PELAGIC FISHERIES DIVISION

Major achievements of research (during 2009-200140

IN-HOUSE PROJECTS

1. Management advisories for sustaining marine fisheries of Kerala and Lakshadweep (PEL/IDP/01)

Fishery, biology and population characteristics of 38 commercially important species of fishes landed along Kerala and Lakshadweep coast were studied

Kerala

- Among pelagics Stolephorus, sardine, mackerel, small carangids (scads) and ribbonfishes improved the production
- Large pelagics like tuna, seer fishes, pelagic sharks, billfishes and large carangids registered sharp decline
- Some resources like leatherjackets, barracudas, needle fishes and flying fishes are the emerging pelagic resources
- Stock assessment of yellow fin tuna shows signs of over-exploitation along the entire region
- Demersal fish production continued its declining trend during the year also
- Huge quantities of juveniles of threadfin breams and lizard fishes were landed all along the coast by trawlers
- Emergence of puffer fish with heavy landings as a commercial resource was witnessed during the period, with increased demand from many quarters.

Lakshadweep Islands

- Yellow fin tuna fishery in general and southern islands in particular showed remarkable increase
- 18 new records from Kerala coast and one from Lakshadweep were reported during the year.

Management Advisories

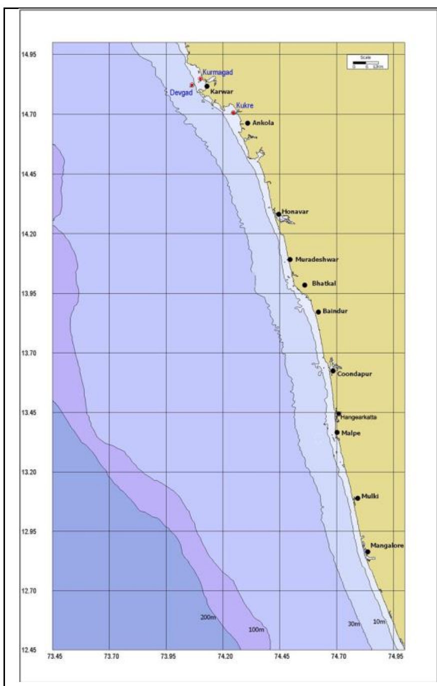
- Juvenile exploitation and their trade has to be restricted.
- Large scale adoption of encircling gillnets and purse seines for bigger sardines and mackerel taking place now will be detrimental as the gears are mainly targeting the larger fishes, probably the spawning stock

Adoption of high-power Chinese made engines with high fuel consumption need restriction/monitoring

2. Management Advisories for sustaining marine fisheries of Karnataka and Goa. (PEL/IDP/02)

a. Karnataka

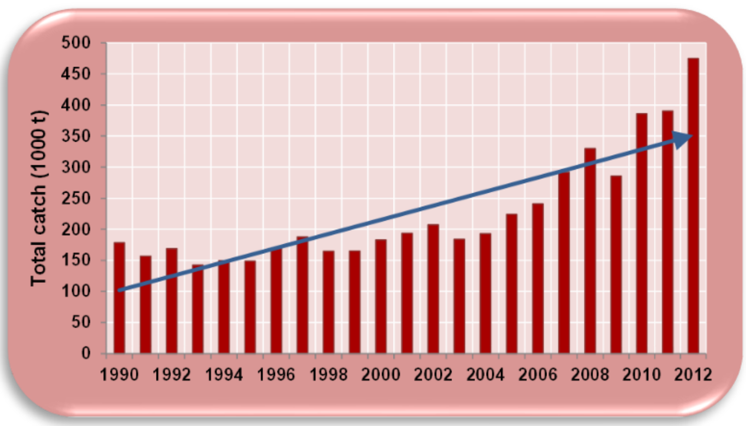
Karnataka State situated between $11^{0}31$’ and $18^{0}45$’N latitude and $74^{0}12$’ and $78^{0}40$’E longitude is located along the west-central part of peninsular India. It is wedged between the Western Ghats in the east and the Arabian Sea in the west. More than a dozen rivers originating in the Western Ghats flow into the Arabian Sea making the nearshore waters highly productive.The 300 km coastline stretch of Karnataka, known historically as the ‘mackerel coast’, is distributed among three districts viz. Dakshina Kannada, Udupi and Uttara Kannada with a continental shelf area of 25,000 km^2

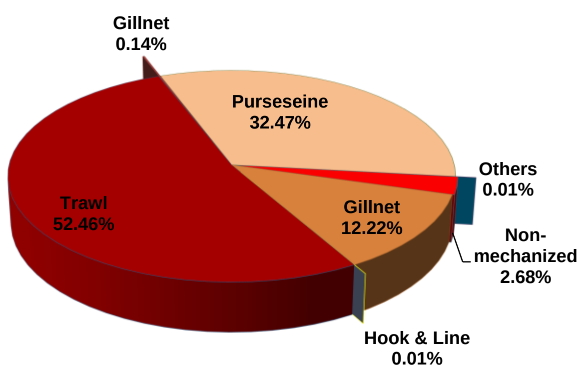


Karnataka **Goa**

Marine fisheries policy for Karnataka prepared with advisories on optimum fleetsize

The marine fish production in Karnataka has increased by several folds from 1,89,000 t in 1986 to 4,75,000 t in 2012. In addition, the sector has generated employment to several people. As per the Marine Fisheries Census (2010), 1,67,429 people are dependent directly or indirectly on fishing activities. The sector also generates revenue for the State through domestic and international marketing. Mechanization and modernization of crafts and gears has enabled the fishers to expand their fishing area from within the territorial waters to beyond 12 nautical miles and exploit resources available therein.





The major issues identified in the marine fisheries sector of Karnataka were

- Oversized fishing fleet

Over the years, the number of crafts operating in Karnataka has multiplied manifold. The area of operation as well as resources targeted have not changed much. As a result, the returns per boat have dwindled and there is a lot of fishing pressure on the exploited resources.

- **Overcapitalization**

  The steep increase in the cost of vessel construction, net materials, diesel prices, ice, labour, overhead charges for post-harvesting, etc., has made the fishing activity expensive. It has resulted in unhealthy competitions among the boat owners resulting in intensified targeted fishing operations using larger vessels with higher fish hold capacity, high speed engines and modern fish finding devices.

- **Destructive fishing methods**

  Several innovative methods such as FADs, use of small meshed gears, high opening trawl nets and illegal methods practiced is causing harm to juveniles and adults of some commercially important species. This is a cause of concern for the sustainability of these resources.

- **Increased landings of trash/ discards**

  Competition among fishermen has resulted in extensive use of small-sized meshes (<20 mm) in cod-end of trawls in order to maximize the harvest from fishing grounds. This has led to the capture of young and undersized fishes. Large-scale destruction of young/ juveniles of commercially important fishes will result in growth overfishing and affect their stocks during the following seasons

- **Weak vessel-based fishing database**

  Marine capture fisheries research requires data on a continual basis from different regions, seasons and depths on catch, effort and cost of fishing and fish population characteristics of discarded and landed catch to estimate optimum yields. Though it has been repeatedly impressed upon the fishing boat owners and the implementing agencies on the need for furnishing fishing logs by all vessels, very little headway has been made in this direction due to the lack of appreciation for such data.

- **Decline in fish stocks**

  Indiscriminate targeted exploitation of some resources (eg. catfish brooders by purse seiners, juvenile fish exploitation by shrimp oriented trawling practices including bull-trawling in the post-monsoon months and mattabale operation practiced during the monsoon months) has resulted in over-exploitation of certain stocks, poor recruitment and growth over-fishing. The emergence of some unconventional gears in conjunction with increased effort (units and fishing hours) and reduced mesh size at the bunt/ cod end has further aggravated the problems of both growth overfishing and recruitment overfishing

- **Impact of climate change**

  Climate change has a direct impact on the marine fishery of the region. The frequent occurrence of cyclones and storms has resulted in regime shifts and change in species composition and disappearance of certain species from its natural habitats.

- **Impact of anthropogenic activities**

  Changes brought about in the environment due to anthropogenic activities other than fishing (sewage discharge, industrial effluents, oil spills etc.) also have an impact on the fishery of the region.

- **Quality control**

  There is great demand for marine products caught from this region in the export market. However, unless strict quality measures are adhered to, the products are rejected leading to great monetary loss to the sector. Though certain measures are in practice, there is need for better handling and preservation of the catch onboard so as to fetch better returns to the fisheries sector.

- **Marketing infrastructure**

  Marketing of fishes is generally at the landing centre. Though some societies and Karnataka Fisheries Federation are involved in the marketing of certain export quality fishes there is need to improve the system. Lack of sufficient cold stores at the landing centre and effective marketing systems like cold chains is affecting the sales and value of the high quality fishes landed.

- **Lack of support prices**

  Fishery products are highly perishable and whenever there is a good catch, the middlemen involved in marketing generally control the price. Support prices that exist for major resources as in agriculture products should be extended to fishery products to reduce exploitation of primary stakeholders by middlemen and enable the fishers to get their due.

- **Lack of guidelines for mariculture activities**

  Farming of marine organisms has made a good beginning in the open-sea and inshore coastal waters. Though this is the best way to supplement marine fish production to meet the increasing demand for seafood, setting up of large-scale marine farms/ enclosures will result in conflicts among fishermen and fish farmers. Absence of a legally viable licensing system and water leasing may lead to conflicts among different stakeholders.

