Proceedings of
Brainstorming Session on

Development of Island Fisheries

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Central Agricultural Research Institute (ICAR)
Port Blair - 744 101
Andaman & Nicobar Islands

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Brainstorming Session on

Development of Island Fisheries

(Held on 21-22 June 2008)

Fisheries Science Division
Central Agricultural Research Institute (ICAR)
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FOREWORD

Andaman and Nicobar Islands encompass 0.60 million sq. km of the Exclusive Economic Zone (EEZ), which constitutes about 30% of the EEZ of India. The Andaman Sea is also potentially rich in grouper, snapper, lobster and shrimp resources that are having export potential. Out of the potential harvestable fishery resources of 1.48 lakh tonnes, tuna resources alone account for 67,000 tones.

A glimpse at the present catch which stands at 28,000 tons per annum against the estimated potential indicates the extent of under-utilization of resources in Andaman. A closer look on the catch composition would suggest that the gulf is widened more specifically due to the gross underutilization of the tuna resources, whose current annual landings linger around 800-1000 tones.

Andaman is also blessed with bays, creeks and inlets areas best suited for cage culture of fin fishes. This provides a great opportunity to exploit the vast resources of the seas around these Islands to our advantage. In the aquaculture front, A&N Islands have large brackishwater areas. The inundation of land, post-tsunami has only added its scope and these areas can be easily utilized for brackishwater farming.

In this context, sustainable exploitation of tuna fishery and development of cage culture industry in the Islands will facilitate establishment of subsidiary industries which will not only boost export but will also generate employment avenues to the people of Andaman. Apart from these, freshwater and brackishwater aquaculture, marine ornamental fish breeding and farming and post harvest technology are some of the thrust areas where emphasis need to be given for development. Hence, a systematic effort to evolve strategies for sustainable development in fisheries sector is the need of the hour and the Brainstorming session has rightly dwelt upon development of island fisheries.

I greatly appreciate the futuristic effort taken by the scientists of CARI for the development of fisheries in this Bay Island. I am convinced that this publication featuring the lead articles related to the identified thrust areas for development of fisheries in Andaman would be of immense use for evolving developmental plans for efficient and sustainable utilization of the valuable resources around the Islands.

Srivastava

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28 March 2009
Port Blair

PREFACE

The Andaman and Nicobar group of Islands are one of the most diverse, biologically rich, but fragile and beautiful islands in the Bay of Bengal. There are 572 islands, islets and rocky out crops and the Islands have an aggregate coastline of 1,912 km, which is about a fourth of the coastline of India. Andaman is having vast potential for the development of fisheries. Large coastal and continental self area, unpolluted water and productive brackishwater area and numerous bays, creeks and inlets areas make it an ideal place for all-round development in fisheries. Tsunami of 2004 not only caused destruction to the natural resources but also created huge losses to agricultural production due to submergence of land, thus endangering the livelihood of the farmers. Post-tsunami, the challenge was to restore and increase the livelihood options of the farmers as well as to evolve ways for sustainable utilization of the natural resources in the tsunami inundated areas. To develop suitable strategies for the development of fisheries in these Islands, a Brain storming Session on Development of Fisheries in the Bay Island was organized at Central Agricultural Research Institute, Port Blair on 21-22 June 2008.

The deliberations were grouped into four major theme areas *viz.,* (i) tuna fisheries in the Bay islands; (ii) value addition in fisheries; (iii) cage culture and freshwater aquaculture and (iv) HRD, conservation and other issues pertaining to fisheries of Bay Island. The lead presentations made by the delegates are compiled herewith, in which the recommendations that emanated from this brain storming session are also included separately.

We take this opportunity to express our gratitude to Dr H. P. Singh, DDG (Horticulture) and Dr. S. Ayyappan, DDG (Fisheries) for their support and encouragement for conducting this programme. We owe the successful completion of the programme to the scholarly stewardship and unstinted support of Dr. R.C. Srivastava, Director, CARI. Heartfelt thanks are due to all the delegates who represented different ICAR Institutes, Department of Fisheries, A & N administration, Regional Stations of Fishery Survey of India and National Institute of Ocean technology for their active participation in the deliberations.

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28 March 2009
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Development of Fisheries in Andaman and Nicobar Islands – A Case of the Potential going Abegging

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1. Introduction

Andaman and Nicobar Islands are known for their pristine beauty and enigmatic history. They are also known for the emerald seas throbbing with life and vivacity being the home for a great multitude of fishes and sea species. The seas of Andaman have been the home for a wide variety of species of pelagic, demersal and oceanic fishes. The pelagic resources include anchovies, sardines, mackerels, carangids, ribbon fishes, seer fishes, neritic tunas, barracuda, etc. The demersal resources constitute perches, silver bellies, pomfrets, scads, scianids, nemipterids, shrimps, lobsters, etc. The oceanic resources are skipjack tuna, big eye tuna, bill fishes (sail fish, marlin and sword fish), pelagic sharks, etc. They also include high value species like prawns, crabs and lobsters. As such, fisheries continued to be one of the major natural resources of the Islands.

2. Status

The Andaman & Nicobar Islands has a coastline of 1,912 km (24% of the coast line of India) with a continental shelf of 35,000sq.km. The Exclusive Economic Zone (EEZ) of the Islands constitute about 28 per cent of Indian EEZ. Details were as given below:

	FSI estimates (2005)	Revalidated Potential Yield, MoA GoI
Pelagic Resources (mainly coastal tunas)	56,000 MT	1,49, 490 MT
Demersal Resources (mainly Perches)	32,000 MT	1,38, 940 MT
Oceanic Resources (mainly oceanic tunas)	56,000 MT	1,49, 490 MT

This huge potential, if tapped optimally, could be a major contributor to the GDP of this tiny Union Territory and to the country as a whole as well. However, as against the estimated exploitable potential as above, the marine fish production in the Islands amounted to just 30,000 t during the year 2007-08 constituting a meagre 19 % of the estimated potential.

There are 97 fishermen villages in the A & N Islands with a population of 15,320. Around 5,617 full-time fishermen and 718 part-time fishermen are engaged in marine fishing activities in the Islands. They operate about 2,808 fishing crafts of which 1,524 are non- motorised/traditional crafts, 1,279 motorised crafts and 10 mechanised boats. The main fishing gear used is drift gillnet, which contributes to over 40 % of marine fish landings. The other fishing gears commonly used are shore shine, hook and line, long line, cast nets, etc. There are 57 beach landing centres and 8 fish markets.

3. Strategy

Fisheries being the major natural resource of A & N Islands, the Island Development Authority had identified fisheries as a thrust area for the development of the Union Territory. ANDFISH, a perspective master plan for the eco-friendly development of fisheries in the A&N Island was prepared and submitted to the UT Administration in August 2005 by the Indian Council of Agricultural Research (ICAR), New Delhi after intense deliberations among its constituent institutes like CMFRI, CIFT, CIBA and CARI. It covers the developmental aspects of coastal and oceanic fisheries, fishing technology, post-harvest handling and processing, brackishwater aquaculture and mariculture for the XI and XII Plan periods. The strategy for development of fisheries on commercial lines included,

- focussing primarily on exploitation of tunas
- upgrading existing crafts with FRP coating and improved gillnets and lines
- introducing 3 new classes of vessels (gill-netters and long-liners) for exploitation of coastal tunas
- introducing large tuna long-liners for the exploitation of oceanic tunas and production of *sashimi* grade tuna for export to South and Far East Asia.

The infrastructure requirements of crafts & gears for development of tuna fishery in the Andaman & Nicobar Islands as envisaged in ANDFISH, the master plan for eco-friendly development of Fisheries are as under :

Details of Craft & gear	Total cost of craft and gear	No. of vessels	Total Cost (Rs. lakh)
For Coastal Tunas			
Motorized / Sail fitted boats (LOA: 10-12 m) with 1000 m Gillnets/longlines	8	125	1000
Mechanized / Sail fitted Gillnetters (FRP Hull fitted with wooden deck- LOA: 12.5m) with 1500 m Gill nets	12	200	2400
Mechanized Longlines (FRP Hull fitted with wooden deck- LOA:12.5) with 1000 hooks longlines.	12.5	200	2500
For Oceanic Tunas			
Longliners 25 -30 m OAL 600 – 700 hp engines Fish hold capacity 30 MT at – 60C – 2000 hooks longlines and 3000 m Gill nets	530	53	28090

In addition to the above, the plan also identified the following:

- Introduction of air/sea connectivity to Bangkok and Singapore markets with cold storage cargo handling facility for export items such as *Sashimi* tuna.
- Development of Fishery Estates with all required facilities (roads, diesel outlets, potable water, ice plants, cold storage, processing plants) at 3 major fish landing centres (Diglipur, Port Blair and Campbell Bay).
- Canning plants to make use of coastal tunas/ skip-jacks.
- Hygienic waste disposal system.

In addition to building the infrastructure for the development of fisheries in the Islands on an on-going basis, the fisheries department of the Union Territory administration provided a wide array of subsidy ranging up to 50 % to marine fishermen or tribes and their cooperatives under various schemes for the purchase of deep freezer, fish transport vehicle (insulated or refrigerated) and tricycle, boats, out board engines, etc. An assistance of Rs.5,000 for renovation of pond or tank is also provided once in five years.

4. Missing Link

Notwithstanding the potential available for the development of fisheries activities, conscious efforts in planning for a structured development of the sector and the massive incentives provided by the Government, achievement under fisheries sector presented a dismal picture. Credit flow to the sector had been rather minimal. Credit flow from the banking sector towards fisheries constituted just Rs.164.08 lakh, Rs.194.57 lakh and Rs.133.76 lakh during the years 2005-06 to 2007-08 respectively, as against the aggregate requirement pegged at Rs.28,090 lakh by the ANDFISH document. It is indeed a paradox that the credit flow to this sector is not commensurate with the priority being accorded by the Government of India and the Union Territory Administration to development of fisheries. This clearly indicates that various players involved have not been acting in tandem so as to secure the possible synergy. Given the scope of this sector for contributing to the GDP as also boosting the export earnings of the country, it is time the prevailing trend is reversed and the growth of the fisheries sector is put on a higher trajectory. There is a need to upscale the development on a commercial basis by an appropriate Public-Private partnership. This will call for a more proactive role on the part of the Administration and the banks. Taking into account the above as also various infrastructural developments, NABARD's Potential Linked Credit Plan for the year 2009-10 has estimated a credit flow of Rs.4959.50 lakh from the banking system in the Islands. This could become a reality only with creation of appropriate awareness among the fishermen community and other prospective entrepreneurs coupled with necessary motivation of the banking fraternity.

5. Looking Ahead

The critical issue that would requires closer scrutiny is the inescapable reality that the achievements under fisheries has been far from satisfactory notwithstanding the huge potential and conscious efforts to tap the same. Potential does not translate into realisable income or tangible wealth with developmental initiatives undertaken in fits and starts in a non-continual manner. It is time that the missing link is identified. Creation of awareness and motivation, training and skill inputs, appropriate policy intervention, adequate financial and marketing support, operational flexibility and on-going support service mechanism need to provided in a streamlined sequence. There are a number of stake-holders and interest groups involved in the development of various components of the fisheries sector. In terms of activities as well, there are a series of tasks from the sea to the market. It is necessary to ensure that the series of activities/responsibilities are carried out in a seamless and structured manner. This would call for a well co-coordinated approach on the part of all the stake-holders starting from the individual fisherman to the administrators, bankers, research bodies and the exporters.

Oceanic Tuna Resources Potential in Andaman & Nicobar Waters

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Abstract

Fisheries forms one of the major natural resources of the Bay Islands. The tuna fishery is mainly contributed by the coastal species viz. little tunny (*Euthynnus affinis*), long tail tuna (*Thunnus tonggol*), oriental bonito (*Sarda orientalis*), frigate tuna (*Auxis thazard*) and dog tooth tuna (*Gymnosarda unicolor*) in A & N islands. The tuna and tuna like fishes belonging to 6 genera, namely, *Thunnus*, *Katsuwonus*, *Euthynnus*, *Auxis* and the bonitos *i.e. Sarda* and *Gymnosarda* are recorded. Commercial fishing gears used for the exploitation of the tuna resources are gill net, hook and lines and tuna long line. In the present paper, an attempt has been made to study the potential of oceanic tuna based on the data collected by Fishery Survey of India, deploying the departmental exploratory survey vessel, MFV Blue Marlin (OAL 35.76m) during the period 2003-2007. As the marine capture fisheries sector plays a significant role in the food and nutritional security, economy, employment generation and export trade, it is important to develop this sector by exploiting the vast unexploited potential of oceanic fishery resources in the Andaman and Nicobar Islands. This paper also attempts to review the oceanic fishery potential in the Island waters.

1. Introduction

The Andaman and Nicobar groups of Islands are situated between Latitude 6°45'N and 13°41'N and Longitude 92°12'E & 93°57'E in the south-east Bay of Bengal. The archipelago with 572 islands are fringed by lagoons and coral reefs. The islands experience both north east and south west monsoons and some Islands are blessed with perennial streams and rivers. The islands have a coastline of 1912 Kms, which is about one fourth of the total coastline of India and about 0.6 million sq.km of exclusive economic zone (EEZ), which accounts for 30% of the total EEZ of India. Being oceanic islands, they do not have practically continental slope. The union-territory has a continental shelf of 16,000 sq.km, which offers great scope for development of coastal marine fisheries. The oceanic region of these islands provides vast scope for exploitation of oceanic resources such as tunas, bill fishes, sharks, etc., Tunas are widely distributed in the tropical and sub-tropical waters and are one of the economically important marine fisheries resources of the EEZ of Andaman and Nicobar Islands. The three species of commercially important species of tuna recorded in Andaman and Nicobar waters are yellowfin tuna (*Thunnus albacares*), big eye tuna (*Thunnus obesus*) and skipjack tuna (*Katsuwonus pelamis*). Among these species, the exploitation level of yellowfin tuna and skipjack tuna is more in comparison to that of big eye tuna.

The important marine fishery resources of these Islands are mackerels, sardines, carangids, silver bellies, perches, anchovies, hilsa, mullets, elasmobranchs, seer fishes, shrimps and crabs. The major fishing gears operated in the Islands are gill nets/ trammel nets, cast nets, hook and lines, shore seines, anchor nets, etc., and these gears are employed from traditional crafts and small motorized boats.

The monthly data collected by *M.F.V. Blue Marlin* (OAL 35.76M) attached to the zonal base of Fishery Survey of India, Port Blair during the period from 2003–07 is considered as a primary database in the present study. Data on the fishing effort, hooking rate and catch data generated during the multifilament tuna long line survey in and around Andaman and Nicobar waters are analysed. As the marine capture fisheries sector plays a significant role in the food and nutritional security, economy, employment generation and export trade, it is important to develop this sector by exploiting the vast potential of oceanic fishery resources with a clear knowledge of its present status in the Island waters. Thus this paper attempts to study the oceanic tuna resources and their present status in the Island waters.

2. Estimates on fishery potential of oceano-pelagics

Marine fishery resources of Andaman and Nicobar Islands are vast and abundantly diversified and various experts have estimated the marine fishery potential in the EEZ of Andaman and Nicobar Islands adopting various methods of stock assessment packages. Jones and Banerji (1973) estimated the demersal resources as 4,000 mt and pelagic resources as 8,000 mt. Kumaran (1973) gave an estimation of 50,000 mt for both demersal and pelagic resources. George *et al.,* (1977) estimated the coastal and oceanic resources as 1,60,000 mt. Sudarsan (1978) gave the estimate of demersal resources as 45,000mt. Antony Raja (1980) estimated the coastal resources as 90,000 to 1,00,000 mt. Joseph (1985) gave an estimate for demersal and pelagic resources as 72,500 tonnes. Sudarsan *et al.,* (1990) estimated the demersal, pelagic and oceanic resources as 2,43,500 mt.

The marine fishery resource potential of Andaman and Nicobar EEZ is estimated as 1,48,000 mt (John *et.al.,* 2005) which comprises of demersal resources (32,000 mt), neritic-pelagic resources (56,000 mt) and oceanic resources (60,000 mt). The major components of the oceanic resources are tunas (76.7%), shark (11.7%) and bill fishes (4.7%). The potential yield of oceanic fishery resources estimated in the EEZ around the Andaman and Nicobar Islands is furnished in Table 2. The potential yield of oceanic fishery resources estimated in the EEZ around the Andaman and Nicobar Islands is furnished below.

Species / Group	**Potential (in tonnes)**
Yellowfin tuna	24,000
Skipjack tuna	22,000
Big eye tuna	500
Bill fishes (Marlin, Sail fish, Sword fish)	2,800
Wahoo (*Acanthocybium solandri*)	200
Pelagic sharks	7,000
Dolphin fish (*Coryphaena sp*)	200
Barracuda (*Sphyraena sp*)	200
Flying fish (*Exocoetidae*)	300
Oceanic squids	2,000
Others	800
Total	60,000

The aggregate potential yield of fishery resources in the EEZ around the Andaman and Nicobar Islands forms about 10% of the total projected fishery potential of the entire Indian EEZ. The aggregate potential yield of fishery resources in A & N Islands as per John et al., 2005 is as below.

	Resources	**Potential (in tones)**
1.	Demersal	32,000
2.	Neretic-pelagic	56,000
3.	Oceanic	60,000
Total		1,48,000

2.1 Marine fish production and its present status

The total marine fish landings and tuna landings during 2000-05 is depicted in Table 1. As per the statistics, it is seen that the tuna landings in the state Kerala is maximum during the period 2000-05 followed by Lakshadweep. The maximum landing was 16,041 mt during 2000 followed by 13,717 mt during 2003. In Lakshadweep the maximum landing was during 2001 when it was 9,243 mt followed by the year 2000 when it was 7070 mt. The landing of tuna like fishes in Andaman and Nicobar islands varied from 217 mt to 801 mt during the years 2000-20005. The marine ecosystem of the Islands is known to harbour 1,200 species of fishes, 580 species of crustaceans, 900 species of mollusks and 300 species of echinoderms. Out of the 1200 fish species, about 350 are commercially important (Krishnamurthy and Soundararajan, 1999). The total marine fish production in the islands was characterized by wide fluctuations during the five years period *i.e.,* 2003-07 (Table 3). The increase in landing was mainly due to the improvement in the fishing gear design, introduction of synthetic fibres in the gears, mechanization and motorizations of fishing crafts. The trend of total marine fish landings in the islands was determined by the landings of demersal and pelagic resources *viz.,* sardines, mackerel and perches. The landings which was 30,636 mt in 2003 decreased considerably to 8,615 mt in 2005 accounting for a decrease of 72% just after the tsunami which struck this island group in 26th December 2004. However, the landings gradually increased to 24,085 mt and 27,993 mt during 2006 and 2007 respectively. During this five years period the average landing of the islands was about 23,647 mt.

3. Region-wise marine fish landings

The fishing activities in the islands are mainly concentrated at a few major fishing centres like Diglipur, Mayabunder, Rangat, South Andaman, Little Andaman, Car Nicobar, Nancowry and Campbell Bay and the marine fish landings from these centres during the period 2003-2007 are given in Table 4. South Andaman was the most active fishing centre in the islands which alone accounted for about 74% of the total marine fishing landings. Besides, South Andaman, Diglipur is another important centre which contributed 17% of the total landings of the islands. The fish landings at Rangat and Mayabunder contributed to the order of 2% and 1.5% of the total landings of the islands respectively.

3.1 Oceanic tuna resources and its biodiversity

The marine fish landings in the islands can be divided into three groups namely the demersal, pelagic and oceanic. The demersal group consists of elasmobranchs, silver bellies, pomfrets, perches, cat fish, polynemids, sciaenids, prawns, crabs and other miscellaneous fishes. The pelagic group comprises of fishes like sardines, thrissocles, *Chirocentrus*, anchovies, mackerels, carangids, mullets, hilsa, ribbonfishes, etc. The oceanic group comprises of tunas, bill fishes, barracudas, pelagic sharks, seer fishes and other by-catches. The oceanic species recorded by FSI is given in Table 5.

4. Tunas

The tuna fishery is mainly contributed by the coastal species *viz.,* little tunny (*Euthynnus affinis*), long tail tuna (*Thunnus tonggol*), oriental bonito (*Sarda orientalis*), frigate tuna *(Auxis thazard)* and dog tooth tuna (*Gymnosarda unicolor*) in A & N islands. The tuna and tuna like fishes belonging to 6 genera, namely, *Thunnus, Katsuwonus*, *Euthynnus, Auxis* and the bonitos *i.e., Sarda* and *Gymnosarda* are recorded from A & N waters. The tunas perform considerable and some times even transoceanic migrations. Being highly valued table fishes, they are of significant importance both as commercial and recreational fishery. Out of these 6 genera, mainly 3 genera are recorded from oceanic region of A & N waters; those are *Thunnus albacares* (yellow fin tuna), *Thunnus obesus* (big eye tuna), *Katsuwonus pelamis* (skipjack tuna) and *Gymnosarda unicolor* (dog tooth tuna). The oceanic species contributes very little to the tuna fishery of the islands. The fishing area for the coastal tunas extends mainly from the eastern part of Little Andaman to North Andaman (Lat 10°N to 15°N) up to the depth of 200 m. This area is influenced considerably by both south-west and north-east monsoons. The coastal tunas are mainly caught from the waters of the islands by drift gill nets and hook and lines. The plank built boats ranging from 5.4 to 7.5m and motorized dug-out canoes ranging from 7.5m to 12m size are engaged in the operation of both the gears for exploitation of the resource. The common species of tunas represented in the fishery and their common size range and maximum weight are given below.

Name of the species	**Common name**	**Common size (cm)**	**Maximum Wt (kg)**
Euthynnus affinis	Little tunny	40-60	13
Thunnus tonggol	Long tail tuna	40-70	43
Auxis thazard	Frigate tuna	40-60	10
Sarda orientalis	Oriental bonito	30-50	06
Gymnosorda unicolor	Dog tooth tuna	40-60	130
Thunnus albacares	Yellow fin tuna	50-150	170
Katsuwonus pelamis	Skipjack tuna	40-80	34
Thunnus obesus	Big eye tuna	60-180	197
Thunnus alalunga	Albacore tuna	40-100	50

5. Fish production and fishery development in A & N islands

The average annual marine fish production during 2t003-2007 is around 23,647 tonnes in Andaman & Nicobar Islands which forms about 16% of the total estimated fishery potential (Table 4). The average production of tuna is 1,122 mt which contributes to about 1.74% of their estimated potential. The exploratory surveys carried out by Fishery Survey of India in the oceanic water indicate the abundance of oceanic resources such as tunas, bill fishes, sharks and other miscellaneous fishes like bonitos, barracuda, dolphin fish, etc. However, the tuna resources provide great potentiality for exploitation.

The total average fish production per year when compared to its potential indicates that still 84% of the fishery resources remain unexploited. Thus, there is a great opportunity and scope for generating revenue and employment to the islands from marine capture fisheries. The important oceanic fishery resources of A & N Islands are oceanic tunas, bill fishes and pelagic Sharks which are under exploited.

The coastal tuna and oceanic tuna fishery resources aggregate to an estimated fishery potential of 64,500 mt (18,000 mt of coastal tuna and 46,500 mt of oceanic tuna). The average catch of tuna is 1,122 mt, contributing only 1.74 % to the fishery which is mainly of coastal tunas. As such, there is no targeted fishery for tuna in A & N waters, which implies that these resources are not at all, exploited which can be exploited from these oceanic waters.

5.1 FSI's contribution towards oceanic tuna resources and their biodiversity

The Port Blair base of fishery Survey of India (FSI) established in the year 1971 is the nodal agency responsible for conducting exploratory surveys in the waters of A & N Islands for estimation of fish stocks. In order to assess the oceanic tunas and allied resources in A & N waters, Fishery Survey of India has been conducting regular systematic exploratory surveys since 1991 by deploying fishery survey vessel MFV Blue Marlin, a tuna long liner. Since then, the vessel is continuously deployed for survey of deep swimming tunas and allied resources in the Indian EEZ around A & N Islands and collecting valuable data to study the stock position, abundance and distribution pattern of these resources. The catch data collected by the vessel MFV Blue Marlin during the period 2003-07 is given in various forms i.e. species-wise, latitude-wise, year-wise, month-wise and sector-wise in Tables 6-8. The abundance index and distribution pattern of tunas and allied resources have also been studied during the survey period. The survey results indicates that tunas are more abundant in the areas off Hutbay, west of Car Nicobar, south west of Nancowry group of Islands, west of South Andaman Islands and north-east of north sentinel Islands. The abundance indices (hooking rate in %) in Lat 1°× Long 1° of Tunas, bill fishes and sharks are given in the Fig. 1. The percentage of catch by number from the survey indicates that sharks dominate the catch followed by yellow fin tuna with 29.4%. The percentage of skipjack tuna and big eye tuna is 1.5% and 1.65% respectively, whereas by weight, sharks account for 50.8% followed by yellow fin tuna with 33.7 (Table 9).

