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Adelie Penguin *Pygoscelis adeliae* sighted in Prydz Bay, Antarctica

(Photo credit: Sajikumar K.K.)

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

Marine Fisheries Information Service
Technical & Extension Series

From the Editorial Board

Warm greeting to all our esteemed readers

The southern Ocean is formed by the merging of the waters of the Atlantic, Pacific and Indian Oceans south of the $60^{O}S$ latitude and constitutes nearly 4% of the earth's surface. Although it is the second smallest ocean among the five, and probably the least explored, its marine living resources such as the Antarctic krill, iconic whales, seabirds and seals are well known as important links in the marine ecosystems. The mention of oceanographic expeditions has for generations, instilled a sense of adventurism through exploration of new horizons, in a scientific quest for knowledge. The Indian Southern Ocean Research Programme was initiated in 2004 by the Ministry of Earth Sciences, Govt. of India to foster multi-disciplinary and multi-institutional research activities. Some of the knowledge gained during participation in such scientific expeditions and with special reference to the cephalopod resources of the Southern Ocean is shared in this issue of MFIS. Closer home, the experience and insights on the various facets of aquaculture through fish seed surveys, wetland site restoration activities and seaweed farming have been documented. It is hoped that these notes will kindle further scientific curiosity on these topics among our esteemed readers.

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Marine Fisheries Information Service

Technical & Extension Series

Contents

Research Communications

Brief Communications

Kaleidoscope

Renewed research focus on cephalopod resources in the Southern Ocean

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Abstract

Researchers from ICAR-CMFRI participated in 2 cruises to the Southern Ocean during 2017 and 2020 to gather information on cephalopod resources of the Antarctic region. Four species of squids including three species of ommastrephid squids such as Purpleback flying squid, *Sthenoteuthis oualaniensis*, Neon flying squid, *Ommastrephes cylindraceus (Ommastrephes bartramii),* Antarctic squid *Todarodes filippovae* and one cranchid squid, the Glass squid *Galiteuthis glacialis* were recorded. The presence of paralarvae and juveniles of ommastrephid squid in surface waters between 45°S to 46°S and 57° 29' E to 72°E indicates this area may be their spawning ground. The paralarvae of mesopelagic glass squids *Galiteuthis glacialis* collected from 66° to 57° S and 80° E to 57° E were aged by analysing their statoliths.

Keywords: *Southern Ocean, cephalopods, paralarvae, statoliths*

Introduction

Investigations of Southern Ocean cephalopods began with the pioneering expedition of HMS Challenger (Hoyle,1886) and Valdivia expedition conducted by Germany (Odhner, 1923). After the 1970s, there has been considerable research effort in cephalopod taxonomy and abundance all over the world. However, very little is known about the abundance and biodiversity of cephalopods in the Southern Ocean sector. Southern Ocean cephalopod fauna is distinctive, with high levels of endemism in the squid and play an important role, linking the abundant mesopelagic fish and crustaceans with higher predators such as albatross, seals and whales. Although not yet commercially exploited species of the family Ommastrephidae have high potential (Collins and Rodhouse, 2006). As a national policy objective (NPMF, 2017) India looks at commercial exploitation of marine resources in Areas Beyond National Jurisdiction (ABNJ), and therefore, it will be appropriate if the stock abundance and distribution of commercial cephalopod stocks are well understood. Besides, India is one among 25 member countries of the CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) aiming for the conservation of marine life in Antarctic Ocean. It is in the light of the above that the Molluscan Fisheries Division of ICAR-CMFRI proposed a study on the assessment of cephalopod biodiversity in the Southern Ocean with particular reference to commercial exploitable cephalopod stocks, including understanding the age and growth of Southern Ocean squids using statoliths and investigating their role as a predator from stomach content analysis. The proposal was approved by the National Centre for Polar and Ocean Research (NCPOR), Goa under the Ministry of Earth Sciences, Government of India and results of the study during the 10^{th} and 11^{th} Southern Ocean expeditions (SOE) are given below.

Cruise transects and sampling

A 111 m LOA, ice-strengthened training ship "*MV Agulhas*" from South Africa, was used for the expeditions (Table 1).

Table 1. Details of the SOE undertaken for research on molluscan resources in Southern Ocean

Expedition	Vessel	Period	Number of participants	Types of equipment carried by ICAR-CMFRI
10th SOE	MV Agulhas	08.12.2017 to 02.03. 2018 (59 days)	35	Issacs-Kidd Midwater Trawl (IKMT), squid jigs, zooplankton net
11th SOE	MV Agulhas	06.01.2020 to 08.03.2020 (62 days)	39	Automatic squid jigging machine, IKMT, Rectangular midwater trawl, squid jigs

10th Indian SOE

Sampling was carried out in the area between 39°56'S to 66°39'S latitude and 57°25'E to 76°24'E longitude as per the cruise track (Fig.1A). 28 observations including those from 7 squid jigging stations, 13 IKMT stations (21 operations) and 8 zooplankton sampling operations were made (Table 2 & Fig. 2).

Ommastrephid squids including Neon flying squid *Ommastrephes bartramii* (Fig.3a), Antarctic flying squid *Todarodes filippovae* (Fig.3b) and Purpleback flying

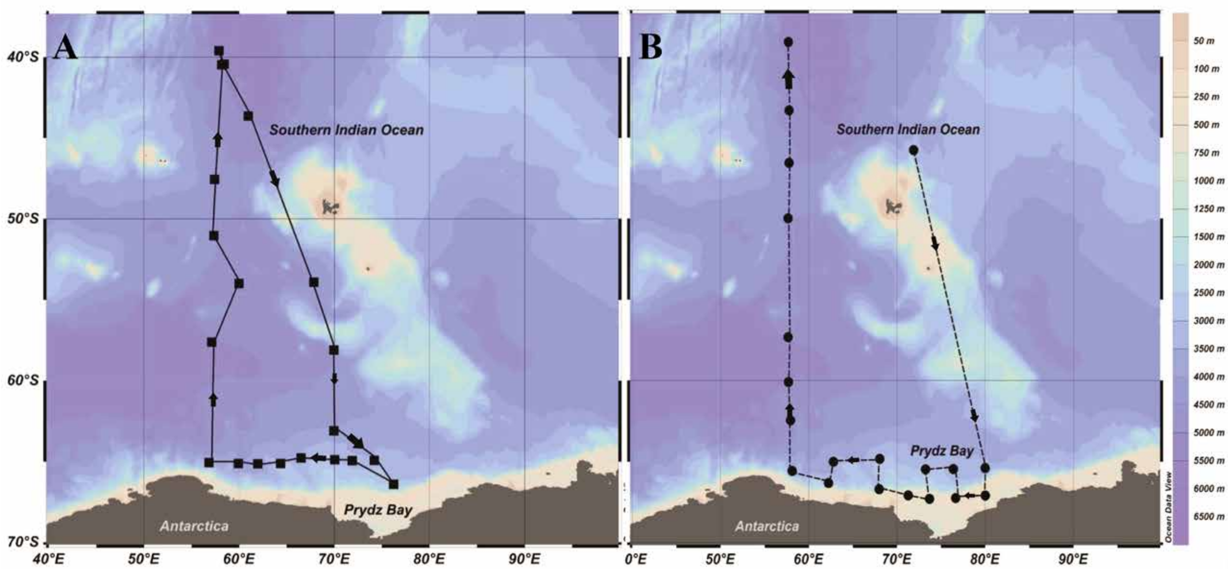

Fig.1. The cruise track and stations for cephalopod observations during (A) 10th and (B) 11th Indian SOE

Table 2. Sampling stations and operations conducted during 10th Indian SOE

Date	Location	Operation	Depth of operation
14/12/2017	40°11’S; 58°30’E	Squid jigging	30 m
18/12/2017	43°02’S; 60°36’E	IKMT	Surface, 200 m
22/12/2017	54°00’S; 68°05’E	Squid jigging	30 m
23/12/2017	54°01’S; 60°07’E	IKMT	Surface, 200 m
25/12/2017	58°55’S; 70°09’E	Squid jigging	30
27/12/2017	63°01’S; 70°05’E	Zooplankton net	Surface
30/12/2017	65°31’S; 74°45’E	Zooplankton net	Surface
31/12/2017	65°32’S; 72°50’E	Zooplankton net	Surface
3/1/2018	66°33’S; 76°24’E	Zooplankton net	Surface
4/1/2018	66°32’S; 76°24’E	Zooplankton net	Surface
5/1/2018	66°37’S; 76°07’E	Zooplankton net	Surface
6/1/2018	66°39’S; 76°06’E	Zooplankton net	Surface

Date	Location	Operation	Depth of operation
8/1/2018	65°28’S; 70°56’E	IKMT	Surface
9/1/2018	65°31’S; 69°08’E	IKMT	100 m
10/1/2018	65°29’S; 66°58’E	IKMT	Surface, 500 m
11/1/2018	65°30’S; 64°56’E	IKMT	Surface, 500 m
12/1/2018	65°46’S; 62°48’E	Zooplankton net	Surface
13/1/2018	65°27’S; 60°57’E	IKMT	Surface, 500 m
15/1/2018	65°27’S; 57°50’E	IKMT	500 m
21/1/2018	57°00’S; 57°36’E	IKMT	Surface, 500 m
24/1/2018	51°04’S; 57°25’E	IKMT,squid jigging	Surface, 500 m
25/1/2018	47°30’S; 57°29’E	IKMT, squid jigging	Surface, 500 m
28/1/2018	40°11’S; 58°24’E	IKMT, squid jigging	Surface
29/1/2018	39°56’S; 57°30’E	IKMT, squid jigging	200 m