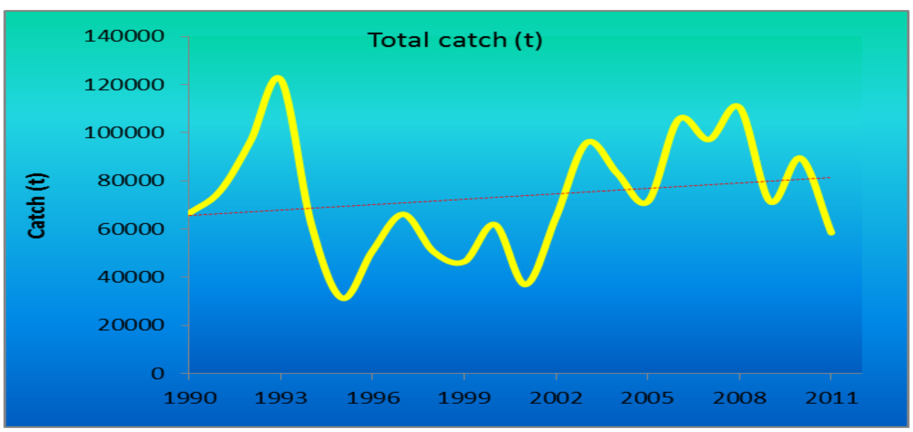
Recommendations

The optimum fleet size was estimated following the methodology suggested by Sathianandan *et al.* (2008). Data for a period of three years (2010-2012) were used for this analysis. The annual catchable potential off Karnataka is 4.25 lakh t (Anon, 1991). Based on this potential, the current yield and actual registered fishing fleet along Karnataka Coast (Dept. of Fisheries, Karnataka, 2012), the optimum fleet size estimated

- Strict registration and licensing system for fishing vessels.
- Fishing effort reduction can be made by fixing fishing quota for existing vessels, by phasing out old units and also by increasing the duration of closed season for different categories.
- The speed-length ratio (OAL and engine capacity) of the vessel should be specified. This will help in stopping overcapitalization, unhealthy competition and social issues arising from it.
- Cod end mesh size of trawl nets should be a minimum of 35 mm. Manufacture of net panes below this mesh size for cod end of trawl net should be banned at the manufacturer's level. Special incentives can be provided to fishermen adopting minimum mesh size suggested.
- For gillnet the mesh size should be specified so as to avoid juvenile and spawner exploitation.
- Keep Minimum Legal Size (MLS) for each species for domestic sale and export. Minimum size at maturity (MSM) can be taken as criteria.
- Make the 'logbook' compulsory for all fishing units.
- Diversify the fishing activity so as to capture commercially important fishes from deeper waters and also utilize unconventional resources.
- Participatory management and conservation of over-exploited as well as juveniles of commercially important resources.
- Awareness program to avoid destructive fishing for juveniles and to avoid discards.
- Empower fishery officials to check any vessel which is suspected to violate rules and take legal actions.
- Establish cold chains and improve marketing infrastructure. Fix minimum support price for major fish resources

- Though considerable information on the hydrography, plankton and upwelling is available for the coastal waters, attempts to link these characteristics to actual fish abundance in space and time has to be made.
- Marine fishery forecast on real time basis-studies on the seasonal/ periodic/ cyclic changes and/or the special phenomena occurring in the marine environment must be strengthened so as to propose measures to manage the exploited fishery.
- Fish farmers/ mariculturists to be provided with license to take up marine farming activities at identified sites to avoid conflicts.
- Promotion of capture based aquaculture in floating cages, pens and rafts.
- Formulation of a coastal water use policy.

The annual marine fish landings in Goa registered a positive trend since 1990 in spite of annual fluctualtion. The lowest catch was recorded during 1995 (3138t) and highest during 1993 (1,21,998 t) with an annual average of 73,324 t (1990-2009) (Fig.1). As in Karnataka, mechanization, motorization, innovation in crafts and gears, expansion of fishing grounds, and an overall improvement in marketing and processing of the exploited fishery resources has contributed to this general increased fish production over the years.



The major issues identified were similar to that observed in the marine fisheries of Karnataka.

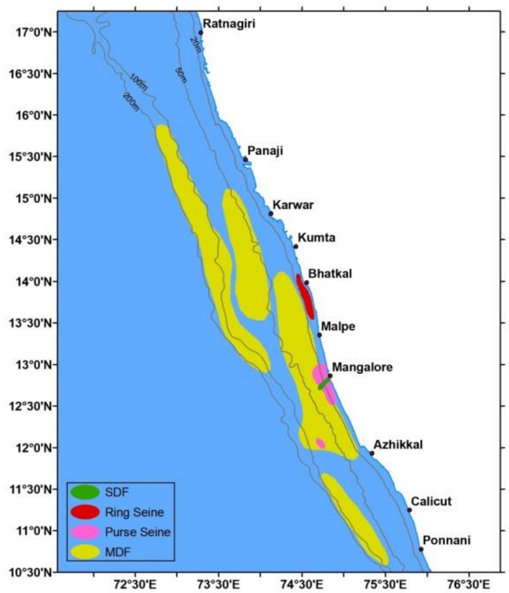
Management options suggested are:

- Strict registration and licensing system for fishing vessels.
- 2. 13% reduction of multi-day fishing trawlers from 2006 level.
- 3. 19% reduction of purse seiners from 2006 level.

- Unit reduction can be made by fixing fishing quota for existing vessels, by phasing out old units and also by increasing closed season for different category.
- The upper limit of length and capacity of the vessel should be specified and maximum period for which the vessel can be away from the shore also has to be limited. This will help in stopping overcapitalization, unhealthy competition and social issues arising from it.
- Cod end mesh size of trawlers should be more than 35 mm. Encourage use of only large meshed nets by giving special incentives to fishermen adopting such management practices.
- For gillnet the mesh size should be specified so as to avoid juvenile exploitation.
- Keep minimum legal size for each species for domestic sale and export. MSM can be taken as criteria.
- Diversify fishing activity so as to capture commercially important fishes from deeper waters and also utilize unconventional resources.
- Participatory management and conservation of over-exploited as well as juvenile of commercially important resources.
- Awareness program to avoid destructive fishing juvenile fishery and to avoid discards.
- Make the 'logbook' compulsory for multi-day trawlers.
- Empower the fishery officials and fishery scientist to check any vessel which is suspected as violated rules and take legal actions against the violators as per the report of the fishery officials and fishery scientists.
- Establish cold chains and improve marketing infrastructure
- Fix minimum support price for major fish resources
- Though considerable information on the hydrography, plankton and upwelling is available for the coastal waters, attempts to link these characteristics to actual fish abundance in space and time to be made.
- Fishfarmers/mariculturist to be provided with license to take up marine farming activities at identified sites to avoid conflicts.
- Promotion of capture based aquaculture in floating cages, pens and rafts.
- Formulation of a coastal water use policy.

Actions initiated:

❖ In-situ data collection from selected crafts/gears types registered at Dakshina Kannada and Udupi districts was continued. Log sheets prepared in local languages, were given to boat crew to get continuous data. Fortnightly georeferenced samples (fish and water samples) collected were analysed for species diversity their habitats and seasonal trends.



❖ Stock classification of major exploited species along Karnataka coast was studied for period 1990 to 2013.Of the twenty pelagic species analysed, 9 were abundant (A) one species was less abundant (LA), 8 species were declining (D), two species were depleted (DE). Amond the 15 demersal species analysed, 6 were abundant, 5 less abundant, two declining, one depleted and one species showed collapsed status. Among the three groups of molluscs studied, squids and octopus were abundant and cuttlefish less abundant. Among curstaceans, prawns and crabs were less abundant and stomatopods indicated a declining trend.

	Av. 3 years 2011-13	Max 1990-2013	% of Historic max	
Oil Sardine	100536	119611	84.1	A
Other Sardines	10178	18352	55.5	LA
Stolephorus	5348	11847	45.1	D
RIBBON FISHES	24623	29468	83.6	A
HALF& FULL BEAKS	358	404	88.5	A
CARANGIDS	41555	54764	75.9	A
Horse Mackerel	5412	7315	74.0	A
Scads	30359	43105	70.4	A
Leather-jackets	687	979	70.2	A
Other carangids	5096	10349	49.2	D
Indian mackerel	54118	77607	69.7	A
SEER FISHES	6824	8620	79.2	A

S. commersoni	6276	7745	81.0	A
S. guttatus	548	1148	47.7	D
TUNNIES	2429	7365	33.0	D
E. affinis	1995	6410	31.1	D
Auxis. spp	246	1232	19.9	D
K. pelamis	28	58	47.7	D
T. tonggol	88	1110	7.9	DE
Other tunnies	73	267	27.2	D
BILL FISHES	10	171	6.0	DE
BARRACUDAS	5130	6926	74.1	A
POMFRETS	2347	2861	82.0	A
Black pomfret	1474	3228	45.7	D
Silver pomfret	861	1081	79.6	A
Chinese pomfret	13	234	5.6	DE
ELASMOBRANCHS	1261	1926	65.5	LA
Sharks	728	1401	51.9	LA
Skates	203	295	68.8	LA
Rays	331	513	64.5	LA
Catfishes	2353	2769	85.0	A
LIZARD FISHES	17455	23907	73.0	A
PERCHES	61216	78667	77.8	A
Rock cods	9736	13495	72.1	A
Snappers	55	329	16.7	D
Pig-face breams	1	70	1.9	C
Threadfin breams	47702	61017	78.2	A
Other perches	3721	9137	40.7	D
CROAKERS	5244	6544	80.1	A
SILVERBELLIES	3839	6058	63.4	LA
BIG-JAWED JUMPER	3376	3916	86.2	A
FLAT FISHES	9291	18185	51.1	LA
Soles	9291	18153	51.2	LA
CRUSTACEANS	18791	43989	42.7	D
Penaeid prawns	12165	21507	56.6	LA
Crabs	1944	2845	68.3	LA
Stomatopods	12391	25597	48.4	D
Cephalopods	21252	26051	81.6	A
SQUIDS	15439	18901	81.7	A
CUTTLEFISHES	7810	12479	62.6	LA
OCTOPUS	651	841	77.4	A

- ❖ Length range, mean, Lm. Lc, growth and spawning stock parameters of 40 dominant species were estimated
- ❖ The food and feeding habits of 36 dominant species contributing to the fishery were analysed for the Index of Relative Importance (IRI). Seasonal variations in prey availability were studied.
- ❖ The landing centre price, wholesale price and retail price of 45 finfish species were collected form Manglaore in Karnataka and Madgoan in Goa and spread sheets prepared.
- ❖ Conflicts between the trawl operators and the fishing for cuttlefish using FADs escalated during 2011. Scientists based on their studies submitted a report on the exploitation of cuttlefish using FAD's made mainly from coconut fronds; the spawning season and behavior of the cuttlefish and the vulnerability of mature spawners to get caught in areas where FAD's are deployed. Based on the report submitted by CMFRI and discussions with all concerned and keeping in view the harmful nature of FAD fishing, the Government of Karnataka banned fishing of cuttlefish by non-conventional methods using coconut fronds (Chowri), torn nets, decaying material and other marine polluting materials/items along the Karnataka coast under the provisions of the Karnataka Marine Fisheries Act 1986, subsection (1) (B) and (C) in the notification dated 07 July 2012. This ban will go a long way in conserving the cuttlefish available along Karnataka Coast and is a positive step taken for the management of marine fishery resources in Karnartaka.

