnataka	36-135	31-135	61-65	61-65	75.5	71.9	52	48
Kerala	42-158	33-130	81-100	66-95	85.7	77.1	55	45
Tamil Nadu	46-150	51-135	86-115	66-100	90.9	84.7	46	54
Andhra Pradesh	63-148	58-138	98-118	88-108	103.6	98.5	35	65
Odisha	61-150	53-147	106-115	101-110	107	101	45	55
West Bengal	65-154	51-141	106-115	96-105	105	99	46	54

Fishing and spawning season

Marine crabs are fished throughout the year in India except in the ban period pertinent with respective states. However, considerable variations were observed in peak fishing season between the states/region during the reporting period. During the past five years, it is more evident due to climate change as happening elsewhere in the world. In spawning season also, similar differences were noticed between the states and among the major three species. All the species are capable of breeding continuously throughout the year and it is difficult to predict the peak annual spawning season very precisely.

Earlier studies have also clearly showed inconsistencies in the seasonal timings of spawning of these crabs, not following a similar or a uniform pattern. All these crabs carry the spawned eggs in their abdomen, attached to the pleopods till hatching. This egg mass is known as 'berry' and according to the stage of embryonic development the colour changes from bright yellow/orange colour to deep grey. These changes take usually 8-10 days depending on the species, size of the mother crab, and water temperature. By recording the prevalence of berried crabs in regular sampling the spawning season of respective species can be assessed. Over the years,

Table 4. Spawning season recorded for three major species from different maritime states of India

State	*P. sanguinolentus*	*P. pelagicus*	*C. feriata*
Gujarat	Sept* & Nov-Feb**	-	-
Karnataka	Aug-Nov* & Feb-Mar**	Sept* & Feb*	Aug-Nov*
Kerala	Apr-May* & Sept**	March-April*	Nov-Dec*
Tamil Nadu	July-Aug*& Dec-Feb**	July-Aug* & Jan*	Jun-Aug* & Dec**
Tamil Nadu (Palk Bay)	Jan-Mar* & Sep-Nov**	Jan-Mar* & Sep-Nov**	-
Andhra Pradesh	Oct-Nov* & Jan-Feb**	Sep-Nov* & Jan- Feb**	Feb-Mar* & Jul-Aug**
Odisha	Oct-Nov* & Jan- Feb**	Nov-Dec* & Feb-Mar**	Oct-Nov* & Feb-Mar**
West Bengal	Oct-Nov* & Jan- Feb**	Nov-Dec* & Feb-Mar**	Oct-Nov* & Feb-Mar**

*Major spawning season; **Minor spawning season

significant variations were found in the occurrence of berried crabs in the fishery of different states and hence it is difficult to forecast the exact peak spawning season for these crabs, usually following a major and a minor peak. Based on the studies conducted on these aspects during 2017-2020 at different centres, spawning seasons (major & minor respectively) of three commercial species are presented in (Table 4).

Conclusion

While closely tracking the marine crab fishery of India for the past fifty years, it is evident that the status of this resource is shifting from by-catch to targeted fishery, at least for a few species. The continuous monitoring and studies carried out by ICAR-CMFRI clearly delineate the status of the stocks in different regions. The overall trend of the fishery showed increase, however, in most of the fishing areas species are less abundant or in the rebuilding state clearly indicating need for ensuring sustainability through proper fisheries management plans. Most of the commercial crabs in India are highly resilient; short-lived and their life span is around 2.5-3 years. These fast growing species breed throughout the year and recorded fairly high fecundity rates. In 2014, Minimum Legal Size (MLS) was implemented for 58 species in Kerala (Mohamed *et al*., 2014), which included the three major species of crabs reported here. Our landing records showed that the percentage of crabs below MLS was considerably low thereafter. All states/regions should follow regulatory measures concurrently otherwise intended result will not be attained. In the case of these crabs an important measure that can be implemented is the prevention of landing and trade of berried females, which alone can create a positive impact on the fishery. ICAR-CMFRI has recommended Fishery Management Plan (FMP) for a few species in certain maritime states, which were prepared based on the inferences evolved through several years consistent studies. The Fishery management for Palk Bay Blue Swimming Crab (BSC), suggests the rules and regulations to be followed for the BSC fishery in Palk Bay (Josileen *et. al,* 2019). Collaboration among the stakeholders is required to achieve the objective of sustainability and rejuvenation of the crab fishery resources in India. This may take considerable time depending on the life cycle of the species and prevailing situation of the ecosystem. There is a general notion that solving issues associated with marine fisheries are impractical or a herculean task, considering the complexity of the In spite of this, by following mandatory regulatory measures we can progress through these conditions. Enforcement of rules and regulations by Central and State governments in areas of their respective jurisdiction and adoption of systematic and precautionary approaches by all the stakeholders from fishers to traders is therefore highly desirable.

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NMFDC, CMFRI, 2020.

Research Communications

Elasmobranch Fishery along Odisha Coast – An Overview

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Abstract

Elasmobranch are a meagre component of the total marine fish landings of Odisha. Landings data of elasmobranchs during 1976-2020 revealed a declining trend with highest recorded in 1979 (4331 t) and lowest in 2018 (308.6 t). In 2020, the estimated landings were 2042 t, registering an increase of about 76% compared to the previous year. Being a non-targeted resource, the elasmobranch fishery comprises sharks, rays and guitarfishes. During the present investigation, 46 species were recorded in landings along the coast. The rays dominated the elasmobranch fishery contributing about 71%, followed by sharks (27%) and guitarfishes (2%) during 2020. Species-wise catch analysis during the year showed *Gymnura poecilura* as the highest contributor of 569 t (30%) followed by *Maculabatis gerrardi* 465 t (23%), *Scoliodon laticaudus* (267 t, 13%), *Maculabatis spp.* (236 t, 12%), *Brevitrygon imbricata* (117 t, 6%) and *Sphyrna lewini* (105 t, 5%). The elasmobranch fishery peaks during the October -December period and lowest landings during the April-June period coinciding with the monsoon fishing ban period. Mechanised sector contributed 93% of the volumes landed and mainly in bottom trawls, followed by motorised (6%) and non-mechanised (1%) sectors.. Due to less demand in local markets, most catches were sent in iced condition to Kochi, Bangalore, Chennai, Delhi, Howrah and Digha by road, immediately after auction.

Key words: Odisha, elasmobranch fishery, sustainability

Introduction

The elasmobranchs comprising sharks, rays, guitarfish and skates are a key group of marine predators, that play an important role in maintaining a healthy ecosystem. Sustainability of elasmobranch fisheries is well recognized globally and a number of studies associating declines shark and ray populations to fishing pressure has been increasing in various regions of the world (Jabado and Spaet, 2017). They are comparatively more vulnerable to exploitation pressure than teleost due to their typical K-strategy life history traits such as slow maturation, greater longevity, and low fecundity. Odisha has a long coast line of 480 km and a continental shelf area of 25000 km^2, extending from east of Subarnarekha River mouth, bordering West Bengal to the Bahuda River mouth at Sunapur, bordering Andhra Pradesh with six coastal districts . This includes Ganjam (60 Km), Puri (155 Km), Jagatsinghpur (67 Km) (Fig.1), Kendrapara (68 Km), Bhadrak (50 Km) and Balasore (80 Km). Although there is no targeted fishery for elasmobranchs along Odisha coast estimated landings show declining trend and contributed nearly 4% of the average marine fish landings in the state during 1976-2020. Study on elasmobranch diversity along the Odisha coast is limited to a few literatures (Barman et al., 2007; Roy et al. 2019) and the present study attempted to address this knowledge gap.

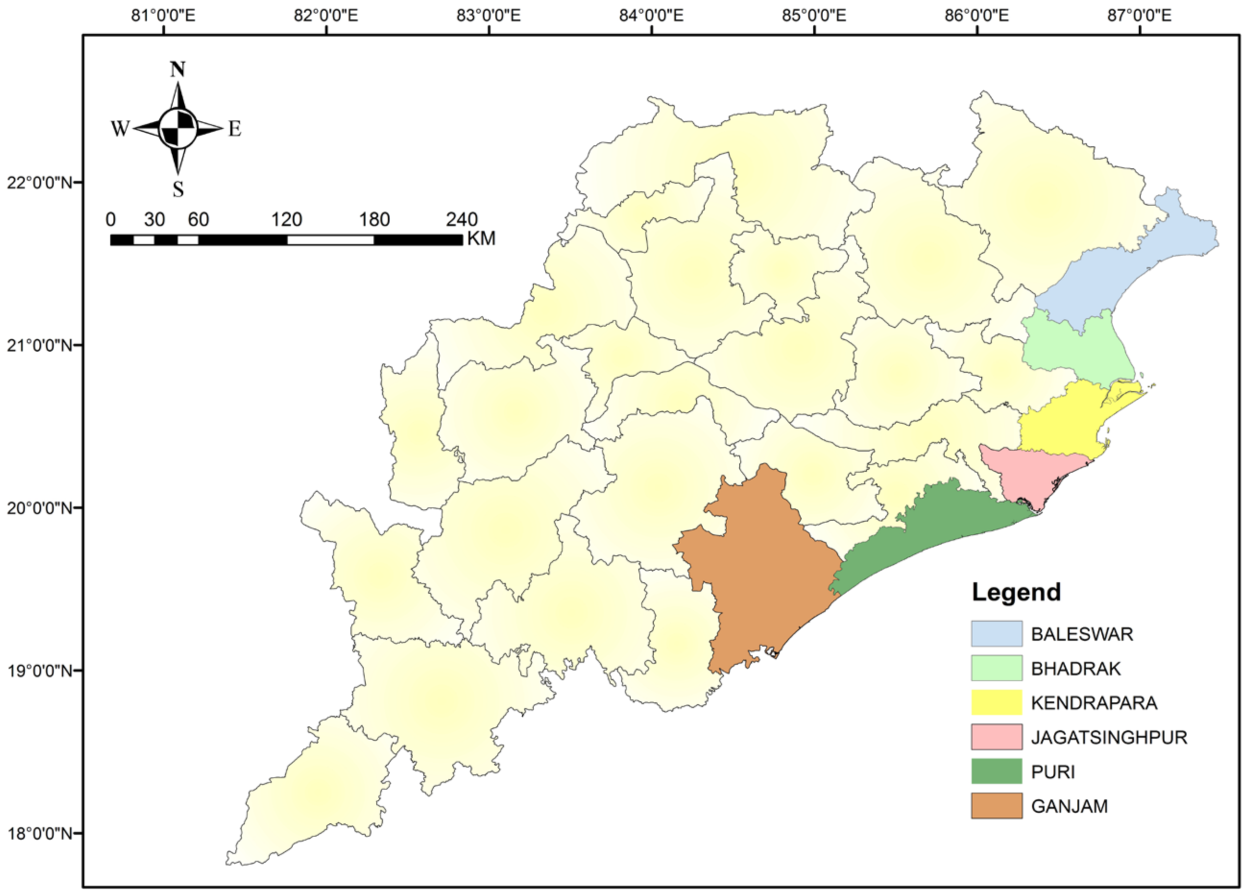

Fig.1. Coastal districts of Odisha monitored for elasmobranch landings

Fishery trends

The elasmobranchs landings in Odisha coast fluctuated between 2974 t in 1976 to 2042 t in 2020 with an average of 2134 t (Fig. 2). The landings during the period has shown a declining trend with highest landings were recorded in 1979 (4331 t) and lowest in 2018 (309 t). The elasmobranch landing during 2020 has shown an increase of 76% compared to previous year landings (1163 t) and being a non-targeted resource, it contributed ~ 1% to the total marine fish landings of Odisha coast.