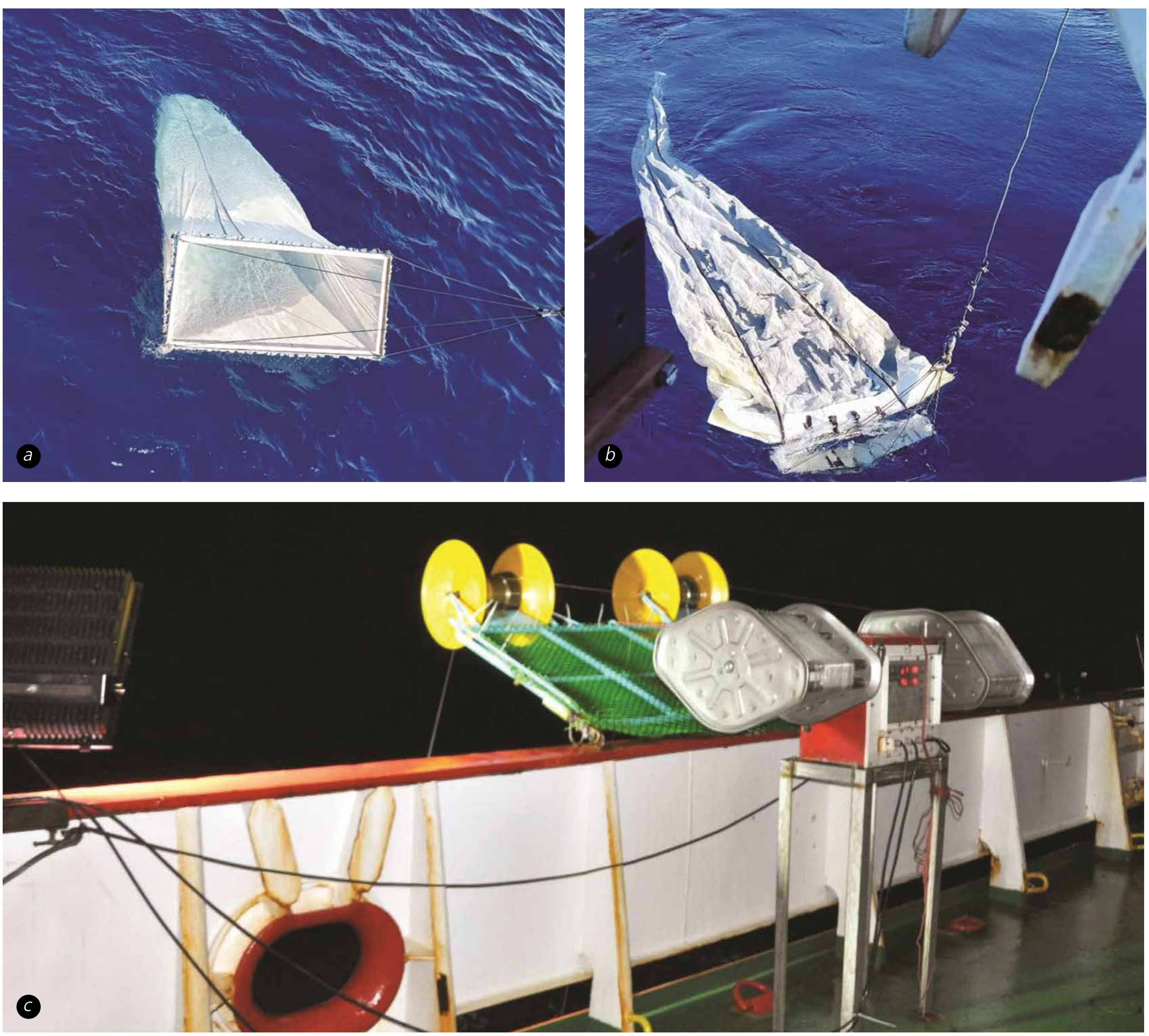

Fig. 2. Sampling operations during the 10th and 11th Indian expedition to Southern Ocean/ Antarctic waters (a) RMT (b) IKMT, for cephalopod paralarvae and juveniles; (c) Automatic squid jigging machine used for the capture of adult squids.

squid *Sthenoteuthis oualaniensis* and their abundance was observed in three stations, 47° S-57° E, 40° S-58° E and 39° S-57° E. Paralarvae of mesopelagic squids collected from 65° S 66° E to 57° S 57° E were identified as *Galiteuthis glacialis* (Fig. 3). Before the 10^{th} SOE, the Neon flying squid, *Ommastrephes bartramii* was considered a monotypic cosmopolitan species with a discontinuous distribution. From the results of the 10^{th} expedition, a combination of morphological and metabolic information were used to resurrect formerly synonymized name *Ommastrephes cylindraceus* (ie., *Ommastrephes bartramii* = *Ommastrephes cylindraceus*) and propose a revision in the distribution range in collaboration with other international cephalopod researchers (Fernandez-Alvarez *et al*., 2020). Additionally, the distribution, abundance and growth of the paralarvae and juveniles of the glass squid *Galiteuthis glacialis* which were collected from IKMT tows conducted at 500 m depth in Prydz Bay, Antarctica has been documented. Early life stages of *G. glacialis* were distributed over the shelf edge waters of Prydz Bay. Their abundance ranged from 1 to 9 individuals/1000 m^3 with highest abundance observed in both 65° S; 70° E and 66° S; 76° E, which is 120 nautical miles (nmi) north of land area of Prydz Bay (Fig.4). The smallest paralarvae were observed in 65° S; 57° E and largest individuals recorded at 57° S; 57°37' E.

A total of 53 early life stage individuals of *Galiteuthis glacialis* ranging in size from 6.3 to 28.4 mm DML were caught during the survey which included 42 paralarvae and 11 juveniles. The pair of statocysts

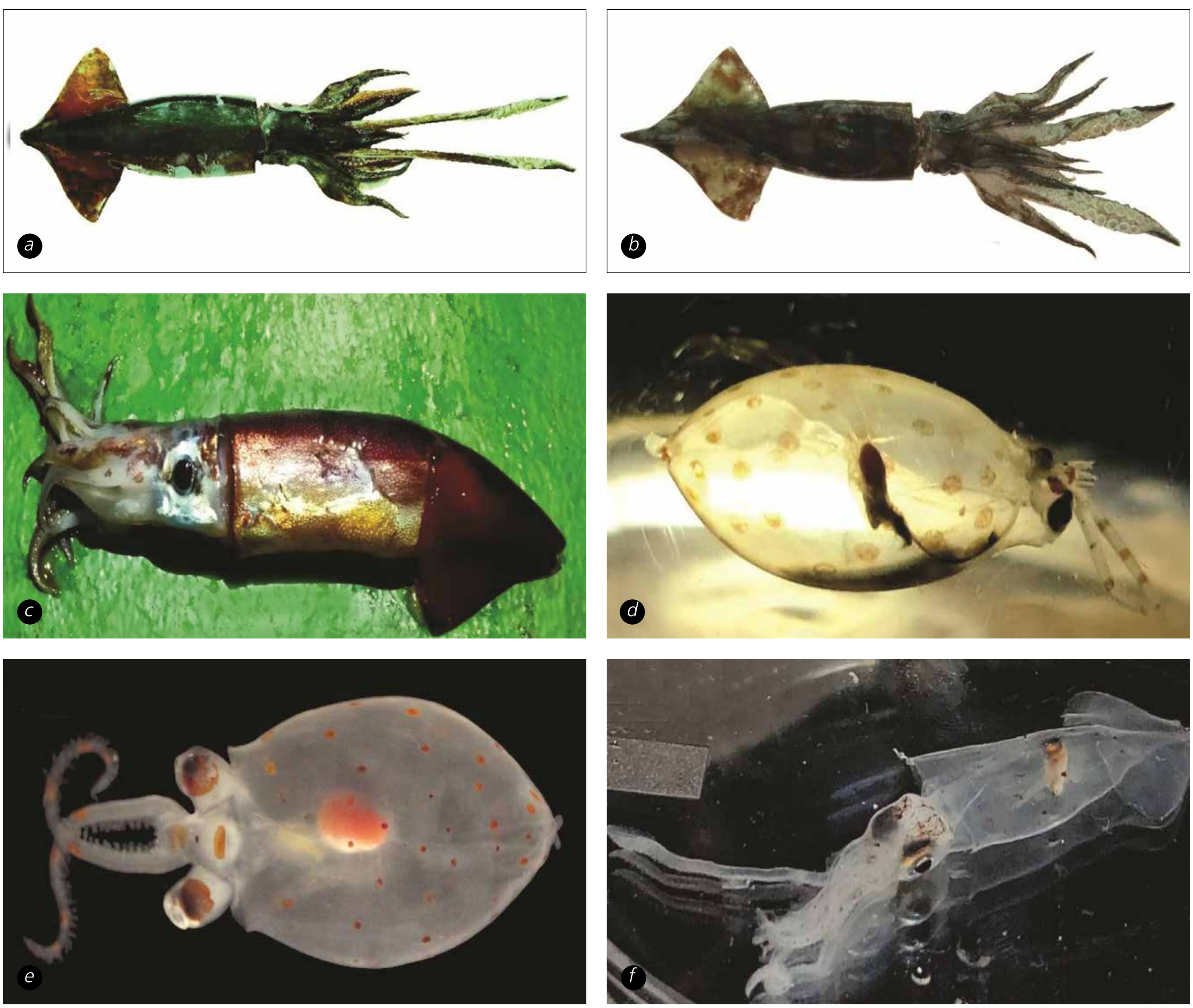

Fig. 3. Squids collected during 10^{th} and 11^{th} expeditions. (a) *Ommastrephes cylindraceus,* (b)*Todarodes filippovae,* (c) *Sthenoteuthis oualaniensis,* (d) Live *Galiteuthis glacialis,* (e) *Galiteuthis glacialis,* (f) Unidentified ommastrephid juvenile

