

# Insights from an exploratory survey based assessment of the deep-sea fish resources of the continental slope in the Indian EEZ

U. Ganga<sup>1\*</sup>, N. Beni<sup>1</sup>, P.T. Jinesh<sup>1</sup>, Hashim Manjeybrakath<sup>2</sup> and Shubhadeep Ghosh<sup>3</sup>

<sup>1</sup>ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

<sup>2</sup>Centre for Marine Living Resources & Ecology, Ministry of Earth Sciences, Kochi-682 508, Kerala

<sup>3</sup> Indian Council of Agricultural Research, New Delhi

\*E-mail: ganga66@rediffmail.com

## Introduction

With declining catches from inshore waters, there is increasing importance being attributed to development of offshore fishing activities. However, unless this development is based on sound scientific basis, taking into account the biological characteristics of the resources, the virgin biomass and fishing grounds available, sustainability will be compromised, resulting in a boom and bust phenomenon. The biological processes such as growth, maturation, feeding, fecundity of the deep-water species are less known than commercially exploited shelf species and can only be assessed using dedicated deep-water exploratory surveys. Time series data obtained through fishery independent surveys are thus critical for making reliable fish stock assessments. It is in this context that the findings under the Centre for Marine Living Resources & Ecology (CMLRE) funded project "Assessment of Deep-Sea Fishery Resources of the Continental Slope of the Indian EEZ" have aimed to achieve the objectives of assessing the magnitude and distribution of the deep-sea fishery resources of the continental slope region through exploratory surveys, and biological information of the hitherto untapped resources, which will be useful for informed decision making on fishing and management strategies to be adopted while developing deep-sea fisheries. An associated outcome was the development of geo-referenced database on trawlable fishing grounds obtained during the several exploratory surveys. This was possible as fishing trials were operated after scanning all the potential fishing grounds in a particular transect for their suitability.

## Exploratory Surveys and findings

In India, oceanographic and fishery resource surveys were first initiated by Research Vessel *RV Varuna* under the

Indo-Norwegian Project during the 60s, supplemented by the FAO/UNDP surveys during the 70s (mostly coastal waters) and catalysed with the introduction of the Fishery oceanography Research Vessel *FORV Sagar Sampada* in the mid 80s. The observations recorded in this communication specifically pertain to 3 surveys among several others, which were conducted in the north eastern Arabian Sea (West coast of India) on-board *FORV Sagar Sampada*. The selected fishing stations were in the 200 and 1000 metres (m) depth contours, in the respective pre-determined cruise transects. The fishing stations in each transect were selected after ascertaining their suitability (regarding fishing ground bottom characteristics, and likely resource availability) based on the scan outputs from the on-board echosounder. The geo-referenced database on trawlable fishing grounds thus created on-board *FORV Sagar Sampada* during various cruises such as Cruise 313 (2 transects & 12 fishing stations), Cruise 322 (7 transects & 11 fishing stations) and 332 (6 transects & 12 fishing stations) forms part of the archived database on potential trawling grounds in CMLRE, Ministry of Earth Science. Three fishing nets were deployed during the Deep sea fishing cruise 332- (1) EXPO model Fish trawl, (2) High Speed Demersal Trawl-Crustacean version HSDT-CV and (3) High Opening trawl (HOT) net while only the first two were used in the other cruises. Biological aspects of selected species of finfishes and sharks were recorded based on samples collected from each station. Details of the transects in each cruise for fishing operations are presented in Tables 1.1 – 1.3.

Fishing cruise 313 spanned for a period of eighteen days with 12 fishery stations surveyed for suitability. Among