Ray landings fluctuated between 917 t in 1981 to 1443 t in 2020 with average of 748 t (Fig. 3). The landings during the period has shown an increasing trend, highest landings were recorded in 2001 (1971 t) and lowest in 1983 (106 t). In 2020, rays constituted 71% of the state total elasmobranch landings, registering an increase

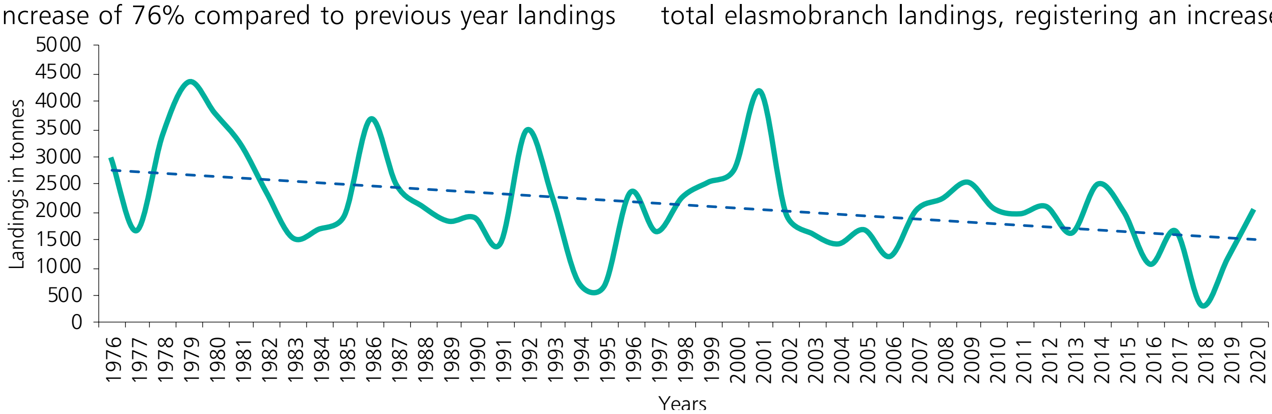

Fig. 2. Catch trend of elasmobranchs along Odisha coast during 1976-2020

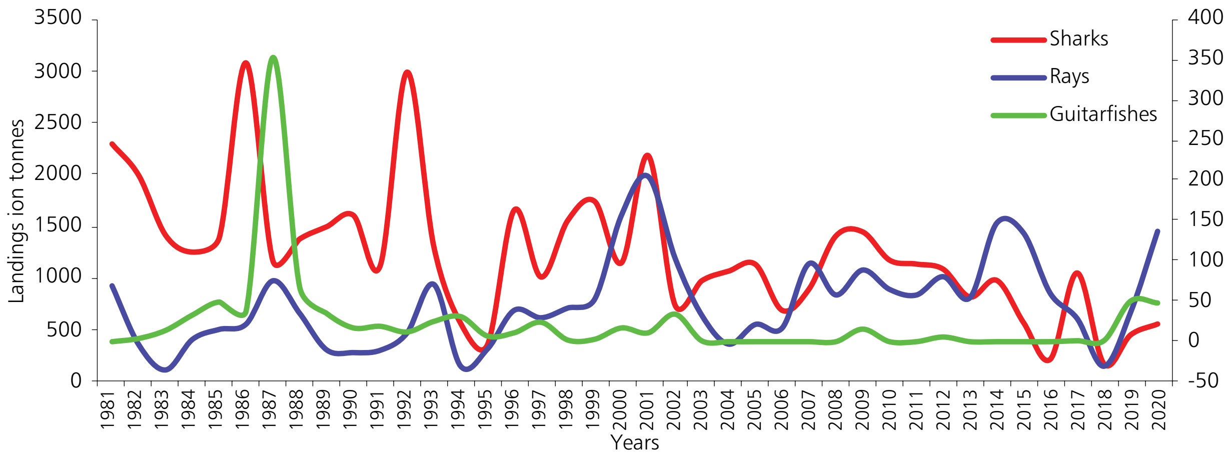

Fig. 3 Catch trend of sharks, rays and guitarfishes along Odisha coast during 1981-2020

of 117% compared to 2019 (666 t). In case of sharks, landings fluctuated between 2293 t in 1981 to 551 t in 2020 with an average of 1227 t (Fig. 3). The landings during the period has shown a decreasing trend, highest landings were recorded in 1986 (3077 t) and lowest of 166 t in 2018. In 2020, sharks contributed 27% of the state total elasmobranch landings, registering an increase of 23% compared to 2019 (447t). Similar declining trend was also observed for guitarfishes where it forms a fishery only in certain years with average landings of 23 t. Their landings were peaked in 1987 (351 t) after which the catch has been declining. In 2020, guitarfish landings were recorded to 50 t, contributing nearly 2% of the state total elasmobranch landings and registering a decrease of 5% compared to 2019 (48 t).

Species composition

Altogether 46 species of elasmobranchs were recorded in landings caught by various fishing gears along Odisha coast (Table 1). Among the species, major share was contributed by *Gymnura poecilura* (569 t, 28%), *Maculabatis gerrardi* (455 t, 23 %), *Scoliodon laticaudus* (267 t, 13%), *Maculabatis spp.* (236 t, 12%), *Brevitrygon imbricata* (117 t, 6%) and *Sphyrna lewini* (105 t, 5%).

In 2020 rays dominated the elasmobranch fishery followed by sharks and guitarfish along Odisha coast. The major ray species landed along the coast during the period were *Gymnura poecilura* (39%), *Maculabatis gerrardi* (32%), *Maculabatis spp.* (16%), and *Brevitrygon imbricata* (8%)

Table 1. List of elasmobranch species recorded along Odisha coast during 2017-2020

Sl.No.	Group	Family	Species	Common name
1	Butterfly rays	Gymnuridae	*Gymnura poecilura* (Shaw 1804)	Long-tailed butterfly ray
2	Stingrays	Dasyatidae	*Hemitrygon bennettii* (Müller & Henle 1841)	Bennett's stingray
3			*Maculabatis gerrardi* (Gray, 1851)	Sharpnose stingray
4			*Maculabatis bineeshi* Manjaji-Matsumoto & Last, 2016	Short-tail whipray
5			*Maculabatis* cf. *randalli* (Last, Manjaji-Matsumoto & Moore 2012)	Arabian banded whipray
6			*Maculabatis pastinacoides* (Bleeker, 1852)	Round whip ray
7			*Brevitrygon imbricata* (Bloch & Schneider 1801)	Bengal whipray
8			*Pastinachus gracilicaudus* Last & Manjaji-Matsumoto 2010	Narrowtail stingray
9			*Pastinachus ater* (Macleay, 1883)	Broad cowtail ray
10			*Pteroplatytrygon violacea* (Bonaparte 1832)	Pelagic stingray

11			*Neotrygon indica* Pavan Kumar, Kumar, Pitale, Shen & Borsa 2018	Indian Ocean blue-spotted maskray
12			*Himantura undulata* (Bleeker 1852)	Leopard whipray
13			*Himantura uarnak* (Gmelin 1789)	Honeycomb stingray
14			*Urogymnus polylepis* (Bleeker 1852)	Giant freshwater whipray
15			*Pateobatis bleekeri* (Blyth 1860)	Bleeker's whipray
16	Pacific eagle rays	Aetobatidae	*Aetobatus ocellatus* (Kuhl 1823)	Ocellated eagle ray
17	Cownose rays	Rhinopteridae	*Rhinoptera javanica* Müller & Henle, 1841	Flapnose ray
18			*Rhinoptera jayakari Boulenger, 1895*	*Oman cownose ray*
19	Devilrays	Mobulidae	*Mobula mobular* (Bonnaterre 1788)	Devil fish
20	Electric rays	Torpedinidae	*Torpedo panthera* Olfers 1831	Panther electric ray
21			*Torpedo fuscomaculata* Peters, 1855	Black-spotted torpedo
22	Sleeper rays	Narkidae	*Narke dipterygia* (Bloch & Schneider 1801)	Numbray
23	Numbfishes	Narcinidae	*Narcine timlei* (Bloch & Schneider 1801)	Spotted numbfish
24			*Narcine prodorsalis* Bessednov 1966	Tonkin numbfish
25	Giant guitarfishes	Glaucostegidae	*Glaucostegus granulatus* (Cuvier 1829)	Granulated guitarfish
26			*Glaucostegus obtusus* (Mülle & Henle 1841)	Widenose guitarfish
27			*Rhinobatos annandalei* Norman 1926	Annandale's guitarfish
28			*Rhinobatos lionotus* Norman 1926	Smoothback guitarfish
29			*Rhina ancylostomus* Bloch & Schneider 1801	Bowmouth guitarfish
30	Sawfishes	Pristidae	*Pristis pristis* (Linnaeus, 1758)	Common sawfish
31	Whale shark	Rhincodontidae	*Rhincodon typus* Smith, 1828	Whale shark
32	Hammerhead, bonnethead, or scoophead sharks	Sphyrnidae	*Sphyrna lewini* (Griffith & Smith 1834)	Scalloped hammerhead
33			*Sphyrna zygaena* (Linnaeus, 1758)	Smooth hammerhead
34	Houndsharks	Triakidae	*Iago* cf. *omanensis* (Norman 1939)	Bigeye houndshark
35	Weasel sharks	Hemigaleidae	*Hemipristis elongata* (Klunzinger 1871)	Snaggletooth shark
36	Bamboo sharks	Hemiscylliidae	*Chiloscyllium griseum* Müller & Henle, 1838	Grey bambooshark
37			*Chiloscyllium burmense* Dingerkus & DeFino, 1983	Burmese bamboo shark
38	Thresher sharks	Alopiidae	*Alopias pelagicus* Nakamura 1935	Pelagic thresher
39	Requiem sharks	Carcharhinidae	*Galeocerdo cuvier* (Péron & Lesueur 1822)	Tiger shark
40			*Rhizoprionodon acutus* (Rüppell 1837)	Milk shark
41			*Rhizoprionodon oligolinx* Springer 1964	Grey sharpnose shark
42			*Scoliodon laticaudus* Müller & Henle 1838	Spadenose shark
43			*Carcharhinus amblyrhynchoides* (Whitley, 1934)	Graceful shark
44			*Carcharhinus leucas* (Müller & Henle, 1839)	Bull shark
45			*Carcharhinus sorrah* (Müller & Henle, 1839)	Spot-tail shark
46	Shortnose chimaeras	Chimaeridae	*Hydrolagus* cf. *africanus* (Gilchrist, 1922)	African chimaera