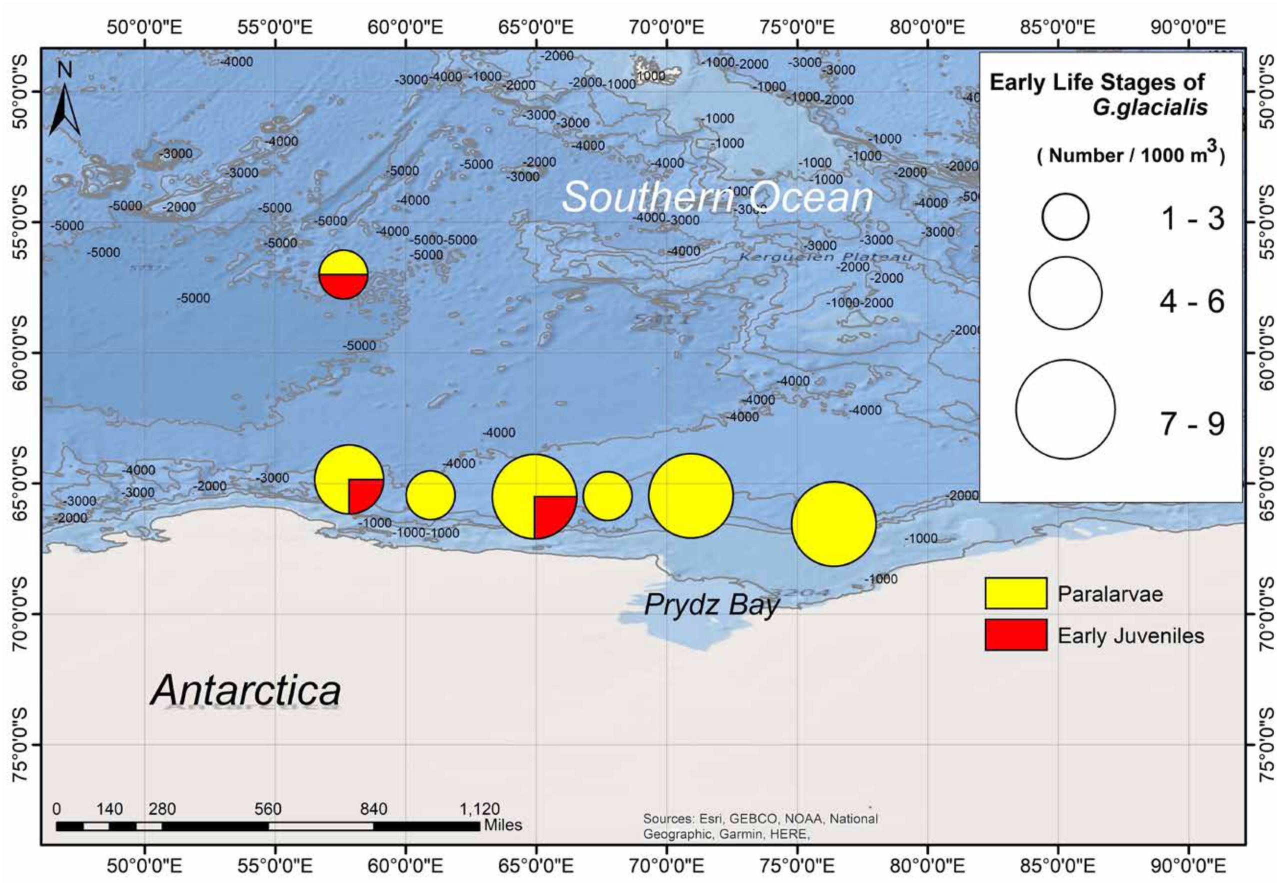

Fig. 4. Distribution and abundance of paralarvae and early juveniles of *Galiteuthis glacialis* in the Indian sector of Southern Ocean (near Prydz Bay). Circles = relative abundance

located in the ventral posterior region of the head had growth rings that ranged from 47 to 106 (6.3 to 28.4 mm DML) (Fig. 5). Age of individuals estimated based on statolith increment counts ranged from 47 to 85 days with a daily growth rate ranging from 0.13 to 0.25 mm dorsal mantle length (DML)/day (mean 0.18 mm) for paralarvae. The early juveniles had an age of 85 to 103 days with a slightly faster growth rate ranging from 0.21 to 0.27 mm DML/day (mean 0.24 mm). The presence of paralarve of *G. glacialis* at the outer continental shelf edge of Prydz Bay during austral summer indicates a probable spawning site in this area (Sajikumar *et al*., 2020). Other observations during the cruise in the Southern Indian Ocean included an opportunistic sighting (39° 59' 49"; 57° 30' 50") of a single sunfish *Mola mola* on 15th December 2017 (Fig. 6).The hydrographic characteristics such as atmospheric temperature (AT), Sea Surface Temperature (SST), humidity and wind speed at the site where the sunfish was sighted are given in Table 3.

Table 3. Hydrographic characteristics of *Mola mola* sighting site.

Characteristics	Variables
Atmospheric temperature (AT)	12.5°C
Sea surface temperature (SST)	16.0°C
Humidity	90%
Wind speed	14 mph
Water depth	3475 m

11th Indian SOE

The sampling was carried out in the area between 39°16' to 67°00' S latitude and 57°28' to 80°04' E longitude (Fig. 1B and Table.4). At each station, sampling for early stages of cephalopods was done using Rectangular midwater trawl (Fig. 2A) and Issacs-Kidd Midwater Trawl (IKMT) (Fig. 2B) operated below the surface and 500 m. Both vertical and horizontal hauls were made. The squids were caught in the night hours after attracting them using LED lamps (4 x 500 watts) by using hand

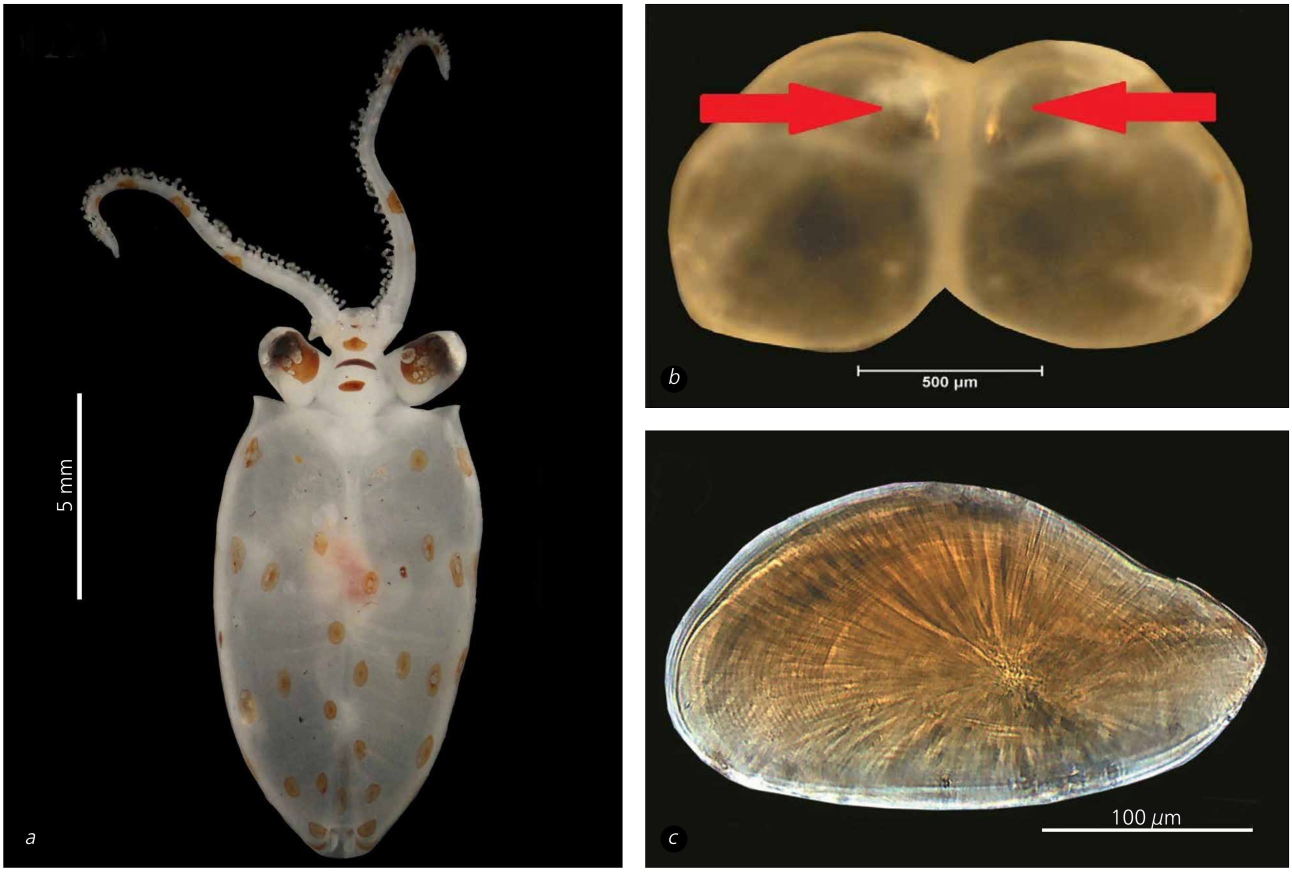

Fig. 5. (a) Dorsal view of *G. glacialis* (11 mm DML), (b) light micrograph of statocyst (arrow indicates the position of statolith), (c) light micrograph of statolith of *G. glacialis* (16 mm DML)

Fig.6. Ocean sunfish *Mola mola* sighted

Table 4. Sampling stations and operations carried out during the 11th Indian SOE

Date	Location	Operation	Depth of operation
29/01/2020	45° 00 S;72°00 E	IKMT, squid jigging	Surface, 500 m
04/02/2020	65° 00 S;80°04 E	IKMT	Surface, 500 m
07/02/2020	67° 00 S;80°00 E	RMT	300 m
08/02/2020	67° 32 S;76°50 E	RMT	250 m
09/02/2020	65° 00 S;76°59 E	IKMT	Surface, 500 m
10/02/2020	65° 00 S;73°59 E	IKMT	Surface, 500 m
11/02/2020	67° 00S; 74°00 E	IKMT	500 m
12/02/2020	66° 50S; 71°00 E	RMT	300 m
15/02/2020	66° 56S; 67°58 E	IKMT	500 m
16/02/2020	67° 00S; 64°50 E	IKMT	500 m
18/02/2020	65° 00S; 62°02 E	IKMT	500 m
19/02/2020	66° 52S; 61°57 E	IKMT	200 m
20/02/2020	65° 31S; 57°29 E	RMT	1000 m
22/02/2020	61° 59S; 57°28 E	IKMT	500 m
24/02/2020	60° 00S; 57°30 E	IKMT	Surface, 500 m
25/02/2020	57° 00S; 57°29 E	IKMT, squid jigging	Surface, 500 m
28/02/2020	50° 24S; 57°29 E	IKMT, squid jigging	Surface
29/02/2020	46° 59S; 57°29 E	IKMT, squid jigging	Surface, 500 m
02/03/2020	43° 00S; 57°30 E	IKMT, squid jigging	Surface
03/03/2020	39° 16S; 57°28 E	Squid jigging	Surface

jigs and automatic squid jigging machine (Hamade MY- 3DP) with centralized control panel (Fig. 2C). However, jigging operations could be carried out only rarely on most of the nights due to very rough seas, strong currents and winds during the expedition. Abundance estimation of ommastrephid squids were undertaken in all stations by visual observation method (Chesalin and Zuyev, 2002).