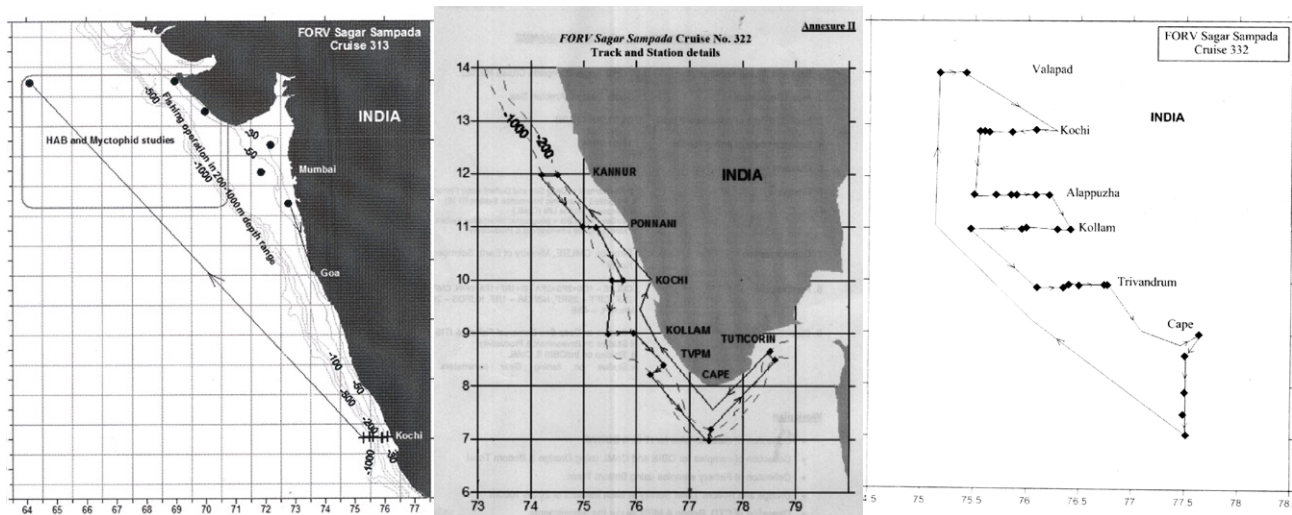


Fig. 1. Transects of exploratory deep-sea fishery cruises 313, 322 and 332

these, four deepsea trawl fishing operations were carried out in the continental slope of north eastern Arabian Sea (20.35.777' N 69.17.804' E to 19.50.344'N 69.25.035'E), where the depth range was 200-400 m. Sea bottom scanning for finding suitable fishing grounds was done with Simrad ER60. Fishing Cruise no. 322 of fourteen days duration covered the latitudes between 12°-7° N on the west coast of India during the period 6 to 19 January, 2014 . Fourteen fishing stations were trawled using either HSDT-CV or EXPO net after scanning with an EK 60 echosounder. 24 species of finfishes were identified from different transects and their taxonomic



Rigging of the HOT trawl net with buoys in preparation for its first fishing trial in Cape comorin transect

Table.1.1 Details of Fishery operations in cruise 313

Date	Transect	Depth (M)	Lat.(N)	Long.(E)	Gear	Effort (minutes)	Catch (kg).	CPUH	Major groups caught
17-2-13	Mumbai	328	18.36.250	69.02.582	Myctophid net	60	0.7	0.7	Myctophids, jellyfish,
18-2-13	Mumbai	355	18.36.250	69.02.582	Myctophid net	60	2.5	2.5	Myctophids, jellyfish,
19-2-13	Mumbai	391	19.12.461	67.59.125	Myctophid net	60	1.2	1.2	Myctophids,
19-2-13	Mumbai	282	19.09.546	67.54.296	Myctophid net	60	1.2	1.2	Myctophids,gapers, jellyfish,
19-2-13	Mumbai	268	19.06.707	66.07.973	Myctophid net	60	2.5	2.5	Myctophids, jellyfish,
20-2-13	Mumbai	268	19.17.840	65.55.013	Myctophid net	60	1.6	1.6	Myctophids, bathyclupeids
21-2-13	Mumbai	372	20.56.040	65.56.529	Myctophid net	60	2.4	2.4	Myctophids, Charybdis sp., jellyfish
21-2-13	Mumbai	281	20.58.555	66.20.700	Myctophid net	60	10.9	10.9	Myctophids, <i>Charybdis</i> sp., jellyfish
22-2-13	Veraval	394	21.04.195	66.20.700	Myctophid net	60	2.62	2.62	Myctophids, <i>Charybdis</i> sp., jellyfish
24-2-13	Veraval	200	20.35.59	69.18.061	Trawl net	60	68.5	68.5	Threadfin breams, bathyclupeids, gapers, <i>Priacanthus</i> sp., <i>Otolithes</i> sp.
24-2-13	Veraval	200	20.15.874	69.25.300	Trawl net	60	9.32	9.32	<i>Priacanthus</i> sp., <i>Solenocera</i> sp., Threadfin breams, gapers, <i>Otolithes</i> sp.
25-2-13	Veraval	315	21.04.195	66.20.700	Trawl net EXPO CV	60	0.5	0.5	<i>Harpadon</i> sp., <i>Cubiceps</i> , <i>solenocera</i>