Fig. 4 . Species of rays recorded along Odisha coast

(Figs. 4,5, 6). Similarly, the major shark species landed along Odisha coast were *Scoliodon laticaudus* (48%), *Sphyrna lewini* (19%), other *Carcharhinus* spp. (12%),

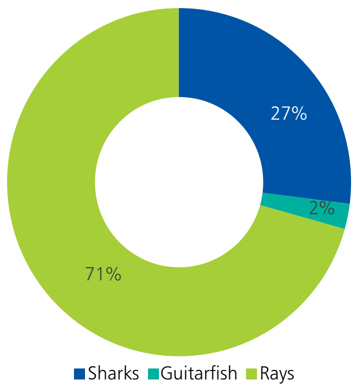

Fig.4. Groupwise contribution to landings of elasmobranchs along Odisha coast in 2020

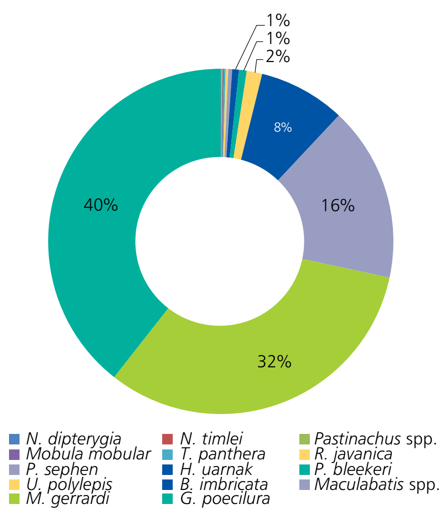

Fig.5. Various species of rays landed in 2020

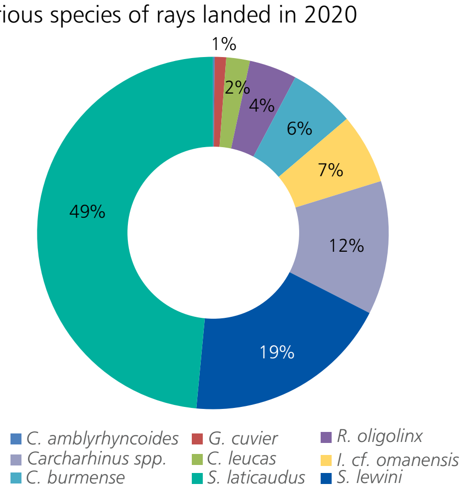

Fig. 7. Species-wise shark landings along Odisha coast during 2020

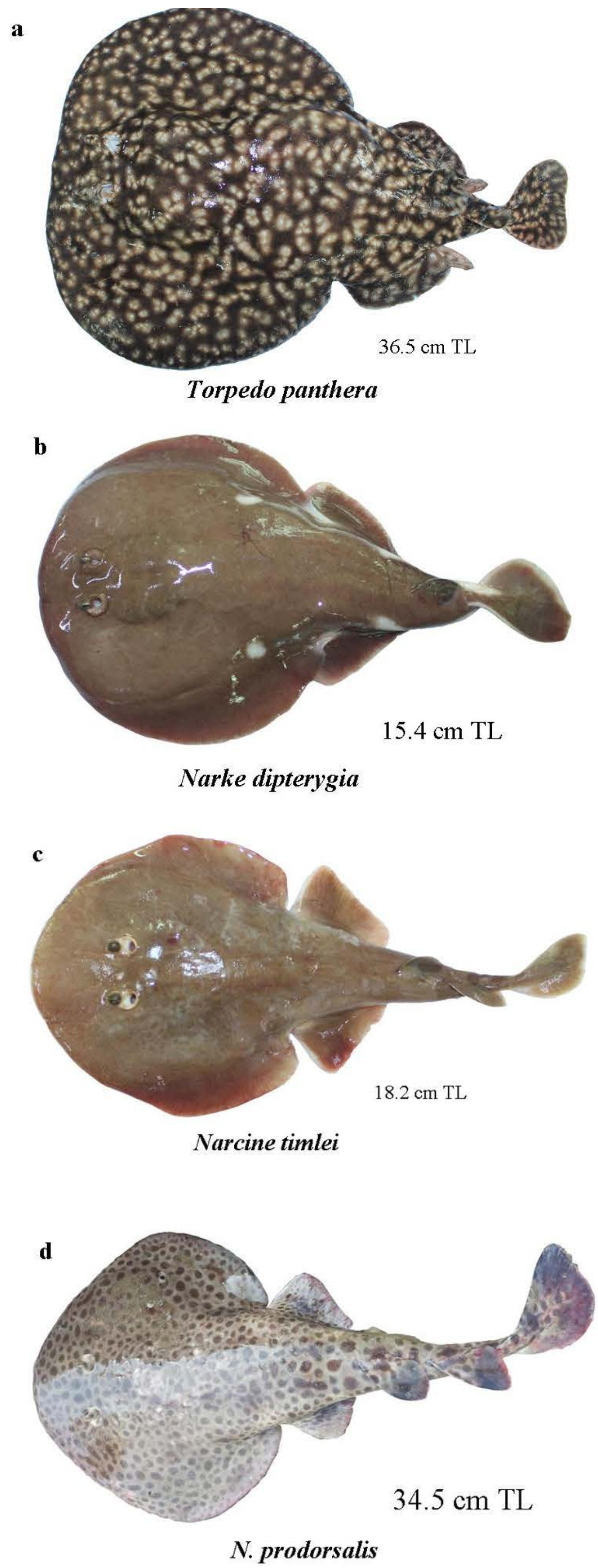

Fig. 6 Species of electric rays recorded along Odisha coast

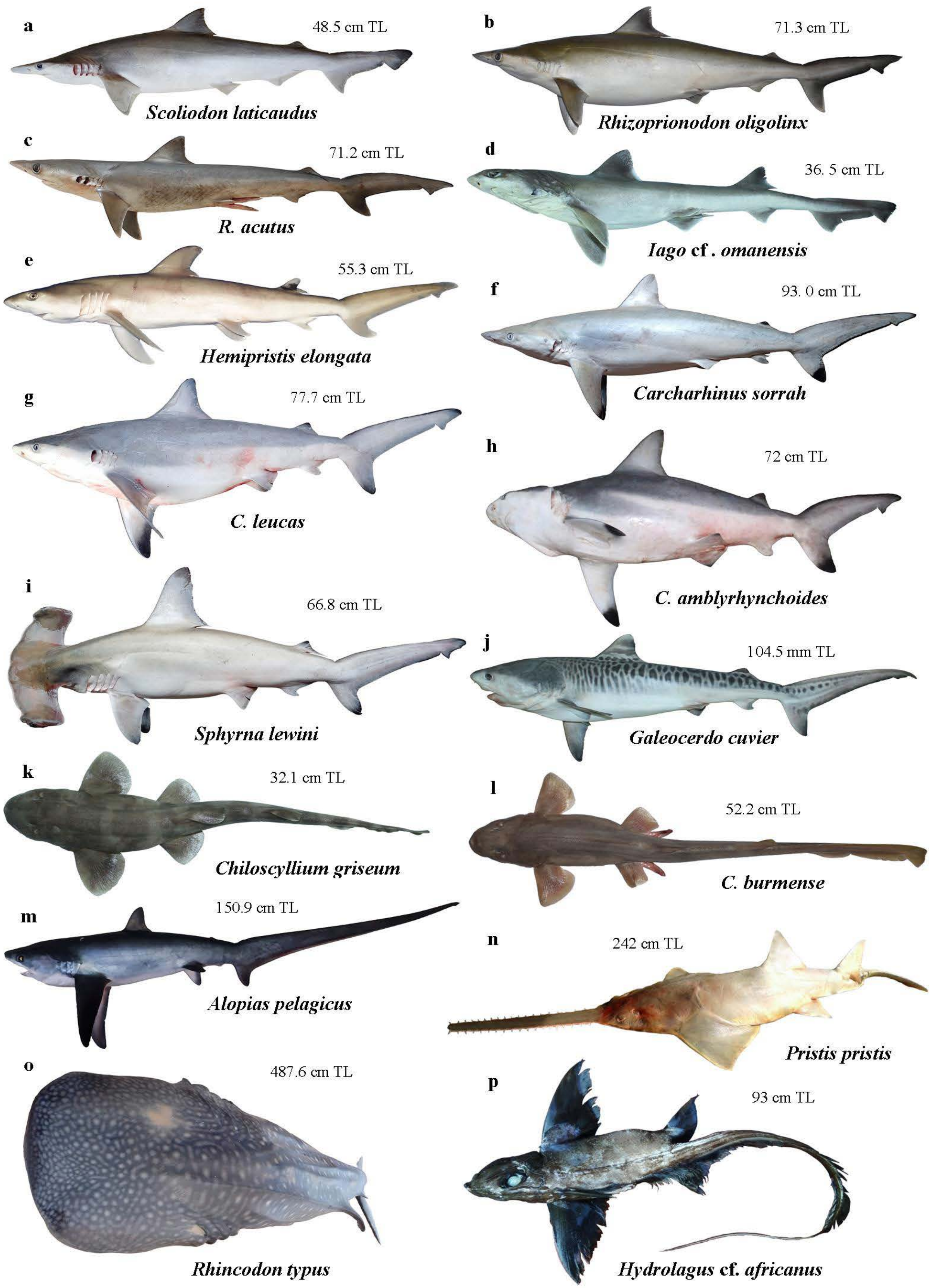

Fig. 8. Species of sharks and sawfish recorded along Odisha coast

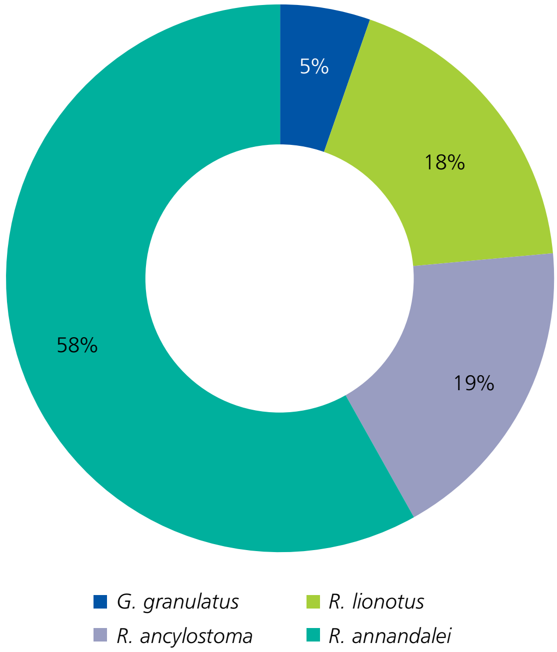

Fig. 9. Species-wise guitarfish landings along Odisha coast during 2020

Iago cf. *omanensis* (6%) and *Chiloscyllium burmense* (6%) (Figs.7, 8). *Rhinobatos annandalei* is the major species contributing nearly 58% of the state total guitarfish landings (Figs. 9,10).