Three species of cephalopods *Ommastrephes bartramii* (*O.cylindraceus*), *Todarodes filippovae* and *Sthenoteuthis oualaniensis* were collected using automatic squid jigging machine and hand jig while *Galiteuthis glacialis* was collected using IKMT. The pelagic neon flying squid *Ommastrephes bartramii* (*Ommastrephes cylindraceus*) was observed at 39°16' S; 57°28' E. Paralarvae and juveniles of ommastrephid squids were observed in surface waters of 45°00' S; 72°00' E and juveniles were observed at 46° 59' S; 57°29' E and 43°00' S; 57°30' E. Paralarvae of mesopelagic squids collected from 66° to 57° S and 80° E to 57° E were identified as *Galiteuthis glacialis*. The IKMT collected paralarvae of *G.glacialis* of 13 mm DML could be successfully maintained onboard in a glass tank up to 4 hours Fig.3d.

During the expedition 25 stations were covered among which 6 were squid jigging stations, 15 IKMT stations (23 operations) and 4 stations for RMT operations. Antarctic Krill *Euphausia superba* was also collected using IKMT from 500 m depth from 45°S to 60°S latitude along the cruise track and these are being analysed.

Seabirds, fish, penguin and seals of the Southern Indian Ocean were recorded during the expeditions. Nine species of seabirds were identified during the expedition (Table 5 and Fig.7). The southern giant petrel *Macronectes giganteus* was the most common species in the Southern Ocean. Several groups of Adelie penguin *Pygoscelis adeliae* Antarctic seals such as crabeater seal *Lobodon carcinophagus* and leopard seal *Hydrurga leptonyx* were observed near Prydz Bay (Fig.8).

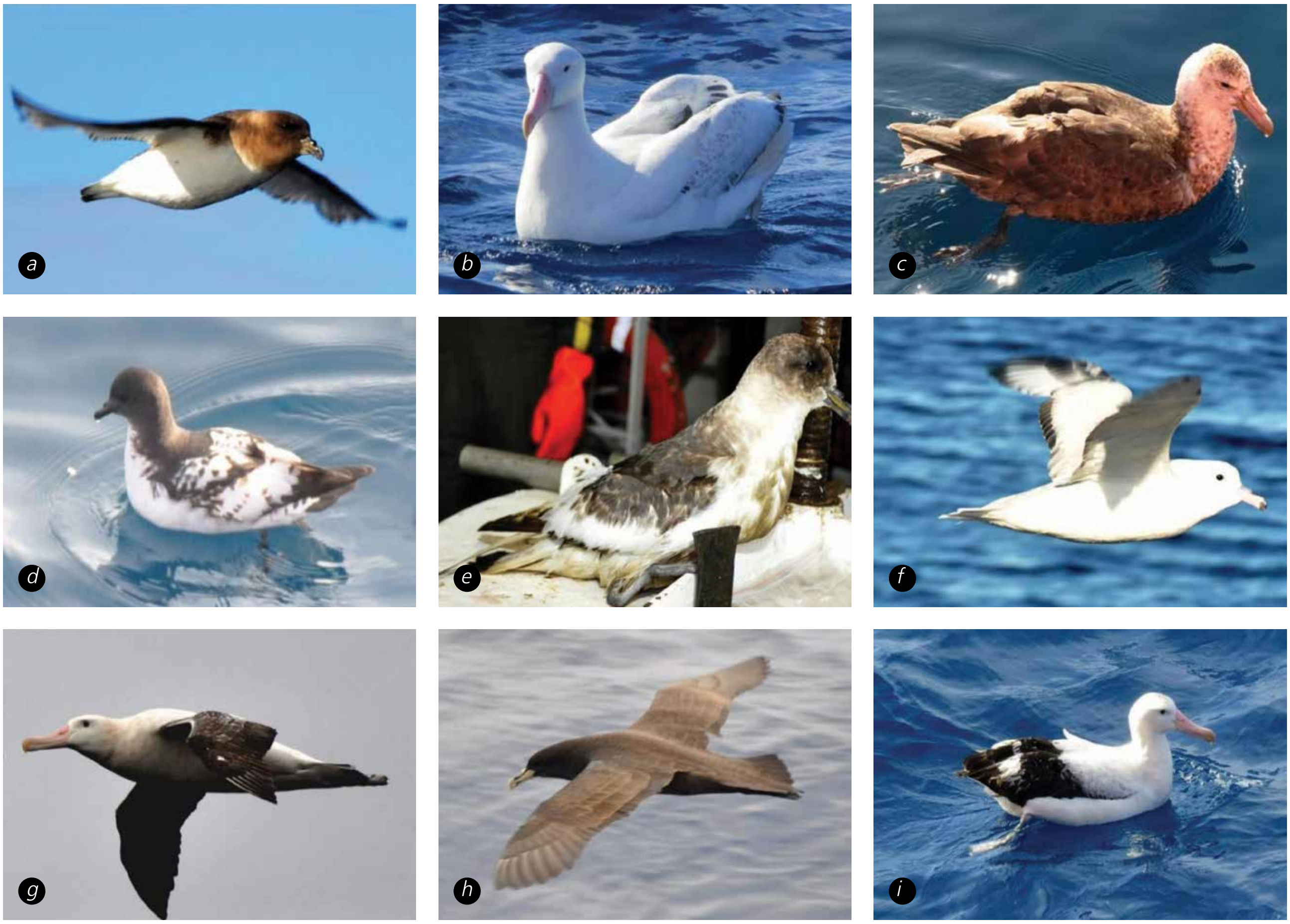

Fig.7. Seabirds observed during the 10th and 11 th Indian Expedition to Southern Ocean/Antarctic waters. (a) *Thalassoica antarctica,*(b) *Diomedea exulans* (c)*Macronectes giganteus,* (d) *Daption capense,* (e) *unidentified,* (f) *Fulmarus glacialoides,* (g) *Diomedea sanfordi,* (h) *Procellaria aequinoctialis,* (i) *Diomedea epomophora*

Table 5. List of birds observed during the 10th and 11th Indian SOE

Species	Common name	Position	IUCN status
Diomedea epomophora	Southern royal albatross	61° 48′ S;57°14′ E	Vulnerable
Procellaria aequinoctialis	White-chinned petrel	40°12′S to 62°35′S	Vulnerable
Diomedea sanfordi	Northern royal albatross	60° 23′S;57°30′E	Endangered
Fulmarus glacialoides	Southern fulmar	65° 20′S;63°12′E	Least concern
Unidentified	-	66° 56′S;67°58′ E	-
Daption capense	Cape petrel	66° 50′S;71°00′ E	Least concern
Macronectes giganteus	Southern giant petrel	57° 00′S to 67°00′S	Least concern
Diomedea exulans	Wandering albatross	61° 00′S;57°28′ E	Vulnerable
Thalassoica antarctica	Antarctic petrel	56°28′S;57°29 E	Least concern

Fig.8. Crabeater seal of Southern Ocean

Endnote

These expeditions suggest the fishery potential of squids belonging to family ommastriphidae, such as *Ommastrephes cylindraceus* and *Todarodes filippovae* distributed up to 45°S during austral summer. The distribution of *Sthenoteuthis oualaniensis* is restricted up to 40°S. The occurrence of the paralarvae and juveniles indicate that Austral summer may be the spawning season for these species in the Southern Indian Ocean. Further on-board/*in situ* statolith increment validation studies for confirming the periodicity of statolith increment formation of Antarctic squids is needed. It is also necessary to carry out more night observations (squid jigging and abundance estimation) especially in the frontal region of the Southern Ocean (40°S) for a comprehensive understanding the abundance and distribution of these valuable resources of the Antarctic. There is also need to understand the relationship between squid stock size, recruitment variability and oceanographic systems.

Acknowledgements

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Preliminary assessment, restoration and aquaculture support for a small wetland

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Abstract

In line with the strategy of regional wetland datasets integration to a common national digital platform, map of small wetlands less than 2.2 ha in Kochi Taluk was prepared. A representative small wetland at Edakochi village of Kerala was selected through maps and field visits for preliminary assessment and restoration. Shuttle Radar Topography Mission's Digital Elevation Model (DEM) was used to assess the general elevation, slope and flow accumulation pattern of the selected wetland along with assessment of the catchment area and drainage pattern. Restoration works of the selected wetland was carried out *vis-a-vis* side bund strengthening and sluice gate fortification. The comparative analysis of water quality assessment of wetland before and after restoration revealed improvement in water quality parameters as well as increase in water level. The Dissolved Oxygen level of the aquatic system was found to have increased substantially along with other several favourable changes in water parameters due to the restoration activities. The restored wetland at Edakochi was further utilised for multispecies farming of prawns, Pearl spot, Milk fish and Grey mullet and the harvest indicated sustainable yield. Aquaculture practice in wetlands with real time scientific advisories could ensure continuous data generation and village level climate resilience.

***Keywords**: Small wetland, Geospatial, Restoration, Aquaculture, Climate resilience*

Introduction

Climate variability induced rainfalls, runoffs, floods and storm water drastically changes the physico-chemical, hydrological, biodiversity and microbial profile of wetland eco-systems. Enhancing village level nutritional security being a national priority, small regional wetlands can contribute significantly as a key habitat for aquaculture production. In view of the significance of ecological and economic functions of wetlands and the threats they face, their monitoring and protection is needed. Regional wetland restoration has been identified as among the prospective climate resilient strategies, with farming of stress tolerant fish species as well as native species, so as to maintain the regional biodiversity profile (Rojith and Zacharia, 2015). The impact on the regional wetland could be cumulative of climatic and non-climatic factors. Scavia *et al.* 2002 states that the most important non-climatic factors comprise drainage of wetlands, overharvesting, discharge of sewage, deforestation, land reclamation, habitat fragmentation, eutrophication, pollution and the introduction of invasive alien species. The hydrology of surface layer of wetlands gets affected by atmospheric inputs such as ratio of precipitation to evapotranspiration (Ferrati *et al*., 2005). An effective eco restoration requires knowledge about wetland dynamics and the factors associated to wetland system, along with the support of regional stakeholders. The study area selected was located at 9.9065° N latitude and 76.2895° E longitude covering an area about 2.115 ha in Kochi Taluk of Ernakulam district, Kerala.