Non-equilibrium production models were fitted to cephalopod catch and effort statistics to arrive at limit reference points (LRP), Y_{MSY} and f_{MSY}. The parameter estimates, *K (carrying capacity), r (intrinsic rate of population growth)* and *q (catchability coefficient)* were 3,00,187 t, 0.1561474 per year, 2.7874050E-08 for Schaefer model. The estimated precautionary limit $Y_{MSY,}$ was 11,718 t and the corresponding f_{MSY} was 28,00,946 h. The current effort, f_{now} expended in the trawling ground is 33,42,587 h for a trawling period of 108.8 h per MDF trip. The results suggest that the fishing effort is 32% in excess of the precautionary target, $f_{0.1}$ estimated at 25,20,851 h as well as 19% above the LRP for sustaining the fishery at MSY levels. Therefore, it is recommended that trawling effort for the MDF be reduced so that the long-term catches of cephalopods correspond to the Y_{MSY} levels in the present fishing area.

Level of exploitation of different resources/species

Name of species	Exploitation level
R. kanagurta	0.76
S. longiceps	0.67
E. devisi	0.82
S. waitei	0.70
M. cordyla	0.60
S. commerson	0.75
D. russelli	0.76

E. affinis	0.63
A. thazard	0.44
T. lepturus	0.70
N. mesoprion	0.61
N. japonicus	0.74
C. macrostomus	0.72
L. lactarius	0.60
M.dobsoni	0.64
M. monoceros	0.55
P. stylifera	0.57
S. choprai	0.63
P.sanguinolentus	0.58
P.pelagicus	0.62
C.feriatus	0.66
L. duvaucelli	0.87
S. elliptica	0.83
S. pharaonis	0.594

Biological reference points of major resources/species and the present biological status in the catch (all gears combined)

Name of species	Lm (cm)	L∞ (cm)	K/yr	t_o	Lopt (cm)	M	Z	MSY (t)	Standing stock	Present yield
R. kanagurta	17.5	31.8	1.1	-0.0833	19.6	2.10	8.75	28888	6603	43910
S. longiceps	15.0	22.8	0.9	-0.1124	13.8	1.79	5.40	42939	15903	57411
E. devisi	6.8	11.7	1.59	-0.0660	6.9	2.81	15.7	3811	485	6258
S. waitei	8.0	11.5	1.5	-0.0728	6.8	2.67	8.99	446	99	627
M. cordyla	25.0	49.6	0.7	-0.1117	31.1	1.49	3.70	1541	833	1841
S. commerson	70.0	162	0.78	-0.0742	106.7	1.61	6.43	2405	748	3605
D. russelli	16.0	28.4	0.7	-0.1302	17.4	1.49	6.29	5693	1810	8689
E. affinis	43.0	79.0	0.89	-0.0807	26.8	1.78	4.77	1809	759	2268
A. thazard	30.5	49.0	0.96	-0.0855	30.7	1.88	3.34	427	255	373
T. lepturus	60.0	134	0.86	-0.0720	87.6	1.78	6.03	7498	2636	11204
N. mesoprion	18.2	31	0.78	-0.1170	19.1	1.78	4.52	17876	7910	21673
N. japonicus	19.5	33.5	0.89	-0.1021	20.7	1.78	6.95	5813	1678	8648
C. macrostomus	11.1	17.8	0.95	-0.1142	10.7	1.86	6.70	4147	1238	5992
L. lactarius	17.2	29	1.0	-	17.8	1.94	4.84	2753	1138	3299

				0.0948						
M.dobsoni	7.1	11.9	1.2	-0.0984	7.0	2.20	6.13	1338	436	1715
M. monoceros	11.6	12.3	1.5	-0.0714	7.3	2.80	6.17	5081	1647	5550
P. stylifera	8.35	19.2	1.4	-0.0701	11.6	2.80	6.56	933	285	1070
S. choprai	6.5	12.0	1.2	-0.0982	7.1	2.23	6.10	954	313	1210
P.sanguinolentus	9.6	16.9	1.9	-0.0432	10.1	2.8	7.15	281	111	239
P.pelagicus	8.96	17.3	1.3	-0.0800	10.4	2.5	3.58	144	50	163
C.feriatus	7.1	13.5	1.2	-0.0951	8.0	2.2	4.21	185	58	232
L. duvaucelli	24.0	42.1	0.9	-0.0949	26.2	0.82	6.31	2477	785	4310
S. elliptica	11.0	17.7	0.85	-0.1369	10.6	1.0	5.77	168	58	278
S. pharaonis	24.0	42.0	1.2	-0.0696	26.1	2.23	5.5	6309	2294	7502

Socioeconomic and behavioral profile of stake holders

A study on the Gender roles of fishermen and fisherwomen was undertaken among a sample of 64 fisher folk engaged in the various sectors of Marine Fisheries. It could be observed that majority of the men (75.00 percent) were middle aged, above 45 years, had higher secondary level of education, had nuclear family type with an average monthly income of Rs.8250. It could be observed that majority of the dry fish wholesalers among women (87.50 percent) were middle aged above 45 years, 50 percent had middle school level of education 87.50 percent had joint family type, 75 percent had medium level of social participation,62.50 percent had a low level of communication behavior. 50 percent had a high level of economic motivation, 37.50 percent had a high and low levels of awareness of developmental programmes and 87.50 percent had a low level of participation in these programmes.

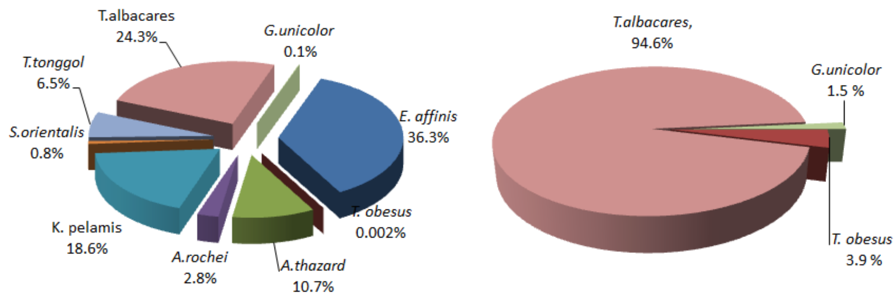
During the period under report, the socio economic component selected for the study was to assess the techno-economic feasibility in the use of various crafts and gears. During this period, data was collected from a total of 96 boat owners from the mechanized sector, 32 each from purse seine owners, single day and multiday trawler owners from Mangalore Fisheries harbour, Dakshina Kannada district. The average operational cost per trip for Purse-seiners was Rs. 15,175. The average cost of the purse seine net was found to be 35 lakhs. The average number of fishing hours/day was 10-12 hrs with an average number of hauls to be 2-4. The average duration of each haul was 3 hrs. The night purse seine is operated during the months of December-May and during night the number of times the net was put was 2-3 for an average period of 9 hours. The average operational cost /trip for a single day trawler was Rs.11,171. The operational cost/trip for a multi day trawler with an average number of 9 days of operation/trip. The operational cost/trip has been worked out as Rs.2,18,415.

It was observed during the study that, majority of the boat owners (71.88 per cent) sold the fish to middle men followed by 28.12 per cent who sold it to co-operative societies. Sale of high value export fish such as cuttle fish, prawns, and ribbon fish was done through middle men (87.50 per cent) followed by 12.50 per cent who sold them to co-operative societies which in turn supplied them to exporters.

3. Strategies for sustaining the tuna fisheries along the coast of India (PEL/IDP/03)

Indian EEZ is very extensive is and characterised by high productivity and species richness. Tunas and allied groups dominate pelagic apex predatory group. The harvestable potential of tunas from the EEZ is estimated as 277,972 t. Neritic tuna represent 23.6% of their potential accounting around 65,472 t. Major share (76.4%) of the potential was supported by oceanic species, 212,500 t. Though the total marine fish production from the EEZ is very close to its potential, total tuna landings constitute only 40 % of their estimated potential. Tuna being one of the important pelagic resources along the coast of India, they contribute to the annual marine fish production to the tune of 3 to 5%. Advancement in harvest and post harvest technologies in the marine fisheries sector during the past three decades ensured better exploitation in the coastal waters. Stagnation of fish production from the near shore waters, forced the fishers to explore and expand the fishing areas into deeper waters for oceanic resources like tunas, pelagic sharks, barracudas, squids etc. Global increasing demand for sashimi grade fishes in the international market has lead to the development of focused and targeted fishery for tuna in several countries including India. Consequently tuna production registered steady increase over the years. This is mainly due to increased contribution by oceanic tunas. In view of the expansion of exploitation into the deep sea oceanic region for yellowfin and other species, fishery was monitored to develop a strong data base required for promoting proper regulatory measures to maintain the stock and production at sustainable level. Since a complete database on the tunas are lacking it is envisaged to undertake data collection on the entire tuna resource exploited along the main coast of India. The information collected will be useful for suggesting guidelines for rational exploitation and sustainability of tuna fishery.

Tuna fishery along the Indian coast including Island territories were monitored and detailed database on fishery, catch composition, biology and taxonomy were developed. Tuna stock was assessed to understand the health of the stock for deciding on the strategies for managing the fishery. Spatial distribution map and fishing grounds of each species were prepared from the information gathered from active fishers and other sources, including published literature.