The elasmobranch fishery attained its peak during October -December contributing about 1040 tonnes (51%) followed by 659 tonnes (32%) during July-September period. During January-March period 315 tonnes (15%) and lowest of 28 tonnes (1%) during April-June (coinciding with the monsoon fishing ban period was observed along the coast (Fig.11).

Targeted elasmobranch fishery has not been practised by any specialised group or community along the Odisha coast. These resources are mostly caught as incidental or as by-catch while targeting other species, and constituted a part of the multi-species fisheries along the coast. Mechanised sector contributed the highest catch (93%), followed by the motorised (6%) and the non-mechanised (1%) sectors (Fig.12). The fishing methods used to catch

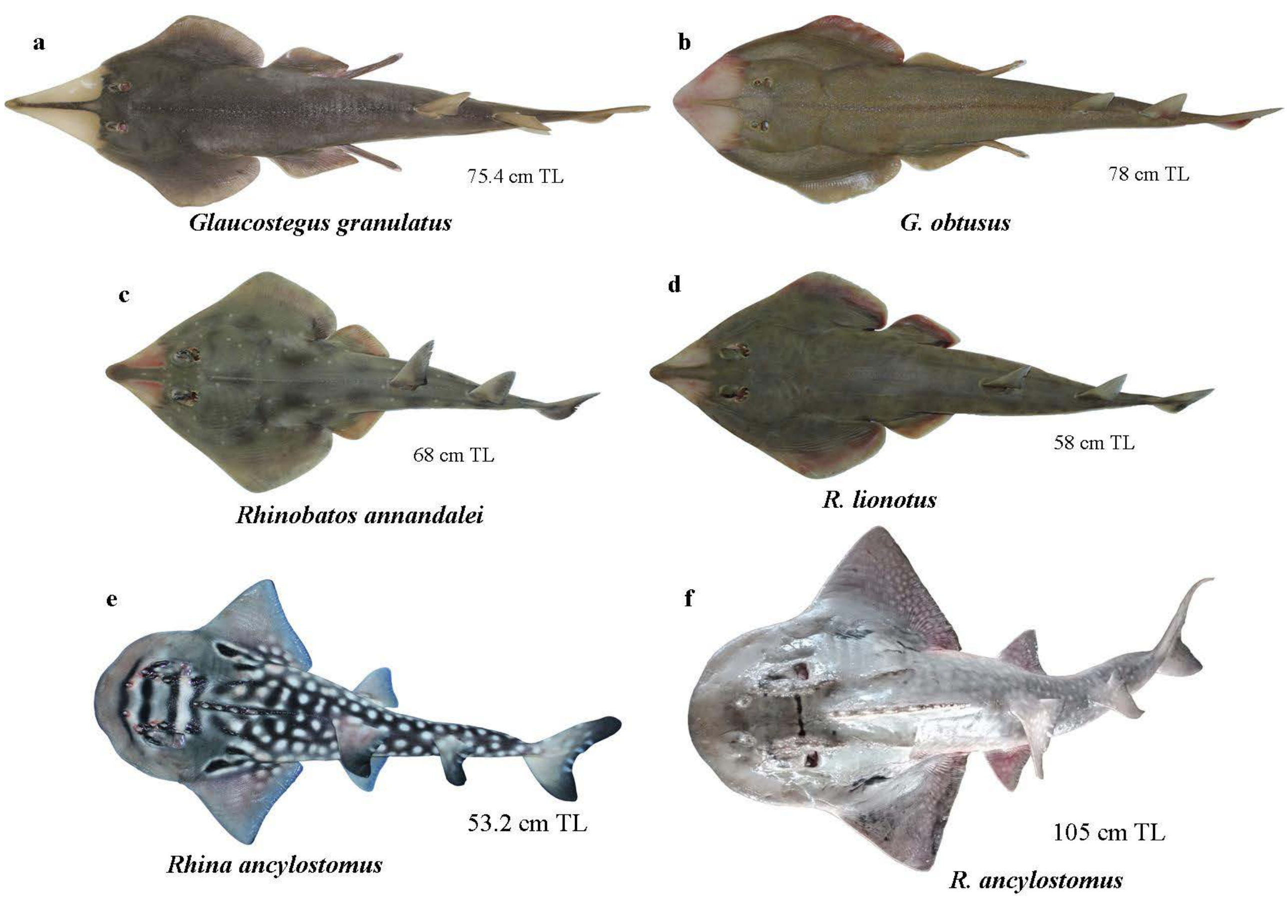

Fig. 10. Species of guitarfish recorded along Odisha coast

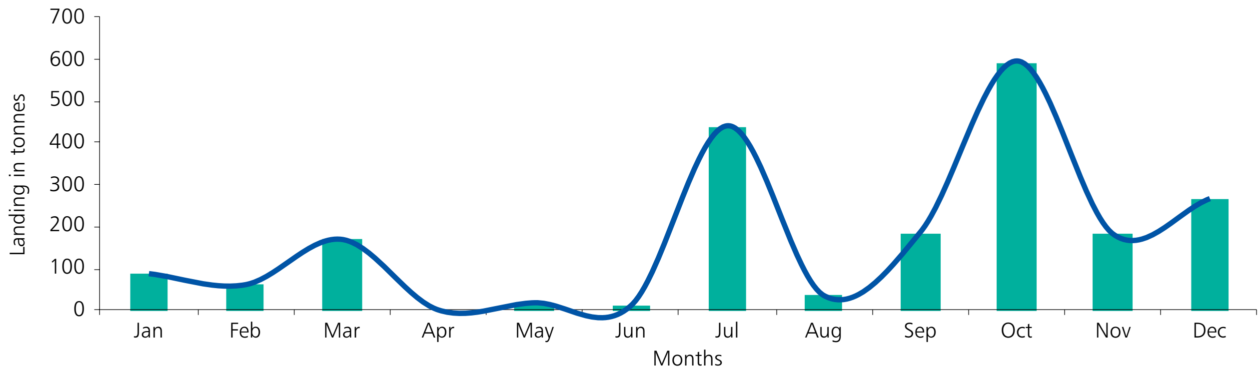

Fig. 11. Month-wise landings of elasmobranch resources of Odisha coast in 2020.

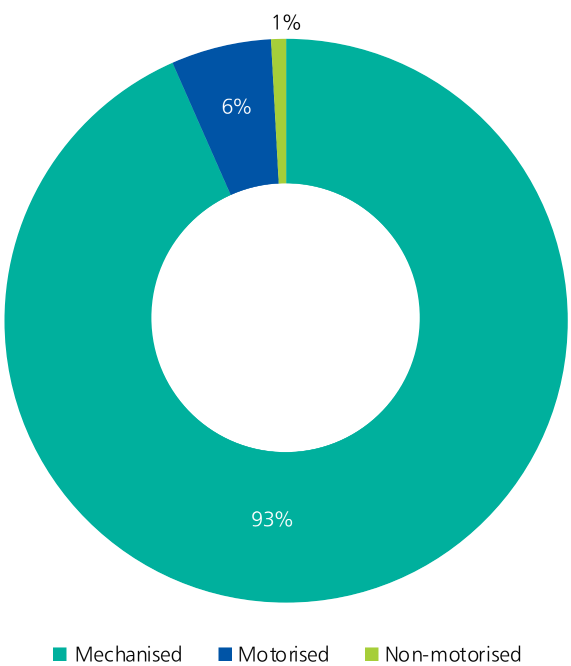

Fig. 12. Sectorwise contribution to the total elasmobranch landings of Odisha coast during 2020

elasmobranchs are bottom trawls, gillnets, longlines, and ringseines. Among them, bottom trawls contributed the highest of about 90% of the total elasmobranch landings (Fig. 13).

Due to little preference for elasmobranchs in local markets in Odisha, most of the catches were sent to Cochin, Bangalore, Chennai, Delhi, Howrah and Digha by road in iced condition, immediately after auction at the landing sites. Sometimes, large sized sharks and rays were cut into pieces, packed in ice and transported.

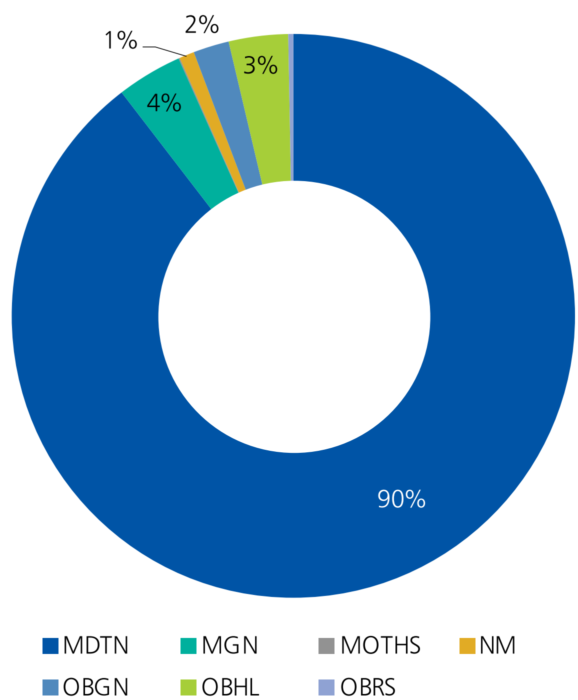

Fig. 13. Gearwise contribution to the total elasmobranch landings of Odisha coast during 2020

MDTN-Multiday trawl net, MGN-Mechanised gill net, MOTHS-Mechanised other gears, NM-Non-mechanised, OBGN-Outboard gill net, OBHL- Outboard Hook and line, OBRS-Outboard ring seine

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Jellyfish fishery along Odisha coast: An Overview