details and biology were documented. Fishing cruise 332 was conducted along the southwest coast and Cape from 24-11-2014 to 10-12-2014. The high opening trawls (HOT) were operated in addition to the normally used

EXPO model fish trawl and the HSDT- CV nets in this cruise. It was observed to be very efficient in that high catch rates were recorded from the 200 and 1000 m depth stations selected for the fishing trials.



Three fishing nets evaluated during Deep sea fishing cruise 332- (1) EXPO model Fish trawl, (2) High Speed Demersal Trawl-Crustacean version HSDT- CV and (3) High Opening trawl (HOT) nets stored on the deck.

Table.1.2 Details of Fishery operations in cruise 322

Date	Transect	Depth (M)	Lat.(N)	Long.(E)	Gear	Effort (minutes)	Catch (kg).	CPUH	Major groups caught
07-1-14		200	10.09.956	75.38.965	HSDT (CV)	60	232	232	<i>N. orientalis</i> , <i>P. cyanea</i> , <i>Bathyclupea</i> sp., <i>Mycetophum</i> sp.
08-1-14		1000	11.04.195	74.55.430	HSDT (CV)	60	1476	1476	Ophiidiformes, <i>Centrophorus</i>
9-1-14		1000	11.58.355	74.16.791	HSDT (CV)	60	1099	1099	Ophiidiformes, <i>Lamprogrammus niger</i> , <i>Aristeus alcocki</i>
9-1-14		200	11.57.317	74.26.081	HSDT (CV)	60	16756	16756	Acropomatids, priacanthids, <i>P. cyanea</i> , <i>Chelidoperca</i> , Lizard fishes
11-1-14		200	8.59.618	75.55.468	HSDT (CV)	60	892	892	<i>N. orientalis</i> , <i>P. cyanea</i> , <i>Acropoma</i> sp., <i>Platycephalus indicus</i> , <i>Chlorophthalmus corniger</i> , <i>Plesionika</i> sp.
11-1-14		1000	8.53.593	75.27.288	HSDT (CV)	60	4408	4408	Ophiidiformes, Eel, Brittle star, <i>Coryphaenoides</i> sp., <i>Alepocephalus</i> sp.
12-1-14		1000	8.05.718	76.25.842	HSDT (CV)	60	1908	1908	Ophiidiformes, Eels, <i>Aristeus alcocki</i>
13-1-14		200	8.21.75	76.29.800	HSDT (CV)	60	1598	1598	<i>Satyrychthys adeni</i> , <i>N. orientalis</i> , <i>P. cyanea</i> , <i>Acropoma</i> sp., <i>Chlorophthalmus corniger</i>
15-1-14		200	8.28.994	78.35.583	HSDT (CV)	60	1756	1756	<i>Bembrops</i> , <i>N. orientalis</i> , <i>P. cyanea</i> , <i>Satyrychthys</i> sp., Crab, Shrimp,
15-1-14		1000	8.29.994	78.35.583	HSDT (CV)	60	793	793	<i>Narces</i> sp., <i>Bathyclupea</i> sp., Tripod fish, <i>Plesiobatis</i> sp.
16-1-14		200	8.38.153	78.29.182	HSDT (CV)	60	60355	60355	<i>Charybdis</i> sp., <i>P. cyanea</i> , <i>N. orientalis</i>