6. Conclusion

The tuna landings from the western Indian Ocean has steadily increased over the last two decades and the landings from the eastern Indian Ocean fluctuate over the last decade (Fig. 2). The exploitation level of the oceanic tuna resources, particularly the YFT in the western and eastern part of Indian Ocean are close to MSY but only in the Andaman waters, the exploitation level is very meager. The present study reveals that 30% of the estimated potential of the marine fishery resources is not yet exploited. It is observed from the study that the exploitation level of oceanic fishery resources compared to that of demersal fisheries in Andaman & Nicobar Islands is very meager due to lack of adequate knowledge and non-availability of infrastructure facilities in the islands. Moreover the business community in the island lacks the entrepreneurship as the deep sea fishing is capital intensive. So, keeping in view the vast potential of oceanic resources and their exploitation level, their importance in the foreign market and significance in generating employment in fisheries sector, it is required to impart training on the deep sea fishing and create awareness among the industry and the fishermen. In order to augment the marine fish production of the Islands, efforts are to be made to introduce medium-sized and larger vessels, which can fish in the distant and deeper waters by using eco-friendly fishing methods namely tuna long line. Most importantly, the exploitation of oceanic tuna resources of the Islands is to be carried out in a manner consistent with the principles of ecologically sustainable development.

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Table 1. Total Marine Fish Landing And Tuna Landing in various States of India during 2000-2005.

State	2000		2001		2002		2003		2004		20
	Total landing	Tuna landing	Total landing	Tuna landing	Total landing	Tuna landing	Total landing	Tuna landing	Total landing	Tuna landing	Total landing
Andhra Pradesh	182502	2885	204941		230426	1221	230426	1221	252738	1425	176685
Orissa	108754	533	114576	533	123175	604	123175	604	102167	522	123175
T.Nadu	372402	4793	321799	4599	373861	4599	373861	4599	364792	4599	398817
West Bengal	186680	--	184091		181500		181600	--	179500	--	160000
A & N islands	30339	467*	27173	801*	25488	217*	306364	536*	30636	536*	30636
Pondicherry	39265	999	39102	283	43465	300	20969	--	44033	--	25467
Gujarat	627173		660524	--	728916	--	641137	--	600605	--	656841
Karnataka	177287	4625	128112	8919	180161	3322	187004	2125	171596	3968	176974
Kerala	574453	16041	594835	13027	589530	12966	619428	13717	589069	1141	557075
Maharastra	398078	3881	413515	5095	388545	4563	388545	4563	422473	2302	435021
Goa	64396	911	69386	348	72396	911	72396	911	83756	1509	84394
Lakshadeep	10082	7070	12701	9243	9149	6656	9149	6656	9149	6656	9149
Daman&Diu	16582	740	170721	621	14372	518	12248	395	13205	456	15046

* Tuna like fishes. Data Source: Ministry of Agriculture (2006)

Table 2 Estimates of fishery potential in Andaman & Nicobar waters

Author	*Area*	*Potential yield (in tones)*	*Method of estimation*
Cushing, 1971	Shelf area	1,00,000	Tertiary production
Kumaran, 1973	i. Latitude 6°20’-15°N Longitude 92° - 93°	50,000	Primary production
	ii. Shelf area	12,000	Primary production
Jones & Banerjee, 1973	Shelf area	12,000	Fish production per unit area
George *et* al., 1977	Shelf area	1,60,000	Primary production, Tertiary production
Sudarsan, 1978	Shelf area	45,000 Standing stock of demersal resources	Swept area method.
Antony Raja, 1980	Shelf area	90,000 – 1,00,000	Tertiary production
Joseph, 1985	Shelf area	72,500	Fish production per unit
Sudardan *et* al., 1989	EEZ area	4,900 (Oceanic tuna & allied species)	Long line survey
Mathew *et* al., 1990	EEZ area	6,90,000	Secondary production
Sudarsan *et* al., 1990	Shelf area	2,43,500	Survey based on secondary and tertiary exploratory production
Bhargava, 1996	EEZ area	9,20,000	Secondary production
John *et* al., 2005	EEZ area	1,48,000	Survey based on secondary and tertiary exploratory production

Table 3 Marine fish Production in A & N Islands during 2003 - 2007

No.	*Year*	*Total fish production (Demersal, Pelagic & Oceanic)* (In tonnes)	Oceanic fish production (In tonnes)	*% Contribution*
1.	2003	30636	370	1.21
2.	2004	26907	182	0.68
3.	2005	8615	107	1.24
4.	2006	24085	11	0.05
5.	2007	27993	12	0.04
Total		1,18,236	682	0.58

Table 4 Region wise Marine fish landing during 2003 - 2007 (In tonnes)

Region	***Distance by sea from Port Blair (Nautical mile)***	***2003***	***2004***	***2005***	***2006***	***2007***	***Total***
Diglipur	100	1336	1374.9	914.0	6823.3	9823	20271.2
Mayabunder	85	221	201.1	174.1	714.3	687	1997.5
Billiground	--	-	8.3	36.5	338.4	222	605.2
Ranghat	50	847	192.5	159.6	801.4	769	2769.5
Kadamtala	50	-	387.1	224.5	365.4	231	1208
South Andaman	--	27157	23818.2	6965.4	14323.8	15461	87725.4
Little Andaman	66	619	498.9	35.8	170.7	261	1585.4
Car Nicobar	150	6	8.5	--	71.3	64	149.8
Nancowry	235	331	275.8	73.3	264.5	217	1161.6
Katchal	228	-	20.3	5.2	62.1	93	180.6
Campbell Bay & Teressa	294	119	121.5	27.0	149.7	165	582.2
Total		**30636**	**26907.1**	**8615.4**	**24084.9**	**27993**	**118236.4**

Data Source: Dept. of fisheries, A&N Administration.

Table 5 Oceanic species recorded by Fishery Survey Of India

FAMILY	*SCIENTIFIC NAME*	*ENGLISH NAME*
SCOMBRIDAE	*Thunnus albacares*	Yellow fin tuna
	Thunnus obesus	Big eye tuna
	Katsuwonus pelamis	Skipjack tuna
ISTIOPHORIDAE	*Makaira mazara*	Blue marlin
	Makaira indica	Black marlin
	Tetrapterus audax	Stripped marlin
XIPHIDAE	*Xiphias gladius*	Sword fish
ISTIOPHORIDAE	*Istiophorus platypterus*	Sail fish
CORYPHAENIDAE	*Coryphyaena hippurus*	Dolphin fish
SPHYRNIDAE	*Sphyraena jello*	Barracuda
SCOMBRIDAE	*Acanthocybium solandri*	Seer fish
	Scomberomorus commerson	Seer fish
CARCHARHINIDAE	*Galeoceredo cuvier*	Tiger shark
	Rhizoprionodon acutus	Milk shark
	Scoliodon laticaudus	Spade nose shark
	Carcharhinus limbatus	Black tip shark
	Carcharhinus albimarginatus	Silvertip shark
	Carcharhinus melanopterus	Black tip reef shark
CARCHARHINIDAE	*Carcharhinus macloti*	Hard nose shark
	Carcharhinus sorrah	Spot tail shark
	Carcharhinus longimanus	Oceanic white tip shark
LAMNIDAE	*Isurus oxyrhincus*	Short fin mako shark
SPHYRNIDAE	*Sphyraena zygaena*	Hammer head shark
ALOPIDAE	*Alopias pelagicus*	Pelagic thresser shark
	Alopias supercilliosus	Big eye thresser shark
	Alopias vulpinus	Thresser shark
Rare species recorded by FSI:		
MOLIDAE	*Mola mola*	Sun Fish
BRAMMIDAE	*Taractichthys longipinnis*	Big Scale Pompfret

Table 6 Latitude- wise and Species-wise Hooking Rates (HR) obtained in exploratory survey in A & N waters during 2003-07.

	Effort (In hooks)	Agg. HR (%)	Hooking rate (%)						
			YFT	SKJ	BET	SAI	SWD	MAR	SHK
5°	3135	1.02	0.06	0.03	--	--	--	0.03	0.51
6°	16190	0.53	0.07	0.006	0.012	0.03	0.018	--	0.234
7°	29665	0.67	0.19	0.006	0.006	0.03	0.03	0.003	0.24
8°	35625	0.62	0.09	--	0.022	0.025	0.01	0.006	0.34
9°	30000	0.83	0.14	0.01	0.05	0.02	0.06	0.01	0.37
	114615	**0.69**	**0.12**	**0.01**	**0.02**	**0.02**	**0.02**	**0.03**	**0.01**
10°	28125	0.92	0.22	0.004	0.007	0.05	0.07	0.02	0.37
11°	58750	0.92	0.29	0.02	0.01	0.05	0.04	0.01	0.32
12°	45510	0.77	0.34	0.013	0.004	0.05	0.02	0.01	0.19
13°	46250	0.77	0.29	0.13	--	0.06	0.02	0.01	0.24
14°	7500	0.61	0.36	0.05	--	0.03	0.03	--	0.09
	186135	**0.83**	**0.29**	**0.02**	**0.01**	**0.01**	**0.05**	**0.03**	**0.01**
al	**300750**	**0.78**	**0.23**	**0.012**	**0.012**	**0.043**	**0.03**	**0.008**	**0.29**

Table 7 Month-wise and Species-wise Hooking Rates (HR) obtained in the exploratory survey in A & N waters during 2003-07.

Months	Effort (In hooks)	Total catch (No/Wt in kg)	Agg. HR (%)	Hooking rate (%)						
				YFT	SKJ	BET	SAI	SWD	MAR	SHK
January	36875	454/13303.5	1.23	0.62	0.01	0.003	0.06	0.05	0.01	0.31
February	26921	213/7368	0.79	0.18	0.007	0.03	0.04	0.01	0.02	0.33
March	28639	173/4745	0.60	0.11	--	0.06	0.01	0.02	0.003	0.24
April	24900	192/4051.5	0.77	0.14	0.01	0.01	0.02	0.13	0.004	0.21
May	13405	76/2209	0.57	0.13	--	--	0.022	0.04	0.015	0.15
June	24775	170/4970.5	0.69	0.15	0.04	--	0.08	0.01	0.03	0.28
July	14375	69/1651.5	0.48	0.10	0.03	--	0.04	0.01	0.01	0.21
August	13750	94/1876	0.68	0.22	0.01	--	0.06	--	0.01	0.13
September	27306	151/5557	0.55	0.07	0.003	0.003	0.03	0.03	--	0.31
October	35963	233/6701	0.65	0.22	0.008	0.008	0.025	0.006	0.008	0.30
November	26250	221/5117.5	0.84	0.23	0.03	0.008	0.08	0.016	--	0.30
December	27591	294/8189	1.10	0.26	--	0.02	0.05	0.02	--	0.50
Total	**3,00,750**	**2,340/65,739.5**	**0.78**	**0.23**	**0.012**	**0.012**	**0.043**	**0.03**	**0.008**	**0.29**

Table 8 Year-wise and Species-wise Hooking Rates (HR) obtained in the exploratory survey A & N waters during 2003-07

Year	Effort (in hooks)	Total catch (No /Weight in kg)	Agg. HR (%)	Hooking rate (%)						
				YFT	SKJ	BET	SAI	SWD	MAR	SHK
2003	51600	362/10546.5	0.70	0.16	0.012	0.008	0.06	0.06	0.02	0.29
2004	56164	428/12015	0.76	0.18	0.009	0.018	0.04	0.02	--	0.32
2005	59429	576/17183	0.97	0.39	0.03	0.003	0.055	0.022	0.003	0.37
2006	57860	384/13287	0.66	0.22	0.005	0.026	0.045	0.021	0.02	0.23
2007	75697	590/12708	0.78	0.18	0.005	0.01	0.021	0.03	0.004	0.25
Total	**3,00,750**	**2,340/65,739.5**	**0.78**	**0.224**	**0.012**	**0.013**	**0.043**	**0.03**	**0.008**	**0.29**

Table 9. Percentage of catch composition recorded in exploratory survey in 2003-07

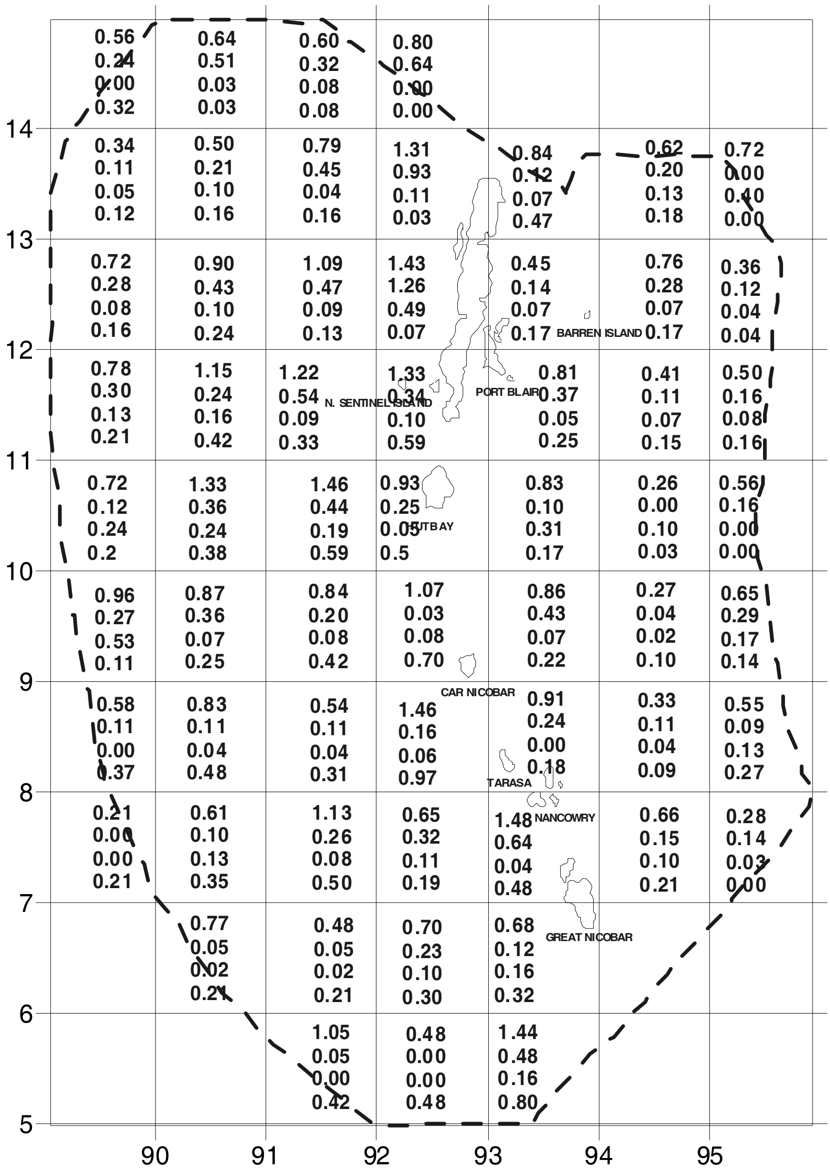
Name of Species	**Catch**			
	By Number	**Percentage (%)**	**By Weight (kg)**	**Percentage (%)**
Yellow fin tuna (YFT)	688	29.4	22125.5	33.7
Skipjack tuna (SKJ)	35	1.5	113.0	0.2
Big eye tuna (BET)	38	1.6	1736.0	2.6
Sail fish (SAI)	124	5.3	3114.0	4.7
Sword fish (SWD)	97	4.1	2311.5	3.5
Marlins (MAR)	25	1.1	1486.0	2.3
Sharks (SHK)	856	36.7	33429.0	50.8
Others (Misc.) (OTH)	477	20.5	1424.5	2.2
Total	**2,340**	**100**	**65,739.5**	**100.00**

Table 10 Potential yield estimate–A & N waters vis-a-vis Indian EEZ

Species	Indian EEZ		A& N waters
	FSI*(1990)	W. Group** (2000)	FSI $ (2005)
Yellowfin	108.9	114.8	24.0
Skipjack	100.2	85.2	22.0
Bigeye	0.3	12.5	0.5
Billfishes	3.8	5.1	2.8
Total	213.2	217.6	49.3 (23%)

* FSI Bulletin No.20
** Working Group for revalidating the fishery potential
$ FSI Bulletin No. 28

Fig.1 Abundance indices (hooking rate) of Tunas, Bill fishes and Sharks in Lat 1°× Long 1° during the period 2003-07



Aggregate Hooking rate
Hooking rate of Tunas
Hooking rate of Billfishes
Hooking rate of Sharks

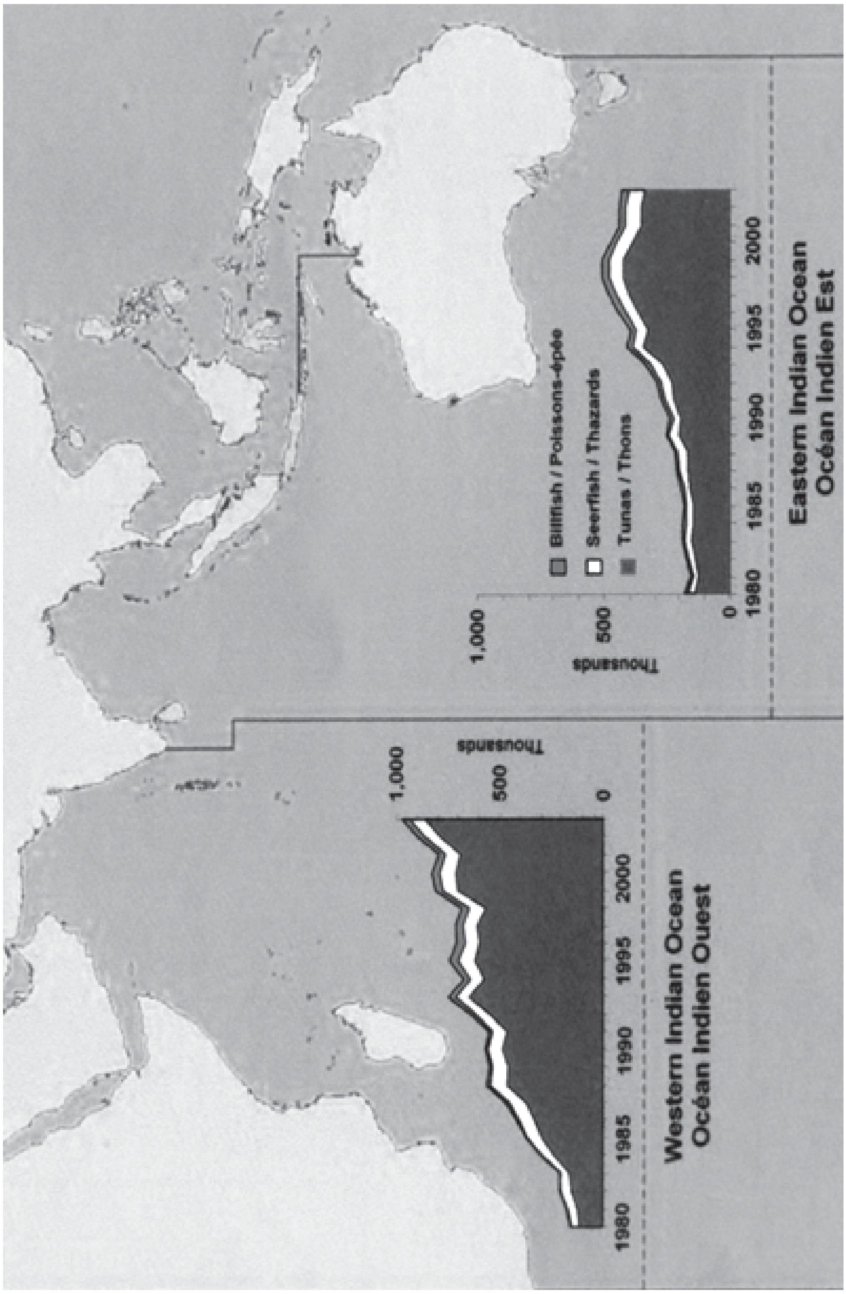


Fig.2. Tuna fishery in the Indian Ocean

Source: IOTC

Development of Tuna Fisheries in Andaman and Nicobar Islands

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1. Introduction

The Andaman and Nicobar group of Islands consists of 572 islands, islets and rocky out crops and have an aggregate coastline of 1,912 km, which is about a fourth of the coastline of India. The continental shelf area is very limited with an estimated area of 16,000 sq. km and the sea is very deep within a few kilometers from the shore. The Exclusive Economic Zone (EEZ) around the Islands encompasses around 0.6 sq. km, which is around 30% of the EEZ of India. This provides a great opportunity to exploit the vast resources of the seas around these Islands to our advantage. The water around Andaman and Nicobar Islands possesses a rich diversity of fishery resources. Over 1,200 species of fishes and shellfishes belonging to 507 genera under 151 families have been identified. More than 2.4 lakh tonnes of potential pelagic, demersal and oceanic fishery resources are estimated to be available for exploitation. Many reports are available on the fisheries around the Island region (Anon, 1990; Dam Roy *et al.,* 2002), which show that the present level of annual exploitation is only 31,000 tonnes. It means at present, only around 13% of the potential is being harvested.

Tuna form one of the important fishery resources of India with an estimated potential of about 2.78 lakh tonnes in the EEZ. The current annual production of tuna is 60,374 tonnes (2007) and contributes to the annual marine fish production to the tune of 2%. Seas around Andaman and Nicobar Islands are one of the best tuna fishing grounds with an annual potential of 180,000 tonnes. Fishery and status of exploitation of coastal tunas has been reviewed by Dam Roy *et al*., (2002) and Madhu *et al*., (2002). Contribution of tuna from this region to the total production of the country is meager and is represented entirely by coastal tunas. The oceanic tunas remain un-exploited.

Reports are also available on the biology of tunas and related fishes of Andaman seas (Vijayakumaran *et al*., 1992; Sivaraj *et al*., 2005a,b). The scientific databases generated by them are of great use in understanding the resource characteristics of several major species.

2. Fishery resources and potential

Marine fishery resources of Andaman and Nicobar Islands are vast and abundantly diversified (Table 1). Various experts have estimated the marine fishery potential in the EEZ of A&N Islands, mostly based on assumptions derived from scanty data (George *et al*. 1977; Sudarsan *et al*., 1990). Fishery Survey of India (FSI) had carried out exploratory surveys to assess the potential of demersal, neritic, pelagic and oceanic resources in the Andaman and Nicobar water by diversified methods. The surveys during the past three decades have provided very valuable information on the composition and magnitude of harvestable resources in the EEZ around the island groups. Their latest estimate (John *et al*., 2005) which is very close to several earlier estimates was used in this paper. According to these estimates, EEZ of A&N Islands has a fishery potential of 243,500 t. Coastal pelagics constitute 57.1% with a potential of 19,000 t and demersal resources 9.2% with 22,500 t. Oceanic tunas and related groups represent 33.7% with a potential of 82,000 t.

Table 1. Major marine fishery resources of Andaman & Nicobar Islands and their potential

Category of resource	Estimated potential (t)
Pelagic Resources	
Mackerel	5,000
Lesser Sardines	10,000
Anchovies	1,000
Other clupeids	10,000
Coastal tunas	100,000
Carangids	1,000
Seer fish	5,000
Pelagic sharks	5,000
Others	2,000
TOTAL	**139,000**
Demersal Resources Perches and others	22,500
Oceanic Resources Oceanic tuna	82,000
GRAND TOTAL	**243,500**

Apart from the above fishery resources, there are several other resources like deep sea crustaceans (lobsters and shrimps), edible and other commercial mollusks, sea cucumbers, soft corals, seaweeds, etc., for which actual magnitude and potential have not been assessed.

2.1 Fishery

The exploitation of fishery resources at present is restricted to near shore waters. There are about 2,973 active and full time fishermen. There is no traditional fishing population in A & N Islands. Fishermen from Andhra Pradesh, Tamil Nadu and West Bengal, who settled in the Islands about six decades ago are engaged in fishing. In a few Islands, fishing is done by the aborigines and Nicobari tribes in traditional way using bow and arrow and spears.

There are about 1,810 fishing boats in operation along the coast during 2005. Split up details of which are; mechanized boats (140), motorized boats (102) and non-mechanised boats (1568). The major fishing gears operated along the region are drift gillnets, shore seine, hook and line, cast net, anchor net and stick net. Mechanized boats are engaged in gillnetting, trawling and hand lining. Over 40% of the catch is contributed by drift gillnets and the rest by other gears. Marine fish production registered a steady increase over the years in the Islands. Estimated marine fish landing was 1104 t (1975) and it increased to 31,000 t (2004) but still forms only 13% of the estimated annual potential yield of its EEZ.

Table 2. Estimated annual yield (in t) of major pelagic and demersal resources from the coastal waters of Andaman and Nicobar Islands during 2003-04.

Pelagic resource	Present Harvest	Demersal resource	Present harvest
Mackerel	1,520	Perches	1,820
Lesser sardines	2,990	Mullets	1,320
Anchovies	830	Pomfrets	320
Other clupeids	340	Polynemids	20
Carangids	4,570	Sciaenids	60
Seerfish	1,680	Silver bellies	750
Pelagic sharks	70	Catfish	130
Coastal tunas	810	Prawns	120
Others	13,160	Crabs	550
Total pelagic catch	25,970	Total demersal catch	5,090

Table 3. Comparison of catch index of A&N Islands with other neighboring countries

Country	EEZ area million km^2	Coast length km	Continental shelf area '000 km^2	Primary productivity ($mgC/m^2/day$)	Marine Fish production (million MT)	Catch index (Catch/EEZ areax100)
Indonesia	3.1	81,000	1,713	685	4.51	145
Thailand	1.76	2,624	39	702	2.92	166
Malaysia	0.45	4,810	418	1401	1.28	284
Sri Lanka	0.52	1,770	28	609	0.3	57
Maldives	0.92		35	387	0.16	17
India	2.02	8,041	500	979	2.70	1.33
A&N islands	0.6	1,192	32	459	0.03	5

Major share of the catch was constituted by pelagic resources (25,970 t) and the rest by demersal resources (5090 t) (Table 2). It means on an average only 19% of the pelagic resources and 23% of the demersal resources are being exploited. When compared to the potential, almost all resources are grossly underexploited and there is vast scope to increase the exploitation of all resources. Catch index of Andaman and Nicobar Island is very low compared to all of its neighboring countries (Table 3).