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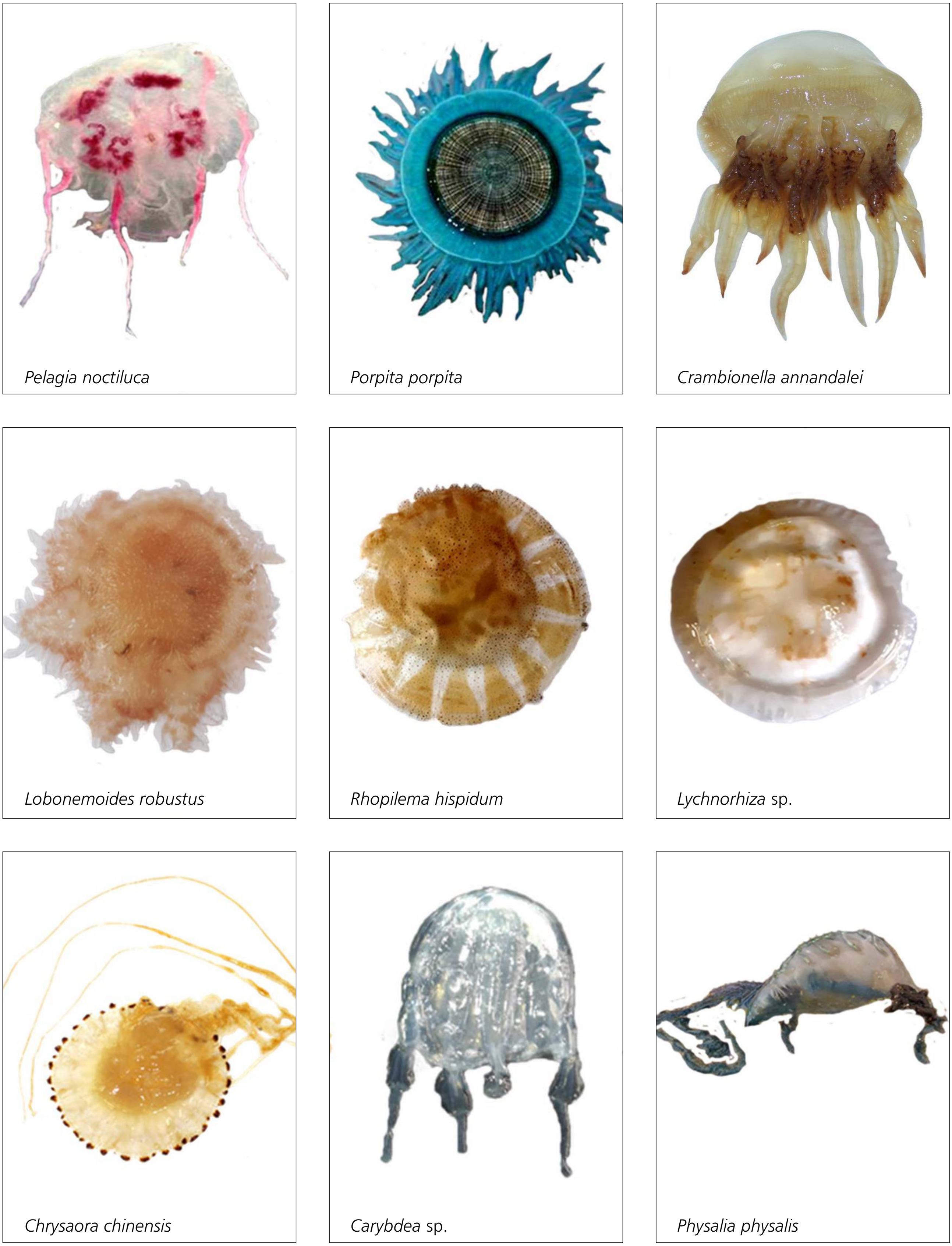
Jellyfish are potentially important marine resources that can become problematic when abundant. Globally, 19 nations are currently involved in fishing of jellyfish, with estimated average landings of about 900,000 tonnes annually with China being the highest producer and consumer of jellyfish, contributing approximately 60% of current global capture production. Jellyfish fisheries are usually characterized by large inter-annual fluctuations in abundance, biomass, and short fishing seasons of less than a few months. Mostly scyphomedusae jellyfish have been caught and processed as human food for centuries in Asian countries, because of their large, tough and rigid bodies with a thick umbrella that gives a product with the desirable crunchy texture when processed (Brotz et al., 2017). In India, harvesting of edible jellyfish started in 1980, mainly for exports. Only four species of edible jellyfish (*Crambionella annandalei, Crambionella orsini, Catostylus perezi* and *Rhopilema hispidum*) are favoured for processing in the coastal states of Andhra Pradesh, Gujarat, Kerala and Tamil Nadu, and the processed products are exported mostly to Southeast Asian countries. By catching these jellyfishes, an additional income in the range of 20-25 percent of their annual income is received by the small scale fishermen (Behera *et al*., 2020). The present study gives an overview of the fishery for jellyfish *C. annandalei* along Odisha coast using information collected through a survey and sampling from Puri (19°47'43.062'N, 85°49'38.5788'E), Pentakaota (19°48'6.6924'N, 85°50'59.4096'E), Astaranga (19°58'27.1344'N, 86°20'20.9976'E), Chandrabhaga (19°52'4.8108'N, 86°47'17.6916'E), and Khirisahi (19°42'49.5432'N, 85°34'45.7284'E) landing centres when mass swarming of the species during December to April led to targeted fisheries.Jellyfish usually occur as by-catch in trawls, shore seines and gillnets along the Odisha coast. Several jellyfish species (*Pelagia noctiluca*, *Lobonemoides robustus*, *Rhopilema hispidum*, *Chrysaora chinensis*, *Chrysaora* sp., *Porpita porpita*, *Lychnorhiza sp.*, *Crambionella annandalei*, *Carybdea* sp. and *Physalia physalis*) are occurring along the coast, but only one rhizostomatids jellyfish, *C. annadalei* forms a seasonal and targeted gillnet fishery (Fig.1). The species were caught in traditional gillnets during day time operated both from motorised (8.5-9 m OAL, 9 hp engine capacity) and non-motorised fishing boats (6.5-8 m) at a water depth of 5-12 m. Gillnets (mesh size 52-58 mm) were set in water for 1-2 hours (soaking time) and usually 2-3 hauls per boat were performed based on the availability of jellyfish. Nearly 70- 100 boats were engaged in jellyfish fishing along the coast. Fishermen usually do some pre-processing on-board and only the oral arms are transported to the shore. However, if the catches are poor, they bring the whole specimen to shore for processing. The survey revealed that each boat caught nearly 20-500 kg of oral arms per fishing trip which were sold to the local traders and processors @ ₹15-22 ($0.21-$0.30) per kg at landing centres.

301 whole fresh specimens of *Crambionella annandalei* collected from the landing centres were brought to the laboratory for detailed studies. Individual jellyfish was dissected and determined the sexes and maturity stages of gonad both by macroscopic and microscopic methods. By comparing the shape, texture and color of the gonad, it was possible to differentiate the sex and maturity stages of the individuals. Bell diameter (BD)



Pelagia noctiluca | *Porpita porpita* | *Crambionella annandalei*

Lobonemoides robustus | *Rhopilema hispidum* | *Lychnorhiza* sp.

Chrysaora chinensis | *Carybdea* sp. | *Physalia physalis*

Fig. 1. Jellyfish species diversity along Odisha coast

Fig. 2. Processing of oral arms of *C. annandalei.*

a. Outboard fibreglass boat with crates of oral arm, b. Transportation of oral arm to processing unit, c. Cleaning with rotors (2 hours), d. Salt Mixing (50kg/t oral arm), e. Grading and cleaning, f. Second soaking tank (12-18 days), g. Transferring from first soaking tank to second (after 12 hours), h. Alum treatment (2kg/oral arm), i. Packing of 16 kg salted semi dried oral arms in 20 L plastic bucket, j. Adding 3 L sea water, k. Adding 1 kg common salt, l. Closing lead tightly, m. Final Product for export

Table 1. Biological aspects of *Crambionella annandalei* sampled

Months	N	Bell Diameter (cm)	Mean BD ± SE	Total weight (g)	Mean weight ± SE	Sex ratio (M:F)	Mature (%)
January	17	16-23	19.5 ± 0.59	208-720	495 ± 43	1.1:1	65
February	112	11-26	22 ± 0.24	100-1209	784 ± 21.1	1.2:1	84
March	120	17-26.5	22.4 ± 0.19	334-1459	897.9 ± 20.9	1.4:1	84
April	52	20.3-27	24.3 ± 0.21	520-1548	1169.3 ± 29.5	0.86:1	98
Total	301	11-27	22.4 ± 0.14	100-1548	879.7 ± 15.8	1.2:1	85

recorded as the standard measurement for the jellyfish ranged from 11 to 27 cm with mean weight (g) in the range of 879.7 ± 15.8g. The overall sex ratio was 1.2: 1 (Male: Female). The BD for female jellyfish ranged between 18–27 cm and between 11 and 26.5 cm in males. The mean total length of female jelly fish (23 ± 0.16 cm) was not significantly different from the males (22 ± 0.21 cm) as given in Table 1.

Three temporary jellyfish processing units were in operation, each at Pentakota, Chandrabhaga and Arakhakuda in Puri district of Odisha (Fig.2). Only the oral arms of jellyfish are processed which is transported to the processing units located in the vicinity of the fish landing centres, immediately after harvest to avoid spoilage.

Oral-arms are first cleaned and washed in a circular polythene tank containing sea water with a rotor for churning the water for 2 hours, to remove the dirt, sand, mucus, membranes, and remnants of gonads. The oral arms are then removed from the cleaning tank, rinsed with the clean sea water and transferred to the soaking tank. In soaking tank, common salt @ 50 kg/t and alum 2 kg/t of oral arms is added in to the 300 l of sea water (25 ppt) and kept for 12 hours. This process helps in penetration of the salt into the tissues, allowing osmosis, dehydration and thus minimizing any spoilage. This is followed by a second soaking (in salt and alum water) for 12-18 days, prior to packing. The semi-dried oral arms are graded into different export categories depending on the size of oral arms and cleaned to remove the remaining dirt particles and membranes before packing. The final processed oral arms are packed in 20 litre buckets, each containing 16 kg oral arms, 3 litres salt water and 1 kg common salt. Processed oral arms of jellyfish are exported to China via Chennai @ ₹500-550 ($6.88-$7.57) per kg as it has a very good demand in Southeast Asian countries.

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Cephalopod fishery off Chennai coast, Tamil Nadu

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Cephalopods are one of the commercially important marine fishery resources along Indian coast and though their contribution in volumes to the total marine landing is low, their high export value is an important factor. Due to the commencement of export of frozen cephalopod products to several countries, the fishery has transitioned from a low-value by-catch to targeted resources fetching high foreign exchange. Cephalopods (comprising squid, cuttle fish and octopus) are landed by multiday trawl net and single day trawlers operating from Madras Fisheries Harbour, Kasimedu, Chennai. In other landing centres in Chennai, only negligible quantity of squids are landed by motorised and traditional boats. While more than 600 trawlers are operated on a regular basis, trawlers exclusively targeting cephalopods are very few and bulk of the cephalopod landings occur as by-catch in the trawl nets.