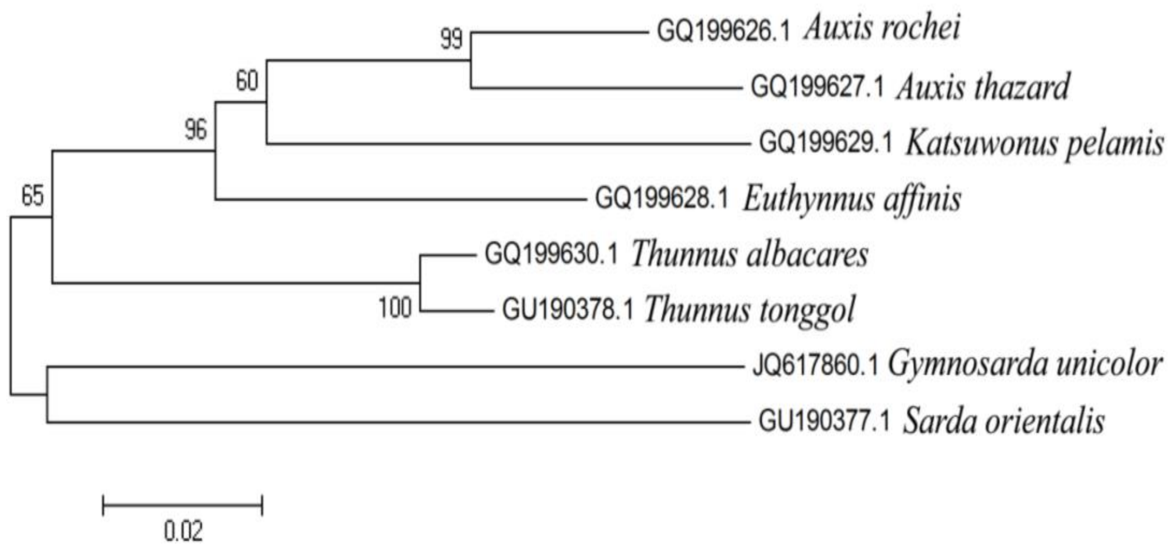


Component different tuna species in the catch (%) in coastal and oceanic fishery

Nine species representing neritic and oceanic species supported the resources and fishery. Kawakawa (*Euthynnus affinis*), frigate tuna (*Auxis thazard*), bullet tunas (*Auxis rochei*), longtail tuna (*Thunnus tonggol*) and bonito (*Sarda orientalis*t) represent the netritic species. Oceanic species were represented by Yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis)*, dogtooth tuna (*Gymnosarda unicolor*) and bigeye tuna (*Thunnus obesus*).

Taxonomy: The morphometric and meristic characters of tunas, including internal strucures like otoliths and liver were studied in detail and a taxonomic key was prepared for use in field for species identification.

CO1 gene sequences of 8 species of tunas were completed and were deposited with NCBI. The sequence developed shows significant genetic variation between species.

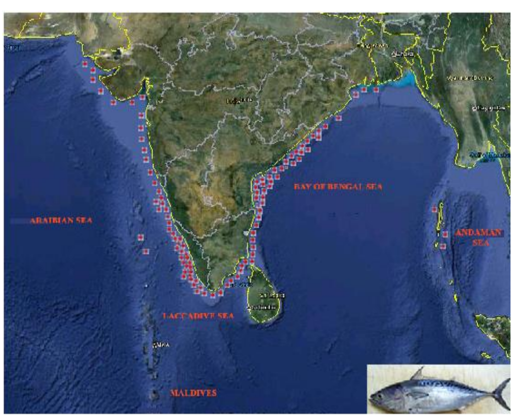


Phylogenitic tree of tuns species of indian waters

Distribution of tunas

Distribution map of tunas and their fishing grounds along the Indian coast were prepared based on the information gathered from different agencies and active tuna fishers.

Distribution map of Kawakawa (E.affinis)

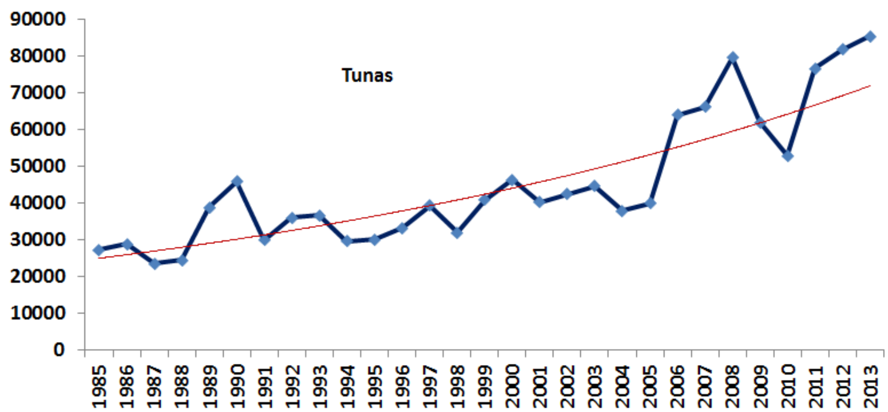


Fishing grounds of Kawa kawa along the Indian coast

The tuna landings during 2006-‘11 formed only 40% of the estimated potential (277,972 t) from the Indian EEZ. Coastal and neritic tunas are exploited very close (98%) to their potential (65,472 t). Oceanic tuna landings represent 23% of the potential (212,500 t), with, yellowfin tuna @ 23.3%, skipjack tuna 24.6% and bigeye and dogtooth tunas at negligible levels.

Production

Tuna fishery during recent years witnessed intensification, modernization and diversification of fishing practices and extension of fishing to new grounds and status of tuna landings changed from incidental bye-catch to targeted commercial catch. Average annual tuna landings during 2006-'11 was 112,365 t and it ranged between 95,372 t and 129,801 t. The landing after reaching an all-time high in 2008 has shown downtrend during 2009 and 2010, but again registered an uptrend in 2011. Average catch by deep-sea fleets during 2006-'10 was 87,239 t and it ranged between 78,904 and 100,268 t. Catch by these vessels also showed a declining trend since 2008.



Production trend in tuna along the Indian coast

Neritic tunas have been exploited both as incidental bye-catch and also as targeted catch. They are exploited at levels very close (98%) to their potential. Evaluation of fishery scenario and spatial production pattern indicate that indicate that fishery in general is restricted to coastal waters of Kerala, Tamilnadu, Andhrapradesh and Gujarat, where naturally high fishing activities are in vogue. Stock assessment indicates that component species are exploited either fully or at near optimum levels offering only very limited scope for further improving their production from most of the present fishing grounds. However, distribution pattern of component species indicate their abundance all along the Indian coast. This offers scope for improving their production from presently less exploited areas of ther coast. Potential from such areas haven to be assessed for expanding their fishery and production.

Oceanic tunas were being exploited as targeted fishery at some part and as incidental catch in several coastal fishery. Their landings accounts only 23% of their potential (212,500 t). The component species yellowfin tuna and skipjack tuna are exploited respectively at 23.3% and 24.6% of the potential. The bigeye and dogtooth tuna remains almost un-exploited. It is to be noted that except from Andhrapradesh, Tamilnadu, Kerala and Lakshadweep no concerted efforts were made to tap oceanic resources. Evaluation of the oceanic tuna fishery shows that fishing for oceanic species from these regions, however were limited to outer continental shelf and adjacent oceanic waters and seamounts along the Laccadive ridges, where skipjack tunas and smaller ones of yellowfins aggregates. Seas around oceanic Island territories are reported to have the highest concentrations of oceanic tunas, but yield from these areas were very low. The spatial pattern of fishing by coastal fleets shows that exploitation limited to small areas leaving vast areas of oceanic EEZ, where big fishes frequents remain un-exploited. The distributional map of oceanic species indicates good abundance of all species in the oceanic part of EEZ. This offers considerable scope for improving their production through expansion of fishery to oceanic waters. However, a precise information on their spatio-temporal distribution and estimates of abundance is still lacking. Since, several Indian registered oceanic fishing vessels and many illegal foreign fishing vessels catches considerable quantum of oceanic tunas from EEZ, the extent and mode of their exploitation and all activities in the adjacent and international fisheries exert considerable influence on the stock abundance and availability for any fisheries, such interactions needs to be seriously accounted during time to time, while assessing the stock and projecting potential.

The major issue in the development of oceanic tuna fisheries is the lack of skilled manpower. Fishers from southern Tamilnadu are the most skilled in oceanic/distant water fishing since time imemmorial, but their interest is mainly on elasmobranchs and billfishes with tunas having only secondary imporatce for offseason fishery. Skill of the fishers for oceanic fishing must be enhanced through disseminating scientific awareness on the distribution pattern of tunas, capacity building through proper training in tuna long lining and post-harvest handling.

The present tuna fleets (modified trawlers) also have several operational limitations for fishing in oceanic waters. Since most of the trawlers have such limitations, their redeployment for deep sea distant water fishing should be made with care. Instead, large long-liners with deep-sea going facilities, adequate carrying capacity and onboard postharvest handling facility needs to be introduced from mainland and Island territories. Introduction of large factory or mother vessels should be considered, so that catch can be collected afresh in the mid-sea and transported to mainland or processed on board.

Recent reports suggests that there are sharp decline in the catch of major oceanic tunas from Indian Ocean and global waters and is attributed to reduction in the effort input by purseseine (IOTC, 2010; 2011. However, these reports showed heavy fishing activities along the Mascaren plateau Chagos-Laccadive ridge and Andaman ridge in Indian Ocean. More than 1/3rd of the catches of different species from this area were by purseseines, of which nearly 50% of yellowfin and 85% of skipjack tunas by FAD associated fishery. Since, smaller ones of all species aggregate in large numbers around FAD's, it is to be assumed that catch by such fishery will be mainly by sub-adults and small juveniles. Such fishing activities are very much rampant especially along the migratory routes by tracking their movement. These developments might have added to the decline in stock and yield of migratory species and is an area which require immediate attention by all stake holder countries.

Summary

- The fishery biological observations and stock assessment of component species indicate that stock in general is healthy with sufficient spawning stock biomass to support successful recruitment.
- Coastal and neritic tuna production reached very close to their estimated potential. The coastal waters of Kerala, Andhrapradesh, Tamilnadu, Goa and Gujarat are intensely exploited and had only limited scope for increasing their production from these grounds. The scope for increasing their production lies with the less exploited coastal areas of mainland and Andaman-Nicobar waters,
- Neritic tunas are available in appreciable quantities over and around knolls, sea ridges and sea mounts. Planning their exploition resquires sound information on their potential in such areas.
- The oceanic tuna fishery is restricted largely to traditionally known productive grounds- shelf break areas, around Island systems, knolls and seamounts where skipjacks and smaller ones of other oceanic species congregate.
- Latrger yellowfins and bigeye tunas are available in deeper waters and they remain unexploited by coastal based fleets. Part of these stocks are being exploited by country registered and illegal foreign vessels.

SPONSORED PROJECTS

1. **Impact adaptation and vulnerability of Indian agriculture to climate change Implementing since April 2007 (as participating Division)**

To understand the impact on climate change on the fishery of oil sardine a small pelagic, SSB and recruitment (in numbers) was studied using Length Cohort analysis of historic annual length frequency data (1964 – 2010) of Central Kerala coast. SSB in % of the total standing stock of oil sardine was high during the 80s and 90s yet some of the lowest catches (1986, 1987, 1993 - 96) were also observed during this period indicating climate / environmental conditions may be influencing spawning activities and also recruitment success.