2.2 Potential and fishery of tuna resource

The most abundant resource of the coastal and offshore waters of Andaman and Nicobar is tunas. Their annual potential of the region has been estimated by George *et al*. (1997), Joseph (1986), Sudarsan *et al.* (1989) and (John *et al*., 2005). These estimates indicated an annual potential of 1,00,000 t for coastal tunas and 82,000 t for oceanic tunas. They together represent nearly 75% of total marine fishery potential in the EEZ of the Island territory. As per the estimates based on exploratory long line survey conducted by FSI, this region has some of the world's richest tuna stocks. But the contribution from this region to the tuna fishery of the country is meager. Present average annual production is only 810 t and is contributed entirely by coastal tunas.

The oceanic tuna resource is represented mainly by yellowfin (*Thunnus* albacares) and skipjack (*Katsuwonus pelamis*). These two species represent 52 and 47% respectively of the oceanic tuna potential and the stock, as a whole is inaccessible to Islanders and remain un-exploited. Though the catch details of the yellowfin tuna caught by FSI survey vessels from the EEZ of Andaman varied widely between 0.08 to 1.54%, it was relatively large compared to many other areas (Sivaraj *et al*., 2005b).

The available catch statistics shows that presently only about 0.8% of the coastal tuna or less than 0.5% of the annual tuna potential alone is exploited from the region.

2.3 Constraints in the development of fishery

In the light of the stock position and exploitable potential of various resources, the primary focus of marine fisheries development of the Island should centre around the unexploited coastal and oceanic tunas available for exploitation. Despite the richness of the resources, fishes of the region have only a limited tradition of tuna fishery and at present it is restricted to coastal species.

There are several constraints in developing a large scale commercial fishery in the region. The major factor responsible for the poor and staggered development of fisheries in the Island territory is the limited capability of the presently available traditional crafts and gears. This prevents the expansion of fishing operation to still deeper waters and endurance fishing for exploiting commercial stocks like coastal and oceanic tunas. Other issues in the development are lack of trained / skilled manpower to take up the fishing operation in high seas, lack of modern and adequate infrastructure for handling, preservation, storage, processing and transportation of fish and fishery products, remoteness of the Islands from rest of the country and limitation in fish trade between the Islands and Indian mainland, poor information and communication linkage, scanty resource database and lack of concerned action plans.

2.4 Commercial tuna fisheries development

Several development schemes had been proposed by various expert groups and task forces in the past. However, concreted efforts are yet to be made and the fishery resources in the Andaman and Nicobar waters by and large remain under exploited. Since the marine fisheries development of the Andaman and Nicobar Islands depends mainly on the success of tuna fishery, any strategy for fisheries development should include the exploitation of primarily coastal tunas together with pelagic sharks, barracudas and seerfishes. It can be achieved through the introduction of new small vessels in a phased manner for drift gillnetting and small long lining and by creating more conducive investment climate for the private sector. Another component which has been hitherto unexploited is the oceanic tunas, which is to be targeted using ocean-going longliners and factory-cum collector vessels with high investment particularly for the harvest of sashimi-grade tuna. As a natural corollary to this development and investment, adequate infrastructure by way of modern fishing harbours, processing fishery estates, power and water suppliers and communication and marketing channels are required to be established.

3. Upgradation of traditional fishing crafts and gear

The main net used in the A&N Islands is gill net, which forms 39% of the total fishing gear units and the next important gear is hook & line, which forms 34%. These gears are mainly used to exploit coastal small to medium pelagics. These gears are designed to exploit mainly small and medium sized fishes available along the shallow coastal region. They have lot of limitations and may not be efficient in deeper areas especially for exploiting larger pelagics. New designs of gillnets of appropriate mesh and body size and also hooks and lines according to the behaviour of target resources have to be introduced for exploiting the targeted tuna resources.

Presently most of the local fishermen are using non-motorized traditional boats (donghies) for fishing. Their operation is limited in the coastal waters within 6 to 7 km from the shore. They have added disadvantage of short life span of about five year. Under these circumstances motorisation will increase the harvest only marginally. Moreover a large number of such boats were already destroyed by tsunami. By providing upgraded boats with distant-water fishing capability and increased carrying capacity in the place of lost ones and also by the phased replacement of the existing ones, the fishing ability can be improved to exploit coastal resources including tunas.

3.1 Introduction of new motorized crafts

Table 4. Cost/ investment involved (in lakhs) in development of Craft and Gear.

Details of craft & gear	Cost of craft and gear	Total Cost of craft and gear/vessel	No. of vessels	Grand total cost
Introduction of new boat-Motorized / Sail fitted with gill nets and lines. FRP:LOA- 10-12 m, B-3.7 m, D-1.5 m Gear : Gillnets/lines (1000 m)	Craft : 7.0 Gear :1.0	**8.0**	125	1000
8.0 125 1000.0 Introduction of new craft: Mechanized /sail fitted gill netter. FRP hull fitted with wooden deck- LOA-12.5 m, B-3.75 m, D-1.6 m Gear: Gillnets (1500 m)	Craft : 10.0 Gear :2	12.0	200	2400.0
Introduction of new craft : mechanized long liners FRP hull fitted with wooden deck – LOA-12.5 m, B- 3.75 m, D-1.6 m Gear: longlines (1000 hooks)	Craft :10.0 Gear: 2.5	12.5	200	2500.0

Present fishing practices could exploit only the coastal tuna resources marginally. They can be exploited more effectively by introducing more efficient motorized gillnetters of LOA 10-12 m to harvest coastal resources including coastal tunas. It will act especially as an alternate option to traditional fishes. Potential resources like coastal tuna, shark and seerfish resources can be exploited by introducing large (12.5 m LOA) gillnetters and longliners. The cost involved in the development of craft and gears are shown in Table 4.

3.2 Pilot demonstration fishing trials

There will be an aversion to accept any introduction including advanced crafts and gears and modern technologies among traditional fishes, especially due to their confusion over its operational and economic viability. Hence, all new introductions of craft and gear or technology to harvest unexploited potential resources should start as pilot demonstration fishing trials to show the techno-economic viability of such new introductions to the end users. Demonstrable techno-economic viability is the only means to attract private investment in to the sector.

3.3 Development of harvest strategies for oceanic tunas

As discussed above, the oceanic tuna resource with an estimated potential of around 82,000 t is totally unexploited. Considering the high economic value of large oceanic tunas in international markets as '*Sashimi grade'* tuna, there are lot of chances for exploiting them profitably. This resource can be exploited by introducing large sea going vessels of LOA 24-27 m with 50 t storage capacity and -60^{o}C freezing facilities for pelagic longlining and gillnetting. It involves setting a main line of many kilometers long with branch lines coming off it. A typical longline carries over 2,000 baited hooks and targets fishes at depths between 50 and 400 metres. The main species targeted by longliners are yellowfin and skipjack. Longline fleets will also catch many billfish species like marlin, wahoo, mahimahi, swordfish, and other species like sharks. There are two broad categories of longliners determined based on the length of time the vessel can be at sea. Large-scale longliners with ultralow temperature freezer capacity can stay at sea for months at a time and only need to come into port to transship or obtain additional supplies. Small-scale longliners fish on an average for two weeks at a time and return to port. However, such commercial tuna long lining is not currently practiced in Indian mainland. The FSI has been carrying out fishery surveys in the Indian seas using tuna longlining. The CIFNET provides training on the use of this method of fishing. The recommended mesh sizes and number of hooks per vessel for coastal and oceanic region are given in Table 5.

Table 5. Recommended mesh size and number of hooks per vessel for coastal and oceanic region.

Sl. No.	Category	Mesh size (mm)	Number of hooks
I.	**Gill nets for coastal / oceanic regions (500-1000 m)**		
a.	Anchovies mesh size	18-22	-
b.	Sardines mesh size	22-26	-
c.	Mackerel mesh size	50-56	-
d.	Carangids mesh size	75-80	-
	Sharks tuna mesh size	100-160	-
	Shark / tuna gill nets (1500-3000 m)	100-160	-
II	**Long lines for coastal regions – coastal tunas**	-	**1000**
III	**Long lines for coastal/oceanic tunas and other large pelagics**	-	**2000**

Considering the very high investment required in the venture, prospective entrepreneurs can be attracted only by demonstrating its operational and economic feasibility. It can be achieved either through, (1) demonstration by foreign entrepreneurs controlled by Govt. of India, (2) demonstration by foreign entrepreneurs in collaboration with Indian companies, controlled by the Govt. of India or (3) inviting expression of interests by private entrepreneurs with or without foreign collaboration and accepting the best offer with terms acceptable to the A&N Administration.

3.3.1 Use of Fish Aggregating Devices (FADs) for increasing fishing efficiency

Some large pelagics like yellowfin, skipjack and dolphin fish used to aggregate around floating materials in the sea, either as a resting place or to feed on prey organisms around it. Such behaviour of certain species can be exploited by deploying FADs. Aggregation of fishes around FADs increases the number of fishing locations and thus increases the overall catch rates. This also considerably reduces the scouting time for fishermen. Permanent, temporary low cost FAD and a multipurpose raft functioning as a FAD were designed, fabricated and deployed by CMFRI in Minicoy Islands, Lakshadweep with remarkable success. In other islands of Lakshadweep the data buoys (for remote monitoring of oceanographic parameters through satellites) deployed by NIOT has also successfully functioned as FAD for tuna fishing and the Administration of the UT of Lakshadweep has recently embarked on an ambitious programme to deploy more than 40 FAD around Lakshadweep islands with technical help of NIOT. Such designs can be tried around A&N Islands to see their usefulness.

4. Building of infrastructure facilities

Improving the exploitation by introducing modern technology alone may not give anticipated results. Once the developmental programmes are implemented, it is certain that tuna production is going to increase on a large scale. As the available facilities are only sufficient to handle the present level of production and utilization, it is imperative that bulk of the extra catch that may arise from increased effort must be processed for export. This demands building up of adequate facilities to handle the catch, storage, processing, transport and marketing along side with the implementation of fishery development programmes. Direct air and sea connectivity with the nearest major world tuna markets like Singapore and Bangkok has to be established. Proper communication link with the mainland and rest of the world also has to be strengthened to get timely information on market trends and demands. The success of implementation of tuna project in A&N islands is linked directly to the establishment of all these essential basic facilities.

If the infrastructure for harvesting fish is strengthened as planned, there will be an additional catch of 25,000 t per annum available for processing in near future. Sufficient facilities have to be developed to handle, process and preserve the additional catch. The major post-harvest processing facilities required are;

i. Out of the existing landing centres, three major centres have to be identified and all the required facilities like road, uninterrupted power supply, diesel out lets, potable water, ice plants, cold storage, processing plant are to be provided.

ii. Any added production is to be preserved and processed for export or marketing in the mainland or for export. Based on the production potential and the places from where the fishing boats are proposed to be operated 3 fish processing estates with modern processing plants as per EU norms are to be set up. It can be integrated with the major harbour development schemes. This will help in developing entrepreneurship and providing employment to local youths also.

iii. Facility for production of value added products such as ready-to-cook, ready-to- serve breaded and battered products, etc. are to be developed in these processing plants to realize maximum return.

iv. Organized fishing and fish processing will generate large quantity of by catch and waste materials which can be converted to valuable products like fish meal, fish body and liver oil, squalene, hydrolysates, livestock feed, pet food, etc. which will help in revenue generation and environmental protection.

v. Tuna is estimated to be the most abundant and untapped resources in this region and hence the first attempt should be aimed at tapping this resource. Along with establishing long line fishing, facilities for immediately transporting the fish to the mother ship for freezing to -60°C and storing at -60°C are to be developed for marketing the fish as *Sashimi grade.*

vi. Cost/ investment involved in establishing processing facilities for export is shown in Table 6.

Table 6. Cost/investment (in lakhs) involved in establishing processing facilities for export.

Facility	Total centres	Unit Cost (Rs. In lakhs)	Total cost (Rs. In lakhs)
Ice plant	9	25	225
Chilled storage	9	20	180
Freezing plants and cold storage	3	600	1800
Canning plant	1	100	100
Insulated vehicle	9	15	135
Refrigerated Vehicle	3	30	90
Curing yards	9	20	180
Squalene extraction plant	1	20	20
Waste disposal unit	9	5	45
Others			50
Total			2825

4.1 Training

Being isolated from the mainland the region is lagging behind in the new fishing and ancillary technologies. By considering this and remoteness of the region, emphasis should be given for manpower development through training in all fishery related areas at regular intervals or as and when necessary. Skilled and experienced fishers from other areas have to be included in the trainer's team along with scientists and other technical people. This will further boost the confidence in the fishers. In this way, the required confident and skilled manpower can be developed in the Islands on a continuing basis.

4.2 Marine resources management and governance

With the development of fisheries, the resources have to be managed properly for ensuring sustainable production. It can be achieved through improving the capabilities of the Fisheries Department to manage, conserve, and protect the

Island's marine resources. The principal output is to develop a systematic monitoring system to facilitate development of an accurate database on fishery, such as fishing vessels operating in the EEZ, catch quantity, species composition, area of capture, biological condition of the species harvested and fishing effort. This will provide the basic information needed for long-term resource management and fisheries governance. An efficient mechanism has to be created for this purpose by the administration with the support of the Department of Fisheries with backstopping by R&D.

5. Conclusion

EEZ around Andaman and Nicobar Islands is very rich in various fishery resources, 3/4th of which is constituted by tunas. Presently only coastal resources alone are exploited and at a marginal level. Entire oceanic resources remain un-exploited by the local fishers. But a good share of which is being poached out by foreign vessels. Being a remotely located oceanic island system with rich marine fishery resources, the economic upliftment can be achieved through judicious exploitation and proper utilization of these resources. Tuna being the most dominant and internationally demanded resource any development in this direction should be centered on it. Nearness of the region with world's largest tuna markets like Singapore and Bangkok will help in developing direct international tuna trade from the Island territory. The developmental strategies described above may serve as a guideline for the development in this direction. Development of fisheries tourism in the line as explained above also will help in promoting employment opportunities and also for the overall economic development of the region.

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A Value Chain for Oceanic Tuna Fisheries in Lakshadweep Sea

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Abstract

The potential yield of fish from the coastal waters of India is fully exploited, and hence, there is little scope to increase production. It has been realized that the possibility of increasing marine capture fisheries production is by exploiting oceanic waters. It has been estimated that only around 10% of the potential of Lakshadweep Sea is exploited at present.

Several factors such as lack of abundance estimates, infrastructure facilities, knowledge on improved harvesting and post-harvesting techniq ues, economics of oceanic fishing and societal entrepreneurship are impediments for venturing into oceanic fishing in the Lakshadweep Sea. A consortium project under the National Agricultural Innovation Project of ICAR will address these concerns, and will intervene at five stages, namely resource assessment, production, processing, economics and consumption in the value chain of oceanic tuna fisheries in the Lakshadweep Sea, leading to an increase in fish production, income, foreign exchange earnings and socioeconomic empowerment of stakeholders. Options for management of natural resources for sustainable growth will also be recommended by devising fisheries advisories for the Islands.

The Central Marine Fisheries Research Institute (ICAR), Kochi is the Lead Consortium Institution, 3 Consortium Partners are CIFT, Cochin Fishery Survey of India and Department of Fisheries, U.T of Lakshadweep. MPEDA, Cochin and L.G. Seafoods would be the Associate Partners.

There will be 17 Activities under 5 work elements *viz.,* Resource Assessment, Production, Post-harvest and Value Addition, Economics and Food Safety and Health Assurance. Economic empowerment of fishing communities, entrepreneurs and traders through increasing the tuna production from the Lakshadweep Sea and enhancing the economic value of the produce are the anticipated outcome from this project.

1. Introduction

Marine fish production in India, which is essentially from capture fisheries, is stagnating at around 2.6 million tonnes for the last ten years. Recent estimates (Srinath *et al.,* 2006) suggest that several Indian marine fish stocks are either in mature or senescent stage. As the potential yield from the inshore waters of India is fully exploited, there is little scope to increase the production. It is feared that marine fish stocks may decline in the future due to excessive fishing, leading to reduction in fish catch, idling of boats and unemployment among fishing communities. Projections of fish supply show that demand will not be met and the price of fish will rise more rapidly under scenarios of collapse in capture fisheries in most of South Asia (Stobutzki *et al.,* 2006). Heavy demand for seafood in domestic and international markets underlines the need for increasing marine fish catch. It has been realized that the possibility of increasing marine capture fisheries production is by exploiting oceanic waters. However, as of today, the size of distant-water fishing fleet in India is very small in spite of 2.02 million km^2 of Exclusive Economic Zone and two major island groups, *viz*, Andaman & Nicobar and Lakshadweep.

Fig 1. Lakshadweep group of islands

The Lakshadweep group of islands consists of 11 inhabited and 25 uninhabited islands. Being oceanic islands, the continental shelf is limited to about 4,336 km2, but the lagoon area extends to about 4,200 km2, territorial waters to 20,000 km2 and oceanic zone to about 4,00,000 km2. The potential fish yield is estimated as 1,00,000 t whereas the present annual production is only 10,000 t. It is estimated that the annual catchable potential yield of tunas is about 50,000 t.

2. Prospects of Tuna Fishery

Tunas are abundant in the oceanic waters. In the absence of effective research and technology interventions for introduction of improved fishing techniques, the fishermen are continuing with the conventional fishing methods; for instance, pole and line fishing for tunas in the Lakshadweep Seas.

The annual average catch of tunas from Lakshadweep was only 7,500 t during 2000-2005 as against the estimated potential of about 50000 t. In other words, only 15% of the potential of tunas is being utilized at present (CMFRI, 2006).

Considering the enormous potential, CMFRI (2006) has recommended several measures for fishery development in Lakshadweep, which include the following

i. Revalidation of potential yield estimates
ii. Up gradation of existing fishing craft
iii. Introduction of new tuna long liner-cum-gill netter for sashimi grade tuna
iv. Modernisation of fishing gear

v. Value addition and production of high-end products such as sashmi-grade tuna; chilled, smoked and frozen tuna loins and high quality masmin
vi. Conversion of tuna wastes into pet food and organic manure
vii. Improvement in marketing and
viii. Training, demonstration and human resource development craft and gear technology and processing for benefit of the stakeholders.

Several factors such as lack of infrastructure facilities, knowledge on improved harvesting and post-harvesting techniques, market intelligence and societal

Pole and line fishing boat in Minicoy Island

Pole & Line fishing traditionally followed by Lakshadweep fishermen

entrepreneurship are the impediments for optimal utilization of the resources. The proposed project will address these concerns, and will intervene at five stages, namely resource assessment, production, processing, economics and consumption in the value chain of oceanic tuna fisheries in the Lakshadweep Sea, leading to an increase in fish production, income, foreign exchange earnings and socioeconomic empowerment of fishing communities and other stakeholders. Options for management of natural resources for sustainable growth will also be suggested by recommending fishing advisories for the Islands.

3. Status of the fishery

3.1 Oceanic tunas

The Fishery Survey of India (Ministry of Agriculture, Government of India) and Central Marine Fisheries Research Institute (ICAR) have been investigating fishery and resource characteristics of tunas, especially the skipjack tuna *Katsuwonus pelamis* and the yellowfin tuna *Thunnus albacares* since the early 1970s. These investigations have helped increasing the production of tunas to certain extent.

Yellowfin tuna - *Thunnus albacares*

However, the fishermen realize very low price (Rs. 20 to 25 per kg) for the tunas. The traditional product of Lakshadweep, *masmin* fetches Rs. 200 per kg after reduction of meat by 80%. Due to difficulties in transporting the produce to the mainland, the producers have to be contended with selling the catch at low price within their islands. On the other hand, the tunas are considered as high-value fish in overseas market and *sashimi*-grade yellowfin tuna fetches about of US$ 7 per kg to the primary producer.

In India, the oceanic tuna long line fishing was introduced in the early 80s and was established in 1986-87. The Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act of 1981 permitted charter of foreign vessels for fishing in the Indian Exclusive Economic Zone (EEZ). Under this scheme, tuna longline vessels operated in Indian waters from 1985 to 1995. Tuna vessels also operated under two other schemes introduced in 1991, (i) leasing of foreign fishing vessels by Indian entrepreneurs for operation in the Indian EEZ, and (ii) joint ventures between Indian and foreign companies in fishing, processing and marketing. The charter scheme was gradually phased out between 1992 and 1995 in favour of joint ventures by Indian-owned vessels. However the joint venture operations also were not successful. Tuna conference held at Visakhapatnam in 1999 recommended conversion of 30% of the existing fleet of Indian trawlers of 23-27m overall length (OAL) for undertaking monofilament tuna longlining.

Horizontal longline fishing for pelagic species evolved in Japan during the 19th and early 20th centuries. In the early 1970s the Japanese longline fishery switched to more equatorial tunas and began fishing for *sashimi* grade bigeye and yellowfin tunas. Korean and Taiwanese boats soon began to replace the Japanese boats in the longline fishery. The advent of monofilament longlines revolutionised the fishery by offering a simpler, more compact, more economical, less labour intensive, but more efficient system of catching pelagic species.

The tuna longline fishery involves two main types of operation: (i) large (typically >250 GRT) distant water fishing with freezers in the ships, which undertake long voyages of several months and operate over large areas as done by several advanced countries; and (ii) smaller (typically <100 GRT) offshore vessels, usually domestically based in tropical areas with ice or chill capacity, and serving to fresh or *sashimi* markets. The latter type of operation is seen in countries such as Sri Lanka, Philippines, Thailand, etc.

The tunas are marketed in frozen, chilled and canned forms, and recently there is demand for tuna loins, *sashimi* and *katsuobushi* products (Hashimoto *et al.,* 2003). The main internationally traded tuna forms are raw materials for canning (fresh, frozen and frozen pre-cooked loins), tuna for direct consumption (fresh/chilled and frozen) and canned (solid pack, chunks, flakes, grated). Japan is the main world market of tuna for direct consumption (*sashimi*). *Sashimi* originates from fresh raw tuna meat, or from tuna frozen at -0.5° to -40°C immediately after harvest. The *sashimi* market requires the use of larger species, such as the bluefin tuna (ensuring the premium *sashimi*), big eye and yellowfin. Tuna for the *sashimi* market is graded on aesthetic characteristics, such as bright/clear appearance of the skin, clear and moist eyes, elastic skin and undamaged abdominal walls, and on high fat content of the fish. It is also common practice in tuna industry to export semi-processed tuna loins to canneries in developed countries. Other tuna commodities include dried and smoked tuna, tuna steaks, tuna burgers, tuna jerky, tuna sausage and tuna roe. Animal feed and pet food are produced from processing wastes of tuna canneries.

Although tuna is the second most important item in world seafood trade, the contribution by India is negligible. Fishing for tuna is not pursued seriously by the fishermen who perceive the return as inadequate. Part of the situation emerges due to the fact that the tuna catch is not of the high-value *sashimi* grade (which requires immediate freezing) for which the fishing vessels lack onboard/onshore infrastructure facilities and also because tuna is less preferred in the domestic market. Hence it may be considered worthwhile to develop at least a small fleet specially for tuna fishing with appropriated market linkages so that it becomes an economically viable proposal for fishermen/entrepreneurs, who wish to venture into tuna fishing. The neighboring island nations such as The Maldives and Sri Lanka have developed the expertise and infrastructure and are able to produce and export high quality tuna products such as loins and *sashimi.*

4. Tuna fishing in Sri Lanka and Maldives

Expanded offshore tuna fishing operations by Sri Lanka by introducing boats of 32-60’ length with modern navigational and communication facilities has contributed to the increase in tuna production. Nearly 1700 boats are in operation and 60,000 t are landed from offshore fishing alone. Further, the Government encourages offshore expansion by supporting ready access to financing and improved facilities and services to shift the fishing effort more towards offshore fishing. On the other hand, Maldives has been encouraging the artisanal fishermen to catch tunas around their islands and the catch from day fishing is transferred to a freezer vessel. These vessels empty their catch in the island where they have cold storage facilities.

5. Why oceanic fisheries has not developed in India

- Uncertainties about abundance, assured catch and seasonality
- Apprehensions about economic returns by operating in a vast oceanic area; heavy investment on large vessels, maintenance and labour.
- Attempts by Government of India by chartering foreign vessels and joint venture operations in the 1980s and 1990s did not succeed, mainly due to the objections raised by Indian fishermen.
- Attempts by Indian private entrepreneurs in the 1990s also did not succeed due to several management problems.
- These fisheries should be located in remote islands where marketing, transportation, cold storage, onshore infrastructure facilities, air cargo facilities are either inadequate or absent.
- In the absence of organized oceanic tuna fisheries and bulk production, the exporters could not constantly supply the produce to the overseas market.
- Fishermen are not well versed with tuna longline fishing technology.
- It was presumed that only large vessels could carry out long-lining, but now small and medium vessels are also suitably constructed to venture into oceanic fishing.
- Lack of knowledge of proper handling procedures for *sashimi* grade tuna.
- The current interest on Yellowfin tuna fishery may be due to recently observed large-scale abundance in the Indian Seas.