The average annual landing of cephalopods off Chennai coast during 2010-2019 was 3134 tonnes, with maximum landing in 2019 (10073t) and minimum in 2012 (1560 t). About 99.2% of cephalopod landings in Chennai was by multiday and single day mechanised trawler and rest by mechanised gillnet and other gears operated from outboard crafts. Over the years, catch per unit hour showed a fluctuating trend with maximum CPH (kg/hr) in 2019 for both multiday trawl net and single day trawlers, although effort (Actual fishing hour) did not vary

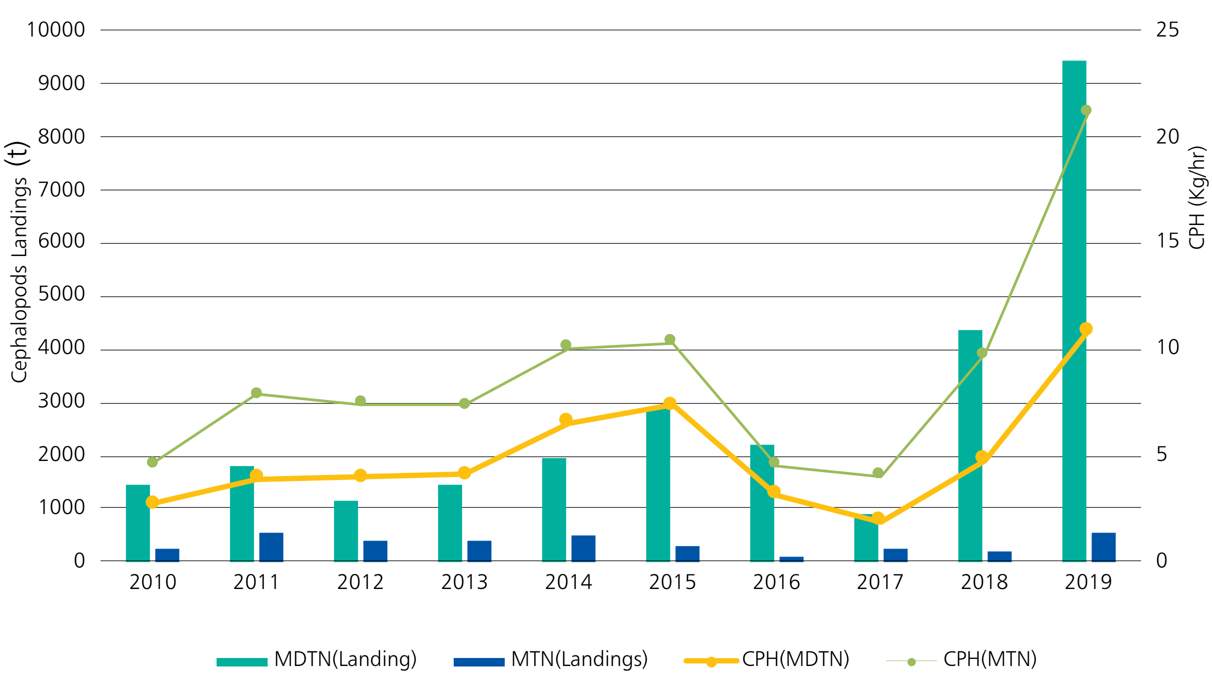

Fig. 1. Trawl landings of cephalopod resources off Chennai coast(2010-19)

much from the previous years.Cuttlefishes contributed 48% to the average landing of cephalopods followed by squids (44%) and octopuses (8%). The cuttlefish landings fluctuated widely with maximum landing in 2019 year and minimum in 2017. Similarly, squid landings fluctuated within the range of 400.73 t in 2017 to 438.16 t (in 2019). Octopus landings fluctuated widely with highest landing in 2019 and lowest in 2010.Maximum cephalopod landing was observed during August to October indicating the seasonal abundance of cephalopods in the coastal waters off north Tamil Nadu.

Resources that regularly contribute to the landing included *Sepia pharaonis, Uroteuthis* (*Photololigo) duvaucelii, S. aculeata, S. brevimana,Sepiella inermis.Octopus dollfusi* and *O. membranaceus.* Among cuttle fish, *Sepia pharaonis* (40%), *S. brevimana* (23%), *S. aculeata* (16%), *S. prashadi* (12%) and *Sepiella inermis* (9%) and among octopuses, *Octopus dollfusi* (39%) followed by *Octopus membranaceus* and *Cistopus indicus* were recorded in trawl net landings in 2019. Among squids, *Uroteuthis (Photololigo) duvaucelii* (51%) formed the major component of the trawl landings in 2019, followed by *U (P). singhalensis* (44%), *Sepioteuthis lessoniana* (3%) and *L. uyii* (2%).

The size range, sex ratio and price range of cephalopod resources landed in Chennai has been indicated in the Table 1. The sex ratio for all the species indicates a male-dominated cephalopod fishery along this coast. Matured specimens of both male and female were present in most of the months indicating protracted spawning of cephalopods.Majority of the resources are exported to the foreign countries while some squids are sold for local consumption.The price of the cephalopod resources vary based on size and quality. Price is considerably high for larger resources.

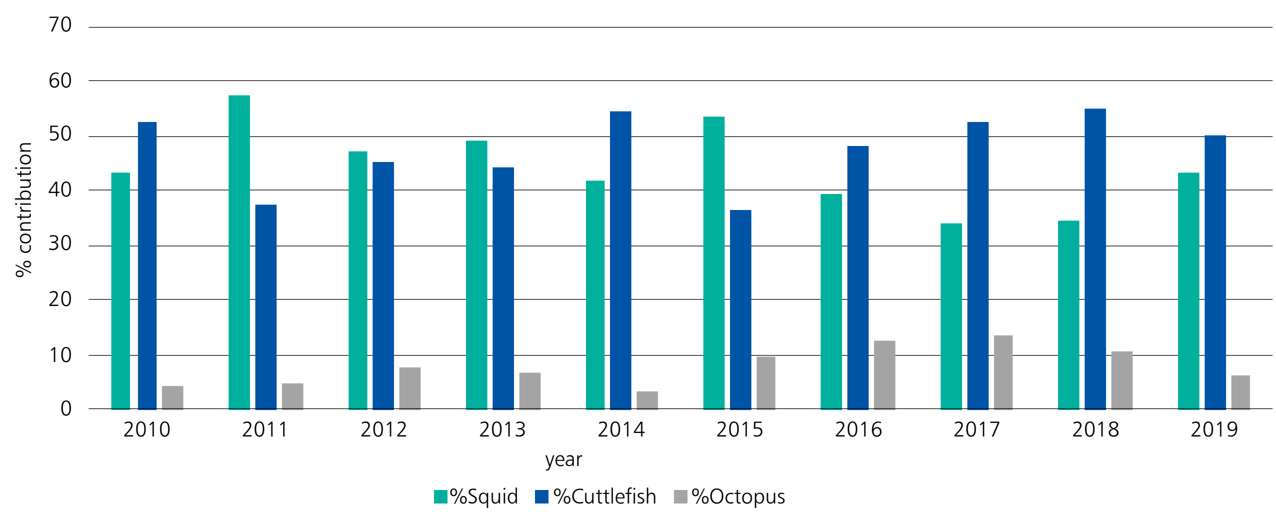

Fig.2. Groupwise landings of cephalopods along Chennai coast (2010-19)

Table 1: Size range (Dorsal mantle length), Mode (Dorsal mantle length), sex ratio of important cephalopod resources in Chennai during 2019

Species	Dorsal Mantle length (mm)			Sex ratio	
	Min	Max	mode	(M:F)	Price range ( ) per kg
Uroteuthis (Photololigo) duvaucelii	27	156	70	1:0.22	250-400
U (P).singhalensis	70	225	100	1:0.62	200-350
Sepia pharaonis	40	165	130	1:0.6	250-450
S. aculeata	60	115	90	1:0.59	100-350
S. brevimana	30	95	60	1:0.88	100-300
S. prashadi	47	115	90	1:0.85	200-350
Sepiella inermis	40	96	70	1:0.80	100-200
Octopus dollfusi	45	180	85	1:0.12	100-300
Amphioctopus membranaceus	25	89	52	1:0.13	100-250

Ocean warming: Evidence on SST increase from inshore waters off Cochin

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Climate change is one of the most critical challenges faced by mankind today and has greatly impacted environmental parameters such as sea surface temperature (SST), pH, annual rainfall, cyclones etc., which is being established through satellite derived remotely sensed datasets. The validity of these observations can be enhanced through ground truth data. We present here probabaly for the first time the ground truth evidence of marked differences in SST, Chl *a*, NPP and the levels of certain dissolved nutrients from the inshore regions of Cochin shelf by comparing the *in situ* data generated at two different decades viz., 1988 and 2014 from the inshore waters off Cochin within 10 – 30 m depth, north and south of Cochin Port Channel (Table 1).

Table 1. Location of sampling points in the inshore area off Cochin during 1988 and 2014.

St. no.	Latitude (N)	Longitude (E)
1	09° 59'44" N	76°09'23" E
2	09° 59'55" N	76°05'58" E
3	09° 59'30" N	76°06'47" E
4	09° 58'45" N	76°05'52" E
5	09° 57'54" N	76°06' 45" E
6	09° 56'38" N	76°05' 50" E
7	09° 56'36" N	76°02'51"E,
8	10°02'60" N	76°09'14" E
9	10°03'17" N	76°05'58" E
10	10°05'40" N	76°05'51" E

The seawater samples were collected on a monthly / fortnightly sampling programme of the institute's FEM Division, aboard *RV Cadalmin IX* during 1998 and *FV Silver Pompano* (as part of an inter-institutional ICAR project National Innovations on Climate Resilient Agriculture (NICRA- Phase I) during 2014. Variation (increase (+) /decrease (-)) in the annual and seasonal mean of hydrographic parameters from the inshore waters off Cochin over the year 1988 (n=18) and 2014 (n=14) are evident (Table 2).The annual mean of SST in the inshore waters off Cochin during 1988 was 28.78±0.32°C and 29.14±0.28°C during 2014, registering an increase of 0.36°C after 25 years, while the subsurface water near bottom registered an increase of 0.19°C only which indicates more warming in sea surface even in near shore coastal regions. Our temporal analysis indicated that warming did not manifest during the monsoon months of 2014 (SST -0.26°C and SBT -1.25°C). However, the pre-monsoon and post-monsoon seasons recorded warming at surface as well as in bottom. This warming trend is agreeing well with the data reported for offshore area of Kerala coast (0.2°C per decade) which was observed through thermal infrared remote sensing satellite data.

Table 2: Variation {increase (+) /decrease (-)} in the annual and seasonal mean of hydrographic parameters from the inshore waters off Cochin over the year 1988 (n=18) and 2014 (n=14).