Wetland Dynamics

The shape file data which consists of water shed data and drainage pattern of Ernakulam district and wetland data of Kochi Taluk was procured from Kerala State Land Use Board (KSLUB). The map of wetland < 2.25ha in Kochi Taluk was prepared by QGIS software and based on this and a field survey, a degraded wetland < 2.25 ha was identified for restoration at Edakochi village. Field visits to assess the degradation status, pollutant source and depth of the wetland, followed by geospatial and water quality analysis were carried out. Shuttle Radar Topography Mission (SRTM) was used in the assessment of general elevation, slope and flow accumulation of the study area. The 30 m Digital Elevation Model (DEM)

Fig. 1. Catchment Area of the study area

data was obtained from USGS's Earth Explorer. Slope of the study area was attained by Terrine Analysis Tool and Flow accumulation and drainage was found out. Restoration of the wetland was carried out by side bund construction and fortification of sluice gate, followed by multi-species aquaculture. Water samples from the wetland were analysed for six weeks each before and after restoration. The temperature, salinity and turbidity of the water samples were measured with standard mercury-in-glass thermometer, refractometer and turbidity meter respectively, while pH was determined using the pH meter. The dissolved oxygen, alkalinity, total dissolved solids, ammonia, hardness was determined by standard APHA methods (APHA, 2005).

Geospatial analysis revealed the total area of the wetland as 2.115 ha. Initial field visits revealed that the wetland was in degraded state with shallowness, inflow of drainage water and dumpage of solid wastes, which cumulatively made the wetland unfit for aquaculture. The elevation, catchment area, slope, flow accumulation and drainage pattern of the wetland were documented. The general elevation of the wetland region was estimated to range between 0 to 5 meters above mean sea level with highest elevations towards southern sides. The catchment of the water body was 437 acres (Fig.1). Slope for the region was between 0 and 5, while the estimated slope within the catchment area was below 5%. Since the elevation data of high resolution was not accessible, demarcating the catchment area for small wetland was tedious.

The area includes *Pokkali* fields with paddy prawn cultivation, aquaculture ponds, river, settlements and marshy lands with a river nearby. Flow accumulation was found to be high at the southern part of the wetland, while the northern portion showed a slight accumulation pattern from which Drainage network was generated. This showed two inlets into the field, through which polluted water and household wastes influxes into the wetland. As a remedy, the side bund construction prevented the drainage influx as well as increased the water level of the wetland, whereas fortification of sluice gate facilitated the water exchange for aquaculture.

Water quality analysis indicated water temperature of the wetland around six weeks before restoration within the range of 25°–27°C, whereas it decreased after restoration, which could be attributed to the increase in the water level. The optimum temperature required for good aquaculture and fish growth is between 24 °

C–27 º C (Santhosh and Singh, 2007) and the restoration efforts could bring a water temperature more suitable for aquaculture. The decrease in pH observed after restoration could be attributed to the acid leach from the sediments dredged and used for the strengthening of the side bunds. Reduction in pH was anticipated as it is common in case of restoration activities involving sediment removal. The optimum pH for aquaculture was attained during the operational phase. The salinity range observed before restoration was 20-27 ppt with the highest observed during the last week (26.5 ppt) and the lowest salinity observed during the first week (20 ppt). Maximum salinity was observed in the pre monsoon season in Kochi taluk. However salinity was found to drop rapidly after restoration which could be attributed mainly to the rainfall. Wetlands with seasonal salinity variations could prefer saline tolerant fish species for aquaculture. Turbidity, which is an indicator of wetland health showed normal variation during the pre-restoration phase, whereas the first week after restoration showed an increase in the turbidity level, which may have been caused by the restoration activities with stable turbidity levels exhibited in later weeks. The dissolved oxygen (DO) before restoration ranged between 3.4 and 4.4 and after restoration increased to the desirable limit (5.0 mg/l O_2–6.0 mg/l O_2) for aquaculture. This increase was mainly due to the increase in water spread as well as reduction in water temperature.

The water alkalinity of medium range (40.0-90.0 ppm) indicates high productivity of water body and the levels before and after restoration was found to be within the desirable limit. The total hardness before restoration was mostly higher, whereas after restoration it is observed to be lowered. High hardness value is detected during the pre-monsoon season, while the reduction is observed after rainfall. Overall decrease in ammonia was also observed after restoration activities, with the range of ammonia prior to restoration as above 0.25 (mg/litre) got reduced to around 0.2 (mg/litre). Due to pollution influx and

Table 1: Water Quality before restoration

Parameters	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6
Temperature (ºC)	26	25	27	25.5	25	26.7
pH	8.7	8.02	7.5	7.3	7.5	7.5
Salinity (ppt)	20	27	26	26.5	27	26.8
Turbidity (NTU)	17.64	17.24	17.14	17.02	16.5	17.39
DO (mg/l O_2)	3.7	3.4	3.3	3.6	3.7	4.4
Alkalinity (mg/l $CaCO_3$)	76	72.8	76.07	72.9	73	77
Total Hardness (mg/l $CaCO_3$)	57	56.7	55	55.5	54	57
Ammonia (mg/l L)	0.3	0.3	0.27	0.23	0.3	0.2
TDS (mg/l solids)	278	370	340	347.3	354	349
Total plate count (cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil

Table 2: Water Quality after restoration

Parameters	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6
Temperature (ºC)	24	23	23.6	22	23	23.3
pH	7.7	7.4	7.4	7.3	7.3	7.3
Salinity (ppt)	25	20	19	22	17	10
Turbidity (NTU)	24.54	16.76	16.34	15.12	14.14	15.2
DO (mg/l O_2)	4.3	4.7	4.8	5.3	5.7	5.6
Alkalinity (mg/l $CaCO_3$)	72	72	72.4	72.03	72.6	73
Total Hardness (mg/l $CaCO_3$)	56.6	55.9	56	56	54	54.2
Ammonia (mg/l L)	0.34	0.2	0.22	0.23	0.2	0.2
TDS (mg/l solids)	441.2	360.6	330	314.2	260	208.1
Total plate count (cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil

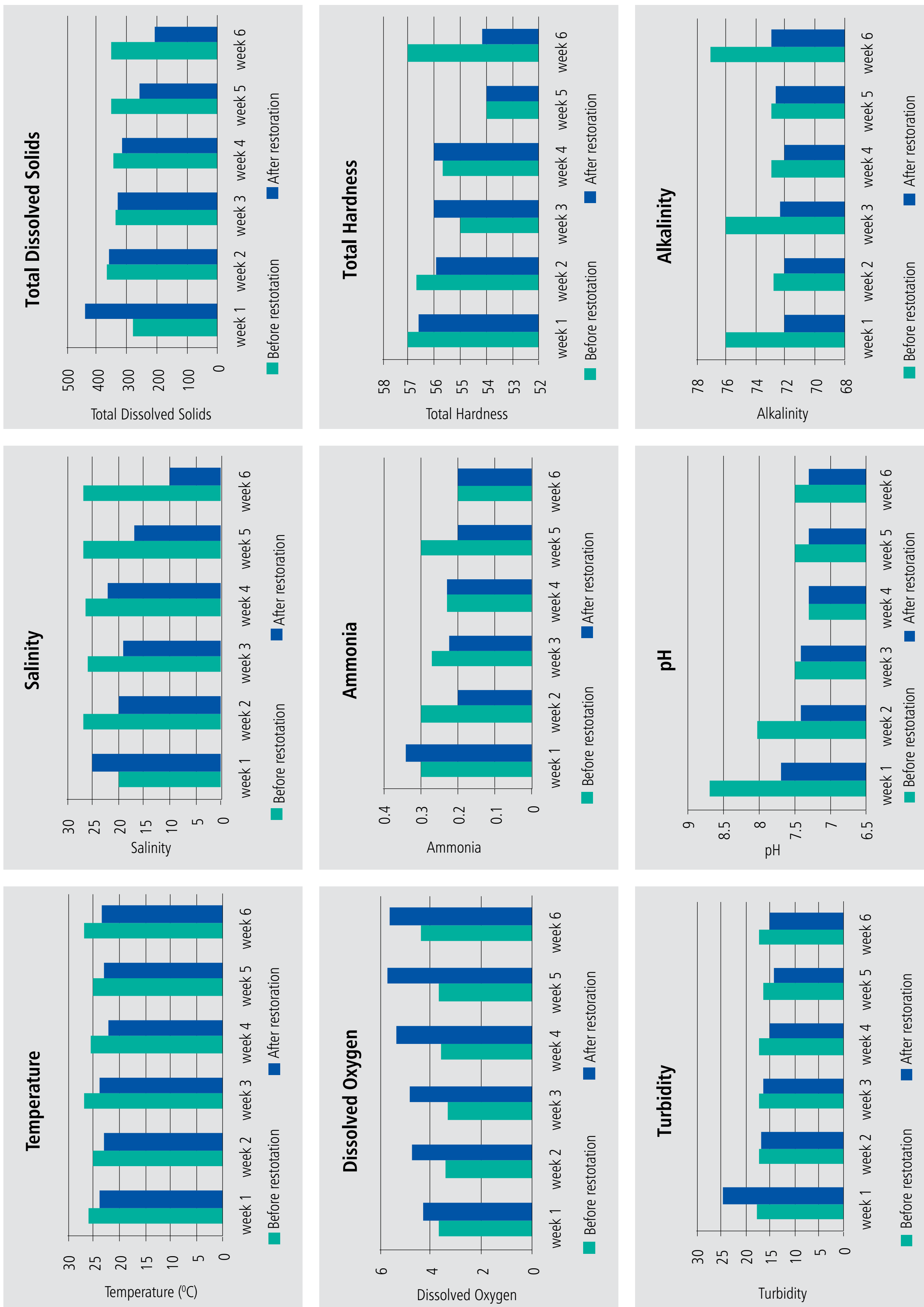

Fig. 2. Water Quality variation before and after restoration

siltation, Total dissolved solids (TDS) value was initially higher, and decreased to a stable desirable value after restoration, after the first week. TDS value in the range of 278-370 before restoration reached 441-208.1 after restoration. No colony of *E. coli* and coliform bacteria was found from the water. The restored wetland is being further utilised for multispecies aquaculture of prawns, pearl spot, milk fish, grey mullet with moderate yields during partial harvest.

Conclusion

A representative degraded small wetland could be successfully restored with generation of water quality and geospatial datasets. The eco-restoration increases the value and potential of regional aquaculture, which can be carried out by private owners, local self-help groups or through lease to stakeholders. The generated data sets such as wetland real images, geospatial profile and periodic water quality parameters are envisaged as inputs to be integrated to the e-platform, developed in collaboration with SAC-ISRO for continuous monitoring and sustenance of the regional wetland ecosystem. The work paves way for real time advisories and continuous monitoring system for regional small wetlands in the country as a competent climate resilient strategy.