The strategies that can be adopted based on the developments in these two island nations are that Lakshadweep island artisanal fishermen should be encouraged to exploit the Yellowfin tuna. Currently the fishermen catch mostly the skipjack tuna by the pole and line fishing. The traditional Pablo boats can be converted to operate long lines and a fish hold with ice to chill the catch until they land in the fishing harbour. The quality of the tuna can thus be improved and fishermen get better price for the fish. The Lakshadweep Fisheries Development Corporation should ensure ice for their fishermen and also have a scheme by which the fish are procured from the fishermen. Larger vessels of 62’ OAL with GPS and RSW system should venture into oceanic fishing and the *sashimi* grade tuna to be brought to the mainland for export. The MPEDA has been providing subsidies to convert trawlers into long line tuna fishing boats.

6. R&D activities on oceanic fisheries in the Lakshadweep Sea

1. CMFRI has conducted studies on tuna resources characteristics with an objective to estimate abundance based on commercial fisheries.
2. FSI has conducted exploratory cruises by using tuna longline vessels with an objective to estimate abundance.
3. CIFT has produced improved *masmin*.
4. CIFT has conducted large mesh drift gillnetting in Lakshadweep islands.

7. Development of yellowfin tuna fisheries in the Indian Seas during 2005-07

1. Private entrepreneurs have converted six Mexican trawlers into tuna longliners and are successfully operating in Bay of Bengal. They have exported nearly 1,000 t of *sashimi*-grade tuna (a high-end product) to Japan and USA in the last two years.
2. Traditional fishermen of Visakhapatnam are harvesting yellowfin tuna in good quantities by using motorized boats. The catch is marketed in frozen form.
3. Marine Products Export Development Authority (Govt. of India) has proposed to focus on exploitation of tuna resources from Bay of Bengal and Andaman and Nicobar sea. They have provision for subsidizing conversion of 108 fishing vessels to facilitate fishing for tunas. An Australian Master Fisherman has been hired for training fishermen on longline fishing and proper handling and preservation for sashimi grade
4. India's tuna export has increased by 90% in 2006-07 in comparison to 2005-06.

8. Objectives

1. *To evolve effective fishing methods for Lakshadweep Sea to increase and sustain production of oceanic tunas and related resources by assessing the status and health of the stocks and ecosystems*
2. *To develop technologies on hygienic and improved handling, processing, packaging and high value products; to develop market intelligence on domestic and overseas market*
3. *To transfer the new fishing and processing technologies and marketing strategies to the stakeholders and empower their efficiency and socio-economic status*
4. *To ensure seafood safety and health assurance to the consumers*

9. Research information on tunas

9.1 Oceanic tunas

Of the six genera of tunas occurring in Indian seas, species belong to the genera *Thunnus* and *Katsuwonus* are oceanic. Four species of oceanic tunas occur in the Indian seas, *viz*., the Yellowfin tuna *T. albacares* (common length in commercial catch: 50-150 cm), the Long tail tuna *T. tonggol* (length: 40-70cm), the Bigeye tuna *T. obesus* (length: 60-180cm) and the Skipjack tuna *K. pelamis* (length: 40-60cm) (James *et al*., 1992).

Tunas are one of the most investigated groups of marine fish. This is because, although they contribute less than 5% to the world commercial total catch by weight, they contribute very high in terms of value (US $5.3 billion) and are the second largest product in international seafood trade. Recently, Pillai and Mallia (2007) have prepared a bibliography on tunas, which contains 2005 references encompassing biology and migration (598), fisheries (371), physiology, genetics and breeding (445), stock assessment (303), harvest and post-harvest practices (117), conservation and management (96) and others (75).

Several global and regional tuna bodies have taken initiative to create and maintain databases. The regional bodies are the International Commission for the Conservation of Atlantic Tunas (ICCAT), Indian Ocean Tuna Commission (IOTC), and the Secretariat of the Pacific Community (formerly South Pacific Commission) SPC. The Inter-American Tropical Tuna Commission (IATTC) covering primarily the eastern tropical Pacific Forum Fisheries Agency (FFA) maintain databases for vessels that are currently and have previously operated in the respective regions.

9.2 Tuna fishing

Since the 19th century, tuna fishing has been carried out in many places in the world. Nowadays, by employing very efficient craft and gears such as purse seines, longlines, pole and line, trawls and gill nets, tuna fishing has emerged as a major organized fishing activity in the world. In India, Fishery Survey of India has conducted extensive exploratory surveys and has collected information on the biology and distribution of tunas, and published atlas for oceanic tunas (Sudarsan *et al.,* 1988, 1989; John and Somvanshi, 2000; Somvanshi *et al.,*1998, 2000). CMFRI has collected extensive data on coastal tunas from commercial fisheries (James and Pillai,1989; Silas and Pillai,1982). Oceanic tuna fisheries is restricted almost exclusively to the Lakshadweep Sea where the island fishermen use traditional pole and line fishing method and target the Skipjack tuna *Katsuwonus pelamis*. A few gill nets are being operated off the northern islands (Pillai *et al*., 2006). The catch is sold in frozen condition or as *masmin* (smoked tuna), which is a product being traditionally developed by the fishermen of Lakshadweep.

Recently, a fishery has emerged for the Yellowfin tuna *T. albacares* off Visakhapatnam (Prathibha Rohit, 2007). By operating hooks and line from catamaran, the fishermen are able to catch good quantities of Yellowfin tuna. Depending on the quality of the fish when landed, a portion of the catch is exported as *sashimi,* but a large majority is sent to domestic market. Simultaneously, industrial fishing for yellowfin tunas has also emerged in the last two years in Bay of Bengal, in which 65% of the catch is exported as *sashimi*. It is understood that about 1000 t of *sashimi*-grade tuna has been exported by private entrepreneurs in India in the last two years to Japan and USA.

9.3 Market for tuna

Tuna is the most widely consumed seafood, and is a cornerstone of the global fish trade (see figure). The world tuna market can be divided into two distinct types: the high-priced *sashimi* market, which is consumed fresh and uncooked; and the low-priced canned tuna market. The *sashimi* market relies on bluefin, bigeye and yellowfin tunas, while the canned tuna market uses mostly skipjack, albacore and bonito. The high-priced sashimi market is very strong catering to the soaring Japanese demand and very recently to increasing demand in Europe and USA. On the other hand, the canned tuna market, especially the low-priced skipjack segment, is relatively oversupplied and facing depressed demand and declining prices. A third segment involving trade in fresh and frozen tuna (particularly loins) is coming up well with doubling of world trade between 1986 and 2005.

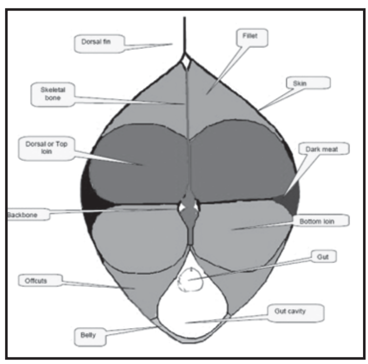
9.4 Post-harvest technologies for tuna

Due to the high global demand for tuna products, a large body of literature exists for development of high quality tuna commodities (Hospido *et al*., 2006). In India, CIFT has carried out considerable research on preservation and storage of seafood, particularly, the tuna meat (Mukundan *et al*., 2002). The tuna meat is cut into different parts and used.

9.5 Chilling

Most of the Indian tuna is exported in frozen condition and only a small quantity is exported as chilled (MPEDA, 2004). Dry ice can be used as a chilling device along with water ice to increase the shelf life of tuna chunks (Jeyasekaran *et al.,* 2006). Discoloration during icing was studied in tuna muscle during ice storage and an attempt was made to evaluate discoloration of meat by Hunter tristimulus values as a substitute for determination of metmyoglobin (metMB) to total myoglobin (Mb) ratio (Chau-Jen *et al.,* 1998).

Cross-section of Yellowfin tuna showing cuts and wastes



9.6 Freezing

Different methods of freezing have been tried to see the effectiveness of each method in tuna preservation. Tuna were frozen using NaCl and $CaCl_2$ solutions or with additional application of N_2 in the ratio of 10:1 and in air current at -25^{o}C and the latter method resulted in 3.5 times longer storage life of the products and also in improvement of the quality of final products (Semenov *et al*., 1987). Effect of storage of the fish before freezing has been evaluated; fish being frozen immediately after killing, after 1-5 days at 5^{o}C, after 2 days at 10^{o}C or after 1 day at 20^{o}C.

9.7 Canning

Indian canned tuna finds limited export market besides catering to the needs of defense personnel and internal market (Govindan, 1972). A procedure for canning of three species of tuna *viz*., skipjack, yellowfin and bigeye tuna has been developed and described by Madhavan and Balachandran (1971). Tuna was also found to be more susceptible to histamine development than sardines or mackerel; 7% of tuna fish samples contained levels above 50 mg% (Ababouch *et al*., 1986).

9.8 Preparation of masmin

An improved method for the preparation of *masmin*, the traditional smoked tuna of the Lakshadweep islands has been developed by CIFT (Nair *et al.,* 1994). The new product contained less NaCl (1.6%), more amino N (0.5702%) and had better digestibility than traditionally prepared *masmin*.

9.9 Packaging/retort pouches

Substantial effort has gone into development of packaging methods for Indian seafoods by CIFT (Gopal, 2000). Laboratory studies on vacuum-drying of cooked tuna fillets before canning in oil showed improved colour, flavour, odour and consistency, increased yield and reduced processing time (Gopal and Shankar, 2001). Rotation of retort cages improves heat penetration in retort pouches during thermal processing; by rotation, the process time for tuna in retort packages can be decreased thereby decreasing energy consumption during processing (Ali *et al.,* 2006).

9.10 Ready-to-serve products

Technology for wholesome pre-cooked, ready-to-serve salads has been developed for prawns (mixed species), seerfish (*Scomberomorus* sp), tunas (*Thunnus* sp) and groupers (*Epinephelus* sp), incorporating emulsified vegetable oil for increasing their calorific value (Govindan, 1969).

9.11 Pulsed light treatment

Pulsed light treatment is an innovative technological concept that has great potential for extending the shelf life of foods, without a heat treatment step. It is a method of food preservation that involves the use of intense and short duration pulses of broad-spectrum white light where each pulse, or flash, of light lasts a fraction of a second and the intensity of each flash is approximately 20,000 times the intensity of sunlight at sea level. It can reduce the microbial load of such products. This can be utilized for the extension of shelf life of chilled fish and disinfestations of *masmin.*

9.12 Utilization of tuna and tuna waste

Several products were prepared with red meat of tuna which is generated as waste during canning of tuna products like wafer, paste, finger, cutlets, etc. (Thankappan *et al*., 1995).

10. Contaminants

10.1 Methyl mercury

Mercury levels in tuna are of great concern to the consumers. There is no way to completely eliminate the presence of mercury from tuna. Al-Majeed and Preston (2000) described the factors influencing accumulation of total mercury and methyl mercury in tuna.

10.2 Dioxins

Dioxins/furans and dioxin-like PCBs are the naturally occurring contaminants in the ocean. Tuna, being a migratory fish is believed to be harbouring residues of dioxins in its meat (EU, 2001). The highest level of dioxins recorded in tuna is about 27-33% of value prescribed by European action level (EU, 2002). The levels of dioxins in tuna fished from Indian waters are not regularly monitored.

10.3 Nutritional Properties

Tuna has low fat content, high protein levels and omega-3 fatty acids. Most processing methods ensure that these health benefits are retained. The high omega-3 content in albacore tuna is widely publicized to reduce cardiac problems, lower blood triglycerides (fats), improve vascular function, modestly reduce blood pressure and reduce inflammation (beneficial for arthritis sufferers), to name a few. Protein is proven to stimulate bone and muscle growth and strength, improve energy levels, help with fat loss and it has a number of neurological benefits. A recent study claims that 180 g servings of albacore tuna provide the weekly requirement for a healthy heart.

10.4 HACCP

CIFT has been successful in developing HACCP protocols for several seafood processes and implemented HACCP/ISO 22,000 in major fish export houses, on board fishing vessels and fish markets. To ensure food safety, HACCP protocols have become an industry standard and the existing value chain for tuna production has to be made HACCP compliant.

10.5 Utilization of tuna waste

Large quantities of wastes are generated when reducing the tunas into value added products.

10.6 Tuna waste

A number of products can be obtained from tuna processing wastes having diverse applications, such as tuna viscera powder as a flavor for feeds, tuna bone products as a dietary calcium source and tuna oil products and tuna eyes as a source of long-chain polyunsaturated fatty acids (DHA and EPA) (Subasinghe, 1996). Incorporation of tuna for feeding broilers showed that it can be used as a source of amino acids. Tuna viscera stored at room temperature for up to 8 h can be used for the production of fermented fish sauce with no detrimental effects on quality (Sirima *et al.,* 2006). Skipjack tuna viscera protein hydrolysate (VPH) is used as a protein supplement in manufacture of sauces and bread. It has been shown that at 10% in sauces and 3-5% in bread there was no negative effects on colour, flavour, taste and texture (Sung and Jung, 1995).

Research on development of oceanic fisheries in the Indian EEZ is a prioritized area in the Vision Document of CMFRI.

11. Researchable Issues

11.1 Biomass estimates of tunas

- Abundance estimates of tunas in the Lakshadweep Sea will be made from the data collected from commercial landings and exploratory cruises.
- A new method will be developed to estimate abundance from hooking rates. The exploratory surveys will be concentrating on surface and sub-surface populations, and not those at depths. These limitations will be considered for estimating the stock/abundance of tunas. These analyses will be useful to estimate the potential yield, to compare the potential yield *vis-à-vis* catch, and to arrive at management decisions for sustaining the fisheries.
- As part of the study, fisheries related environmental parameters such as sea water temperature, salinity, pH, chlorophyll *a* content, etc will be collected

from the fishing grounds. These variables will be correlated with the tuna catch for understanding their relationships.

- The suitability of different dead baits will be tested to identify the most ideal bait. The live bait resources around Lakshadweep will be assessed and the most suitable baitfish identified. Different systems will be tested to maintain live baits on board the vessel.
- From the data collected, analysed and estimated, database will be created and charts and atlas will be prepared on a GIS platform on the distribution and abundance of fisheries resources in the Lakshadweep Sea. The fishing effort, catch and resource status before and after the NAIP intervention will be mapped.

11. 2 Ecosystem modeling

It is obvious that fishing has an impact on ecosystems. Targeting and removing biomass from a complex of species feeding on each other is bound to affect the food web. It is important to assess whether the impact of a fishery is likely to have indirect effect on the long-term viability of other fisheries. From a more conservation point of view, the goal could also be formulated as ensuring that the exploitation of various resource species leaves the ecosystems with their biodiversity and structural integrity maintained, thus allowing future services.

- Ecosystem models that can describe the biomass flows between different elements of exploited ecosystems, and can provide answers to "what if" questions regarding the likely outcomes of alternate fishing policies will be developed.
- The introduction of new fishing practices, which would selectively target tunas, and their potential impact on sustainability of target and non-target resources need to be studied. It is proposed to use *Ecopath* software including *Ecosim* and *Ecospace,* and their various components, which basically revolve around trophodynamics of the ecosystem.
- The model will provide valuable information on system throughput, maturity, production efficiency and flow of energy within the ecosystem. The analysis, in addition to evaluation of the impact of new fishing practices on the ecosystem, would help to evolve management policies on the optimum number of craft and gear for sustaining the fisheries.

11.3 Development of management advisories

- Based on stock estimates, the potential biomass will be estimated. The quantity of fishes that can be exploited will be determined based on ecosystem models as increase in fishing operations should not lead to overexploitation of the resource, decline in resource and livelihood problems for the Island fishermen. The Management advisories will be drafted based on participatory discussions with various stakeholders and submitted to the Island administration for implementation.

- *9*tuna fishing in Lakshadweep.
- It is proposed to fabricate newly designed fishing gear such as tuna longlines, which will be operated from the modified Pablo boats.
- The impact of the new fishing practices on the fishermen and the fisheries will be analyzed. A benchmark survey of existing fishing practices and socioeconomic status of fishermen will be conducted. The ecological impact of the introduced fishing practices will be assessed by Trophic Modelling (Activity 2).

11.4 Production of value added products

- Development of package of practices for handling of tuna during and after harvesting, landing, etc.
- To ameliorate the undesirable thermal effects on foods, non-thermal technologies will be developed that rely on techniques other than heating or cooling operations. This is ideal for increasing the shelf life of tuna and to reduce the microbial load / disinfestations of masmin products.
- Carbon monoxide, a gas that is also a component of wood smoke, prevents the flesh from discoloring. It can even turn chocolate tuna into red. The process requires standardization of amount of CO and duration of treatment.
- Attempts will be made to standardize hygienic smoked tuna products using latest technologies. This will minimize the wastage substantially, since second quality tuna can be used for producing smoked products.
- Development of improved techniques for *masmin* production.
- Utilization of tuna waste for the production of calcium phosphate, silage and extruded products from red meat.

11.5 Biochemical and microbiological assessment of products

- Determination of quality parameters (histamine, benzopyrene, biogenic amines, nucleotides, presence of pathogens, other microbial hazards, etc) in each stage during harvesting, handling, processing etc.
- Determination of parameters like protein, fats, saturated fat, dietary fibre, carbohydrate, vitamins and minerals for nutritional labeling.

11.6 Economics of fishing and demand-supply scenario

- The economics of the improved fishing operations will be assessed. The market chain from producer to consumer will be evaluated.
- Techno-economic evaluation of the products developed is required for assessing the economics of operation, and evaluating sustainability.
- Various demand-supply scenarios and returns to investments for different stakeholders in the marketing channel will be developed.

11.7 Development of HACCP protocols

- Identification of hazards from harvesting to packing which includes development and implementation of HACCP, SSOP and GMP plans.

12 Expected outcome/ impact/ Deliverables

1. Abundance and biomass estimates, and distribution atlas of oceanic tunas in Lakshadweep Sea. Suitable live and dead baitfishes for catching yellowfin tuna.
2. Trophic model of the oceanic ecosystem.
3. Fisheries Management Advisories for sustainable development of marine fisheries in the Islands.
4. A new generation of improved small and medium class fishing crafts for efficient harvesting of tunas.
5. Well trained and skilled fishermen in long-line fishing and handling techniques.
6. Emergence of improved post-harvest technologies and value added products.
7. Technology for effective utilization of wastes from tunas.
8. Emergence of marketing channels for profitable domestic and overseas trade.
9. Availability of high-value safe seafood to the consumer.

13. The NAIP intervention is expected to result in

1. Threefold increase in tuna production from the Lakshadweep islands.
2. Significant increase in the economic value of the produce.
3. Social and economic upliftment of island fishing communities and other stakeholders. A benchmark survey of the social and economic status of the fishermen will be conducted before start of the project and evaluation of the social and economic status after completion of the project to study the impact. Fishing and marketing of yellow fin tuna will help them to get higher price. It is expected that tuna fishermen in the island, the fishing industry and fish processors will be benefited.

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Aquaculture in Andaman: An Emerging Opportunity Post-*Tsunami*

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Abstract

Fertile arable lands lying above the highest high tide level mark in Port Blair were submerged in a fortnight as the lands got subducted to a depth of 1.25 m. The ingression of water was very high that vast areas of agricultural land became saline. The inundated areas were having features unique from place to place. There were sites, which remained permanently inundated even during the lowest low tide. In some sites water started coming in during high tide and moving out during low tide, while some areas got dried up after the immediate ingression without showing any influence on the tidal cycle. The South West area of Port Blair was severely affected. Mangrove forests dried up with *Rhizopora sp.* alone withstanding continuous saline water logging phases in many places. Outlet channels, which used to serve as pathways for flushing out freshwater collected in catchment areas, started acting as inlet channels through which seawater started going in during high tide and moving out during low tide. Vast areas of land, which used to support the crops, vegetables and paddy cultivation, became barren with the saline water ingression. Tens of hundreds of people became jobless with mainstream agriculture activity coming to a stand still. Coastal aquaculture is opening up as a viable option in the submerged areas. A feasibility study was conducted in search of an alternate livelihood for the farmers affected by subduction of lands due to the earthquake occurred on 26 December 2004.

1. Introduction

During 24th December 2004, an earthquake measuring 8.9 Richter scale struck Andaman and Nicobar group of Islands at early hours. This was followed by Tsunami, causing destruction of very high magnitude in terms of loss of property as well as life. Consequent to the earthquake there was subduction of land up to 1.5 m due to which seawater has intruded inland area to a large extent and inundated the lands which were previously used for agriculture. The areas where the affect was maximum are Sipighat, Chouldari, Teylarabad, Badmaspahar, Port Mount, Methakhadi, Dunduspoint, Namunaghar, etc in South Andaman. As a result of which the farmers who were practising agriculture are now forced to search for a viable alternative livelihood. Shrimp or fish farming is one of the viable commercial alternative to agriculture in these areas. Since agriculture lands are inundated there is livelihood related issues in the Islands.

All the submerged areas of South Andaman viz. Sipighat, Chouldari, Krikabad, Badmaspahar, Portmout, Muslim basti, Ograbraj, Mithakhari, Namunaghar, and Dunduspoint were visited by the Scientists of Fisheries Science Division, CARI along with the officials of Directorate of Fisheries and Directorate of Agriculture, A&N Administration during 2006. Consultation was made with the revenue officials of respective areas (Tehsildar, Revenue Inspector and Patwari). After conducting the survey a rough design of the farms were prepared. The stakeholders, *i.e.,* the owner of plot against each proposed farm were listed out. Efforts were also made to accommodate the plots in the farm area without causing any division/ bifurcation as far as possible.

2. Scope of shrimp farming in Tsunami submerged areas

The first and foremost requirement for entering into the venture is the acquisition of suitable land. Prior to Tsunami 608ha of brackishwater areas were identified as suitable for shrimp culture in the islands. Besides this, about 1,206 ha of coastal agricultural lands in South Andamans are inundated with seawater, which cannot be used for productive agriculture.

The following table shows the area affected by tsunami in South Andaman which can be suitably developed for aquaculture.

No	Area	Area in ha
1.	Sipighat	103.72
2.	Dhanikhari	7.36
3.	Chouldari	60.00
4.	Crickbad	20.66
5.	Badmaspahar	36.33
6.	Port Mout	37.45
7.	Lalpahar	23.30
8.	Mithakhadi	144.53
9.	Namunaghar	44.05
10.	Danduspoint	20.31
11.	Ograbranj	66.23
12.	Muslimbasti	48.35
13	Kadakachang	21.85
	Total	630.12

A suitable site is one that can support optimum conditions of the growth of shrimps at targeted production level. Most of the lands available along the coastline are owned by the State Governments. In some cases, the entrepreneur has to get it on long term lease form the revenue authorities of the State Government. If it is a private land, one has to preferably purchase on outright basis. While selecting the site for the project, the entrepreneur should ensure the following.

i) Areas should be accessible by road even during the monsoon season.
ii) The area should be free from Mangrove area with large tree stumps.
iii) The areas should be flood free.
iv) Location with a natural slope for proper drainage should be selected.
v) Social problems due to competing use of water resources and drainage of wastewater should be properly taken care of.
vi) Site should have good pollution free water supply of both freshwater and brackishwater. Water quality parameters required for the culture of *Penaeus monodon* are given below.

Water Parameters	Optimum level
Dissolved Oxygen	3.5-4 ppm
Salinity	10-25 ppt
Water Temperature	26-32 (C^o)
PH	6.8-8.7
Total nitrite nitrogen	1.0 ppm
Total ammonia (less than)	1.0 ppm
Biological Oxygen Demand	10 ppm
Chemical Oxygen Demand	70 ppm
Transparency	35 cm
Carbon dioxide (less than)	10 ppm
Sulphate (less than)	0.003 ppm

Infrastructure namely electricity, ice factory, cold storage, communication facilities etc., are necessary for successful management. After selecting the suitable site, a license should be obtained from the Aquaculture Authority as per the existing norms and guidelines of the local administration and that of Supreme Court. For undertaking shrimp culture within CRZ and outside CRZ the following assumptions have been made.

	Improved Traditional (within CRZ)	Extensive (outside CRZ)
Farm Size	5 ha	5 ha
Culture period	4-4 ½ months	4-4 ½ months
Stocking density	50,000/- ha	1,00,000/- ha
Survival	70%	65%
Expected production	1.2 ton/ha./crop	2.5 ton/ha/crop
Price of shrimp has been taken as Rs.250/kg		

Brood Stock: It is estimated that 9,320 brooders of tiger shrimp are available in Andaman and Nicobar Islands, of which 2,976 brooders could be collected annually for seed production.

2.1 Physical and financial outlay

Details of the physical and financial outlays involved for setting up of 1 ha brackishwater prawn farm are furnished in Annexure II. It can be seen from that the total cost including working capital expenses for raising the first crop in a 5 ha prawn farm works out to Rs. 14.00 lakhs. While submitting the project to the banks for sanction of loan, the entrepreneurs are expected to submit detailed plan and estimates for all the civil works to be undertaken as also invoices of various items to be purchased from the suppliers. The financial analysis for extensive system of shrimp faming has been shown in Annexure III.