	Temperature (°C)		PO_4-P (mg/l)		NO_3-N (mg/l)		SiO_3-Si (mg/l)		Chl *a* (mg/l)		NPP (g C/ m^3/d)
Season	Sur.	Bot.	Sur	Bot	Sur	Bot	Sur	Bot	Sur	Bot	Sur
Annual	0.36	0.19	-0.321	-0.348	-1.306	-1.408	-5.73	-5.089	-1.28	-0.615	0.03
Pre monsoon	0.68	0.63	-0.298	-0.609	-0.204	-0.479	-0.608	-0.819	-2.11	-0.234	-0.075
Monsoon	-0.26	-1.25	-0.53	0.443	-2.775	-2.805	-6.343	-1.972	-1.514	-1.69	0.63
Post monsoon	0.63	0.91	-0.135	0.008	-0.553	0.941	-10.24	-12.48	-0.216	0.108	-0.56

It is reported that the SST has been consistently higher during the past three decades than at any earlier time since reliable observations began in 1880 (IPCC, 2013). The SST is known to vary regionally, while most parts of the world's oceans have seen temperature rise, some parts of North Atlantic Sea have actually experienced cooling (NOAA, 2016). It was an interesting observation that other than temperature and net primary production (NPP), the levels of dissolved nutrients and chlorophyll *a* were appreciably lower during 2014 than during 1988. Similarly the levels of Phosphates at the bottom and NPP during the monsoon months were also found lower than that of 1988 although Kerala received higher rainfall (643.2 mm higher than that of 1988) during 2014.

With the available data it could be concluded that the SST along the Cochin coast has been increasing and since 1988 to 2014 is around 0.4°C. Regular and continuous *in situ* observations on the hydrographic parameters are essential for understanding the warming trend and to validate the remotely sensed satellite data.

Brief Communications

Fishery status of large pelagic resources of Andaman and Nicobar Islands

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The Andaman and Nicobar with an aggregate coastline of 1,912 km has an estimated annual harvestable potential of marine fish around 2.4 lakh tons. The fish landing data obtained from Dept. of Fisheries, UT of Andaman & Nicobar Islands was used for analysis. Marine fishery is limited to territorial waters by around 7,500 active, full time fishermen mainly by traditional and motorized boats using drift gillnets, hooks and line (hand lines), cast net, shore seine, anchor net and stick net. Trawls are also operated from certain locations using mechanized boats. The aborigines and Nicobari tribes in a few Islands are involved in subsistence fishery using bow & arrows and spears. Marine fish production over the years registered steady increase. It was 1,104 t (1975), which increased to 31,000 t by 2004 and 38,583 t during 2014-19, which forms only 15.8% of the estimated potential yield of the EEZ.

The seas around territory support one of the richest stocks of large pelagics (LP) of the Indian Ocean. The vast seamounts and ridges, around the territory an ideal environment and provide safe haven for feeding and their aggregation. The dominant LP resources of the region are tunas, billfishes, seerfishes, wahoo, barracudas, queenfishes, rainbow runners, pelagic sharks etc. Details of exploitable potential and present level of the landing is provided in the Table 1 below.

LP fishery of the region at present is limited to coastal seas by motorised/mechanized boats engaged in gillnetting and hand lining. Despite large potential, the present level of landing is very meager, to the tune of 6,327 t representing 7.9% of their estimated potential with coastal tunas (33%), billfishes (23%), seerfishes (15%), barracudas (11.8%) and pelagic shark (14.4 %)

Table 1. Harvestable potential of major LP resources and average landings during 2014-2019

Resource	*Potential yield (t)	Landing (t)
Coastal tunas (kawa kawa, frigate tuna, long tail tuna, bullet tuna)	18,000	2,066
Yellowfin tuna	24,000	93
Skipjack tuna	22,000	85
Bigeye tuna	500	11
Billfishes	2,800	1,473
Barracuda	2,200	746
Dolphin fish	200	-
Wahoo	200	-
Seerfishes	1,800	941
Pelagic sharks	11,200	912
Total LP potential	80,300	6,327
Total marine potential	2,43,500	38,278
LP component (%)	33	16.5

*Proceedings of Brainstorming session on 'Development of Island Fisheries', ICAR-CARI, 2008

recorded. The landing fluctuated between 5,000 and 6,750 t during 2013-19 with landing of coastal resources maintaining a steady level and oceanic resource on increase (Fig 1). Coastal LP resources comprising coastal tunas and seerfishes dominated the landing (59%) and oceanic LP mainly comprising oceanic tunas (yellowfin, skipjack, bigeye & dogtooth tunas), billfishes, pelagic sharks, king seer, wahoo, large barracudas and dolphin fishes were recorded.

Several schemes had been proposed by various expert groups and task forces in the past to develop the fisheries in the region. The main reason for the non-development of the fishing Industry and under-utilization of the valuable LP resource can be attributed to total absence of enthusiasm among the local fishers, because of the lack of appropriate market linkages for disposing the produce, if caught which forced them to limit the fishery activity at sustenance level within in near-shore waters, only to meet the local demand. Large natural abundance of high value resources like, tunas, seerfishes, billfishes barracudas etc in the mostly pollution free oceanic waters, proximity to many international seafood markets and transit point like Singapore are major strengths. The local fishers who are mainly descendants of traditional seafaring community from Tamil Nadu, Andhra Pradesh and West Bengal ettled decades back can be adequately trained for oceanic fishing activities.

The connectivity with Indian mainland, existing fishing sector dominated by traditional and small mechanized crafts with operational capacity limited to shallow territorial waters are handicaps to target large high value fishery resources available in deeper oceanic waters. Further, the existing infrastructure is highly inadequate to handle and process the fish catch. A well planned fishery development programme supported by a scientific fishing policy is the need of the region. Assessment of fish stock health and operational viability through a phased development will allow the tapping of the huge fishery potential of the region. Island based infrastructures like modern harbours, processing estates and marketing channels to ensure quick transport of products to international markets like Bangkok and Singapore is needed.Introduction of factory/mother vessel(s) in the open sea itself is an alternative to development of on land facilities. Collection of fresh fish catches and development of high value *Sashimi* grade products will be possible. Considering the high investments that will be required for such ventures, establishment of special economic zone can be considered.

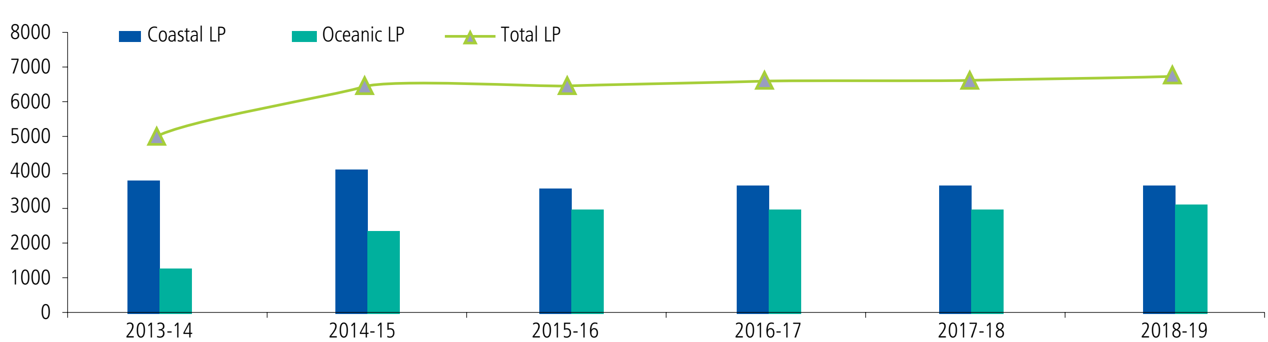

Fig 1. Landing trend of LP resources along Andaman-Nicobar area (Data source: Dept. of Fisheries, UT of Andaman & Nicobar)

Brief Communications

Fishery for large pelagics in Lakshadweep

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Fishermen of Minicoy in Lakshadweep islands have a history of targeting skipjack tunas with the pole & line from time immemorial. Introduction of motorised fishing crafts and popularization of pole and line fishing in other islands during the 1960s and '70s has led to fish landing grow from less than 500 ton in the 1960s to over 20,000 tons in the recent years. The recent fishery developments are recorded in this communication. The fish catch data collected by the Department of Fisheries from inhabited island using enumerators was used for the analysis. The gear wise catches recorded during onboard observations in 90 fishing operations (55 pole and line and 35 handline operations) during 2018 and 2019 is reflected. Species wise and island wise fish landing data for the year 2000 to 2019 was also used for the study along with information gathered from literature search and consultations with the fisheries department officials and the fishermen.

The estimated total fish landing of Lakshadweep in 2019 was 22 928 t of which tuna constituted 85%. Among tunas, skipjack (35.8%) and the yellowfin tuna (31.69%) were the major contributors. During 2015-2019 period, large pelagics constituted nearly 93% of the landing dominated by tunas (88%) in the total fish landing. Other large pelagics such as mahimahi, wahoo, billfishes, carangids, needlefishes, barracuda *etc* formed nearly 5% of the landing (Table 1).

Steep increase in the skipjack and yellowfin tuna landing can obviously be attributed to the recent developments in the island tuna fisheries and changing fisherman priorities based on the increasing demand for tunas in the market supply chain. November-April is the most productive period for tuna fishing in the Lakshadweep waters with the pole & line fishery contributing 65 % of the total fish landing.

The prominent fishing gear employed is hook and line, principally pole & line, hand-line and troll line in the order of importance. Use of drift gillnets is limited to the monsoon months. In the pole & line fishery catch skipjack alone constituted nearly 75% of total catch, followed by yellowfin and neritic tunas and others such as rainbow runner, mahimahi, billfishes, wahoo, sharks and trigger fishes constituted 3% only. Yellowfin tuna constituted nearly 93% of the catch in hand-lines with other resources caught being billfishes, mahimahi, rainbow runner and skipjack tuna.

Though tuna fishing is carried around all inhabited islands, historically Minicoy, Agatti and Kavaratti have been the major fish producing islands. The recent introduction of improved fishing vessels has enabled the fishermen to camp and fish in distant islands depending on the resource availability. Kadmath, Kavaratti, Agatti and Minicoy contributed 66% of the total fish landing in Lakshadweep

Table 1 Fish landings (t) in Lakshadweep (2015-2019)

Groups/Year	2015	2016	2017	2018	2019	Average	% share
Tunas	12516	23959	14154	24923	19444	18999	88
Large pelagics (Non-tuna)	785	740	842	1542	1684	1119	5
Sharks and Rays	51	59	58	72	42	56	0.01
Other pelagics	42	29	29	67	417	117	1
Perches	357	234	315	792	788	497	2
Small lagoon fishes	2458	628	422	537	555	920	4
Total landings	16209	25650	15819	27933	22929	21708	

(Fig.1). Consistent presence of tuna shoals in the vicinity of Kadmath Island having vast lagoons with abundant livebait resources and availability of ice, have made this atoll a regular camping for them since 2016. In contrast, Androth, an atoll without lagoon has historically been a non-tuna fishing island. Similarly, other smaller islands with fewer fishing crafts show a lesser contribution.