Acknowledgement

We express our sincere gratitude to the Indian Council of Agricultural Research for providing financial support for the study through the National Innovations in Climate Resilient Agriculture (NICRA) project implemented at ICAR-CMFRI. We are also grateful to the Director, ICAR-CMFRI for providing facilities for carrying out the study. We thank the Kerala State Land Use Board (KSLUB), Trivandrum for providing the necessary data inputs and Mr. Shelton D'couto for agreeing to use his wetland for our experimental work.

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Research Communications

Seasonal availability of commercially important fish seeds in estuaries of Kozhikode, Kerala

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Abstract

Availability of fish seed for culture is one of the major constraints in expanding mariculture in India. Capture-based aquaculture (CBA) is the practice of rearing wild collected fish seeds from early life stages to adults in captivity to marketable size, employing different aquaculture techniques. It is estimated that about 20 percent of world aquaculture production comes from CBA. The availability of cultivable fish seeds in estuaries of Kozhikode district in Kerala has been surveyed and the potential wild seed grounds identified were in Kadalundi, Korapuzha and Karuvanthuruthi estuaries. The quantitative availability of fish seeds in these localities during different seasons was evaluated.

***Keywords**: Mariculture, CBA, fish seed calendar*

Introduction

Capture-based aquaculture or CBA is popular in many parts of the world due to the lack of commercial supply of "seed" (larvae, juveniles) of many of the high valued species groups. In India, capture fishing using *Dol* nets (Gujarat and Maharashtra), shore seines (east coast of India), *Thalluvalai* (southeast coast) and chinese dip

Fig.1. Seed survey in Kadalundi estuary

nets (Kerala), land a large number of juveniles of high-value species like seerfish, pomfrets, mackerel, shrimps etc., which can form a very good source of fish seed for CBA without affecting the ecosystem and livelihood of fishermen. This study was envisaged to understand the seed resources of three important estuaries of Kozhikode district, namely, Kadalundi, Karuvanthuruthi and Korapuzha.

Findings of the fish seed surveys

The fish seed survey was carried out every month during January- December, 2016 using a cast net, in selected stations covering Kadalundi, Korapuzha and Karuvanthuruthi estuaries. The cast net having an 8 mm mesh size, covered 5 m diameter when deployed in the water body. The seeds collected using cast net from each station were identified using FAO fish identification sheets and quantified by counting species wise numbers in each cast net operation.

The major cultivable seeds available were *Liza melanoptera, Penaeus indicus, Lutjanus argentimaculatus, Etroplus suratensis, Mugil cephalus, Gerres filamentosus, Gerres longirostris, Acanthopagrus berda, Lates calcarifer, Siganus javus and Siganus vermiculatus.* The seeds of *L.melanoptera, P. indicus, L. argentimaculatus* and *E. suratensis* were available throughout the year.

Fig.2. Select fish seeds collected

(a) *Liza melanoptera,* (b) *Lutjanus argentimaculatus*
(c) *Etroplus suratensis,* (d) *Acanthopagrus berda,*
(e) *Siganus vermiculatus*

Table 1: Major cultivable fish seeds available at Kadalundi, Chaliyar and Korapuzha estuaries of Calicut:

Kadalundi estuary

Species available	Local name	Size (cm)	Seasonal availability	Peak availability
Liza melanoptera	Malan	3.2-11.5	January-December	October-April
Fenneropenaeus indicus	Naran	3.5-8.5	January-December	September-December
Lutjanus argentimaculatus	Chemballi	7.5-20.0	January-December	June-January
Etroplus suratensis	Karimeen	3.5-12.0	January-December	August-December
Gerres filamentosus *Gerres longirostris*	Prachi	2.5-8.0	May-August	June-August
Siganus javus, *Siganus vermiculatus*	Karadu	6.0-10.0	May-November	June-September
Acanthopagrus berda	Aeri	8.0-13.0	December-March	November- December
Lates calcarifer	Narimeen	8.0-15.0	November-February	November- December

Karuvanthuruthi (Chaliyar estuary)

Species available	Local name	Size (cm)	Seasonal availability	Peak availability
Liza melanoptera	Malan	5.2-15.5	January-December	June-December
Fenneropenaeus indicus	Naran	4.0-7.5	January-December	September-November
Etroplus suratensis	Karimeen	4.5-12.0	January-December	September- November
Lutjanus argentimaculatus	Chemballi	4.9-6.6	January- December	September- January
Leiognathus brevirostris	Mullan	4.5-6.1	May- December	July-October

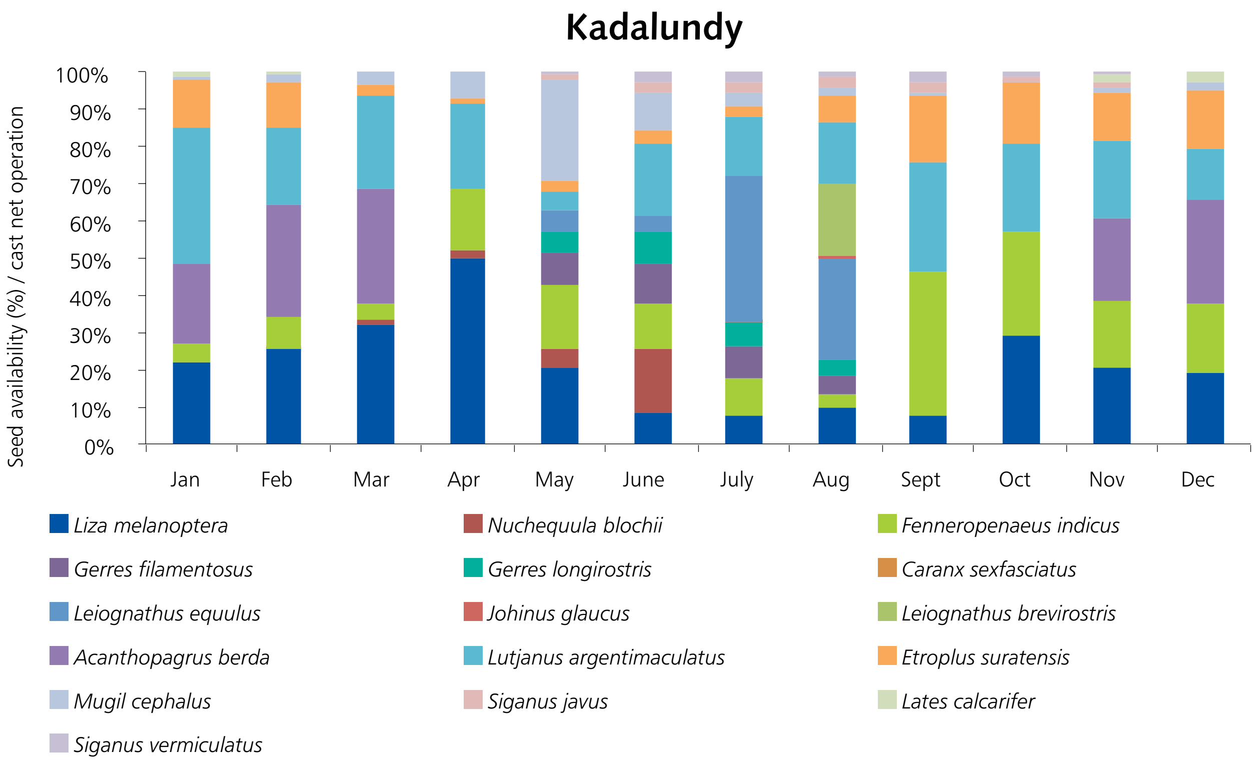
Korapuzha estuary

Species available	Local name	Size (cm)	Seasonal availability	Peak availability
Liza melanoptera	Malan	3.2-12.3	January-December	September-February
Etroplus suratensis	Karimeen	2.0-8.0	January-December	July- September
Fenneropenaeus indicus	Naran	4.0-9.5	January-December	August-November
Siganus javus	Karad	3.5-8.5	March-September	July-August
Lutjanus argentimaculatus	Chemballi	5.0-15	January- December	August- January

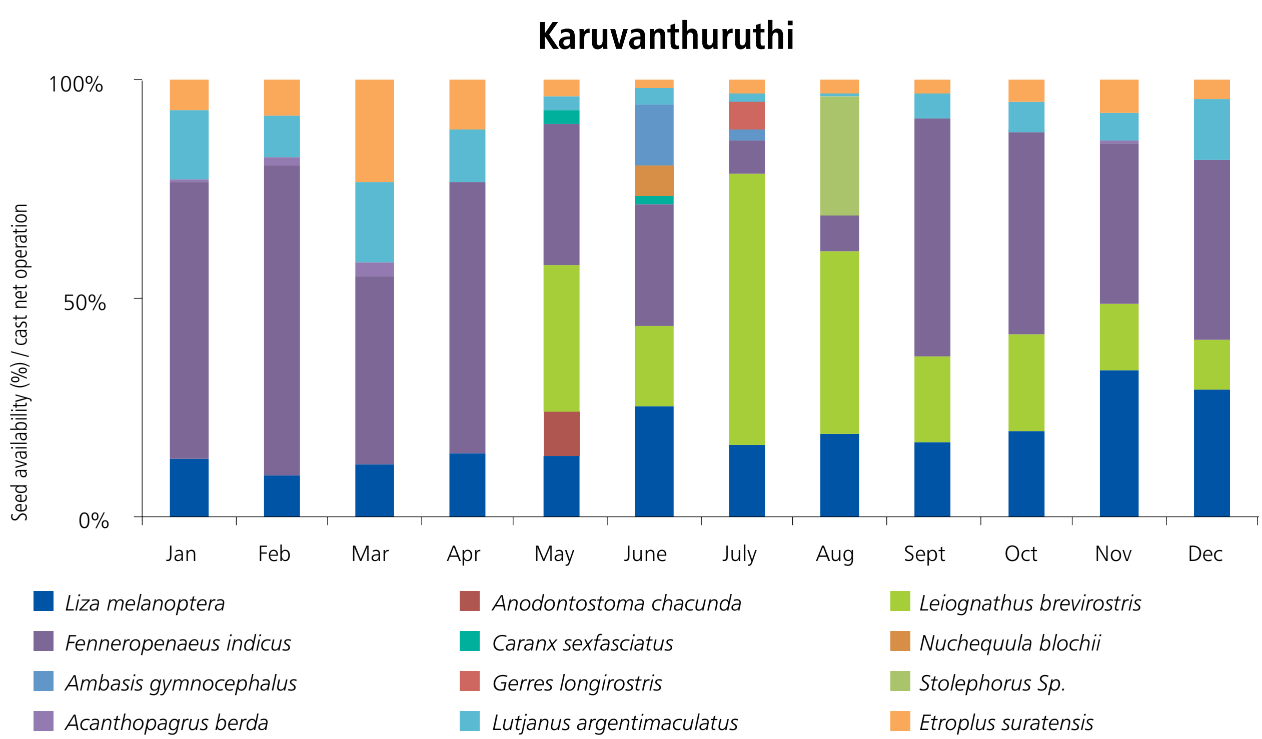
Liza melanoptera, *Lutjanus argentimaculatus*, *Etroplus suratensis,Gerres filamentous, Gerres longirostris, Acanthopagrus berda, Siganus javus, Siganus vermiculatus, Lates calcarifer* and *Penaeus indicus* were the dominant commercially important seeds available at Kadalundi. The seeds of *P.indicus, L. melanoptera, L.argentimaculatus, E. suratensis* and *M. cephalus were* available throughout the year. The seeds of *Siganus* spp. and *Gerres* spp. were dominant during the south west monsoon (June -August) season. Other seeds available were those of Silver bellies such as *Nuchequula blochii, Leiognathus brevirostris* and *L. equulus.* The major seeds available at Karuvanthuruthi were *P.indicus Leiognathus brevirostris, Liza melanoptera, Lutjanus argentimaculatus* and *Etroplus suratensis.* Other seeds available included *Anodontostoma chacunda*, *Nuchequula blochii, Acanthopagrus berda*, *Caranx sexfasciatus*, *Gerres longirostris* and *Leiognathus brevirostris.* The major cultivable seeds available at Korapuzha were *Liza melanoptera, Etroplus suratensis, P.indicus, Lutjanus argentimaculatus* and *Siganus javus*. Other fish seeds available were *Anodontostoma chacunda*, *Scomberomorus commersonii, Leiognathus equulus, Etroplus maculatus, Gerres longirostris, Mugil cephalus, Ambasis gymnocephalus* and *Leiognathus brevirostris* (Fig.3). These locally available species when used for culture reduces the risk of exotic fish diseases and their spread in native waters.