2. **Assessment of myctophids resources in the Arabian Sea and development of harvest and post harvest technology (Implementing since April 2007(as lead Division)**

Myctophid/ lanternfishes are the most ubiquitous fishes in the world ocean with a total estimated biomass of 600 million tons. The Indian Ocean has a rich fauna of lanternfishes both in number and biomass. Their biomass was estimated as 100 million tons in the Arabian Sea. They form major portion (20-35%) of the bycatch in the deepsea shrimp trawls. By considering them as the future protein source for human and other domestic animals, the project was initiated to understand their biology and stock dynamics in the Arabian sea for developing future strategies for exploitation and utlization.

Myctophid catch by deep-sea shrimp trawlers operating from different harbours along the Kerala coast were monitored to develop database on their catch, catch composition, taxonomy and biology of species. They were caught in appreciable quantity along with other mesopelagics. The deep-sea shrimp trawlers operate between off Quilon and off Mangalore, along the southwest coast of India (8^0 20' – 12^0 38' N; 74^0 20' – 76^0 25' E) at depths of 200-500 m. Fishing was carried out both during day and night hours. Myctophid catch ranged between 840 and 1,680 kg/weeklong fishing trips. Besides, several fold of them discarded back into sea for want of storage space onboard fishing vessels. Annually an average of 2,667 t of myctophids were landed during 2009 – 2011. Catch rate estimated as 6.3 - 9.5 kg/hr with an average of 7.9 kg/hr. Fishery though occurred year round, peak landings were during November- February. Catch was supported by five species *viz*., *Diaphus watasei* (74.23%), *Neoscopilus microchir* (20.57%), *Benthosema fibulatum* (1.94%), *Diaphus garmani* (1.69%) and *Myctophum obtusirostre* (1.58%). *Diaphus watasei* and *Neoscopilus microchir* were available round the year whereas, other species occur only seasonally. Myctophids from Lakshadweep waters were also collected during other fishing trips. Three species, *Symbolophorus rufinus*, *Myctophum spinosum*, *Diaphus thiollieri* represented the surface collection from this area.

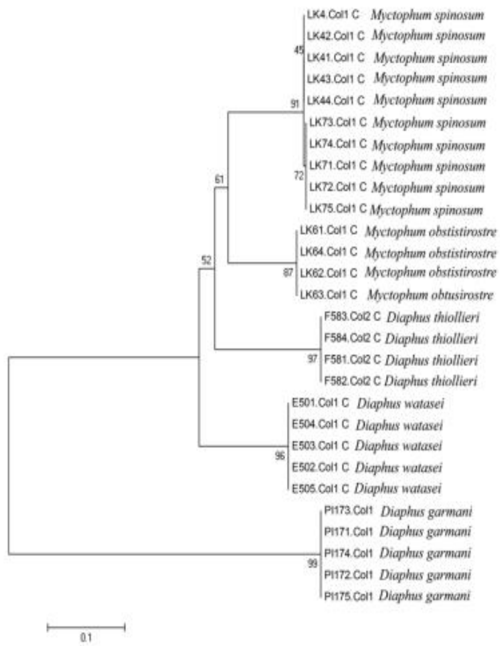
Myctophid species collected during the study

Taxonomic studies:

Morphometric and meristic details of eight species; *Diaphus watasei*, *Diaphus garmani, Diaphus thiollieri, Neoscopelus microchir, Myctophum obtusirostre Myctophum spinosum, Symbolophorus rufinus* and *Benthosema fibulatum* were studied in detail and taxonomic data were updated. DNA sequence was also used to confirm identify of the species. Barcoding of five species *M. spinosum, M. obtusirostre, D. thiollieri, D. watasei* and *D. garmani* were completed. The COI sequences of five species of myctophids showed a clear cut barcode split congruent with morphological diversity. Interspecific distance showed that 9.6-13.1% divergence between *Myctophum s.* with *M. obtusirostre* and *D. watasei* with *D. garmani* respectively. Very low intraspecific divergences were found in four specimens of *M. spinosum.* Maximum of 0.5% interspecific divergence found in *D. watasei.* Sequences were deposited in the Barcode of life Database (www.barcodelife.org).

Nutritional evaluation of *D. watasei* shows that their meat contains 15.6% protein, 11.7% fat, 0.5% minerals, 0.3% soluble carbohydrate and 0.01% crude fibre. This shows that nutritionally they are comparable with other commercial food fishes and hence could be a potential source of alternative protein and fat for future. Since huge quantity of this protein rich resources are being discarded in to sea every year; concerted effort may be put to make use of this resource effectively for the society, like development of value added product for human consumption or as a protein source in the diet of other domestic animals and fishes. Success of such attempts will lead to the targeted exploitation and use of this present day discards.

There is no commercial exploitation of myctophid resource from any part of the world, indicating that the huge stock as a whole remains grossly under-exploited. Also the extent of distribution and abundance of the resource in the ecosystem remains to be ascertained further along with exploitable potential. A clear understanding of the biology and population parameters of all component species is the essential pr-request in the development of future strategies for their exploitation. However, such information is limited. So, dedicated attempt must be made to study and fill this knowledge gap.



Neighbor-joining tree of myctophids

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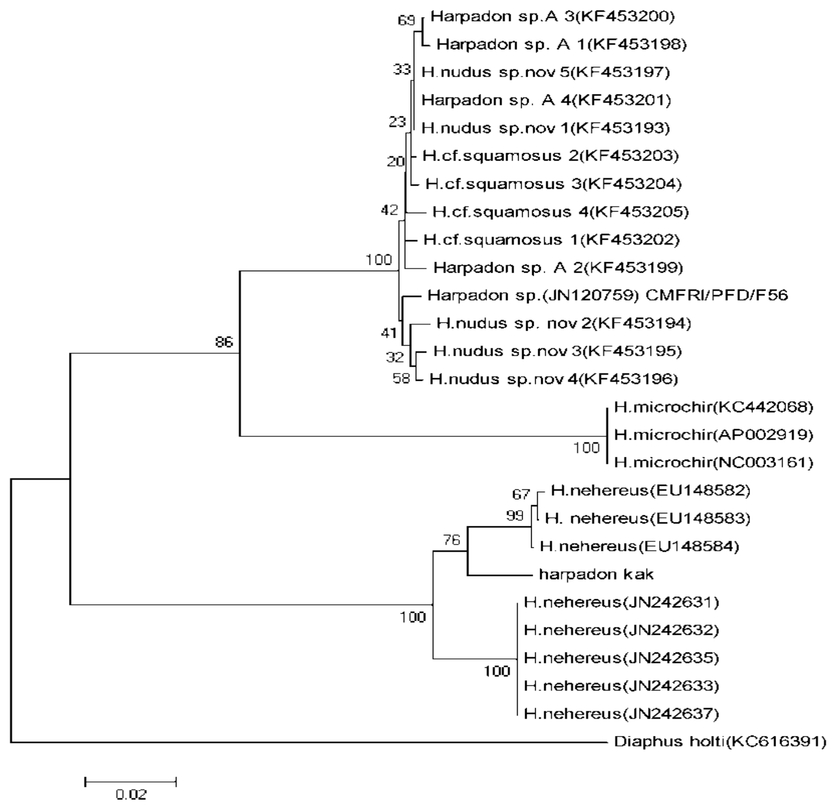
3. Assessment of demersal fishery resources of the Indian continental slope and Central Indian Ocean (Implementing since April 2007(as lead Division)

- Exploratory deepwater fisheries resource surveys onboard FORV *Sagar Sampada*were made in the Arabian sea and Bay of Bengal. A previously unreported species of Genus

Harpadon from the Northern Arabian Sea of Indian EEZ has been caught off Veraval at 275 – 310 m depths. Morphologically these differ from *Harpadon nehereus* the only reported species in the Northern Arabian Sea by its distinctively small size (220 mm TL_{max}) and very short pectorals (9.4-11.1 % SL). DNA barcoding (sequencing of ca. 650 bp region of mitochondrial gene Cytochrome oxidase subunit I) and phylogentic analysis confirmed the results and indicate presence of 3 species in Indian seas which is important from the perspective of fisheries management for bombayduck.



- A fishing ground for the deep sea shrimp *Aristaeopsis* (*Plesiopenaeus*) *edwardsiana* (Johnson, 1867) off Trivandrum was located with a high CPUE of 14 kg hr-1.

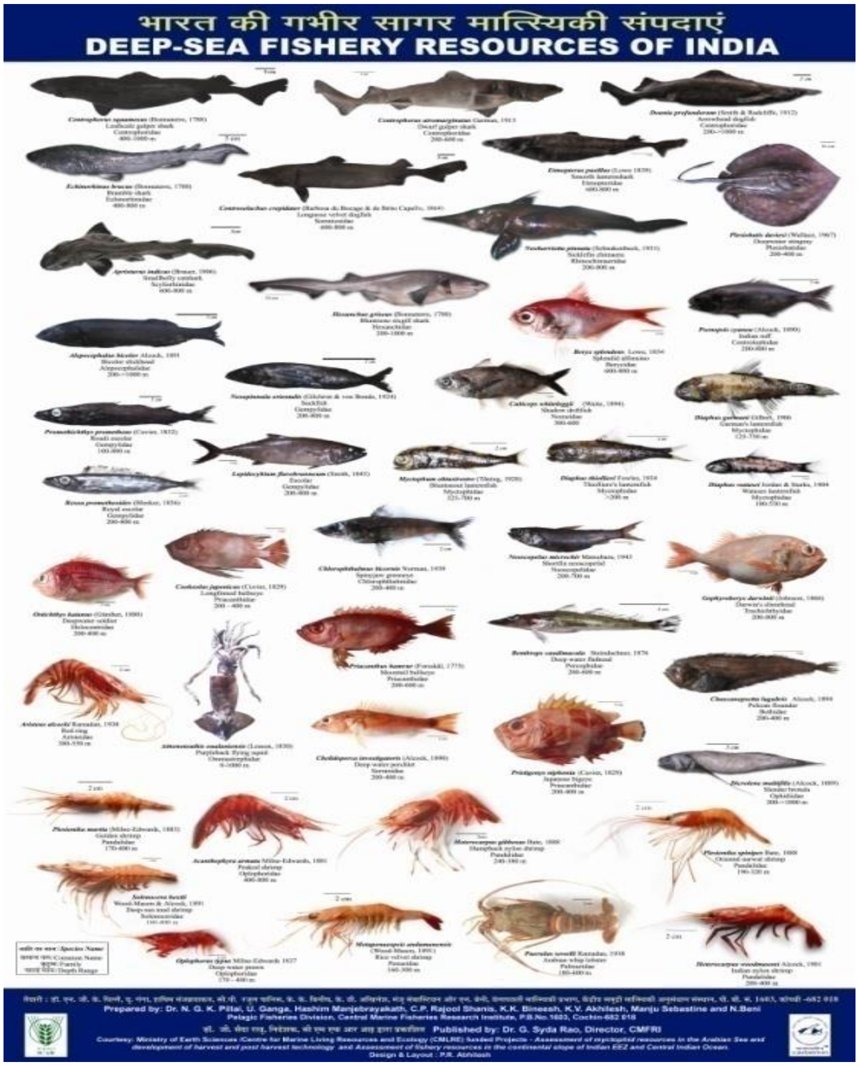
- The taxonomically difficult complex of *Plesionika* 'narval' group comprising 14 species found in the deep-sea (> 200 m depth) was studied using standard taxonomy as well as molecular DNA tools. The occurrence of *Plesionikaquasi grandis* as the dominant species in the deep-sea shrimp fishery along the southwest coast of India was confirmed (NCBI GenBank Accession number JF340436).