2.2 Marketing

Due to huge gap between supply and demand of shrimps in local as well as international market, there may not be any problem in marketing the same. Shrimps can either be sold by the farmers directly in the market or to exporters for processing. Shrimps are exported in frozen form with head on, head less, battered and breaded, or IQF products or any other form with value addition. They need to be packed as per the requirements of importing countries. It is always advisable to get in touch with local distributing agents of the customer country. Hygienic packaging, display and appearance of the packet are key factors to attract consumers of importing countries.

3. Arable lands to saline soils: A shifting phase in subducted lands of Andaman

The ingression of water was very high that vast areas of agricultural land became saline. The inundated areas were having features unique from place to place. There were sites, which remained permanently inundated even during the lowest low tide. In some sites water started coming in during high tide and moving out during low tide while some areas got dried up after the immediate ingression without showing any influence on the tidal cycle. The South West area of Port Blair was severely affected. Mangrove forests dried up with species like *Rhizopora* alone withstanding continuous saline water logging phases in many places. Outlet channels, which used to serve as pathways for flushing out freshwater collected in catchment areas, started acting as inlet channels through which seawater started going in during high tide and moving out during low tide. Vast areas of land, which used to support the crops, vegetables and paddy cultivation, became barren with the saline water ingression. Tens of hundreds of people became jobless when subduction rendered the lands unsuitable for agriculture. It is under such scenario that coastal aquaculture has emerged as a viable option in the submerged areas and there is a growing trend in number of farmers venturing into aquaculture. The Central Agricultural Research Institute is playing a pivotal role in conducting awareness and training camps for the prospective farmers on the technical feasibility of commercial brackishwater aquaculture in Andaman.

Annexure I

Technical Parameters for establishing an extensive shrimp farm

A. Design and Construction of shrimp farm

An extensive shrimp farm should be of the size 0.4- 0.5 ha and preferably drainable from the management point of view. The ponds generally should have concrete dikes, elevated concrete supply canal with separate drain gates and adequate life supporting devices like generation and aerators.

The design, elevation and orientation of the water canals must be related to the elevation of the area with particular reference to the mean range of tidal fluctuation. The canals and dikes may be fitted as closely as technically possible to existing land slopes and undulation for minimizing the cost of construction.

A.1 General earth work

It is normally carried out in the following order:

(i) Site clearing
(ii) Staking of center lines and templates
(iii) Preparation of dike foundation
(iv) Excavation of drainage canals
(v) Construction of dikes (peripheral and secondary)
(vi) Forming and compaction of dikes
(vii) Excavation of pits for gates
(viii) Leveling of pond bottom
(ix)Construction of gates and refilling of pits
(x) Construction of dike protection.

The topsoil may be set aside and should again be spread later to preserve pond bottom fertility.

A.2 Essential Components

The essential components of a shrimp farm are:-

i) Ponds
ii) Water intake structure
iii) Store room for feed and equipments
iv) An area for cleaning of the harvest

v) A workshop and pump house
vi) Watch and ward room, office and a mini laboratory.

B. Ponds

From the management point of view, it is better to go in for ponds of 0.4-0.5 ha size. These ponds should be preferably completely drainable. Secondary dykes partition the ponds. In order to render over all protection to the cultured stock and all related structures a perimeter dyke also can be constructed.

The height of the perimeter dyke will depend upon the following factors, such as:

i) The height of water column in the pond

ii) Free board

iii) Wave action

iv) Shrinkage factor

v) Type of soil (it decides the shrinkage factor)

C. Gates

They regulate the inflow and outflow of water into the pond and also are responsible for maintaining the desired water column in the pond. The main gates are constructed on the perimeter dyke and are usually located on the partition dykes and they regulate the water column in the individual ponds. It can be made out of concrete or PVC or Asbestos piping.

D. Drain canals

They are generally trapezoidal in cross section and its discharge capability is decided by area of cross section and velocity of water flow.

E. Pond preparation

Proper pond preparation will ensure higher production. The main objectives of pond preparation are:

i) To eradicate weed fishes and organisms
ii) To remove obnoxious gases
iii) To improve the natural productivity of the pond eco-system
iv) To maintain high water quality for proper growth and higher survival percentage.

Draining out the entire water and drying the pond bottom till it cracks usually eradicates the unwanted organisms. This also helps in removal of obnoxious gases and oxygenation of the pond bottom. It also improves the fertility of the soil.

Liming is done for correcting the pH and to kill pathogenic bacteria and virus. In undrainable ponds, mahua oil should be applied at 200 ppm to eradicate the weed fishes. After around two weeks time organic and inforanic fertilizers are applied to enrich the soil and water. Once the thick lab-lab is formed, the water level is raised and the pond is made ready for stocking.

F. Selective stocking

The most suitable species for culture in India are the Indian white prawn, *Penaeus indicus* and tiger prawn, *P. Monodon*. The stocking density varies with the type of system adopted and the species selected for the culture. As per the directives of Supreme Court only traditional and improved traditional shrimp farming can be undertaken within the CRZ with a production range of 1 to 1.5 tonnes/ha/crop with stocking density of 40,000 to 60,000/ha. Outside the CRZ area, extensive shrimp farming with a production range of 2.5 to 3 tonnes/ha/crop with stocking density of 1,00,000/ha is allowed. In order to have uniform growth of the cultured animal, it is always advisable to go in for hatchery reared seeds.

G. Food and feeding

Shrimp diets may be supplementary or complete. In an extensive system, the shrimp need to be provided with supplementary feed. Although natural food items have good conversion values but they are difficult to procure in large quantities and maintain a continuous supply. At present most of the aquaculture farms depend on imported feed with a FCR of 1.5-1.8. The feeding could be done by broadcasting all over the pond. If the feeding trays are employed in selected pockets in the pond, wastage in feed can be reduced.

H. Harvesting

The average culture period required is around 120-150 days by when the prawns will be of 20-30 g size, depending on the species. Harvesting can be done by draining the pond water through a bag net and also by hand picking. It is possible to get two crops in a year. Harvested shrimps can be kept between layers of crushed ice before transporting the consignment to market.

Prospects of Brackishwater Aquaculture with Special Reference to Asian Seabass, *Lates calcarifer* Seed Production and Farming

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1. Introduction

Aquaculture has developed rapidly over the last three decades and has become an important industry for generating revenue, providing employment and nutritional security for the millions of people. The ever increasing population and the raising demand for animal protein is causing pressure on fisheries development globally. Fish and fishery products contribute around 15% of the animal protein supporting the nutritional security. The world fish production is in the order of 146.3 million metric tons, of which 50% is contributed by aquaculture. The contribution of aquaculture to the total fish production was around 15% in 1990 which has grown about 50% in 2005. Farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with the intervention in some form or the other in the rearing process to enhance production such as regular stocking, feeding, protection from predators and health care is aquaculture. In global fish production, eight top countries occupied by Asian countries, where India stands next only to China. China accounts for 70% of global production which formed 50% in value, where as India is at a distant 2nd with 5% production and 4% in value. The global average per capita consumption of fish is around 15 kg. The present average per capita consumption in India is around 9 kg. In countries like Japan and some of the South East Asian countries the average per capita consumption is more than 100 kg. Considering that 50% of Indian population will be fish consumers by 2020 and the percapita consumption reaches the global average of 15 kg, the domestic requirement itself will be in the order of more than 9 million tons. The average fish production in India is around 7 million tons equally contributed by freshwater and marine. The yield from capture fisheries is static and in some cases the trend is declining. It has been estimated that the maximum sustainable yield is only around

3.90 million tons from marine fisheries. It is necessary that the coastal aquaculture has to make a greater contribution in the fish production in the Indian context. By 2020, the coastal aquaculture in India is expected to support to the tune of around 3,50,000 tons, from the current production of around 1,50,000 tons. This implies that a quantum jump has to be made in the ensuing years. Out of this, shrimp is expected to contribute to around 2,50,000 tons and the rest has to come through fishes and other non-conventional groups.

India is bestowed with a coastal line of 8129 km, 3.50 million ha of estuaries, 3.90 million ha of backwaters, 0.40 million ha of mangroves, 1.19 million ha of potential brackishwater area suitable for aquaculture, 3.15 million ha of freshwater reservoirs, 2.25 million ha of ponds and tanks, 0.82 million ha of bheels and ox-bow lakes, 2.04 million ha of medium and large reservoirs and 1,46,000 km of irrigation canals. These aquatic systems are either underutilized or unutilized. These areas can be brought into aquaculture to enhance production and productivity.

Development of aquaculture has become imperative for the following reasons:

- Means of protein rich fish production - "Nutritional security"
- Generation of employment – "Livelihood security"
- Improvement of economic status and social upliftment – "Social security"
- Culture of nutrient utilizers like seaweeds and mollusks improve water quality – "Environment security"
- Reduce pressure on wild stock – "Conservation"
- Biological indicator for water quality
- Integrated farming like paddy cum fish culture reduces other outputs

2. Status of Coastal Aquaculture

Coastal aquaculture is a traditional practice in India. In the low lying fields of Kerala (pokkali), West Bengal (bheries and gheries), Orissa, Goa (khzan) and Karnataka (kar) which experience influx of saltwater, traditional farming of fish/shrimp are practiced. The practice is just allowing juveniles of fish/shrimp in the fields, allowing them to grow without any supplementary feeding; facilitating water exchange through tidal waters and harvesting periodically at 3-4 months. With the improvement of technologies and realizing the importance of aquaculture, these practices were improved with the supplementary stocking of feeding with water quality management with higher production. The technology improvements made in the aquaculture sector opened new areas for the scientific farming which is called as semi-intensive and intensive farming of farming with production as much as 10 tons per ha during the culture period of 4-5 months. Mainly shrimp aquaculture is pracitised in the coastal area. The technology advancement helped in the establishment of more than 380 hatcheries with a production capacity of 5-300 million seeds totaling around 20 billion and more and more areas were brought under shrimp farming. The present area of operation in the coast line is around 1,60,000 ha and total production is around 1,50,000 tons of shrimp.

The coastal aquaculture witnessed a phenomenal growth during 1980s and in the beginning of 1990s. But the growth did not progress as visualized from the later part of 1990s due to socio economic and environmental issues coupled with the outbreak of uncontrollable diseases like WSSV on shrimp. One of the reasons attributed for this is the unregulated development and disease outbreaks. The coastal aquaculture in India was also solely dependent on single species, tiger shrimp, which has brought the pronounced impact on the coastal farming sector questioning the very sustainability of the coastal aquaculture.

3. Diversification in the coastal aquaculture

For the sustainable eco-friendly aquaculture practice, diversification to other species is considered as one of the important component. Fishes like Asian seabass (*Lates calcarifer)*, groupers (*Epinephelus tauvina)*, snappers (*Lutjanus* Sp.) which are high value carnivorous fishes and Grey mullet (*Mugil cephalus)*, Milk fish (*Chanos chanos)*, Pearl spot (*Etroplus suratensis)*, Rabbit fish (*Siganus* sp.), etc., which are herbivorous/ omnivorous are suitable candidates for farming in the coastal eco-system. The species like Cobia (*Rachycentron canadum*) and silver pomfret are being considered as candidate species for farming. Efforts have been made to develop comprehensive technology packages for seed production under controlled conditions and farming for these candidate species. Technologies have been developed elsewhere in the world.

In Indian scenario, successful technology has been developed by the Central Institute of Brackishwater Aquaculture for the seed production of Asian seabass, *Lates calcarifer* under controlled conditions and farming. The controlled breeding of groupers, *Epinephelus tauvina* and grey mullets *Mugil cephalus* and pearlspot, *Etroplus suratensis* has also been successful. Development of broodstock for the captive seed production of milk fish is in progress. Cobia and Silver pomfret have been taken up as priority species owing to their high value in the domestic and international markets.

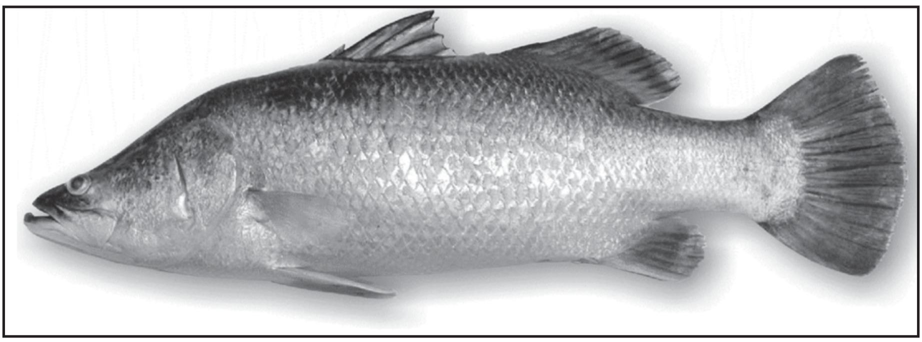
The following discussion will be on the current developments on the seed production of Asian seabass, *Lates calcarifer* which can be a model for the production of marine finfish seed under controlled conditions.

4. Seed production technology for Asian seabass, *Lates calcarifer*

Successful seed production in the hatchery depends upon the availability of healthy matured fishes. For selecting potential breeders, viable broodstock under captive conditions has to be developed. Adult and sub-adult seabass can be procured from wild catch or from farm reared stock. The fish procured for broodstock should be devoid of external injuries or internal hemorrhage. The fish should be healthy and free from any parasitic infection. The fish can be treated with acriflavin (1 ppm) for 10 minutes and later with antibiotic, Furozolidone (10 ppm) for one hour as prophylactic treatment to avoid infection due to minor injuries, if any during collection and transportation. The fish should be kept under hatchery condition for 3-5 days for close observation before shifting to brood stock holding facility for further maintenance. Fishes can be maintained at 1 kg/m^3 in the broodstock tank and fed with trash fish in frozen form at 5% of the body weight. Fresh low cost fish like Tilapia (*Oreochromis mossambicus*), sardines (*Sardinella sp*), Horse mackrel (*Decapterus sp*) etc. can be given to the fishes. The broodstock tanks are to be disinfected once in three months to avoid contamination. Healthy gravid fishes can be obtained in 6 – 8 months from a well maintained broodstock fish providing good water quality and feed, under controlled conditions.

4.1. Captive maturation and spawning

The Asian seabass, *Lates calcarifer* can be made to breed under controlled conditions both spontaneously (natural spawning) and by induced spawning with exogenous hormone administration.



Asian Seabass (*Lates calcarifer*)

4.1.1. Natural spawning

This can be achieved by the manipulation of some of the important water quality parameters like salinity, temperature, pH, etc. required for the maturation process, stimulating the conditions prevailing in the marine environment with a flow through arrangement wherein the seawater pumped into the broodstock maturation tanks is recycled using the biological and pressure sand filters so that the water conditions are stable. With this process, the fish could be made to spawn spontaneously throughout the year, even beyond the normal spawning seasons. This has paved way for the production of seed under controlled conditions throughout the year.

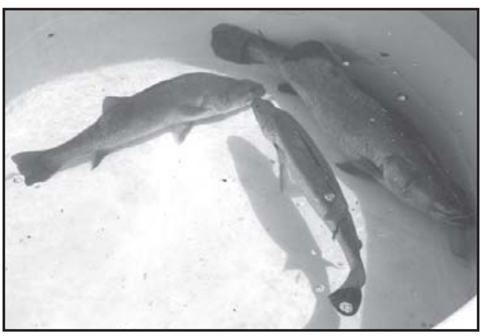
4.1.2. Induced spawning

4.1.2.1. Selection of spawners and sex ratio

Matured female fishes will have ova with diameter more than 450 µ. Males will ooze milt if the abdomen is gently pressed. The gonadal condition is assessed by ovarian biopsy. Brood fishes selected for induction of spawning should be active, free from disease, wounds or injuries. Female fishes should be around 4-7 kg and males around 2-3 kg. Since seabass spawning is found to have lunar periodicity, days of new moon or full moon or one or two days prior or after these days are preferred for inducing the spawning. Female seabass are generally larger (>4 kg) than the males (2-3 kg). To ensure proper fertilization, normally two males are introduced for one female in the spawning tank.

4.1.2.2 Induced spawning by hormone injection

The commonly used hormones in the finfish hatcheries for induced spawning are: LH-RHa, Luteinizing Hormone Releasing Hormone analogue (Signa Inc., USA), HCG-Human Chorionic Gonadotropins, Ovaprim, Puberogen, Carp pituitary glands – Pimozide. After selecting the gravid fishes, the amount of hormone to be injected is assessed. The dosage level has been standardized as LHRHa @ 60-70 µg/kg body weight for females and 30-35 µg/kg body weight for males. Since the spawning normally occurs in the late evening hours, when the temperature is cool, hormone is injected normally in the early hours of the day between 0700 – 0800 hours.



Spawners

Injection of Hormone

4.2. Spawning

Fishes injected with LHRH-a hormone respond to spawning after 30-36 h of injection. Spawning normally occurs in the late evening hours, 1900 – 2000 h. At the time of spawning the fishes will be moving very fast and a milky white substance will be seen in the water surface. There will be a fishy odour which can be felt few meters away. Prior to spawning activity, the males and the females will be moving together exhibiting courtship. Spawning activity in seabass coincides with lunar periodicity. During full moon or new moon days, the activity is found to be in peak. However with recirculation system, CIBA's seabass hatchery could achieve spawning in any time of the month. Hence, induced spawning is done during new moon/full moon days and one or two days prior or after these days. Seabass is a protracted intermittent spawner and in one spawning the fish may release 1-3 million eggs. The process of spawning will follow during subsequent day also. If the condition is good, both female and male respond simultaneously resulting in spontaneous natural spawning and fertilization.

4.3. Fertilization

Fertilization is external. In natural spawning of seabass in good maturity condition, fertilization will be 70 – 90%. The size of the fertilized eggs will be around 0.75 – 0.80 mm. The fertilized eggs will be floating on the surface and will be transparent. The unfertilized eggs will be opaque and will slowly sink to bottom. After spawning and fertilization, the water level in the spawning tanks can be increased and allowed to overflow through overflow outlet. The eggs will be pushed by the water flow. Below the overflow pipe a trough covered with bolting cloth of mesh size 150-200µ is placed and the water with the egg is allowed to pass through. The eggs are collected in the next bolting cloth, washed and transferred to the incubation tanks. Since fertilized eggs will be floating on the surface, a bolting net cloth of 150-200µ mesh size can be used for collecting the eggs from the surface. The cloth is stretched as net and towed along the water surface. The collected eggs after washing are transferred to the incubation tanks. The water in the spawning tank is siphoned into small tank covered with collection net cloth through which the water will be allowed to pass through. The eggs collected in the net cloth are transferred periodically to incubation tanks.

4.4. Incubation and Hatching

The eggs collected from the spawning tank are washed to remove the debris that would have adhered to and transferred to the hatching tanks for incubation and hatching. The hatching tanks can be cylindro-conical tanks of 200-250 l capacity. Eggs are kept at 100-200 nos./litre density. Continuous aeration is provided. A temperature of 27 – 28^{0}C is desirable. The eggs will hatch out in 17-18 h post fertilization, after which the larvae are transferred to larval rearing tanks. The unfertilized eggs in the incubation tank can be removed by siphoning. The larvae are scooped gently using scoop net and transferred into buckets of known volume. After estimating the total number, based on random sampling, the larvae will be transferred to rearing tanks.

4.5. Larval rearing for fin fishes in India

Rearing of hatchlings through various developmental stages providing required environmental parameters and feed is the most important phase in the seed production technology. This is still more significant in marine fishes like seabass, grey mullet, grouper, cobia, etc. Seabass larval phase extends up to 21 days and during this time, the feed requirement, type of feed, quantity etc. also vary with every stage.

4.5.1. Larval rearing tanks and stocking density

Tanks of 4-5 t capacity are preferred for operational convenience. Freshly hatched larvae from the incubation tanks are transferred carefully to the rearing tanks. Larvae are stocked initially at 40-50 No/litre. Depending upon the age and size, the larval density is reduced to 20-25 No/l on 10th day, and the density is maintained around 10-15 No/l after 15 days.

4.5.2. Feed and feeding during larval rearing

Green unicellular algae like *Chlorella* sp, *Tetraselmis* sp, *Nannochlorpsis sp* or *Isochrysis* sp are needed for feeding the live feed (zooplankton), Rotifer and for adding to seabass larval rearing tanks for water quality maintenance. Rotifer (*Brachionus plicatilis*) or *B. rotundiformis* is the most preferred diet for the fish larvae in their early stages. The size of the Rotifers varies from 50-250 µm. The larvae at early stage (up to 7 days) are fed with small sized rotifer *i.e.* less than 120µm and later assorted size rotifer can be fed. The larvae are fed with *Artemia* nauplii from 9th-21st day and after which *Artemia* adults can be given. Rotifers (*Brachionus plicatilis*) are given as feed to the larvae from 3rd day. Rotifer is maintained in the larval rearing tanks at a concentration of 20 No/ml initially and from 4th to 15th day the rotifer concentration is increased to 30-50 No/ml gradually. Every day after water exchange, the food concentration in the tank should be assessed and fresh rotifers should be added at the required concentration. *Artemia* nauplii are given as feed along with rotifers and green water from 10th day. By this time the total length of larvae will be around 4 mm. Larvae can be feed exclusively with *Artemia* from 16th day to 24th day. The density of the brine shrimp nauplii in the rearing medium is maintained at 2000 No/l initially and gradually increased to 6000/l as the rearing days progress. The daily ration of *Artemia* nauplii is adjusted after assessing the unfed *Artemia* in the rearing tank at the time of water exchange.

4.5.3. Water exchange

To maintain water quality in the larval rearing tanks, 30-40% of the water is exchanged daily. The salinity should be maintained at 30 ppt and temperature at 27-29^{0}C. The water level reduced (30-40%) in the rearing tank is leveled up with filtered quality seawater and green water after taking cell count of the algae in the rearing tank. Algal water is added daily upto 15th day to maintain the concentration at about 20,000 cells/ml in the rearing tank.

4.5.4. Nursery rearing

4.5.4.1. Nursery Rearing in Hatcheries

Seabass fry of 25-30 days old in the size of 1-1.5 cm can be stocked in the nursery tanks of 5-10 ton capacity of circular/rectangular (RCC or FRP) tanks. Outdoor tanks are preferable. The tanks should have water inlet and outlet provision. Flow through provision is desirable. *In situ* biological filter outside the rearing tanks would help in the maintenance of water quality. The water level in the rearing tanks should be 70-80 cm. Good aeration facility should be provided in the nursery tanks. Nursery tanks are prepared a week before stocking. The tanks are filled with water up to 30-40cm and fertilized with ammonium sulphate, urea and superphosphate at 50, 5 and 5 gm respectively per 10 t of water. The natural algal growth would appear within 2-4 days. In these tanks freshly hatched *Artemia nauplli* at 500–1000 l are stocked and fed with rice bran to grow into biomass. When sufficient *Artemia* biomass is seen, seabass fry are stocked at 800-1000 No/m^3. The pre-adult *Artemia* would form good food for seabass fry. The fry will not suffer for want of food in the transitional nursery phase in the tank since the larvae are habituated to feed on *Artemia* in the larval rearing phase. Along with '*Artemia* biomass', supplementary feed and cladocerans like *Moina* sp can also be given. Minced fish/shrimp meat passed through a mesh net to make each particle of size of around 3–5 mm is used as supplementary feed, which has to be done 3-4 times a day. Feeding rate is 100% of the body weight in the first week of rearing, which is gradually reduced to 80%, 60%, 40% and 20% during 2nd, 3rd, 4th and 5th week respectively. Regular water change to an extent of 70% is to be done daily. The left over feed and the metabolites have to be removed daily and aeration should be provided. In a rearing period of 4-5 weeks in the nursery rearing, the seed will be in the size of 1.5 to 3 g/4-6 cm with survival rate of 60-70%. Adopting this technique the hatchery at a stocking density of 1000 No/m^3 in survival rate up to 80% has been achieved.

4.5.4.2. Nursery Rearing in Ponds

Nursery ponds can be around 200-500 m^2 area with provision to retain at least 70–80 cm water level. The pond is prepared well before stocking, by repeated netting, draining and drying the pond to remove any predator/pest fishes. In case where complete draining is not possible, water level is reduced to the extent possible and treated with Derris root powder at 20 kg/ha or mahua oil cake (MOC) at 200-300 kg to eradicate unwanted fishes. Use of other inorganic chemicals or pesticides is avoided because these may have residual effect. After checking the pond bottom quality, if the pond bottom is acidic, neutralization is done with lime application and water is filled.

In order to make the natural food abundant, the pond is fertilized with chicken manure at 500 kg/ha keeping the pond water level as 40-50 cm. Subsequently, the water level is gradually increased. After 2-3 weeks period when the natural algal food is more, freshly hatched *Artemia* nauplii are introduced. Normally 1 kg of cyst is used for 1 ha pond. These stocked nauplii grow and become biomass in the pond forming food for the seabass fry. Seabass fry is stocked at 20-30 No/m^2 in the early hours of the day after acclimatizing to the pond condition.