Locally available seeds can be effectively used for CBA in that particular locality (Fig.4). New employment opportunities (e.g. divers, "seed" collectors, harvesters, etc.) can arise in places with limited economic opportunities. Although it can bring high profits, CBA can also have negative impacts in the long run if harvest of seed is uncontrolled

Kadalundy



Karuvanthuruthi



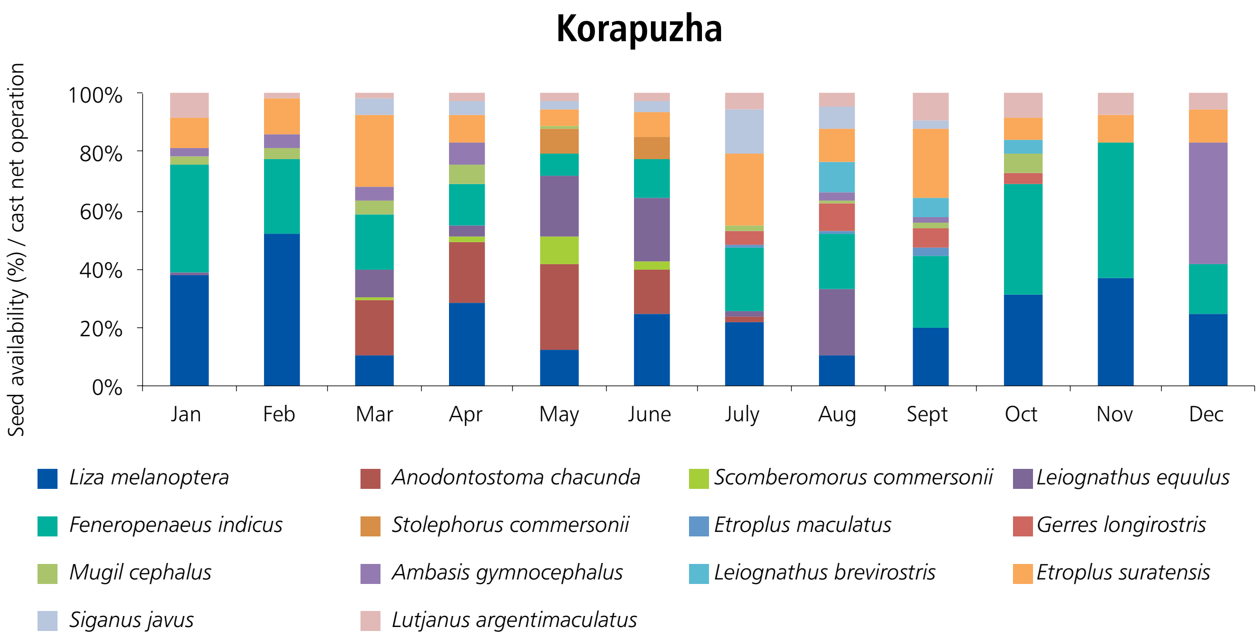


Fig. 3. Seasonal availability of fish seed in various sites surveyed

Fig.4. Seed calendar indicating seasonal availability of various species wise

and sustainability issues are not addressed. Therefore sustainable development of CBA should be based on careful site selection, pre-assessment of the carrying capacity of sites, good health and feed management practices, stocking density control, and periodic assessments of their impact on the local ecosystem.

Fishers livelihood improvement through seaweed farming - A success story

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The Mandapam Regional Centre of ICAR-CMFRI selected Puthukudi village, Thondi in Ramanathapuram district of Tamil Nadu for implementation of Scheduled Caste Sub-Plan (SCSP) a programme fully funded by Government of India. This village has 97 per cent of SC families in the total village population and majority of them are involved in fishing. Moreover, this village is located near to the sea shore and mariculture activities like cage farming, marine ornamental fish seed rearing and seaweed farming can be easily adopted by them. The fishers of the village also showed keen interest to take up additional livelihood activities. The local panchayat extended full cooperation to implement the SCSP programme and a list of interested beneficiaries comprising 28 fishers belonging to Kadiayar community was selected for undertaking seaweed farming activities (Table 1). The number of monoline units per fisher was decided based on the fund availability under various projects of the Institute /All India Network Project (AINP) or National Innovations in Climate Resilient Agriculture (NICRA)

An awareness programme on mariculture technologies for diversified livelihood under SCSP was organized at Puthukudi village on 12th September 2019 (Fig.1). The importance of SCSP programme and the benefits of cage farming, marine ornamental seed rearing units and seaweed farming were briefed to the beneficiaries. Representatives from State Fisheries Department, Thondi Panchayat, Village Administration and Fishermen Cooperative Society participated in the meeting. Forty fishers from Puthukudi village participated and interacted with the officials. Followed this a training programme on "Mariculture Technologies for Diversified Livelihood" was successfully organized at Mandapam Regional Centre during 19-21 November, 2019. Sixty beneficiaries from Puthukudi village, Thondi participated and benefitted from the Hands on training on marine ornamental fish seed rearing, seaweed farming and sea cage farming extended to them (Fig.2). Field visit to sea cage farms, seaweed farms and marine ornamental fish seed rearing units, Thangachimadam were arranged and the trainees interacted with established fish farmers and marketers.

Monoline method of seaweed farming was adopted as the Puthukudi coastal area had low wave action, shallow depth and less herbivorous fishes which are ideal for monoline method of seaweed farming. Four casuarina poles of 10 feet length and 3-4" diameter were placed at

Fig.1. Awareness creation on mariculture technologies and SCSP

Table 1. Details of activities under SCSP programmme

Programme	Activities	No. of beneficiaries
INSTITUTE - SCSP	7 groups were formed for seaweed farming and each fisher allotted 20 monoline units	20
AINP-SCSP	2 groups and each fisher given 21 monoline units	6
NICRA-SCSP	One group and each fisher given 25 monoline units	2

Fig.2. Training programme on "Mariculture Technologies for Diversified Livelihood"

10 × 20 feet distance each in the corner. On four sides 6mm rope was tied, on which the seaweed seedling rope was tied. A total of 10 polypropylene-twisted ropes were used for planting. Around 150 – 200 grams of seaweed fragments were tied at a spacing of 15 cm along the length of the rope. A total of 40 seaweed fragments were tied in a single rope. The total seed requirement per raft was 60 – 80 kg per monoline unit. One segment (120 feet length and 20 feet breadth) constitutes 10 monoline units (Fig.3). HDPE fishing net was used for making fencing for avoiding grazing by fishes in the sea and drifting away of the seaweed seeded nets. Used PET bottles were tied on each rope for increasing the floatability. Inputs for farming the seaweeds were provided to each fisher participant in the programme (Table 2).

Initially during the second week of November, 2019, the seaweed farming was initiated with one group (two members per group). The harvest made in the last week of December 2019 yielded 8.7 tonnes of fresh seaweed from 20 monoline units (Figs. 3- 6). These were utilized as seeding material for expanding additional 150 monoline units under the project. A total amount of ₹34,800/- was generated by the beneficiaries under the project as their revenue (₹17,400 per beneficiary). The second crop was initiated during the first week of January, 2020 with three groups. The harvest was made during mid February, 2020. Around 24 tonnes of

Table 2. Inputs provided for the seaweed farming programme

Particulars/Description	Quantity Required (Per unit)	Quantity Required (20 units)
3-4" dia Casuarina/eucalyptus poles 4 nos each pole length as 10 ft (without any natural holes, crakes etc.,)	40	800
3mm PP twisted rope for plantation – 20bits of 0.5 m each	420 gm	8.4 kgs
HDPE braider pieces (20 pcs x 20 ropes = 400 pcs of 25 cm each)	165 gm	3.3 kgs
HDPE fishing net to make fencing for avoid grazing & drifting	1.0 kg	20.0 kg
Anchoring rope of 6mm thickness to make fencing between the poles - used to tie the plantation ropes	100 gm	2 kgs
Used PET bottles 20 nos - for increasing the floatability in 20 ropes	20	400