Table.1.3. Details of Fishery operations in cruise 332

Date	Transect	Depth (M)	Lat.(N)	Long.(E)	Gear	Effort (minutes)	Catch (kg.)	CPUH	Major groups caught
28-11-2014	Cochin	950	9.51.849	75.29.596	HSDT CV	40	138.00	207.00	Alepocephalids, deep sea shrimps
29-11-2014	Cochin	200	9.40.357	75.39.092	HSDT CV	60	4021.00	4021.00	<i>Charybdis</i> spp, <i>N.orientalis</i> , <i>P. cyanea</i> .
29-11-2014	Aleppey	1020	9.27.982	75.29.847	HSDT CV	40	46.13	69.20	Alepocephalids, deep sea shrimps
30-11-2014	Alappey	225	9.27.297	75.47.053	HSDT CV	60	2000.00	2000.00	<i>N.orientalis</i> , <i>P. cyanea</i> , <i>cubiceps</i> spp.
01-12-2014	Kollam	330	8.54.060	75.53.748	HSDT CV	60	221.00	221.00	<i>N.orientalis</i> , <i>P. cyanea</i> , <i>cubiceps</i> spp.
02-12-2014	Kollam	355	8.52.909	75.43.140	HSDT CV	60	400.00	400.00	<i>N.orientalis</i> , <i>P. cyanea</i> , <i>cubiceps</i> spp.
02-12-2014	Kollam	370	8.58.3	75.32.6	HSDT CV	60	78.00	78.00	<i>N.orientalis</i> , <i>P. cyanea</i> , <i>cubiceps</i> spp.
04-12-2014	Cape	235	7.05.797	77.26.579	HOT	60	1500.00	1500.00	<i>Satrichthys adeni</i> , <i>P. hemisticta</i> , <i>Bembrops</i> spp.
05-12-2014	Cape	285	7.30.682	77.57.618	HOT	60	71.46	71.46	<i>N.orientalis</i> , <i>P. cyanea</i> , <i>cubiceps</i> spp.
06-12-2014	Thiruvananthapuram	285	8.26.550	76.25.291	HOT	60	10000	10000	<i>T. auriga</i> bulk catch approx. 10 t.
07-12-2014	Thiruvananthapuram	1023	8.27.510	76.05.536	HOT	60	214.50	214.50	Alepocephalids, deep sea prawns
09-12-2014	Valappad	350	10.28.137	75.24.567	HOT	60	13.86	13.86	<i>Plesionika</i> spp, echinoderms & assorted mix



A mixed catch of *N. orientalis* and *Charybdis* sp. (Station 4 of Cruise 332)



Mixed catch of finfishes, crustacean and molluscs from 200 m depths (Station 12 of Cruise 332)



Mixed fish and crustacean catch in HSDT (CV) net (Station 5 of Cruise 332)

## Deep-sea fishery resources of the upper continental slope

The Pearly Hairtail *Trichiurus auriga* Klunzinger (1884) belongs to the family Trichiuridae and mostly occur in the continental shelf margin and the upper part of the continental slope, usually in the 150–300 m depths strata. This species has been considered to be available only in the Red sea earlier until reported in a few numbers from the surveys by RV *Varuna* (Silas and Rajagopalan, 1974). The UNDP-FAO pelagic fishery surveys in the Indian EEZ had indicated high concentration of ribbonfishes in the upper slope regions of the south west and south east coast of India. A huge catch of around 10 tonnes of *T. auriga* was captured from the 200 m depths station (8° 26.55'N 76 25.29' E) using the HOT net. *T. auriga* the deep-sea cutlass fish, is characterised by absence of barbs on its fang like anterior teeth, small pelvic fins, slender body with a longer head as compared to other species of *Trichiurus* and *Lepturacanthus* (Ganga *et al.*, 2015b). A relatively smaller sized species, it becomes mature around 21 cm size compared to size at first maturity around 45 cm reported for *T. lepturus* (Largehead hairtail) which is a large growing commercially important species with good demand for export. DNA barcode data was deposited in Barcode of Life Database (BOLD) for any species verification/validation as field level identification with the closely resembling juveniles of other species of *Trichiurus* can be tricky (Silas and Rajagopalan, 1974).