4.5.4.3. Nursery Rearing in Cages/Hapas

Floating net cages/hapas can be in the size of 2x1x1 to 2x2x1 m depending upon necessity. Cages are made with nylon/polyethylene webbing with mesh size of 1 mm. Fry can be stocked at 400-500/m^2. Feeding rate can be as described for nursery tank. The net cages have to be checked daily for damages caused by other animals like crabs. The net cages will be clogged by the adherence of suspended and detritus materials and siltation or due to foulers resulting in the restriction of water flow. This would create confinement in the cages and unhealthy conditions. To avoid this, cages/hapas should be cleaned everyday. Regular grading should be done to avoid cannibalism and increase the survival rate. Even in higher stocking density at 500/m^2, a farmer can get a survival of 80% in the farm site when the fry were reared in hapas adopting the trash fish feeding and other management strategies mentioned above.

Nursery Rearing in Hapas

4.6. Farming

4.6.1. Traditional coastal aquaculture in India

Seabass is cultured in the ponds traditionally as an extensive type culture in the Indo-pacific region where seabass is distributed. In low lying excavated ponds, whenever the seabass juveniles are available in the wild (For eg. Apr-Jun in West Bengal, May-Aug in Andhra Pradesh, Sep-Nov in Tamil Nadu, May to Jul in Kerala and Jun-Jul in Maharashtra), seed collection centers are established and juveniles of assorted size seabass are collected and introduced into the traditional ponds which will be already with some species of fish, shrimps and prawns. Forage fishes like Tilapia will also be available in these types of ponds. These ponds will have the water source from adjoining brackishwater or freshwater canals, or from monsoon flood. The juvenile seabass introduced in the pond will prey upon the available fish or shrimp juveniles and grow. Seabass is a species with differential growth and if they are introduced into the pond at times of food scarcity, the larger may resort to feeding upon the smaller ones, thus reducing the number.

Seabass are allowed to grow for 6-7 months till water level is available in these ponds. At the time of harvesting there will be large fish of 4 to 5 kg as well as very small fishes. This is a common scenario in many coastal areas. In this manner production up to 2 ton/ha/7-8 months have been obtained depending upon the number and size of the fishes stocked and the feed available in the pond. However, this practice is highly unorganized and without any guarantee on production or returns for the aquaculturists. With the advances in the technology in the production of seed under captivity the seabass culture is done in South East Asian Countries and Australia in more organized manner with assured supply of uniform sized seed and quality feed.

4.6.2. Pond based fish farming

Seabass seeds are stocked in a well-prepared pond at stocking density of 10,000/ha. The seed size of 2.0 gm and above is preferred for stocking in the grow-out farms. Water depth should be maintained not less than 1.0 m. Seabass fishes stocked can be fed with minced meat of trash fish. Low value fishes like tilapia, sardines, horse mackerels which can be bought from the commercial fish landing centers, washed and frozen in cold storages for using when required. The fish can be taken out an hour, prior to feeding, thawed and minced using meat mincer. Feed can be made as dough ball like paste and placed in trays and kept hanging in 4-5 places in the pond. Initially the fishes are fed *ad libitum,* in any case not more than 100% of body weight on wet weight basis of biomass and gradually reduced to 10% at the last phase of culture period. Feed rations are given in two doses one in the forenoon and another in afternoon.

4.6.3. Fish farming with formulated feed

Seabass is cultured with extruded floating pellets in Australia, Thailand, Malaysia and Singapore. Being a carnivorous fish, seabass needs high protein diet. Normally, in the preparation of diet for seabass, the animal ingredients are added more than 60%, so that the required protein levels can be maintained. The nutritional requirement of the seabass is as follows - 55% protein, 15% lipid, 2% fatty acids and 15% carbohydrates. Since, Seabass feeds mainly on the fishes and shrimps moving in the water column (pelagic), the pellet should be slow sinking and should be in the column for reasonable time so that the fish can ingest the food before it reaches the bottom. The extruded pellets will have reduced loss and better digestibility due to pre-cooking. The flavor of feed also can be retained with addition of excess fish oil. The pellet size should be from 2.0 to 6.0 mm as per the size of the fish.

4.6.4. Grow-out culture of seabass in cages

Fish culture in cages is eco-friendly and allows intensive culture practice so as to increase fish production. Cages can be installed in open sea or in coastal area. The former is yet to be developed in many countries where seabass is cultured but coastal cage culture is an established household activity in the South East Asian countries. There is abundant potential in India for cage culture in the lagoons, protected coastal areas, estuaries and creeks. Since, cage culture of seabass has been proved to be a technically feasible and viable proposition this can be taken up in a large scale in suitable areas. Cage culture system allows high stocking density and assures high survival rate. Feeding can be controlled and cages can be easily managed. Fishes in the cages can be harvested as per the requirement of the consumers, which will fetch high unit price. Above all, cage culture has got low capital input and operating costs are minimal. Cages can be relocated whenever necessary to avoid any unfavorable condition.

4.6.4.1. Stocking density

In the cages, fishes can be stocked at 25-30 Nos/m^2 initially when they are in the size of 10-15 g. As they grow, after 2-3 months of culture, when the fish attained a mean body weight of 150g, the stocking density has to be reduced to 10-12 Nos/m^2. Cage culture is normally done in two phases – for 2-3 months till they attain 100-150g and afterwards for 5 months till they attain 600-800g.

4.6.4.2. Feeding in Cages

Fishes in the cages can be fed with either extruded pellets or with low cost fishes as per the availability and cost. Floating pellets have advantages of procurement, storage and feeding. Since, a lot of low cost fishes which fetch around Rs.3-5/kg only, are landed in the commercial landings in the coastal areas, they can be used as feed for seabass culture. The rate of feeding can be maintained around 20% initially and reduced to 10% and 5% gradually. In case of pellet feeding, the feeding rate can be around 5% initially and gradually reduced to 2-3% at later stage.

The feed conversion ratio (FCR) works out to about 6 or 7, if fed with low value fishes and 1 to 1.2 if resorted to pellet feeding as reported in Australia. However, the cost effectiveness of the pellet feeding for seabass in grow-out culture has to be tested.

4.6.4.2. Production

Since seabass can be intensively stocked and properly managed, the production will be high under cage culture. Frequently culling and maintenance of uniform sized fishes in the cages will ensure uniform growth and high production. Production of 6-8 kg/m^2 is possible in the cages under normal maintenance while production as high as 20-25 kg/m^2 could be obtained in intensive culture of seabass in cages.

5. Problems in the Coastal Aquaculture

5.1. Viable production technology:

- Availability of adequate quantity and quality seed is the major constraint in the development of farming of fishes. Till date in India, except in the case of Asian seabass (*Lates calcarifer*) for many other species, the technology for seed production under controlled conditions is not available.
- The grow-out technology package for almost all the species of fishes identified suitable for farming is to be standardized. Though technical viability has been demonstrated for some fishes like seabass, groupers, milkfish, mullets and pearlspot, the economic viability needs to be standardized and the farmers need to be convinced.
- Eco-friendly farming in enclosures like cages and ponds for the culture of fishes in coastal waters is suggested both for increasing production of fish as well as livelihood option for coastal folk. However, the techno-economic viability and technology package is not available though the feed demonstrations are successful.

5.2. Market price

- The economic viability of any farmed product mainly depends on the market price it fetches. When compared to the market price of shrimp, fishes fetch lower price though there is no much variation in the production cost between the two.

- Availability of marine fishes in the market is highly variable. Most of the species are low-priced compared to other animal protein sources and the price also varies with location and demand.
- There is no organized trade for the brackishwater farm-grown fishes as for shrimp. Domestic market network for farmed fishes and export niches are yet to be explored.

5.3. Resources utilization and conservation

The coastal resource is multifaceted and different stakeholders have conflicting interests. The major challenge lies in utilizing the aquaculture resources without conflicts among the stakeholders.

5.4. Environmental and social issues

Coastal aquaculture has attracted greater debate on its impact on the environment than many other activities. Though, aquaculture is an activity dependent on the hygiene of the environment, due to the unregulated high density aquaculture activity experienced in some places has evoked negative response from the environmentalists calling for remedial measures and the attention of all associated in aquaculture activity to evolve a guideline for sustainable aquaculture.

5.5. Development of suitable feed for finfish culture

Feed is an important input in the aquaculture practice. Absence of cost effective feed suitable for fish farming in different culture system like pond, cage or pen is the major constraint in the expansion of brackishwater fish aquaculture.

6. Future scope

- The vast coastal aquaculture resources are grossly under-utilized and are yet to be utilized optimally.
- New candidate species in crustaceans, mollusk, fin fishes, seaweed can be taken up to utilize the vast coastal stretch available in the country.
- Cage and pen farming must be developed to reduce the environmental impacts of coastal aquaculture.
- Development of finfish culture would open up an altogether new enterprise with growing employment opportunities for the coastal fisherman.

7. Thrust areas for future research

- Captive broodstock development, captive maturation and induced breeding of different cultivable marine fin fish.

- Development of live feed culture technology (Rotifers, Moina, Daphnia, Copepods, etc)
- Feed development for the brood fish and different fish larvae
- Health management of broodstock and larvae
- Genetic improvement and selective breeding
- Development of transgenic fishes for better growth and health
- Development of pen and cage culture system for fin fish
- Bio-security in hatchery and farming system

8. Conclusion

The importance of coastal aquaculture will become more apparent in the coming year with demanding pressure from an ever increasing world population. Coastal aquaculture has great potential for the production of food, alleviation of poverty and generation of wealth for people living in coastal areas, many of whom are under-privileged. The assurance of mature and sound techniques in coastal aquaculture is the most important channel towards a sustainable aquaculture industry, which calls for development of practical strategies. The first is to expedite the research on different aspects of aquafarming. Second is to formulate and implement systematic regulations and self controls. An integrated regulation system must be imposed to ensure that the environment is not harmed by practicing coastal aquaculture and the natural trait of propagated fish are not lost in the process. Thirdly it is important to strengthen regional, national and international communications and information exchange. Exchange of technical know-how is necessary to prevent research duplication for human resource management. India is all set to witness a boom in coastal aquaculture, given the current thrust for research on the development of culture technologies at the national and international scenario.

Utilization of Tsunami Affected Land for Shrimp Culture

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1. Introduction

The Andaman and Nicobar Islands have many fragile ecosystems like mangroves, coral reefs, etc, which are very sensitive to environmental changes. Tsunami stuck the Andaman and Nicobar Islands on 26th December 2004 and caused great losses to human life, agricultural crops, livestock, forest cover and aquatic resources. A significant portion of forest and mangrove areas were also destroyed. Mangrove forests of Andaman and Nicobar Islands constitute approximately 17% of the total mangrove area of India and it has decreased significantly after tsunami. Due to the change in the island topography after tsunami, the coral reefs in some of the northern islands have been permanently exposed. While the tsunami had resulted in the fragmentation of branching corals and toppling of the massive upturning, the earth quake caused cracks in the coral reefs. The cultivated land available before Tsunami 2004 was 50,000 ha which came down to 43,339 ha. The area under paddy has drastically come down from 12,000 ha to 7,685 ha due to submergence of low lying areas or seawater intrusion. Several agricultural lands became saline and unsuitable for crop cultivation, some freshwater areas are still inundated with saline seawater. In recent times, utilization of those inundated areas for economic activities is getting top priority. As both shell and fin fishes have very good demand in Andaman, using those areas for fish culture activities will not only utilize the tsunami affected area for production purpose but will also generate employment avenues for the people of Andaman.

2. Situation arised due to tsunami

The effect of tsunami in Andaman can be categorised into three situations.

1. **Situation I:** Low lying coastal areas where there is permanent stagnation of seawater and the depth of impounding increases with high tide.

2. **Situation II:** Low lying coastal areas where sea water reaches with every high tide and recedes with low tide.
3. **Situation III:** Low lying coastal areas where seawater intruded only during Tsunami and then receded permanently.

3. Water level maintenance

For brackishwater culture purpose, a pond has to have a minimum of one meter water level throughout the culture period. In this condition, areas coming under Situation I, as such can be used for fish culture purpose, however, for situation II slight modification is necessary as water level will continuously fluctuate. For situation II, to maintain water depth to a minimum of 1 m, bundh or dyke has to be erected along with self operated sluice gate system for entry and exit of water. Second situation will be better for those species require regular water exchange like shrimp. If sluice gate is made with proper design, apart from water exchange, complete draining of the water will also be possible. This will reduce harvesting cost significantly.

There are many species that can be cultured profitably in the brackishwater. However, due to scarcity of seed and other input materials, only few are becoming popular in India. Few important species like seabass, shrimp, mudcrab, mullets are some of the important candidate species that can be cultured in Andaman. A brief summary on extensive farming practice of shrimp is mentioned here with.

4. Extensive Shrimp farming

Tiger shrimp is the single most important species that are cultured very extensively in the brackishwater area of India and getting lot of export earnings. However, in the recent times due to dreaded WSSV virus, shrimp culture has been severely affected in the coastal states of India. Very high stocking density and poor water quality management are some of the causes of this disease in mainland. Due to high tourist inflow, rate and demand of tiger shrimp is also very high in Andaman. Though presence of WSSV has been detected in shrimps of Andaman but till now no report of death of shrimp due to this virus has been reported. Hence, extensive shrimp culture practice can be done in the tsunami inundated land areas.

4.1 Site selection

Site selection is an important step for success of a shrimp farming. In Andaman after tsunami sizable area has gone under water. To demark the potential area for brackishwater aquaculture, a detailed survey was conducted in South and Middle Andaman and it was found that out of about 4000 ha of submerged agricultural farmlands, 630.12 ha is suitable for coastal aquaculture. The farm site should not be located too close to ecologically sensitive areas like marine national parks, mangroves, etc.

In general, the major soil types of Andaman including tsunami affected areas are moderately acidic with pH ranging from 5.5 to 6.5, covering the hill slope. Slightly alkaline soils with pH ranging from 7.5 to 8.0 mainly occur in Neil, Havelock, Makka Pahar area of South Andaman, Little Andaman and the Nicobar group. Soils of Dhanikari are more acidic (pH 3.4-4.7) in comparison to others areas. Mean values of EC in all soils are almost identical and fall in the safe range (1.0 dSm-1), except Dhanikari soils, which are highly saline (4.6 dSm-1). It is always better to have soil pH between 7 to 8 for the brackishwater aquaculture, though soil pH >5 can be used for farming after adjusting pH of the soil. The pH of the water for shrimp farming can be 7.5-8.5. Some of the important water quality parameters like temperature (28-33^{0}C), pH (7.5-8.5), transparency (25-4.5cm), dissolved oxygen (5-7ppm), salinity (15-25ppt), alkalinity (200ppm), nitrate (<0.03ppm), nitrite (<0.01ppm) are considered to be tested periodically and maintained within the optimal range (as given in parentheses against each parameter) for shrimp farming activities.

4.2 Dyke construction

Drying the pond bottom and proper water exchange are essential for shrimp culture activities. In Tsunami affected areas, tide-fed system of culture will be more preferable compared to pump-fed farming system. Hence, Situation II can be ideal area for shrimp farming activities as expenditure for filling water to compensate water loss due to evaporation and for regular water exchange will be minimised.

Dyke is very essential for shrimp farming. Pond dyke has to be made about 1.5 m so that water level can be maintained about 1m. The peripheral dyke can be made as per the land pattern and should be strong to withstand continuous tidal thrust mainly as it is the bundh facing the sea and exposed to flood, cyclone, etc. The height of the peripheral bundh can be up to 1.5- 3 m. The height may depend upon the highest flood level and highest high tide level. A free board of 0.6 to 0.7 is required above the water level. The slope of the dyke can be 1:1 for clayey soil, 3:1 for sandy soil.

An outlet has to be made for maintaining the water level as well as for regular water exchange. Outlet sluice gate has to be made in such a manner that it prevents entry of pest and predators but facilitates water exchange. It can be made either by wood or concrete structure. Ponds can be of either rectangular or square shape. The other important criteria for site selection include availability of adequate quantity of quality water free from too much of suspended solids and a sufficient tidal range for pond drainage and drying. Clay and loamy soils are preferable. Ponds can be made in sandy soil also but seepage loss has to be taken care. For construction of new pond, care should be taken during site selection so that at any point of time, shrimp farm does not affect the mangroves or ecologically sensitive areas like marine national park, etc.

4.3 Pond preparation

Pond bottom conditioning: It is an important management steps for shrimp farming. When tsunami effected sites are taken for production purposes, it should be selected in such a way that by using the sluice gate of the dyke, whole water can be drained out when required. For the ponds where complete water removal is not possible, the remaining water should be properly treated to remove preys and predators or should be pumped out. After complete drainage, the pond has to be dried till cracks are developed. Tilling, ploughing or raking of the pond bottom has to follow after drying. This will facilitate oxidation process and release of minerals.

Liming: Soil pH of Andaman is relatively acidic and it has to be corrected by applying lime after drying the pond bottom. Lime is first spread over the pond bottom and mixed thoroughly with soil. The water is filled in the pond up to 30 cm level and drained after 7 days. Filling and draining of water has to be done two to three times till the pH stabilizes near 7. If soil pH is >6.5, then though lime material is not required for pH adjustment, lime can be applied at 5 kg/100m^2 areas for general conditioning of the pond.

Amount of lime materials (MT/ha) required to raise the pH to 7.0

Soil pH	Quantity of lime material (t/ha)				
	Agri- lime	Dolomite	Hydrated lime	Quick lime	Shell powder
4.0	16.6	17.0	25.5	13.8	19.2
4.5	13.9	14.2	21.2	11.5	16.0
5.0	11.1	11.3	17.0	9.2	12.8
5.5	8.3	8.5	12.7	6.9	9.6
6.0	5.5	5.7	8.5	4.6	6.4
6.5	2.8	2.8	4.2	2.3	3.2

Fertilization for production of natural food: Shrimp post larvae released into the pond require copious amount of natural food in the form of plankton for their growth and development. For production of natural food pond fertilization is a common practice. Organic carbon content in soils of Andaman and Nicobar islands is usually more than 0.5 per cent. Hence, 50-100 kg cow dung or 17-35 kg dry poultry manure/ 0.1 ha water spread area of pond is sufficient to develop sufficient quantities of zooplankton. The manures are soaked in water overnight and applied in the water in the next day. Urea and super phosphate can be applied at 2.5-5.0 kg/0.1ha pond area. After application of chemical fertilizers, water level can be raised. Algal bloom will start developing after 5-7 days. Secchi disc visibility of 25-40 cm is optimum for shrimp farming activities.

5. Stocking of shrimp PL

The recommended stocking density for the extensive method of shrimp farming in Andaman is 4-5/m^2 (40,000-50,000 no/ha). PL should be procured from reputed hatcheries. PL should be always uniform in size and colour, disease free, active and swim against water current created in the container. During stocking, care should be taken that PL are not transferred suddenly from one environment to another. Any sudden change of water quality like pH, salinity, temperature can cause mass mortality of the shrimp post larvae. Before stocking, post larvae should be acclimated to the pond water to avoid stress and shock. Salinity has to be adjusted slowly at 3 ppt per day. The temperature and pH can be adjusted by first allowing the plastic bags to float on the surface for about 30 min (without opening). The bags are then opened, pond water allowed to mix with water of plastic bag for about 30 min and then the PL released slowly in to pond. In Andaman, CARI and few other private agencies are producing shrimp PL.

5.1 Feeding

In shrimp culture operation about 40-50% of the recurring expenditure is spent towards feed. The aim of the feeding management is to avoid over feeding or under feeding. Under feeding results in poor growth while over feeding leads to economic loss to the farmers apart from polluting the environment. Feed of shrimp should contain 38-40% protein in the diet and should be stable up to 4 h in the pond condition. The size of the feed should be made according to the size of the larvae (1.0-2.5mm). Quantity of feed given is based on average body weight and estimated survival of the shrimp. Feeding rate gradually decreases from 8-10% of body weight to 5-3% of the body weight. Regular sampling (fortnightly) with cast net has to be done to ascertain the size of the shrimp and accordingly the pallet size and feeding regime has to be modified. Feed can be given 4-6 times in a day by splitting the total dose equally. Shrimp is active during night hence feeding schedule is adjusted in such a manner that maximum percentage of feed is given during evening and night hours.

5.2 Water quality monitoring

Seawater of Andaman is quite congenial for shrimp farming as water is free from pollution and organic load. Regular water exchange is the easiest and most efficient method for maintaining proper water quality at the farm level. As extensive method of shrimp farming is recommended for Andaman with not much water exchange till 30 days of stocking. Water has to be filled in to compensate evaporation and seepage loss. Water exchange is also required in the time of emergencies like low dissolved oxygen, movement of shrimp to the surface, very high fluctuation of pH, cloudy and rainy days persisting for a long time.

Low dissolved (DO) oxygen is the most important parameter for survival and growth of the shrimp. Regular water exchanges can somewhat rectify the problem but that will decrease the plankton population. Paddle wheel aerators need to be installed if the stocking density is high (6-10/m^2). Aerator is generally used in the early morning when DO concentration become very low. Aerators are not required for extensive method for shrimp farming but results will be better if one uses that.

5.3 Regular health monitoring

Diseases are caused when the equilibrium between host, pathogen and environment is lost. Most of the diseases occur when the water quality is sub-optimal and stressful to cultured shrimp and therefore water quality should be maintained within optimal levels. Any sign of distress to the farmed shrimp has to be noted and recorded. Sluggishness of movement, inactiveness, broken appendages, discolouration in the body, reluctant in feeding, white spot on the body, behavioural changes are some of the symptoms of diseases. Proper consultation has to be made with professionals to rectify those problems. Water exchange has to be stopped if any such case is recorded in nearby areas also.

6. Harvesting of shrimp

Complete harvesting can be done by opening the sluice gate and fixing the bag net to collect the shrimp. After complete harvesting, left over shrimp can be collected by hand picking. An average production of 1.5-2 MT /ha can be obtained from a shrimp farming in Andaman if proper management practices are followed.

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Prospects of Enhancing Fish Production in Andaman and Nicobar Islands and Lakshadweep through Oceanic Fish Aggregating Devices (FAD) and Sea Cage Culture of Fish

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Abstract

The Andaman and Nicobar Islands and Lakshadweep Islands are naturally bestowed with very rich biodiversity in land and marine environment. The tropical ecosystems provide many opportunities for the island communities to develop their socioeconomic status while preserving the natural resources. In these islands the oceanic resources like tuna are yet to be harvested fully against their estimated potential. This article deals with the possibilities available for enhancing the fish production in Andaman and Nicobar Islands and Lakshadweep Islands though oceanic Fish Aggregating Devices and sea cage culture of fishes.

1. Introduction

Andaman and Nicobar Islands (A&N Islands) comprise of a chain of 550 islands, (6° 45’ N and 13° 45’ N latitude and 92° 12’ E and 93° 57’ E longitude) spread over a distance of 1120 Km with the coastline of about 1962 km. The exclusive economic zone (EEZ) of A&N Islands comprises of 0.6 million sq km^2, which is roughly about 30% of Indian EEZ. The continental shelf of this island group has an area of about 35000 $km^{2.}$ The islands together have a total land spread of about 8300 km^2 and consisting mostly of steep hills, enclosing valleys clothed with dense tropical forests. The coastal areas have a rich growth of mangrove vegetation and fringing coral reefs with narrow beaches. These islands have steep continental slopes and as a result of which oceanic conditions prevail close to the shoreline. The coastline is quite wavy with many bays, lagoons and creeks, supporting rocky, sandy and muddy beaches. In addition to 33,000 ha of mangroves, the islands have a total brackish water area of about 110,000 ha. The islands frequently experience earthquakes of various magnitudes. The last 9.15M maga earthquake on 26th December 2004 followed by tsunami resulted in rise and subduction landmass in Andamans. The northern parts of Andaman Islands rose where as the southern areas had subduction. Port Blair experienced about 1.02 meter of land subduction, which resulted in large damage to the infrastructures and inundation of large area of arable land areas along the coast (give ref). Naturally occurring creeks and bays as well as inundated subducted land provide ideal conditions for finfish and shell fish culture. Similarly, the deep sea conditions prevailing around the islands give scope for capture fisheries development. There are about 1200 species of fishes in Andamans which include about 250 species of ornamental fishes. At present the fish harvest is about 28,000 tonnes annually, whereas the estimated potential is about 1.48 lakh tonnes, which includes 65,000 tonnes of tuna resources (Sampath *et al.*, 2004). However, various species of tuna resource harvest around the A&N islands is only 800-1000 tonnes annually.

Lakshadweep is a group of Islands, one of the Union Territory of India, located in the west coast of India, which is spread between 8° and 12° 30 North latitude and between 71° and 74° east longitude. There are a total of 36 islands which covers an area of 32 Sq. Km. Out of 36 islands 11 are inhabited and the fishery activities are being carried out from these islands. Lakshadweep has immense potential for development of marine fisheries and seafood. Minicoy, Agati, Suheli and Bitra are important with regard to Tuna pole and line fishery. The estimated marine fishery potential in the EEZ of Lakshadweep is about 90,000 tonnes consisting mainly of tuna and tuna like fishes, elasmobranchs, perches, etc. However, present fish harvest around the islands in the order of 14,000 tonnes. The approximate estimated potential for the exploitation of tunas around Lakshadweep is 50,000 tonnes, whereas the present harvest is only about 10,000 tonnes. Tuna resources form one of the main sources of food for islanders of Minicoy region. Pole and Line fishing is the main mode of fishing of Tuna in Lakshadweep waters. The success of pole and line fishery of skipjack tuna in Lakshadweep directly depends on the availability of sufficient quantities of suitable live bait fishes around the islands. Since tuna shows high migratory behavior, the traditional fishing boats spend considerable time searching for fishes and fishing locations.