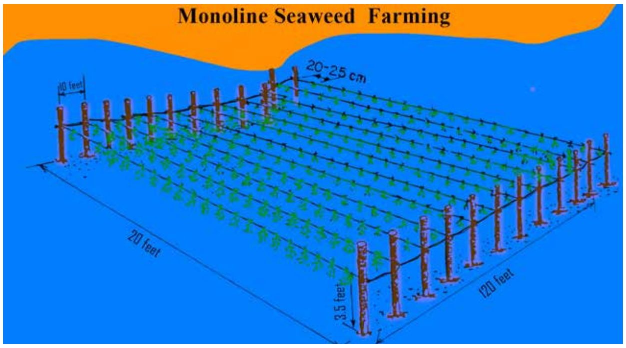

Fig.3. Diagramatic view of a segment (10 monoline units)

fresh seaweed was harvested. The fresh seaweeds were utilized for expanding 400 monoline units under the project. An amount of Rs. ₹96,000 was generated by the beneficiaries under the project as their revenue (₹13,500 per beneficiary).The third crop was initiated during the last week of February, 2020 with seven groups. As an impact of 'total lockdown' due to COVID -19 pandemic, the beneficiaries decided to undertake partial harvest and to continue the farming with remaining seaweed. The harvest was made during the first week of April, 2020. Around 2,648 kgs of dry seaweed (26,480 kgs

Fig.4. Beneficiaries actively involved in seeding the ropes

Fig.5. Taking the seeded ropes for tying on the poles

Fig.6. Seeded ropes tied on the pole

Fig.7. Aerial view of the seaweed farm, Puthukudi village, Thondi

wet weight equivalent) was sold and ₹1,27,104 was generated by the beneficiaries as their revenue amounting to ₹6,500 per beneficiary (Figs. 4-8). The projections for the future harvest of seaweeds under this programme in a cycle of 45 days with 20 monoline units per fisher appear to be good assuming that 8-9 months will be the crop period in a year depending on the climatic conditions (Table 3).

For marketing the seaweed harvest, the beneficiaries were linked with the AquAgri Pvt, Ltd., Manamadurai to sell their produce. The marketing personnel of this firm are procuring the farmed seaweed either in fresh/ dry form at the farming site itself. Joint account for each group was opened in Canara Bank, Thondi where the amount pertaining to purchase of harvested seaweed is deposited in the respective group accounts.

Table 3. Expected annual output during 2020-21

Annual seaweed production (Average yield: 250 kg per monoline) (Retaining 60 kg for next crop, total fresh seaweed production from 20 monoline units; 5 cycles)	19000 kg
Total seaweed production (from 20 monoline units; 5 cycles) on dry weight basis (10 %)	1900 kg
Gross Revenue in ₹ (@ ₹55 per kg of dried seaweed)	104500
Total cost of production (@ ₹2000 × 20 monoline units)	40000
Net income (Gross revenue – Total cost of production) in ₹	64500

Fig.8. Ropes ready for harvest after 45 days

Since entire cost is met under the SCSP, each fisher can earn around one lakh rupees annually or about ₹10,000 per month. This is the first Government enabled livelihood improvement initiative for fishers in the Puthukudi village and beneficiaries expressed happiness that the income through seaweed farming will be very useful in improving their standard of living .

Acknowledgement

The authors are grateful to the Director, ICAR-Central Marine Fisheries Research Institute, Kochi and Chairman, TSP & SCSP, ICAR-CMFRI, Kochi for the encouragement and support for implementing the programme.

Stranding of Indian Ocean humpback dolphin along Uttara Kannada coast, Karnataka.

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Strandings of two Indian Ocean humpback dolphins along Uttara Kannada coast of Karnataka, during November, 2019 and April 2020 is reported. One dead dolphin was washed ashore at Murdeshwar beach of Bhatkal taluk on 11.4.2020 in decayed condition (Fig 1). Based on the external characters, with the help of the available photograph it was identified as a female Indian Ocean humpback dolphin *Sousa plumbea* (G. Cuvier, 1829). It had beached about one kilometre away from the northern side of the Murdeshwar Temple,surrounded on three sides by Arabian sea. Murdeshwar Bay is a safe place for berthing indigenous crafts and gill nets are the major gear used by local fishers as the bottom is rocky and unsuitable for trawling. The coral reef Island, Nethrani is 20 km away from this beach. The stranding happened during the national lockdown period from 23rd March to 14th April 2020 in connection with COVID- 19 pandemic and when no fishing activities were permitted along entire Indian coast. The dolphin might have entered the shallow water in pursuit of fish schools. As there was no fishing, the mortality is attributed to physical strain in trying to get away from the shallow coastal waters. While collecting the detailed information on this stranding event, another anecdote of a dolphin stranded on 8.11.2019 at Holangadde beach of Kumta Taluk in decomposed condition with photographic evidence was accessed. This was also identified as *Sousa plumbea* (Fig 2). Both dolphins were buried by concerned forest officials and Gram Panchayath authorities at their respective stranded localities. The author thanks Department of Forest, Department of Fisheries, local newspaper 'Karavali Munjavu' and Gram Panchayat officials for providing the dolphin stranding information and photographs during lockdown period.

Fig. 1. The dolphin stranded on Murdeshwar beach.

Fig. 2. The dolphin stranded at Holangadde beach, Kumta.

Unusual landings of large sized Yellowfin tuna by purse seiners at Karwar, Karnataka.

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Unusual landings of large sized Yellowfin tuna *Thunnus albacares* (Bonnaterre, 1788) was observed at Baithkol Fisheries Harbour, Karwar during the period 16th to 22nd February 2020. Six tunas were landed by two purse-seiners with individual weights ranging from 68 kg to 103 kg. One purse-seine unit landed with only one yellowfin tuna weighing 68 kg in the early morning hours of 16.2.2020. The other multiday purse-seine unit of OAL 19.8 meter overall length (OAL) fitted with a 350 hp Sonatrac engine was operated at a depth of 54 meter off Belekeri (N 14^{0} 38' 100" E 073^{0} 52' 500") during night hours on 18.2.2020 and four yellowfin tuna weighing 103, 97, 82 and 78 kg each were hauled in and sent immediately by a carrier boat to landing centre which reached in the morning hours of 19.2.2020. The same purse-seine boat landed one Yellowfin tuna of 71 kg after multiday fishing on 22.2.2020. The Yellowfin tunas were sent to Goa for marketing and observation indicates the availability of large sized yellowfin tuna in northern Karnataka. The other fishes in the landings by purse-seiners included Indian mackerel *Rastrelliger kanagurta*, squid *Loligo duvauceli*, Little tunny *Euthynnus affinis*, seerfish *Scomberomorus commerson* and scad *Decapterus russelli*.

Fig. 1. Yellowfin tuna landed at Baithkol Fisheries Harbour, Karwar.

Deformities in finfishes along the coast of Andhra Pradesh

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During regular field surveys, four abnormal fishes were collected from commercial trawl landings at Visakhapatnam Fishing Harbor from March, 2018 to December, 2018. The collected specimens were subjected to thorough clinical examination for the detection of abnormalities. Deformed specimens of *Rachycentron canadum*, *Sphyraena putnamae, Fistularia petimba* and *Lepturacanthus savala* were identified and recorded. Cobia, *R. canadum* (TL: 380mm) was found to have deformities in the scoliotic, lordotic and kyphotic bends of the posterior part in the vertebral column (Fig.1). In sawtooth barracuda, *S. putnamae* (TL: 360 mm), compression and fusion of vertebral bone resulting in abnormal curvature of vertebrae was observed (Fig.2). A caudal fin deformity was found in the red cornet fish, *F. petimba* (Fig. 3). There was complete absence of caudal fin and its supportive skeletal elements and the median extension of the caudal fin ray. The tapering part of caudal fin and the posterior part of dorsal fin were not found in Savalai hairtail, *L. savala* (Fig. 4). Both the species (*L. savala* and *F. petimba*) did not possess any scar tissue on the posterior part of their body. In *L. savala,* complete fusion of dorsal fin with posterior part of the body was observed. This indicates the possibilities of skeletal deformity in the caudal portion, and cannot be attributed to have been caused during escape from a predator. Such morphological and spinal deformities are reported in fishes globally. However, further studies are required to decipher the causative factors responsible for such deformities, and its impact on the affected fishes.

Fig.1. Spinal deformity in *Rachycentron canadum*

Fig.2. Spinal deformity in *Sphyraena putnamae*

Fig.3. Caudal fin deformity in *Fistularia petimba*

Fig.4. Deformity in the tail portion of *Lepturacanthus savala*

Guidelines for authors

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Seafood Trade
Marine Biotechnology

Technical articles should be written in English and should communicate in a popular style, salient research findings and technologies of relevance to the marine fisheries sector. Articles will be selected for publication considering its current relevance, innovative ideas and scope for application of the new knowledge to the benefit of various stakeholders.

Preparation of Articles for MFIS

Contributions are invited under 4 Sections: Lead Papers, Research Communications, Brief Communications and Kaleidoscope.

Research Communications are limited to 12 A4 pages including figures/tables and a brief abstract. The articles can carry graphs & photographs. Upto 5 relevant references can be quoted in the text with complete reference provided at the end of the article. An abstract limited to 200 words and 3-5 keywords should be provided.

Brief Communications may be limited to 6 A4 pages, will include photos only and references are not required /optional.

Kaleidoscope section will include any short communications of preliminary results of topical, scientific interest related to any of the above themes.

Title page of all communications should include authors' full name (s), institute's mailing addresses and the e-mail address of the corresponding author. The title of the paper must be relevant and brief. General text must be typed in 12-point, Times New Roman font with 1.5 spacing in a single column format. Headings within each section must be short and follow a logical sequence. Acronyms, abbreviations and technical terms should be written out in full the first time they are mentioned. Layout of the text should be simple without any elaborate formatting styles.

Tables should be kept to minimum, with a short heading and conform to the size and lay-out of the MFIS. Artwork files should be of high resolution in TIFF/JPEG (minimum 300 dpi) or in MS-Excel format only and bearing appropriate captions. Embedded graphics in word processor files are not accepted.

References should be brief and complete with Author (s) name (s), year, Journal name, Volume, page number (s) to provide the reader enough information to trace the reference easily. It should be provided at the end of the text following the format given below.

Taylor *et al*., 1998. *Aquaculture*, 162: 219-230. (Reference with more than two authors)

Friedman and Bell. 1996. *J. shellfish Res*., 15: 535-541. (Reference with two authors)

Pauly, 1980. *FAO Fish. Tech. Pap*., 234.

Submission of article

Authors are requested to submit soft copies of the articles indicating the category of the submission to Editor, MFIS at the E-mail address *pmemfis2017@gmail.com*

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