- Distribution pattern of deep-sea fishes indicated three major clusters of distribution, namely upto 400 m, 401 – 1000 m and > 1000 m. Certain species like *Bathyurocongervicinus* and *Alepocephalus bicolor* had wide distribution in terms of depth (200 - >1000 m) while species like *Anoplogastercornuta* and *Aristaeopsisedwardsiana* were found only beyond 800 m depths. *Chlorophthalmus* spp. were predominant in the 200 – 400 m depths while the eel *Gavialicepstaeniola* was most abundant in the 400 -600 m depths.

- Species like *Chlorophthalmusagassizi*, *Neoepinnulaorientalis* and *Priacanthushamrur* exploited a wide range of prey and most of the species in the 200 – 500 m depth zone fell in the trophic guild of macronekton foragers with a varied diet of planktonic crustaceans (mysids, euphausiids and decapods), cephalopods, chaetognaths, myctophids and other mid-water fishes. Piscivory was common among the large fishes of the 200 -800 m depth zone while deep-sea squids were comparatively rare in the diet of deep-sea fishes found here.

- New records of gapers *Champsodon nudivittis* and *C.snyderi* from the northern Arabian Sea was reported. Study confirmed the presence of a *C. Nudivittis* population in the northern Arabian Sea comprising of reproductively active, mature fish, which was believed to be absent so far. It is a carnivorous predator, feeding on young of several commercially important fishery resources such as the pandalid shrimps, sergestid shrimps (*Acetes*) and the Indian codlet *Bregmaceros* spp. found in the northern Arabian Sea.

- A poster on deep-sea fishery resources was published which gives details of 10 species of sharks, 22 species of finfishes, 10 species of crustaceans and 1 species of mollusk of the deep sea habitat that are of potential interest to the fisheries sector. The scientific name, family, common name, depth of usual occurrence are presented along with specimens depicted to scale



4. A Value Chain on Oceanic Tuna Fisheries in Lakshadweep Seas (Funding - NAIP -ICAR)(Project No.: 2000035103)

The project was implemented to expound an integrated plan of fisheries development in Lakshadweep and to improve livelihood as well as employment opportunities for the stakeholders. The project aimed at developing a value chain for tunas through technological interventions and collective approach for proper exploitation and utilization of oceanic tunas. Consortium leader was Central Marine Fisheries Research Institute (CMFRI), Kochi, Co-Investigators were CIFT- Kochi, FSI-Mumbai, Department of Fisheries, Lakshadweep and MPEDA, Kochi. Private firms, NGO's and stakeholders were taken as partners. Work was carried out systematically and the objectives were envisaged within the time frame.

Background information and interventions

i. *In depth information on the technological advancements in fisheries and allied areas and socio-economic status of fishers of the Islands were lacking, which were the basic requirements for deciding on the level of interventions required.*

- A baseline survey was conducted in two islands, Agatti, a typical fishing island and Kavaratti, the Administrative capital, with advanced technological developments over other islands. Fisheries plays main role in the economy of Lakshadweep Island Full time fishermen are less in terms of proportion in islands where there were more avenues to pursue non fishing ventures. Even though male dominate processing activities, females also closely followed the activities which indicates near equal share in manpower. The annual potential fish yield has been estimated as 100,000 tonnes. But only less than 10% is exploited. Catch was support by about fifteen commercially important species. Though rich in biodiversity, exploitation was mainly on skipjack tuna by targeted fishing. This fishery in general is at sustenance level.

ii. *Earlier reports indicated the region as rich in diversity; fishes alone represented more than 600 species with rich stock abundance. However fishing activities were restricted mainly to territorial waters centered on skipjack tunas. Considerable fishing activities were also reported from deeper waters by other fishers. In order to have a precise idea on the level of exploitation on major resources especially tunas and to assess the scope for fishery expansion, a resource assessment was carried out.*

- The annual catchable potential of fish was estimated to be around 100,000 ton with major share, 50,000 t to 90,000 t tunas and like fishes. Lakshadweep fishers could exploit only around 10% of this potential. The dominant resource, yellowfin tunas are abundant in deeper waters, but remain non-targeted by them. Skipjacks were exploiting at its optimal level with limited scope for further increase; whereas yellow fin tuna and all other resources remain under-exploited and offer large scope for augmenting production.

- Eco-model for Lakshadweep pelagic ecosystem was simulated. Tuna and apex predators were sustaining mainly on crabs, small tunas, flying fishes, squids, caesionids, and spratalloides. It is found that prey abundance influence the tuna availability and fishery. This suggested a balanced fishery approach to maintain the equilibrium of ecosystem and sustaining the yield

- Exploitation strategy and fishery management plans for resource managers and policy makers of Lakshadweep was proposed for the development of fishery. A document ***"Road map for sustainable fishery development for Lakshadweep***" was prepared and submitted

iii. *Pole and line from Pablo boats was the major gear in fishing followed by gillnets, handlines and troll lines. The major catch was skipjack tunas. Yellow fin and other large pelagics were nominal in the catch. In order to generate awareness and also to equip them for exploiting yellowfin tuna and other large pelagics, existing crafts /boats were modified and new medium sized vessels were leased and introduced for demonstration of the longline fishing method.*

- 15 traditional Pablo boats were modified to suit the operation of longlines for exploiting large yellowfins and large pelagics.

- Two medium sized (62') tuna longliners were leased and fishers were trained onboard on tuna longline operation.

- Exploratory surveys were conducted by leased vessels and FSI research vessels, the areas of yellowfin tuna abundance were located and a spatial distribution map was developed. Potential fishing grounds were identified between latitude 8 – 12° N and longitude 73-74.4° E.

iv. *Since only single day fishing being practiced to meet the demand for domestic consumption, canning and Masmin preparation, proper handling and preservation practices were not followed. Moreover, for Masmin preparation traditional methods were followed with minimum quality standards. Disposal of waste into beaches pause threat to the fragile ecosystem.*

- An improved package of practices for handling for fish catch was developed and demonstrated on board and at landing centres to ensure the quality of harvest and products.

- Protocol for preparation of improved *Masmin* using liquid smoke was developed and popularized. The new product was free from benzopyrene and with promising export potential.

- Several value added and ready to eat products were developed, production parameters were standardized and demonstrated to women SHG's, NGO's and other stake holders.

- Technologies developed for the production of nutraceuticals/value added products for human and pet animals from tuna processing wastes were standardized and demonstrated to stake holders.

- The products developed were field-tested for acceptability and performance evaluation. The technology for "Tuna Kure" production was transferred to M/S Amritha metals, Kochi for commercial production. MOU was signed during Agri-Investors meet organized at New Delhi.

- Several processes were developed and standardized for the enhanced quality and consumer appealing of tuna products. They include:

  - *Pulsed Light treatment for extended shelf life and superior organoleptic value*
  - *Application of carbon monoxide for enhanced colour of sashimi grade tuna*
  - *Liquid smoke production for benzopyrene free masmin production*

Impact of Interventions

- Increased awareness attracted more fishers to yellowfin fishing by modifying their single pole and line fishing practice to double pole and line, carrying steady uptrend in production during the period.

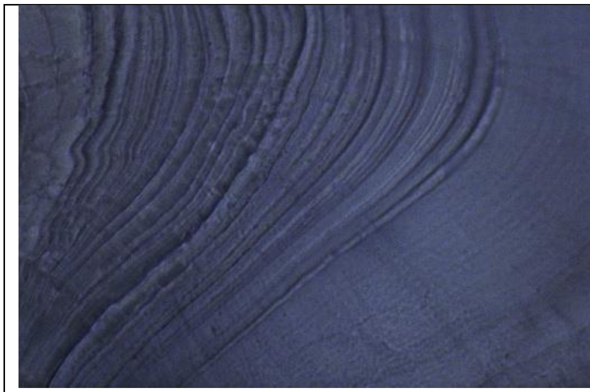
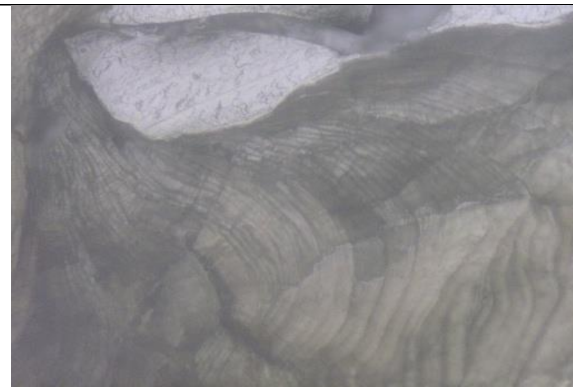
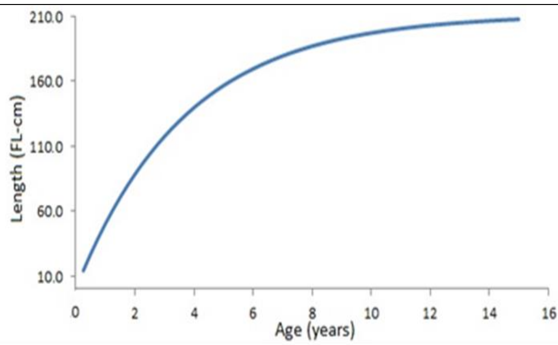
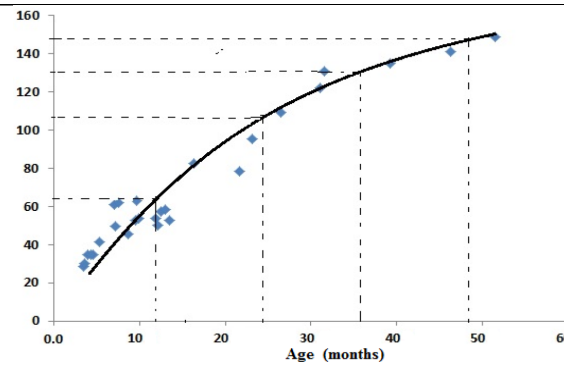
- The first milestone achievement of the project was a prospective entrepreneur of Agatti Island who introduced a new 60' vessel mainly for yellowfin tuna fishing and transportation to mainland. At public sector level, Lakshadweep Fisheries dept introduced a 10 t carrier vessel to collect catch afresh from fishers and for transport them to mainland. Department of Fisheries, UT of Lakshadweep envisaged several promotional plans to encourage oceanic fishing. They are offering financial assistance for the introduction of large multiday day fishing boats and also for the upgradation and modification of existing crafts