This paper deals with the activities carried out by NIOT in the areas of ocean science and Technology in A&N Islands, Lakshadweep and other coastal areas in the mainland in the country for improving livelihood security of coastal people through programmes such as sea cage culture of fish and deployment of Fish Aggregating Devices (FAD).

2. Societal activities carried out by ANCOST, OSTI, NIOT

The Andaman Nicobar Centre for Ocean Science and Technology (ANCOST) is the field unit of Ocean Science and Technology for Islands (OSTI) programme of NIOT. It started as a project under the Living Marine Resource Enhancement (LMRE) Programme sponsored by former DOD during the 9th plan period and later got integrated as the Ocean Science and Technology for Islands (OSTI) programme of NIOT during the 10th Plan period with the main intention to provide science and technology initiatives for helping island communities.

The major project taken up in the LMRE programme was breeding, rearing and sea ranching of selected marine organisms of commercial value, particularly lobsters and mud crab. Pilot scale technologies were developed for fattening of lobsters and mud crabs. Laboratory scale experiments were carried out on spiny lobsters, *Panulirus homarus* and *P*. *ornatus*, *P*. *versicolor* and sand lobster *Thenus orientalis*. Technology for fattening of lobsters was developed at seafront laboratory (SFL) facility of NIOT, at Neelankarai, Chennai (Vijayaklumaran *et al*., 2005; 2008; Senthil *et al*., 2004; 2005). Various stages of juvenile lobsters were fed with mussel meat, clam meat and trash fish. The mussel meat and clam meat fed lobster showed good growth rate over a period of 6 months, since the biochemical composition of the mussel were found to be good source of necessary protein, lipid and carbohydrates (Vinithkumar, 2002). After this field level studies were carried at Tharuvaikulam, Tuticorin. The growth rate observed in the laboratory conditions was 30 gm per month. The fattened lobsters attained exportable size within 5 months. The maximum growth attained was 35 gram per month. Later, the technology was developed for fattening of lobsters in sea cages, which was disseminated to the coastal communities through various training programmes.

NIOT with cooperation from the Department of Fisheries, Tamil Nadu State to extended this technology at field level through cage culture of lobsters for the benefit of coastal communities. The activities on cage culture of lobster were developed as eco-friendly and community oriented technologies to give an alternative income to the coastal communities. The cages were designed to withstand higher sea wave loading. Cages were made of steel, FRP, PVC and plastics. The deployed cages also acted as fish aggregating devices at the culture sites. Mussel culture techniques near the cages for feeding the lobsters were also imparted to the coastal people. The concept of people's participation to conserve of marine biota along with their economic upliftment was given prior importance (Vijayakumaran, et al., 2006). At Taruvaikulam near Tuticorin in Tamil Nadu state, the cages were distributed to selected beneficiaries and later to women self help group (WSHG) under DRDA programme with 30% subsidy. The members of the WSHG were trained in lobster stocking in the cages, periodical feeding and cleaning of cages, culture of mussels for feeding, harvesting and related activities. The Lobster fattening technology transfer was carried out at various places of East coast of India in villages near Pulicat like Thirumullai nagar, villages near Kaaraikal such as Palaiyaru, Madavaimedu, Thirumullaivasal, Kodiakarai, Avarikaddu, villages near Mandapam such as Pamban, Chinna Eerwadi, villages near Tuticorin such as Tharuvaikulam, Kulasekarapattinam and village in Kanyakumari at Chinna Muttam. Apart from this cage culture activities were also carried out at Parangipettai Thirumullaivoil and Kodiakarai.

Fig. 1. Map showing Societal activity locations of NIOT

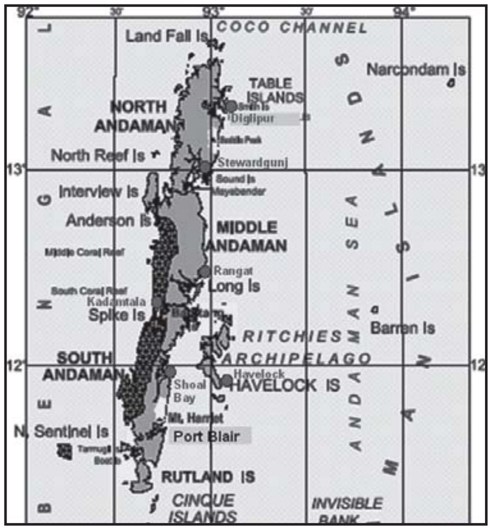

Fig. 2. Map showing Societal activity locations of NIOT at A & N Islands

Table 1.Societal activities carried out by OSTI at Tamil Nadu and ANCOST at Andaman Nicobar Islands

No.	Date	Sites	Purpose	Beneficiaries
1.	09.07.2002 - 13.07.2002	NIOT Campus, Chennai	Training on Lobster fattening and larval rearing	19
2.	15.05.2003	Tharuvaikulam, Tamil Nadu	Training on cage culture of Lobsters	50
3.	18.08.2003	Havelock island, Andaman	Training and distribution of cages for mud crab fattening	10
4.	29.08.2003 - 30.08.2003	Kadamtala island, Andaman	Training and distribution of cages for mud crab fattening	20

5.	27.01.2004	Havelock island, Andaman	Training and distribution of cages for mud crab fattening	20
6.	28.01.2004	Port Blair, Andaman	Distribution of cages to beneficiaries from Brindaban by Secretary	40
7.	29.01.2004	Havelock island, Andaman	Secretary met with PRI members and beneficiaries. Training and distribution of cages for mud crab fattening	20
8.	21.2.2004	Stewardgunj, Andaman	Training and distribution of cages for mud crab fattening	20
9.	22.2.2004	Brindaban, Andaman	Training on mud crab fattening	20
10.	23.2.2004	Shoal Bay, Andaman	Training on mud crab fattening	20
11.	11.03.2004	Tharuvaikulam, Tamil Nadu	Training on cage culture of Lobster for Vairam Self Help Group	12
12.	04.08.2004	Erwadi & Pamban, Tamil Nadu	Training on cage culture of Lobster	25
13.	04.12.2004	Tharuvaikulam Tamilnadu	Dr. Bruce Philip from Australia visited and explained Lobster and crab cage cultures	100
14.	10.12.2004 - 11.12.2004	Chirala, Andhra Pradesh	Training on cage culture of Lobster and crabs	
15.	18.12.2004	Havelock island, Andaman	Training and distribution of cages for mud crab fattening	10
16.	20.12.2004	Diglipur, Andaman		20
17.	02.01.2005	Nagapattinam district, Tamil Nadu	Training on cage culture of Lobster for Tsunami affected fishermen	67

The dissemination of lobster fattening technology was aimed at providing an opportunity for additional income to the fishing communities. Fishermen regularly catch various sizes of different lobster species from natural environment in small numbers along with other catch. The collection consists of adult, juveniles and sometimes post puerulus (baby lobsters). The fishermen also get soft-shelled lobsters as well as berried lobsters in their catch. The under sized and soft shelled lobsters fetch very low price in the market. Similar is the case for soft-shelled and berried lobsters. When the juvenile lobsters are caught they are never thrown back to the sea but sold at lower prices at the land. Instead of this, the undersized juvenile lobsters are fattened and fetch good price. Thus fisherman get alternative source of income. The fishermen were advised to keep the berried lobsters collected by them in the cages until the eggs are hatched out. The lobster cages themselves attract smaller young ones and act as peurulus collector. Once they enter into the cages, the puerulii grow fast as there are no natural predators and there is no food scarcity. Otherwise, these young ones may be predated by other organisms. When the soft shelled organisms are collected they are allowed to grow in sea cages, which help in the hardening of shells to fetch higher price. The number of cages deployed at each site is restricted, depending on the local resource availability.

Fattening of mud crabs were also carried out at A&N Islands during the 9th and 10th plan periods. The technology for cage culture of mud crab was developed at ANCOST. The major mud crab species available in Andaman were *Scylla serrata*, *Scylla tranquebarica*, *Scylla oceanica* etc. The crabs (weighing 200 – 300 g) could be grown at a rate of 60 gm per month. The harvest was done after 3 to 4 months of fattening. The technology developed was transferred to island community. A manual was prepared in local languages such as Hindi and Bengali for mud crab fattening through cage culture. Training / workshop were conducted to islanders at Kadamatala, Shoal Bay, Brindaban, and Steward Gunj at Andaman Islands. ANCOST has distributed the cages for fattening of mud crabs to many beneficiaries at the above sites. Suitable suggestions were given for modification of creak for cage culture at Brindaban. Similarly training programme at Bamboo flat near Port Blair bay was conducted in A & N Islands. In some areas of A&N Islands naturally available stocks of crabs are more. In those areas, while doing collection fishermen get soft shelled and under sized crabs which are mostly thrown in the land. These crabs could be used for fattening purposes.

3. Development and deployment of Fish Aggregating Device by NIOT

Apart from cage culture lobsters and crabs, designing and deployment of Fish Aggregating Devices (FADs) were carried out at 28 locations in Lakshadweep Islands which was partially funded by Lakshadweep Administration.

Any floating objects in the sea attract fishes. In fact, the expression FAD has become more restricted, to mean a man-made floating object, anchored or not, set up to aggregate fish (mostly pelagic species) (SPC FAD Bulletin, 1996). Many of the floating materials like, wooden logs, data buoys, marker buoys, boats, ships, etc., attract fishes. It is well known that migratory tunas, aggregate around floating logs and other drifting objects, sometimes in very large numbers. Having observed this behaviour, fishermen learned that they get higher catches when they found floating objects and fish near them. Some industrial fishing techniques rely on this tendency of tunas to gather near natural floating objects to improve their catch; many tonnes of tuna have sometimes been taken around even small bodies of floating debris. Since most of these materials and structures offer good space for attachment, easy transport and food from the surrounding waters. The biofouling organisms will create a micro or mini ecosystem which over a period will grow in to feeding or resting place for many of the smaller organism such as inverterabrates, fishes, juveniles and their larval forms. The colonization will result in aggregation of bigger fishes around these structures for predatation of smaller fishes. Naturally the bigger tuna like fishes get attracted due to the availability of shade or light and even food from lower tropical level to higher topical level by predation. While the smaller fishes are available closer to the FADs the larger tuna like fishes always found away from the FADs (Anderson, J and Gates, P.D. 1996).

Fish aggregating devices (FADs) are popular form of fisheries resource enhancement and management activity in many parts of the world. FADs are used worldwide in tropical and semi-tropical waters by recreational, artesian and commercial fishers, to concentrate pelagic fish for capture. It has been established that FADs are more effective when they are moored in deep water (Prado, 1991). At present, approximately 1.2 million tons of the three main species of tuna (yellow fin, skipjack and big eye) that associate with drifting FADs and over 100 000 tons of by-catch are caught each year in the Atlantic, Indian and Pacific oceans, which is approximately 1.5 % by weight of the world's capture fishery each year. There are many advantages in using the FADs. It helps aggregating the fishes from larger area to a smaller area. Thus citing and catching the fishes are easy with a little effort. It helps in reducing the operation time and saving the fuel as well as cost of overall operation. The fishermen can concentrate their fishing effort to smaller areas to catch more fishes to increase the catch per unit effort and maximum sustainable yield. In an area like A&N Islands, with the availability of higher tuna resources, FADs will help in augmenting the fisheries production of the islands. NIOT has installed many data buoys all around India to collect oceanographic and atmospheric parameters. Even though they are not designed as FADs, these data buoys are also acting as FADs. NIOT had deployed moored data buoys near to Lakshadweep Islands for the collection of oceanographic and metallurgical data under the Armex programme. It was noted by the local fishers that these moored data buoys which were anchored in deep water, acted as FADs bringing in more fish around them. Based on the fish aggregation around data buoys, the Lakshadweep Administration requested NIOT to deploy FADs around each of the inhabited islands. The FADs were specially designed by NIOT and deployed around the Lakshadweep islands. The NIOT designed cylindrical, HDPE FADs for deployment in Lakshadweep.

4. Design and construction of FAD

NIOT has designed and developed FADs to suit the Lakshadweep waters. Under normal sea wave loading conditions, the expected life span of FAD would be more than one year. The mooring system and the total design were verified using the softwares and expertise available. Only tested components were procured for assembling the entire system. During the monsoon seasons, the mooring systems of the FAD are subjected to severe sea wave loading conditions. Hence periodic repair and maintenance of FADs are required.

The FADs were fabricated by using the readily available yellow colour, High Density Polyethylene (HDPE) pipe with a diameter of 710 mm, and 2.5 m length. Both top and bottom end was sealed with HDPE lids. The bottom of HDPE pipe was filled with marine grade concrete to maintain the vertical position of FAD. Also air sealed containers were placed inside the HDPE pipe to increase the buoyancy. The entire HDPE pipe was filled with polyurethane (PU) foam at a density of 32 kg/m^3 without leaving air gap or over space. For nighttime visibility the floats were provided with marker lamp powered by solar panel. The FADs were also fitted with underwater light powered by solar and battery.

The mooring system of the FADs was designed using a software named ARCFLAX. The mooring system consists of combination rope comprising of steel and nylon. Apart from that negatively and positively buoyant nylon ropes were also used. The entire FAD system were moored by anchor to take care of the upward & horizontal movement of the moored system due to wave and current action and to withstand approximately 3 tonnes of sea wave loading during normal sea conditions. Unexpected pilferage or tampering of the mooring by fishermen or any other persons or objects is not considered in the load calculation. This is due to the fact that these loads are very high and it will lead to the breakage of the mooring system.

The appendages are important components of FADs. The numbers of appendages or their surface area has an influence on the time necessary to aggregate fish. The appendages accumulate marine growth as food for small fish species, which attract predators, which in turn will attract even larger predators such as tuna, dolphin etc. All the above factors were taken into consideration prior to the designing of the appendages for the FAD and are fixed 5 m to 25 m below the surface for maximum primary production.

5. Site selection survey

The NIOT made a tentative deployment chart based on bathymetry, shipping channels and fishing grounds traditionally operated by trawlers and discussed with Department of Fisheries, Lakshadweep Administration, local fishing communities and local fishermen cooperatives to put forward their views in order to avoid conflict of interests. As the part of pre-deployment survey NIOT scientists had formal meeting the Director-in-Charge of the Department of Fisheries, Lakshadweep. President cum Chief Councilor, District Panchayat, Chairperson, Village (Dweep) Panchayat, officials from the Department of Fisheries from the islands, Agatti, Kalpeni and Minicoy and elected representatives and fishermen from various islands. After the discussion the NIOT scientist visited 7 islands and interacted with the fishers before finalising the deployment sites.

6. Deployment of FADs

28 FADs were deployed at depths ranging from 470 to 1085 m in Lakshadweep in February 2006. As a larger ship with deck space to accommodate 28 FADs and their accessories were not available for deployment, NIOT hired a barge, Blue Fin, from Mumbai with large deck space. The barge was fitted with ecosounder to do bathymetric survey of the deployment sites. At each site of deployment a bathymetric survey was conducted using the ecosounder and appropriate locations were selected.

7. Monitoring of FADs and the fish catch

The monitoring of fish catch and maintenance of FADs were the responsibility of the Administration. A questionnaire to collect pre-deployment data was given to the Administration with a request to gather at least 100 opinions from each island. The Administration was also requested to monitor the fish catch and collect related information around the FADs as per the following norms.

- Catch-and-effort data, broken down as far as possible by time, fishing area, fishing gear, fish species and fishing vessel.
- Economic data and information on fishing vessel operations.
- Market data: fish price and sales volumes, and information on market trends.
- Social information, including observations on FAD programme effects, FAD use, and the incidence of conflicts or cooperation among users.
- Apart from this the fishermen were asked not to catch juvenile and berried fishes, and not to tie their boats to FADs, since it will increase the load on the FADs and mooring system. The increased loading would result in damage of FADs as well as damaging of mooring system and nylon ropes.
- The Administration was requested to carry out experimental vertical long

lining around the FADs with their vessel equipped for long lining to demonstrate the availability of large fishes below 200m level.

8. Feed back

The Lakshadweep Administration informed to NIOT that there was increase in fish catch around FADs and few FADs were lost during the south west monsoon. Loss of batteries and minor damages to few FADs were also reported. On request from NIOT two technical personnel from Administration were sent to NIOT Head Quarters at Chennai and were given training in maintenance and repair of FAD components.

Tuna dominated the catch around the FADs. Other fishes like carangids, coryphaenids, lethrinids, belonids, hemiramphids, scombromorids and xiphids were also caught around the FAD's. The administration has reported that fish catch during 2006 has reached a record level after the deployment of FADs. The fishers have nicknamed the FAD as "Fish Bank". Based on the success of the FAD deployment, the administration has requested NIOT to replace the lost FADs and deploy more numbers around the islands. At present during 2008-09 about 20 more FADs are going to be installed at Lakshadweep islands.

9. Conclusion

Andaman and Nicobar Islands and lakshadweep with rich biodiversity and unexploited fishery resources, have a good scope for sustainable development of fisheries sector. For this, proper environment-friendly technologies with proper management actions are the need of the hour. It is hoped that careful planning with various stakeholders of the fisheries sector will help to improve the fisheries sector of A&N Islands.

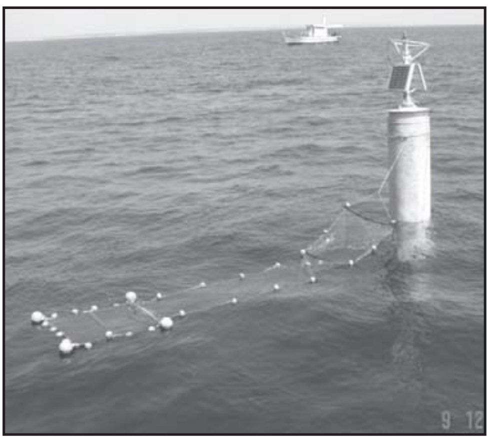

Fig. 3. Fish Aggregating Device (FAD) deployed by NIOT at Lakshadweep islands

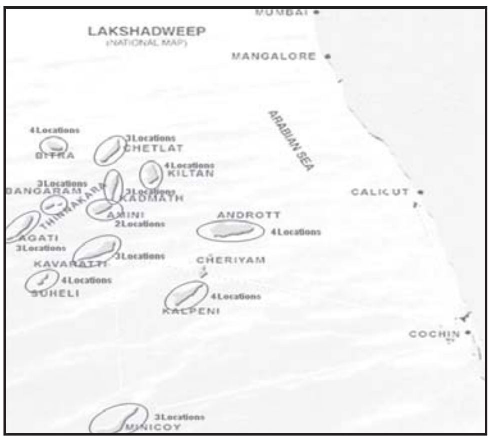

Fig. 4. Locations of FADs deployed at Lakshadweep Islands

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Prospects of Cage Culture in Andaman and Nicobar Islands

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1. Introduction

Cage farming has enormous potential to augment fish production. The persistent decline in capture fish stocks of the world oceans due to over fishing was one of the major driving courses behind development of alternative methods like cage culture. World has witnessed major developments in coastal aquaculture, especially in marine cage farming in the recent past. The top ten countries that have made a mark in cage culture are Norway, Chile, China, Japan, U.K., Canada, Greece, Turkey, Republic of Korea and Denmark. Cage culture means culturing aquatic organisms either in fresh water or in the sea in enclosures erected in aquatic systems. Cage culture is practiced in many countries for many years for production of commercial species, like bluegill, hybrid striped bars, carp, channel catfish, salmon, tilapia and trout. Modern cages culture is a highly evolved and technically refined activity, using modern materials and technological inputs and practices.

There are basically two types of cage culture systems: hatchery-based and capture-based. The source of stocking materials (seed) decides the type of farming activity. In capture-based system seeds are obtained from very early stages to adult from wild while in hatchery-based system, seeds are collected from reliable hatcheries. Based on the management practice, degree of stocking and nature of feeding, cage culture can be grouped into extensive, semi-intensive and intensive as usually referred in land-based culture systems. About 130 species of fin fishes and a dozen species of crustaceans are cage farmed throughout the world. For cage culture mostly high value carnivorous fishes are used like yellow tall, snapper, black sea bream, etc in Australia and Japan; Salmon in Norway and Scotland; sea bass, grouper and snapper in Malaysia; black tiger and lobster in Phillipines.

2. Types of Cages

Cages have developed a great deal from their humble origins and today there is a great diversity of types and designs. They may be classified in four basic types they are fixed cages, floating cages, submersible cages and submerged Cages.

2.1. Fixed Cages

Fixed cages consist of a net bag supported by posts driven into the bottom of a lake or river or in shallow area of sea. They are commonly in use in some tropical countries such as the Philippines. Fixed cages are comparatively inexpensive and simple to build. They are limited in size and shape and their use is restricted to sheltered shallow sites with suitable substrates. Mussel culture, oyster culture, etc can be done in fixed type of cages.

2.2. Floating Cages

The floating cages are most widely used and can be designed in an enormous variety of shapes and sizes to suit the purpose of the farmer. It is also less limited than most other types of cage in terms of site specifications. Some floating types are designed to rotate in order to control fouling. The floating cages rotate about central axis incorporated into the collar while other designs are rotated by means of moving the floatation elements or by adjusting the buoyancy of the frame members.

2.3. Submersible Cages

The position of these cages in the water column can be changed to take advantage of prevailing environmental conditions. The cages are typically kept at the surface during calm weather and are submerged during adverse weather or during harmful algal event. Some submersible designs rely on the bag being suspended from buoys or a floating frame on the water surface.

2.4. Submerged Cages

Submerged cages, which are little more than wooden boxes with gaps between the slates to facilitate water flow are anchored to the substrate by stones or pots. Net mesh bag designs are used in lakes and reservoir in Russia and China. All species do not readily adapt to being cultured in submerged cages.

3. Characteristics of cage culture

Cage culture is becoming a very popular venture for culturing mostly high value fishes in many countries. The key characteristics of the cages are :

- The coastal aquatic resources can be optimally utilized and the productivity can be enhanced manifolds.
- Marine cage culture can be done in bays, creeks, lagoons even in the open ocean.
- Ability to utilize water bodies unsuitable for conventional pond harvesting methods such as seining or complete pond draining.
- Optimized carrying capacity per unit area.
- Flow of current brings in freshwater and removes metabolites, excess feed and feacal matters.
- Fishes in cages grow at a much faster rate.
- High stocking density can be maintained in a small area.
- Production and return per unit of cage area is very high.
- Relative ease of harvest and monitoring

The significant disadvantages of cages are:

- Capital requirement for initiation a cage culture practice is relatively high for common to marginal farmers.
- Chances of Incidence of diseases and their spread among the cage-farmed fishes are high due to high stocking density.
- Poaching can be a serious threat for cage culture as harvesting is very easy.
- Greater size differentials among fish at harvest due to competition and aggression among fish.
- Species produced in cages are completely dependent on the commercial diets. If proper in care is not taken fishes may have nutritional deficiency disease as well as poor growth.
- During low oxygen occurrence, fish in cages cannot migrate to areas of higher oxygen level and in extreme cases may die also.

4. Broad guidelines for cage culture practices

In the discussion that follows specific points to be taken care during different stages of cage farming are summarized.

4.1. Site Selection

Site selection has to be done in such a way that the place where cages will be set will get the best water quality within and in the surrounding area. The area should be free from sewage dumping sites and free from pollutants. As a large number of species are maintained in a small area, any adverse water quality will significantly affect the species cultured inside. Site also should be selected so that cages are easily accessible.

Following points are to be considered during selecting the site suitable for cage farming.

- Type of species to be cultured.
- Water quality characters around the surrounding area
- Annual variability in physical and chemical properties.
- Type and nature of bottom.
- Tidal amplitude and current patterns.
- Wind and wave action.
- Drainage and run off conditions.
- Pollution of discharge area.

4.2. Criteria for species selection

Species selection is the most important criteria for success of a cage culture operation. The species selection is focused on the availability of the quality seed in required size and numbers. A farmer should always select a species for cage culture provided seeds are produced in hatchery or quality seed are available from natural collection in plenty. Another important criterion is that fishes should be amicable and able to withstand high density in a small confined environment. The species should grow fast and relatively disease resistant. Fishes having cannibalistic nature are not preferred for culturing in cages. In cage culture, fishes are grown only on supplementary feeding and hence species to be cultured should accept supplementary feed readily. And above all, the species should have high market demand and price. This is the reason that throughout the world, mostly high value carnivorous fishes are being cultured.

The Common Species used for cage culture operation in many countries

- Grouper (*Epinephelus sp*)
- Snapper (*Lutjanus sp*)
- Sea Bass (*Lates calcarifer*)
- Tuna (*Katsuwonus pelamis)*
  Tuna (*Thunnus albacaus)*
- Shrimps (*Penaeus sp*)
- Rabbit fishes (*Siganus sp*)
- Milk fishes (*Chanos chanos*)
- Mullets (*Mugil sp*)
- Lobster (*Panulirus sp*)
- Crabs (*Portunes sp*)
- Yellow tail (*Serriola quinqiradiata*)

4.3. Design and construction

Though it has been established that cage culture is a profitable venture, following guidelines are the keys towards achieving that.