Fish landing in the islands grew from nearly 500 t in the 1960s to over 25,000 t in the year 2018 recording a steady growth rate with inter-annual fluctuations. The policy interventions right from the introduction of first ever custom-made motorised fishing craft in 1959, followed by motorisation, establishment of boat building yards, introduction of improved fishing crafts, diversified fishing methods, mechanisation in pole & line fishing, establishment of ice plants, deployment of collector vessels for fast disposal of catches at mainland have all contributed to the increase in marine fish catch (Fig. 2).

Tunas has been the major resource landed forming over 80% of the fish landed all through the years with a clear dominance of skipjack. It is principally due to their relatively higher abundance, pole and line fishing skill of the people as well as the traditional product, *Masmin* that commands a good market. The skipjack tuna touched the all-time high

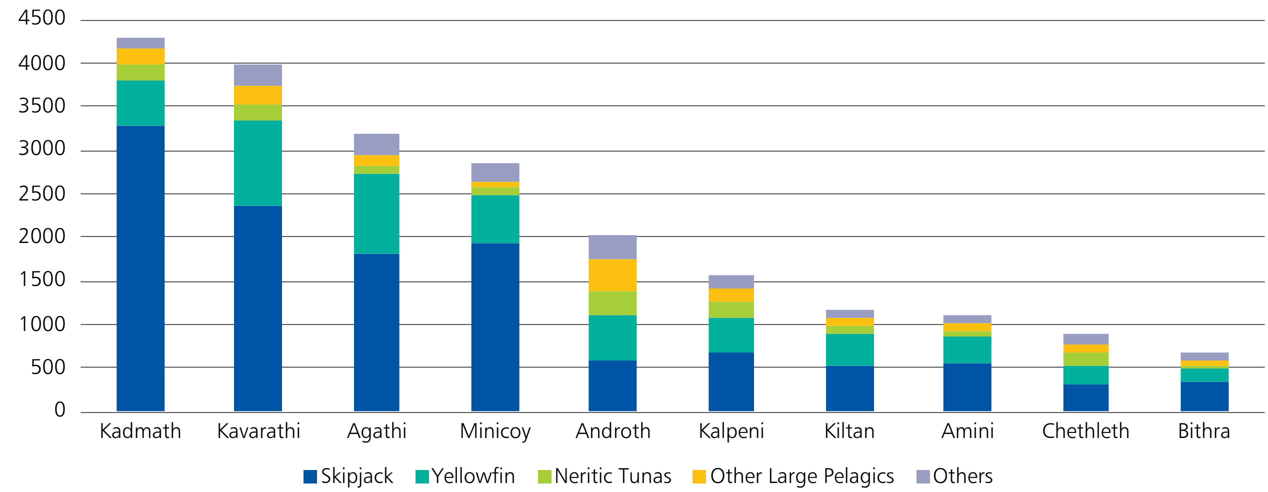

Fig. 1 Island-wise species-wise average fish landing during 2015-2019

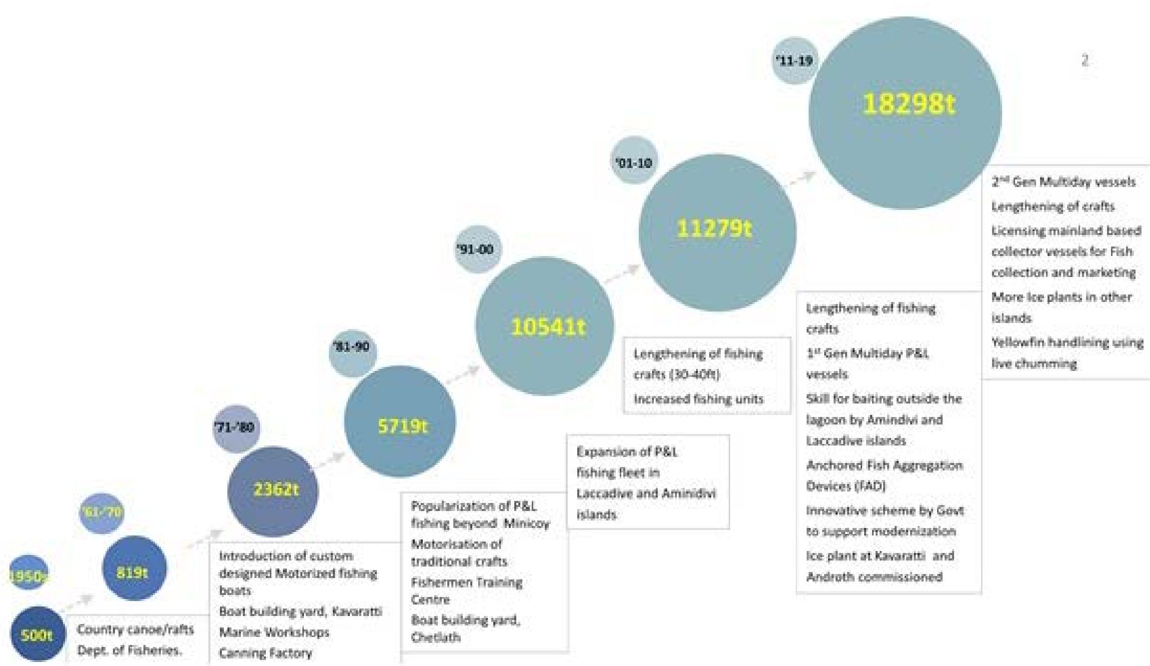

Fig. 2 Time line of fisheries development in Lakshadweep

landing of 20891 ton in 2016 with a contribution of 81% of the total fish landing. Though an abundant resource, yellowfin was not targeted, principally due to marketing concerns. Decline in skipjack tuna landing during 2010-12 period paved the way for surge in yellowfin landing to 5600 t in 2013 from the average of 810 t for the decade 2000-2010. Since then, they have emerged as an important fishery with steady increases during the past few years. Modified pole & line gear (with twin poles) and hand-line were the gears relied. A policy initiative by the U.T. Administration in 2017 to permit deployment of leased fishing vessels from mainland by the locals for collection and transportation of the catch for mainland markets further encouraged tapping of yellowfin leading to a record high landing of 10193t in 2018 which boosted the overall fish landing of Lakshadweep to touch the historic high of 27,933t. Recently, fishermen are catching yellowfin tuna using handlines with live chumming using Redtoothed trigger fish (*Odonus niger*) and other fishes like fusiliers and green chromis as livebaits.

Oceanic tuna resources have been the mainstay of fishery in the Lakshadweep islands with the estimated potential for annual harvest of tuna resources at 75,000 tons. However, the average landing for the last five years at 21,708 t is forming only around 29% of the potential. This suggests scope for enhancing tuna production from the islands. The profitability for the skipjack tuna fisheries has been decreasing in recent years due to over dependence on *masmin* which has an almost stagnant market price for last several years while the input cost, especially the fuel cost has increased significantly. This highlights the urgent need for diversification in utilisation of skipjack tuna catches. Export oriented fish processing industries of appropriate scale to meet the twin objective of economic utilisation of the resources and ensuring livelihood opportunities for the islanders is desirable. The yellowfin tuna fisheries can be expanded further to tap deep-swimming larger tunas with appropriate gear for an added objective of developing *sashimi* grade tuna.

Kaleidoscope

Note on range extension of guitarfish *Acroteriobatus variegatus* in Indian seas

The stripenose guitarfish *Acroteriobatus variegatus* (Nair and Lal Mohan, 1973) has been listed as a Critically Endangered (CR) in the IUCN redlist for elasmobranchs. It belongs to the family Rhinobatidae (Rhinopristiformes) and among the 10 species of *Acroteriobatus* found in the western Indian Ocean, is the only endemic guitarfish with a very restricted distribution range, being known only from southern India and Sri Lanka. It is a regular landing by bottomset gillnet at Thengapattinam and Kanyakumari FLC, and occasional landing by trawls in Kochi, Neendakara, Colachel, Muttom and Tuticorin (unpublished data).The size range observed in the gillnets was between 40.5 and 89.2 cm, whereas it was 55-70 cm Total Length (TL) at Beypore fisheries Harbour, Kerala where it occurs occasionally in the landings by multiday trawls (Figs.1 & 2).

Fig. 1. Stripenose guitarfish landings at Beypore Fisheries Harbour

A single specimen of *A. variegatus*

Fig.2. Male *A.variegatus* landed at, Beypore Fisheries Harbour in September 2019

Fig. 3. Female *A.variegatus* landed at Pamban Therkuvadi, Tamil Nadu in June 2021

was observed in the bycatch of a single day mechanised fish trawler (24 m OAL fitted with 193 Hp engine power) operated at a depth of 70 m off Mandapam (Gulf of Mannar) at a distance of 37 km from the land. The fish was landed at Pamban Therkuvadi Fish Landing Centre, Tamil Nadu on 18th June 2021. The total length, disc width and weight of the fish were 76 cm, 24 cm and 1.02 kg respectively (Fig. 3). The maximum reported size of this species is 75 cm (Last *et al*., 2016). The depth of operation recorded off Kozhikode, Kerala for the same species was 50-100 m. The present observation suggests the range extension in its known distribution further north in the Arabian Sea by 180 km and Gulf of Mannar by more than 120 km as the earlier studies indicated the distribution from Cochin to Tuticorin. The distribution range provided by Kyne *et al.* (2017) needs further confirmation.

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Occurrence of hammer oyster in the Gulf of Mannar, Tamil Nadu

Malleus malleus (Linnaeus, 1758) is the species of black hammer oysters coming under the order Pterioida, family Malleidae. *Malleus* genus is characterized by hammer shaped outline of the valves which are nearly equivalved; hinge line extremely long and at nearly perpendicular to the rest of the valves. Generally found in clean sandy bottom of intertidal areas in which hinge lines are buried while the most distal regions are projecting outside the sandy bottom, it is also found in coral reef areas. In the present case, this species were by-catch from seagrass beds off the Veerapandi pattinam at Gulf of Mannar as epifaunal organisms. Length of the specimen ranged between 165-190 mm with a hinge line upto 113±18 mm. Black hammer oysters is the longest among all the hammer oysters. Maximum shell length recorded was 220 mm. During the late seventies to early eighties diversification of traditional fishing methods to exploit near shore fish and shrimps such as ''*Thallumadi*'' (modified version of the shrimp trawl) and ''*Disconet*'' (an improvised drift gill net) was recorded in Gulf of Mannar . Black hammer oysters are caught as by-catch during *Thallumadi* operations here which was used in the lime industry according to local fishers In the ancient days, hammer oysters were highly prized by collectors with sale of *M. malleus* recorded for 240 francs in Paris and 32 guilders in Holland during the 18th century (Dance, 1966). Awareness needs to be created among the workers of shell craft industry regarding the utilization of this potential raw material for decorative purpose rather than in lime industry.

Fig.1. External view of the adult *M. malleus*

Fig.2. Internal view of the adult *M. malleus*

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