Research achievements

Database on the marine fisheries of Lakshadweep and biology of component species in the fishery were developed and their population and eco-path parameters were estimated and stock assessment of tunas were conducted.

Validation of Age estimates of yellowfin tuna using hard parts

Yellowfin tuna was aged following growth inscriptions on hard parts of the body such as otoliths, scales and dorsal fin spines. Since, otoliths provided consistent results, presently relied only on otolith inscriptions. The otolith based age estimate was used to validate the age estimates obtained from modal progression analysis . The results indicated that the species grow much faster than the earlier estimates by modal progression analysis.

	
Yellow fin tuna Otolith Section with age rings (Daily rings)	
	
Growth following modal progression	Growth following growth rings in otolith

Health of the stock

Tunas and other large pelagics in Lakshadweep waters remain under exploited. Yellowfin tuna fishery is very much at its initial phase of exploitation. Fishery by Islanders limited to territorial waters and adjacent seas and catch was constituted by skipjack tunas relatively small yellowfin tunas. Large yellowfins from deeper waters remain inaccessible to them. Fishery data indicated that during 2004-2012 only around 10.0 % of the estimated fishery potential was exploited. Large pelagics and reef associated fishes yet to be targeted by Lakshadweep fishers.

Trophic model .

1. The biotic components of the ecosystem were divided into 25 functional groups.
2. The Functional groups includes – marine mammals, birds, all tunas, large pelagics, small pelagics, halfbeaks and silver bellies, reef associated – herbivores, carnivores, omnivores, Bait fishes, crustacean, molluscans, seaweed, sea grass, zooplankton, phytoplankton and detritus.
3. Model trial runs were done for a period of 10 years and simulation was also done using

Ecosim software.

4. Model runs show that functional groups influencing pole and line fishery in Lakshadweep ecosystem are baitfishes, small pelagics, reef associated carnivores, herbivores, and large pelagics. The inter-relationship between different functional group is well balanced and simulation studies shows how the stock and yield will change if different functional groups were affected by fishing or otherwise.

Fisheries management advisories

The present situation offers considerable scope for enhancing production of tunas and large pelagic from this area. However, the fishery development should be taken up in phased manner. Since, Island territory have lots of inherent limitations, all fishery development package will be successful only if there is active participation from mainland

Since fish being highly perishable commodity and having limited internal market in the Island territory, the fishery development activity should start with the development of adequate facilities to handle process and store or transport the surplus catches to outside market. As a natural corollary to this development and investment, adequate infrastructure by way of modern fishing harbours, processing fishery estates, power and water supplies and communication and marketing channels are required to be established.

Size of the facilities developed should be decided based on the planned production in each phase. Two or three major centres have to be identified based on the endowment pattern from where the fishing boats are proposed to be operated and facilities like jetties, uninterrupted power supply, diesel out lets, potable water, ice plants, processing plant and cold storage to be provided.

So the components of the development strategy should include ensuring or establishing the basic requirement as follows.

i. **Adequate power supply** for ice plants, processing plant and cold storage and jetties.

ii. **Adequate freshwater supply:** Large quantum of freshwater is needed for ice preparation and processing for storage.

iii. **New ice plants or revive the existing ones at all islands** to ensure adequate ice supply.

iv. **Processing units with modern facilities** to produce Sashimi/loins grade tuna and other products of export importance at all Islands .

v. **Added facilities** like, (a). Fish feed cum oil extraction units, to prepare value added products like fish meal, fish oil, live stock/fish feed etc from the tuna processing waste. (b). tuna kure production units to prepare value added ready to eat snack products from red meat.

vi. **Improved masmin production and packing units** to promote the export.

vii. **Cold storages of required specifications** at all Islands.

viii. **Jetties** for fishing boats at strategic points.

ix. **Diesel outlets and portable water** supply.

x. **Modification/diversification of surplus Pablo boats** for yellowfin tuna fishing.

xi. **Introduction of large high-tech vessels for tuna fishing f**rom distant waters.

xii. **Introduction of Carrier ships** to collect the catch afresh from the fishing units in the mid-sea, to process onboard or to transship to nearest processing facilities.

xiii. **Equip fishing units with advanced communication facilities** like VHF and GPS, to enable quick dissemination of the appropriate information in time.

xiv. **Pilot demonstration, fishing trials and training:** *A*ll new introductions of craft and gear or technology to harvest unexploited potential resources should start as pilot demonstration fishing trials to show their techno-economic viability.

xv. **Ensure adequate market linkages and communication network:** Direct air and sea connectivity with the mainland and nearest major world tuna markets has to be established.

xvi. **Cage culture of Yellofin tuna**: Small yellow tunas always form a component of pole and line catches, they can be culture in open sea floating cages of large cages under PPP programme with mainland association.

Production

Improvement of existing small craft and skill development

Fifteen Pablo boats; including two Department boat at different Islands were were modified for demonstrating tuna longline fishing for harvesting large yellowfin tunas.

Fishers form all Island were trained in modification/conversion of Pablo boat. They were trained in splicing ropes, rigging monofilament into main line and branch lines for long lining operations

Products & processes developed and standardized for commercialisation

Products developed

- *Improved Masmin*
- *Value added products from Masmin*
  - *-Masmin flake*
  - *-Masmin Powder*
- Smoked tuna in oil

  Value added products from processing waste

  Ready to eat products

  -Tuna kure- protein rich snack product from red meat
- Ready to cook product

  -Tuna soup powder, pappad and wafers


Tuna Kure

Tuna Kure packets

- Animal feeds

  -Silofish feed, pig feed and pet feed

- ***Nutraceuticals***

  -PUFA from tuna eye & red meat

- ***Confectionaries***

  -Gelatint from tuna skin

- ***Other products***

  -Sausage, tuna ball, tuna Kebab, tuna burger, tuna cutlet, tuna roll

These technologies were standardized and ready for transfer to private entrepreneurs. If adopted will ensure new employment opportunities, development of small scale industries and income generation. Women empowerment through self help groups will be an additional benefit for the island and reduce the pollution. It will also reduce the health hazard concern of the island ecosystem.

Processes developed/standardized

- Pulsed light treatment for shelf life enhancement
- Carbon monoxide treatment for tuna steaks to enhance and maintain the colour and appearance.


Tuna meat before & after CO treatment

Handling protocols for fish on board and at landing centres were developed and transferred to stake holders for for improving the quality of produces to ensure better consumer acceptance and enhanced demand.

S kill enhancement programmes were conducted on improving the quality standards of traditional products, development of value added products and effective way for utilizing processing wastes into value added products. Some of the suggestions were already taken up by some entrepreneurs.

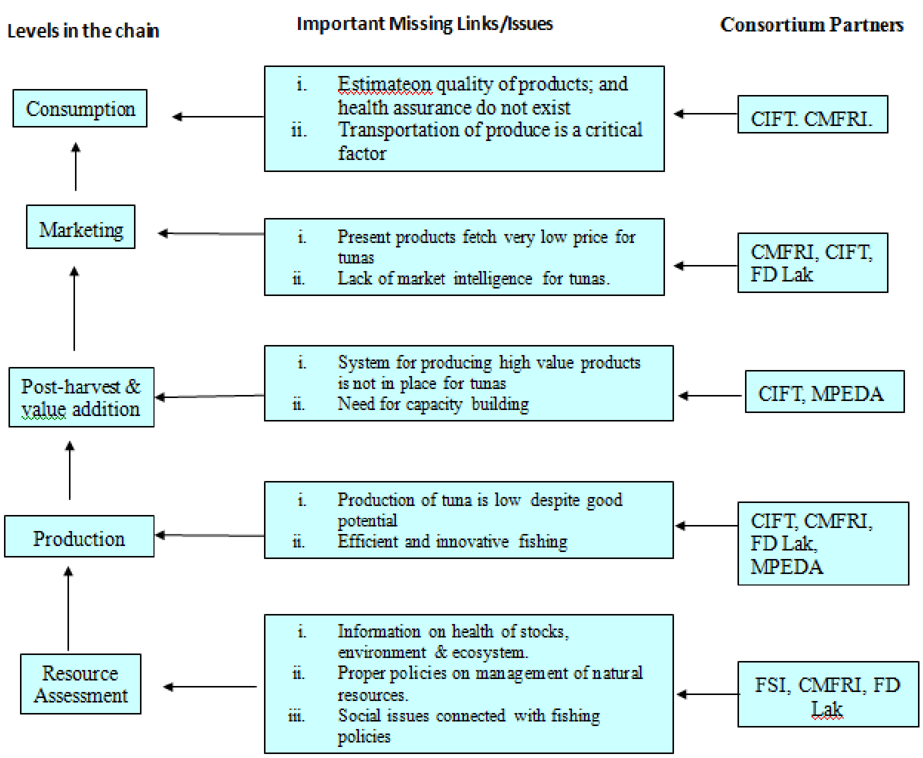
Inpact of intervention

- Fishers were trained on all aspects of yellowfin tuna fishing right from modification of existing boats to fishing. With increasing awareness on yellowfin tuna and its potential fishers diversified their fishing activity to harvest large yellowfins. They are using double pole and line techniques for catching large yellowfins. Vertical hand lines were also used for fishing in deeper waters.
- The UT of Lakshadweep is implementing several promotional activities like financial assistance for introducing new large multiday day fishing boats or for up gradation / renovation of crafts. Further, the UT of Lakshadweep has proposed to procure a mother vessel and also tuna long liners for operation in Lakshadweep seas.