- The cages must be seaworthy and made in cost effective manner and should have provision for storing supplementary feed in sufficient quantities.
- An optimum mesh size as per the size of the species and local condition has to be fixed during designing a cage. Smaller mesh sizes can be used to hold young fish, but smaller size cages require frequent cleaning.
- Rectangular cages with the long side exposed to the prevailing winds are recommended to maximize natural water circulation through the cage.
- Multiple cages can be anchored to the pond bottom or attached to each other with a rope.
- Cages should be placed in areas of adequate depth. Sufficient depth will facilitate easy distribution of faecal matter and water circulation but also prevent crabs and other fouling organism to damage the cages.
- Gentle water current is recommended for cage culture. High turbulent water is not recommended as that may damage not only the cages but also render the fishes inside to spend lot of energy for maintaining stability.

Design, type and size of cages mostly depend upon several factors like local condition, species to be cultured, investment levels of a farmers, compatibility and environmental concerns, mode of operation and re-usability of cages.

Shape

Circular cage bags make the most efficient use of materials and thus have the lowest costs per unit volume but they suffer from a number of disadvantages. Because the surface area: volume ratio is comparatively small, water exchange may be impaired and the technology required to construct a supporting collar for a circular enclosure can be more sophisticated than for other shapes.

Size

Size is very important for fabrication of marine cages. One advantage of increasing bag size is that costs per unit volume are less for bigger size cages. This is one factor behind the trend towards the use of progressively larger rearing units in intensive marine fish culture in cages. In Western Europe, cages of 100-150m^3 were used for rearing Atlantic salmon in the 1960’s to 1990’s and they are gradually replaced by cages up to 50 times of this volume. The trend towards large rearing units have resulted in holding tens of tones of fish in a single cages.

It is assumed that depths much greater than 10-12m would be poorly utilized by fishes. Cage depth of 3-10m is acceptable for most species.

Materials used for cage culture

The materials used to construct the cages should be strong, light, and corrosion and weather resistant. Fouling is another problem for most of the cages hence, antifouling paints can be used to reduce fouling problem in cages. Net materials used should be smooth textured and non- abrasive to fish. The materials used to fabricant the cage frame and collar should have similar properties like reduced drag, resistant to deformation in strong currents and facilitate easy harvesting. Cost is however, the most important factor that determines the feasibilities of a cage.

4.4. Seed Supply

Right type of seed in adequate quantities is a challenge in cage farming. Hatchery seed production of species for culture is very essential for quality and continuous supply. Large seed resource of some species like mullet and milk fishes can be collected from wild. However, there is a need to understand the basic biology of the potential species before advocating capture based stocking.

4.5. Stocking management

Standardization of stocking density and species, based on particular location and on other parameters is very much important for profitability of a cage culture operation. In normal condition stocking density 120/m^3 and for a period of 8 months is necessary. If initial stocking density is very high, thinning has to be done as fishes grow. Proper stocking rates and uniform size seeds have to be maintained in cages. Over stocking and excess feeding may lead to water pollution and fish health problems.

Stocking

Stocking density of a cage is very important as far as growth and health of fishes are concerned. It is based on cage volume. If stocking is done at lower densities, fishes will become bigger in a shorter time span compared to higher densities. In cage culture, fish are always stocked at higher densities in comparison with the pond culture. Stocking fishes at densities lower than recommended may result in aggressive behavior of the fishes. It is also important to maintain uniform size stocking materials to avoid differential growth among the fishes. This is a serious problem in case of seabass farming when seeds are collected from wild population.

Recommended Stocking Rates for Cages

Cage Size	Stocking Rates
4x4 feet (round)	250-400
4x4x4 feet	320-500
8x4x4 feet	640-1,000
8x8x4 feet	1280-2,000
6x12x4 feet	1,500-2,300

The best time for stocking is when the water temperature is cool. This will lessen stress- related diseases and mortality. The fishes should be slowly acclimated to the water temperature in the cages by allowing the seed bags to float for a while before releasing them.

4.6. Feed and feeding management

Kind of feed to be given to culture species basically depends upon type of fish that are cultured and the feed availability. When feed is made it should be nutritionally balanced, stable in water, less polluting, readily eaten by the cage fishes, have better storage capacity and longer shelf life. Feeding habit of fishes has to be properly studied to reduce wastage and effective utilization of feed. In cage culture operation, feed alone costs more than 50 % of the total expenditure and hence efficient utilization of feed will ensure better return. Nutritionally balanced diet in required quantities is the prerequisite for success of a cage culture operation. Hence, proper feeding management and standardized BMP for cage culture are essential.

4.7. Husbandry and management

Adequate and careful husbandry and management is very much essential for cage culture. It is also essential to monitor water quality parameters continuously. Optimum stocking and feeding is also essential to avoid stress to fishes. Regular checking of the stock for the sign of disease, removal of metabolites and treatment of infected fishes are essential steps for the cage farming. Monitoring of growth and disease problems is important to ensure good productivity. Disease fishes, if any spotted, have to be removed from the cages and treated separately. Frequent checking of netting material is to be carried out to ensure they are not worn out or clogged by algae.

5. Cage culture in India

Development of cage culture is still in its infancy in India. The Central Marine Fisheries Research Institute, Cochin has taken pioneering efforts in demonstrating the potential of marine cages in India. Attempts have been made for cage culture of grouper at Gulf of Mannar, sea bass in the experimental cages at Tuticorin and the recent on at Vishakapatnam. NIOT, Chennai has taken up few demonstration projects to popularize cages. The Rajiv Gandhi Centre of Aquaculture under the aegis of MPEDA, Cochin has also established cages in Andaman for the its grouper breeding programme.

Andaman and Nicobar islands are bestowed with Bays and creeks all along their coast line. The total coast line of Andaman and Nicobar Islands is about one third of India. Several attempts were made in the past by research organization, Government organizations as well as private farms to initiate cage culture in Andaman but with little success. Until recently, the cages used as a temporary holding arrangement of captured fishes in live fish trade are the only ones known of being in operation in Andaman. MPEDA (2007) reported 12 tones/ha of seabass production in cage culture system at their Aquaculture Demonstration Farm, Puducherry. In experimental scale, cage culture of groupers and snappers has been initiated by CARI, Port Blair by designing the cages with locally available materials.

Scope and sustainability of cage culture in Andaman and Nicobar Islands

Andaman and Nicobar islands situated in Bay of Bengal have numerous bays, creeks, lagoons and islets with varying depths and different substrate which are suitable for several types of mariculture operations particularly cage culture. The Island is having a coastline of about 2000 km encompassing about 16,000 sq. km of continental shelf area. It is having about 6 lakh sq. km of EEZ, which is almost 30% of the Indian subcontinent.

For cage culture, aquatic environment where cages are installed should be congenial. Uncontaminated and pollution free waters of Andaman and Nicobar Islands will be an added advantage for cage culture in this Bay Island. Now-a-days, Andaman and Nicobar Islands is well connected to main land by air and ship. Daily several flights are plying from Andaman and therefore, transportation may not be a difficult task. As such, grouper and snapper are high value commodity and can easily absorb the transportation cost. Tourism is one of the main sectors contributing to the economy of Andaman and Nicobar Islands. Hence, development of eco-tourism in the cage culture sites can lure lot of tourists. Hence, there is tremendous scope for development of cages in Andamans.

As site is not a problem, culture of many marine fishes in cages can be standardized for the Island conditions by taking care of local condition, species cultured, investment levels, compatibility, environmental concerns, mode of operation, re-usability of cages, etc. Grouper and snapper are two important groups of fishes having very high export demand in many South East Asian countries. Both these group of fishes are present abundantly in Andaman waters and every year a substantial amount of these fishes are being exported from Andaman. These species are collected from wild and fattened in cages in live fish trade in Andaman. Water bodies of Andaman facilitate natural breeding ground of many fishes and hence, fish seeds can be collected from the nature till the breeding programme is standardized for the fishes. Cage culture will not only increase direct employment opportunities but will also facilitate developments of many ancillary Industries like fishmeal-based formulated feed industry. Cage culture will increase the demand for low value fishes and thus enhance the income levels of the fishermen.

Every year sizable quantities of grouper are exported from Andaman to South East Asian Countries. Some of the commercially important grouper fishes available in Andaman are listed below.

- *Cromileptes altivelis* (Barramundi cod)
- *Cephalopholis argus* (peacock grouper)
- *Cephalopholis boenak* (choclate grouper)
- *Cephalopholis cyanostigma* (Blue spotted grouper)
- *Epenephelus areolatus* (Arelate grouper)
- *Epenephelus coloides*(Orange spot grouper)
- *Epenephelus bleekeri* (Bllekers grouper)
- *Epenephelus malabaricus* (Malabar grouper)
- *Epenephelus tauvina* (Greasy grouper)
- *Plectropomus aerolatus* (Square tail coral trout)
- *Plectropomus maculates* (Spotted coral trout)
- *Plectropomus pessuliferus* (Roving coral trout)
- *Variola albimariginata* (Lyre tail trout)
- *Variola louti* (coromation trout)

Indiscriminate and unregulated proliferation of unscientific cage culture practices in the open sea and bays and lagoons could pose many threats from the environmental and common property utilization angles. Marginalization of poor fishers could be fallout of the situation resulting from lack of small pelagic and low value fish for the small scale fish processing sector.

For sustainable cage culture operation, following points have to be taken into consideration.

- Protection, identification and prohibition of some area suitable for cage culture from shipping, fishing and other water activities.
- Proper site selection and resource mapping of stocking materials has to be done.
- Pre-installation survey in the specific sites has to be carried out specially to see worthiness of cages in specificities from waves and currents.
- Coordinated approach and market information to the fisherman, wholesaler and exporters will ensure supply as per demand. This will reduce unnecessary harvest of the fishes.
- Captive breeding technology has to be standardized for different varieties of fishes. This will decrease the pressure on wild stock as well help the farmers to ensure continuous supply of the seed materials.
- Endangered, vulnerable and species with limited information on growth, feeding and reproduction have to be exempted from harvest and scientific study has to be encouraged for these species.
- Option for ranching program should be open for and depleted stock.
- Training and demonstration of cage making and management for smooth running of the cage culture operation.
- Total ban on use of destructive methods of fishing like cyanide, non-selective gear, etc near the cage culture sites.

6. Conclusion

A clear cut Governmental policy is very essential for development of an industry. It is right time that a comprehensible policy should be made for the development of open sea cage farming in India. For making policy several points has to be taken care like leasing pattern of water body, ownership rights, protection from poaching, crop insurance, preventing stock escapes and mixing with wild stock, culture sites issues, etc. A knowledge-based master plan for cage farming in bays, creeks and open sea in coordination with other related departments/ministries like shipping and surface transport, ocean development, environment and forests, etc would help to establish this industry to its true potential. This sector offers great promise to expand the livelihood options of the fishers and farmers in the Bay Islands.

Main Reasons for the Failure of Fisheries Sector in Bay Islands - A Brief Report

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1. Introduction

Andaman & Nicobar Islands situated in the Bay of Bengal have abundant marine wealth in terms of quantity and diversity of species. Except for a few fishing grounds these waters mostly are under-exploited by either the Andaman or Indian Fishermen. Poachers from Indonesia, Myanmar and Thailand who operate in the Andaman waters illegally not only steal our valuable marine wealth, but also destroy our valuable fishing grounds by using unethical methods of fishing like purse-seining, pair-trawling and also by using explosives. As per the latest report from the Fisheries Survey of India, approximately 1.48 lakh tonnes can be fished out annually without damaging the ecological balance exclusively from A&N territorial waters. But the present scenario poses a different picture, less than 5% is being caught by the local fishermen from these Islands.

2. Main reasons for the failure

(a) Non-availability of mini / medium fishing crafts
(b) Non-availability of traditional fisherman
(c) Lack of awareness on latest fishing techniques
(d) Poor incentives for taking up shrimp/crab/fish culture
(e) Inadequate infrastructural facilities.

3. Solutions for the above mentioned problems

3.1. Non-availability of mini/medium fishing crafts

The A&N Administration with the assistance of various Central Government agencies should introduce attractive subsidy/interest-free loan schemes to lure various sections of people to invest in the fisheries sector. The scheme should restrict the number of fishing crafts and period. For the sustained growth of the fishing industry and to avoid over-exploitation, the scheme can be in 3 categories:

Category – I: The FRP boats with a maximum engine capacity of 30 HP, fitted with the latest fishing equipment along with 400 litres insulated box.

Under this scheme Economically Weaker Fishermen should be benefited. The total number of boats can be restricted to 300 nos.

*Category – II: M*ini-trawlers/mini-liners (13 -16 m) with 65-120 HP engine

These boats can be made of FRP/wooden, fitted with the latest fishing, navigational and life saving equipments with 4.0 MT insulated capacity fish hold. The subsidy scheme should be restricted to 25 fishing crafts.

Category – III: Deep sea trawlers/longliners (17 25 m with 165- 330HP)

These crafts can be made of FRP/Wooden/Steel body, fitted with the latest fishing, navigational and life saving equipments with 15 MT insulated capacity fish hold. The subsidy scheme should be restricted to 25 fishing crafts.

The subsidy / interest free loan scheme should be as follows:

- 25% central subsidy.
- 50% Interest free loan for a period of 3 Years.
- 25% Investor's contribution.

With the above mentioned schemes, the dearth of fishing crafts problem will be solved.

3.2. Non-availability of traditional fishermen

One has to get enough confidence that they can earn substantially in the fishing profession. With so many fishing crafts entering the arena, there will be enough scope for the unemployed youth, tribal, regular and agriculture labours to take up fishing as their main activity which will be much more beneficial.

3.3. Lack of awareness on latest fishing techniques

The proposed fishing crafts should have 25% of their staff from mainland India for the initial period of 3 years. These professional fishermen will train our local people in the following fields:

(1) Usage of latest fishing gear.
(2) Assessing the weather and deciding the species to be caught.
(3) The time of fishing.
(4) Repair and maintenance of fishing craft and gear.

3.4. Poor incentives for taking up shrimp/crab/fish culture

A detailed survey of the submerged lands has to be undertaken along the creeks to identify the lands which are useful for shrimp/crab/fish culture. Most importantly one should bear in mind the fragile ecology of these Islands. To avoid pollution, natural seed and eco-friendly feed can be utilized. This farming was started 2 decades ago in mainland India and A&N Administration should encourage to establish the local farming sector, which will benefit the farmers.

3.5. Inadequate infrastructural facilities

- Ice plants should be constructed in all major islands and ice should be made available round the year to the fishermen. The ice plants at Rangat, Diglipur, Hutbay and Campbell Bay should be strengthened. ice plant should be received as it is very essential.
- On top priority the fish landing centres has to be created.
- Full fledged Fisheries Jetty with facilities like ice plant, overhead drinking water storage facility, diesel/petrol pump, auction hall, workshops, shed for repairing fishing gears, a dormitory with toilet facility, medical care facility for the fishermen, etc is needed.

If the above problems are sincerely addressed, our fisheries sector would grow at the desired pace, which will lead to many social and economic benefits to the coastal society as discussed below.

- Employment Generation: Directly this will ensure livelihood for 1000 fishermen and more than 500 women fish vendors who sell fish in the local market.
- With the existing processing plants and the proposed processing plants fully operational, an additional employment to 250 people will be generated directly and 250 people indirectly.
- With 50 nos. of trawlers/longliners in operation, the activities of foreign poachers will be curtailed.
- With so many fishing crafts, the fish prices in the local market will come down drastically which will benefit the entire population of these Islands.
- Earning valuable foreign exchange by way of export to foreign countries.

It is strongly opined that if the above suggestions are implemented in a time-bound fashion, the sector would witness an all-round development with all stakeholders would be benefitted from the inclusive growth process.

Appendix

Appendix 1

Recommendations

The Brainstorming session on Development of Island Fisheries was organized at Central Agricultural Research Institute, Port Blair during 21-22 June 2008 involving all the stakeholders *viz.,* representatives of fishermen and farmers, local administrators, fisheries scientists from local and mainland institutions, policy makers, etc. The deliberations were held under four major theme areas *viz.,* (i) tuna fisheries (ii) value addition (iii) cage culture (iv) HRD, conservation and other issues pertaining to fisheries of Bay Island. The major recommendations that emanated during the session are summarized below.

General Recommendations

- The Brainstorming session highlighted that consistent and responsible policies sensitive to the local needs within the framework of national priorities are prerequisites for social empowerment, livelihood enhancement and sustainable development of the fisheries sector.
- Efficient management of the sector requires improved information flows at the state, regional and national levels between and among the research institutions, development departments and policy makers.
- Professionally trained personnel at the field and technically trained fisheries professionals at the helm would help take forward the development mission of the Fisheries department at a faster pace and greater ease. Towards this goal, all the vacancies in the Fisheries Directorate under the A&N Administration should be filled with candidates having professional training on the subject on priority basis. The top and middle level officers of the directorate should be sent for periodic training on the frontier areas of fisheries and aquaculture so as to keep pace with the developmental needs of the sector.
- Specific capacity building programmes are to be evolved for the farmers and fishers through practical hands-on training, result demonstration and cross-country visits to augment the skills of the stakeholders for the optimal utilization and management of natural resources.

- In view of the urgent need to optimally utilize the hitherto unexploited tuna resources and to enhance the fish production in the Islands through cage culture in protected areas, mission mode projects must be introduced with required financial support and incentives/subsidy schemes.
- Considering the number of stake-holders and interest groups involved in the development of various components of the fisheries sector and the diversity of tasks associated at every level from the sea to the market, it is necessary to ensure that all the activities/responsibilities are carried out in a seamless and structured manner, which calls for a well co-coordinated approach on the part of all the stake-holders starting from the individual fisherman to the administrators, bankers, research bodies and the exporters.

Recommendations specific to Tuna Fishing

In spite of the huge potential of capture fisheries, the current catch indicates gross under-exploitation of the marine resources. In the post-tsunami period, significant increase in the number of fishing boats did not reduce the gulf between the potential and the actual fish landings in the Islands due to the fact that the present catch consists of non-tuna resources only, which accounts for about 25% of the potential fisheries resources. It is high-time strategies are evolved for targeting the tuna resources, which account for about 75% of the fisheries potential of the islands.

- The fact that vast coastal and oceanic resources of the Islands are grossly under-utilized in spite of decades of development programs calls for re-visiting and periodically reviewing development schemes in order to change the course of fisheries development in the coming years.
- The exploitation level of oceanic fishery resources compared to that of demersal fisheries in Andaman and Nicobar Islands is very meager due to lack of adequate knowledge and non-availability of infrastructure facilities in the islands. To bridge this gap, awareness on the deep sea fishing should be created among the industry and the fishermen through training.
- In order to augment the marine fish production of the Islands, medium-sized and larger vessels, which can fish in the distant and deeper waters by using eco-friendly fishing methods need to be introduced. Up-gradation of crafts and gears should be prioritized for commercial tuna fishing. Vessels like long-liners and gill netters must be introduced. Long line fishing is a capital intensive enterprise and would be viable only high value products like 'Sashimi' are produced from the catch. Hence, the programmes to support introduction of long liners should be complemented with those for transporting the fish to the mother ship for freezing and storing.

- The designs of gillnets (mesh and body size) and hooks and lines should be optimized according to the behaviour of target tuna resources and the same introduced for exploiting them.
- CARI should co-ordinate with the mainland agencies/institutions to validate the predictions of Potential Fishing Zone and make this information available to the fishermen through the development department.
- Considering the level of entrepreneurship of business community of the islands in general and that of fishermen in particular, it is imperative that a carefully designed, community-centered credit and subsidy policy which is sensitive to the local aspirations is vital for popularizing the capital intensive deep sea fishing in the Islands.
- The credit flow to this sector is not commensurate with the priority being accorded by the Government of India and the Union Territory Administration for fisheries development. Appropriate awareness has to be created among the fishermen community, prospective entrepreneurs and bankers in order to match the NABARD's estimated credit flow of about 50 crores from the banking sector in the Islands during 2009-10.
- There is a need to upscale the development on a commercial basis by an appropriate Public-Private partnership. This will call for a more proactive role on the part of the Administration and the banks.
- If the infrastructure for harvesting fish is strengthened as planned, there will be an additional catch of 25,000 t per annum available for processing in near future. Sufficient facilities have to be developed to handle, process and preserve the additional catch. Organized fishing and fish processing will generate large quantity of by-catch and waste materials which can be converted to valuable products like fish meal, fish body and liver oil, squalene, hydrolysates, livestock feed, pet food, etc. which will help in revenue generation and environmental protection.
- Out of the existing landing centres, three major centres (Diglipur, Port Blair and Campbell Bay) must be developed as *Fish Processing Estates* with modern processing plants as per EU norms and all other support facilities like roads, uninterrupted power supply, diesel outlets, potable water supply, ice plants, cold storage, etc. Facility for production of value added products such as Sashimi-grade tuna, chilled, smoked and frozen tuna loins, high quality masmin, ready-to-cook, ready-to- serve breaded and battered products, etc. are to be developed in these processing plants to realize maximum return.

- The geographical proximity of the region with world's largest tuna markets like Singapore and Bangkok offer great opportunity to develop direct international tuna trade from the Island territory. Hence air/sea connectivity to these markets must be established with cold storage and cargo handling facility for exporting items such as *Sashimi* tuna. Advantage of proximity of islands to Jakarta may be explored for establishing an export channel to Japan via Jakarta.
- Large pelagics like yellowfin, skipjack and dolphin fish are known to aggregate around Fish Aggregating Devices (FADs), either as a resting place or to feed on prey organisms around it. Installation of FADs would increase the number of fishing locations and the overall catch rates while considerably reducing the scouting time for fishermen. Tailor-made designs of FADs need to be established at different places, seeking technical expertise from National Institute of Ocean Technology, which has demonstrated the usefulness of such structures in Lakshadweep Islands.
- The market functionaries from capture to fish processing to final product development of tuna based products are diverse and need to be strengthened. The increased production would enhance the scope for domestic fish marketing. The administration should establish chains of retail fish stalls in the lines of "*Neithal*" of Tamilnadu Fisheries Development Corporation (TNFDC), Chennai, which is a success story.

Recommendations specific to Coastal aquaculture

- Brackishwater aquaculture has emerged as a prospective enterprise for the coastal farmers as seawater has intruded their agricultural fields due to subduction of land following the major earthquake and tsunami. Extensive method of shrimp farming is advocated for such localities using the seeds produced from disease-free tiger shrimp brooders from Andaman. While the seed production technology of sea bass has been standardized for sea bass by CIBA, Chennai for other fishes the farmers need to depend on seeds from wild collections.
- One essential step towards promoting cage culture is to formulate a comprehensive and development oriented leasing policy for allotment of water bodies to traditional fishers, co-operatives, women SHG, etc.
- Suitable credit and subsidy schemes need to be evolved for supply of inputs to popularize cage farming in the protected water bodies of Andaman. Community-based cage culture as done in Kerala backwaters may be

demonstrated by the Fisheries Department involving NGOs and SHGs to sensitize the fishers and farmers on the prospects of this enterprise in Andaman.

- The development department must identify the places suitable for establishing cages drawing the experiences and expertise of CMFRI, NIOT, CARI, RGCA, etc and promote large scale cage culture in identified sites.
- Availability of seeds is an essential link in popularizing cage farming in Islands. Appropriate schemes need to be evolved to establish seed production units at Andaman so as to cater to the needs of the Island farmers. The prospective farmers may be trained at CIBA, Chennai on seed production technology of seabass and Cobia.
- CARI should establish a cage for demonstration purpose and serve as a nodal agency to transfer the technology drawing the expertise of other local and mainland agencies/ institutions.

Import of fish seeds from mainland for commercial farming in the Islands should be discouraged. Appropriate measures for quarantine should be established and administrative framework put in place to meet contingencies.

Appendix 2

Invited Delegates

• Dr. H.P. Singh	*Deputy Director General, (Horticulture), ICAR, New Delhi*
• Dr. S. Ayyappan	*Deputy Director General (Fisheries), ICAR, New Delhi*
• Dr. N. Sarangi	*Director, CIFA, Bubaneshwar*
• Dr. K.K. Vass	*Director, CIFRI, Barackpore*
• Dr. N.G.K. Pillai	*Director, CMFRI, Cochin*
• Dr. Paul Pandian	*Deputy Advisor (Fisheries), Planning Commission, New Delhi*
• Dr. Vasudevappa	*Senior Executive Officer, NFDB, Hyderabad*
• Dr. Kripakaran	*Group Head, NIOT, Chennai*
• Dr. A.K. Banthopathyay	*(Ex. Director, CARI), Kolkata*
• Dr. R. Soundararajan	*Principal Scientist, NBFGR, Lucknow*
• Dr. E.V. Radhakrishnan	*Head of Division (Crustacean Fisheries), CMFRI, Cochin*
• Dr. A.R. T. Arasu	*Principal Scientist, CIBA, Chennai*
• Dr. P.T. Mathew	*Head of Division, CIFT, Cochin*
• Dr. P. Pravin	*Senior Scientist, CIFT, Cochin*
• Dr. M. Baiju	*Technical Officer, CIFT*
• Dr. V. Krishnamurthy	*Director, Directorate of Fisheries, A & N Administration.*
• Dr. Anrose	*Zonal Director, Fishery Survey of India, Port Blair*
• Dr. Vinithkumar	Officer-In-Charge, *ANCOST, NIOT, Port Blair*
• Dr. Saunand	*Regional Director, IGNOU, Port Blair*
• Dr. Nithyanandan	*Deputy General Manager, NABARD, Port Blair*
• Mr. Sunil	*NABARD, Port Blair*