- Department of Fisheries UT of Lakashadweep is introducing a 10 t carrier vessel to collect and transport catch to mainland/processing facilities. This vessel is at its final stage of construction and will be commissioned soon.
- Horizontally, a large (59 ft) new multi-day fishing boat was introduced from Agatti island by a prospective entrepreneur by taking the cue from the recent developments on yellowfin tuna fishing. The boat was commissioned in February 2014 and already completed two fishing cruises. The catch consisting of tunas, other large pelagic, sharks etc were landed at Mangalore. Results of both sorties were highly encouraging.

- A progressive local entrepreneur of ***Agatti Island,*** after getting awareness on value added products, established a small scale Industry "**Lakshadweep foods**" for the pre[aration and marketing of value added products from *Masmin* such as, *Masmin scrambles/flakes*, *Masmin powder* and *Mas-appam*. The products received very good acceptance among the local consumers and along the northern Kerala.

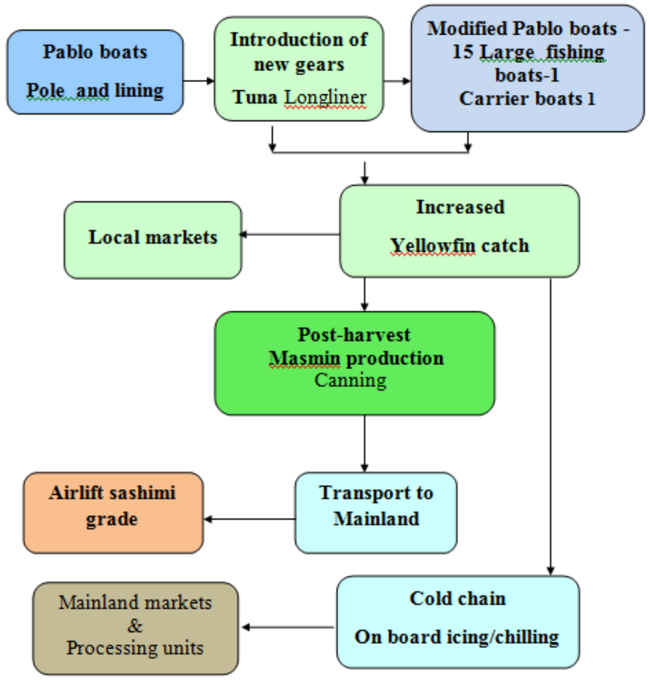
The value chain prior to NAIP



A VALUE CHAIN ON OCEANIC TUNA FISHERIES IN LAKSHADWEEP SEA

Levels in the Chain	Important Missing Links/Issues	After NAIP Intervension
Consumption	1. Estimates on quality of products & health assurance do not exist 2. Transportation of products is a critical lacking factor	Nutritional, microbial and organoleptic quality estimate of all products are availbale Cold chain for whole tuna under chilled transport established under private sector. A New carrier vessel under public sector will be commissioned soon. Improved processing and packing methods for extendedshelf life of tuna and tuna products were developed and standerdized.
↑		
Marketing	1. Low price for tuna and tuna products 2. Lack of market inteligence for tunas	Demand for improved traditional *Masmin*, yellowfin tuna *Masmin* and other value products are on the increase High perfomance and acceptability for fish/pet/pig feed prepared from tuna waste
↑		
Post Harvest & Value Addition	1. System for producing high value products is not in place for tunas 2. Need for capacity building	Processes and protocoles were standerdised for the preperation of quaity *Masmin* Women SHG's trained on value addition
↑		
Production	1. Low production of tuna despite good potential 2. No efficient and innovative fishing	Awarness on commercial value of yellowfin tuna & related resources were created among fishers Ecofriendly monofilament long lining technology introduced and fishers were trained. Double pole & lining introduced for yellowfin tuna fishery. As a resultYellowfin tuna production registered uptrend
↑		
Resource Assessment	1. Information on health of stocks, environment & ecosystem is lacking 2. No proper policies on management of natural resources	Database on ecology, biology and status of exploitation of major oceanic resource developed. Strategies for sustainable exploitation and management of tuna resource and fishery proposed

Present Value Chain for oceanic tuna in Lakshadweep



5. Satellite Telemetry Studies on Migration patterns of Tunas in the Indian Seas 'SATTUNA'(funded by INCOIS)

Tagging with pop-up tags of highly migratory fishes was found to be a good method to collect data on the movement of tunas. With this aim the present project was envisaged and proposed by Indian National Centre for Ocean Information Services (INCOIS) in December 2010.INCOIS has been providing Potential Fishing Zone (PFZ) Advisories to the fishermen community. The PFZ advisory predicts the possible fishing grounds in the ocean and has limitation in predicting the availability of species types. Keeping in view of this INCOIS has planned to develop species specific forecasts for few commercially important species. The tagging data could help in incorporating more parameters so as to enhance the accuracy levels for the prediction of the probable tuna fishing grounds. It was decided to have the complete baseline information on the environmental and biological parameters related to Tuna that helps in evolving better management procedures and accurate prediction to enhance the production. In this context a collaborative program on the above aspects with four national organizations having expertise in different aspect in satellite tracking, fishery biology, stock population, deep sea surveys, etc were brought under one umbrella to get a holistic picture on the movement, stock structure, abundance and life history traits of yellowfin tuna in the Indian Ocean. The collaborating organizations were Central Marine Fisheries Research Institute (CMFRI), Fishery survey of India (FSI) and Centre for Marine Living (CMLRE).

The main objectives of this study were to:

- To develop the baseline database on the environmental and biological parameters influencing the tuna migration and breeding.

To develop and improve the Tuna Fishery Forecast System (TUFFS) with better accuracy levels in predicting the probable tuna fishing grounds

The main activities assigned to CMFRI were:

Activities assigned

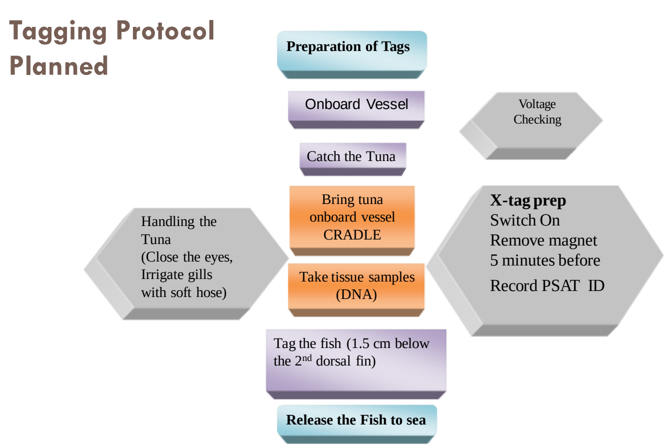
Tuna tagging with pop-up tags onboard commercial tuna boats

Hydrographic data collection at tagging point

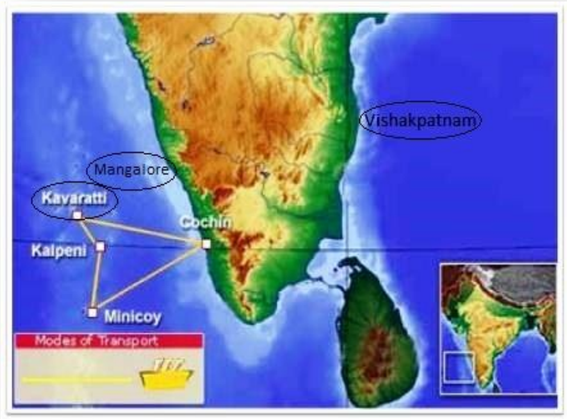
Analysis of tagging data

Biology of tuna

Analysis of ichthyoplankton samples collected



Tagging was undertaken at three location- Visakhapatnam, Laksadweep islands and off Manglaore



During the review period, thirty fishes were tagged and released into the waters. The details of all the fishery, environmental and hydrography parametes were recorded in log sheets provided.

Details of plankton collected

Phytoplankton (no. /m^3)

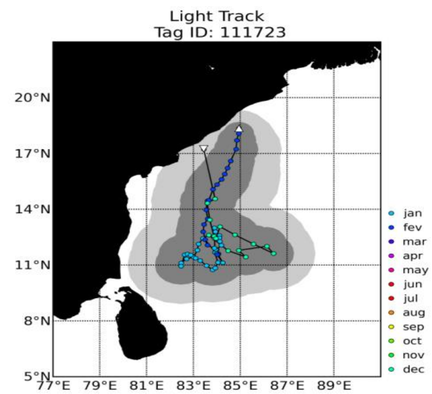
Group/Genera	22.01.2014	24.01.2014	25.01.2014
*Ceratium*spp	70	57	11
*Fragilaria*spp	32	0	0
*Rhizosolenium*sp.	19	0	0
Coscinodiscus sp.	0	96	11
Biddulphia sp.	0	38	0
*Thallasionema*sp	0	19	0

Zooplankton (no./m^3)

Group/Genera	22.01.2014	24.01.2014	25.01.2014
Copepods	64	67	87
Cladocera	80	742	81
Sagita sp.	9	0	17
Oikopleura sp.	6	0	0
Polychaeta	3	0	0
Fish eggs	64	0	0
Decapod larvae	0	0	11
Acanthometron	0	1	1

Most of the satellite tags deployed in the Indian seas during the first phase have popped off after few days to eight months duration. Data from tags that have remained out at sea for more than 3-4 weeks have been decoded and analyzed by INCOIS. Preliminary information on the movement of tunas in the Indian seas has been obtained (fig.1). In most of the cases, tunas have remained within the Indian EEZ. Information on the the number of dives made during a 24hour period, the temperature preference of the fish and the general track has been identified. A collaborative meeting is proposed to carry out detailed analysis f the data collected.

Preliminary results obtained by INCOIS from popped off tags



	
Tagging in progress	Collection of fin clipping
	
Releasing tagged fish	Phyto and zooplankton collection