High Opening trawl net operated loaded with deep sea ribbon fish *T. auriga* catch ready for hauling

The high opening trawl net (HOT) operated corroborates the observations on development and performance of the HOT nets reported by Kunjipalu *et al.*, 1984, which



*Trichiurus auriga*, caught from deep sea (station 10 cruise 332)



indicated their good performance in tapping bottom and off-bottom resources vertically distributed within about 6m from the sea bed. Similar high catch rates and comparable fish composition consisting of commercially useful or edible deep sea fishes like *Cubiceps* sp., *Neoepinnula* sp., ribbonfishes and deep sea prawns were recorded in the HOT nets operated during the cruise 332 also. An estimated 4 tonnes bulk catch of the deep sea swarming crab *Charybdis* spp. was also recorded in the High speed Demersal Trawl- crustacean version (HSDT-CV) net operated at 200 m depth in the cochin transect (9° 40.86 N 75°38.92 E) covered on 29-11-14.

The Sackfish *Neoepinnula orientalis* (Family Gempylidae) was encountered in several stations during cruise 322 and cruise 332. It has emerged as a significant by-catch in commercial deep sea shrimp trawl landings and found acceptance on a small scale in the domestic market with size groups of 14 – 28 cm total length (TL) recorded in the by-catch (Beni *et al.*,2017).

Catches of Indian Ruff *Psenopsis cyanea* (Family Centrolophidae) recorded in cruise 332 at <500 m depth stations indicates it as one of the most promising fishes for exploitation from the deeper seas as catch rates are relatively high due to its yet untapped nature. Its meat is reported to have good texture and organoleptic characters with a very high fat content that is comparable to the highly favoured and nutritionally rich Indian oil sardine *Sardinella longiceps*, a small pelagic fish occurring in the coastal waters (Central Institute of Fisheries Technology,1990).

Bombay duck *Harpadon nudus* sp. nov. distinguished from its congeners by the following combination of characters: slender, completely scaleless body with very short pectoral (8.6–13.8 % SL) and pelvic (16.4–21.6 % SL) fins, large eyes (9.1-15.1% HL) and single pair of nares with flap, situated close to tip of a narrow and pointed snout (Ganga *et al.*, 2015) was also recorded.

Sea Robins (Family Peristediidae) were captured in the surveys off Cape transect in cruise 332. A species mix consisting of at least 3 species with the dominant species as *Satrichthys laticeps* was observed. More studies on taxonomic validation of the species recorded and its species-habitat distribution characters is required, although all species occurred in the same fishing haul.

*Chlorophthalmus corniger* (Family Chlorophthalmidae) or Green eyes were observed < 300 m depths. Species are divided into 2 groups distinguished by the presence / absence of two large thorn shaped terminal teeth (directed anteriorly) on the tip of the jaw. *C. corniger* is presently considered the senior synonym of *C. bicornis*. High catch rates of *C. aggassizi* in the 300–400 m depth zones with catch rates of approximate 4 tonnes (t) per hour have been recorded during the *Sagar Sampada* surveys during the eighties (*Proceedings of First workshop Scientific Results of FORV Sagar Sampada*). However only *C. corniger* was recorded during the present surveys.

*Chelidoperca investigatoris* (Alcock, 1890) (Family:Serranidae) was observed in several stations during the surveys. 3 species



Clearing the huge catch of *T. auriga* caught in HOT from the deck



HSDT-CV net operated laden with deep sea swarming crab



Deep sea swarming crab *Charybdis smithii* (Cruise 332 station 2)

*C. investigatoris*, *C. macaulicauda* and *C. occipitalis* are reported in the checklist of fishes of Arabian Sea. The species *C. investigatoris* which is the most common is distinguished by a bright yellow line passing from tip of mouth through the eye to the caudal fin. It is commonly seen in the by-catch of trawlers operating in deeper waters targeting deep-sea shrimps. *Pterygotrigla hemisticta* (Family Triglidae) are a group of fishes widely distributed in the Indo-Pacific and commonly occurring near sea mounts. Body has prominent spines (nasal, rostral and base of second dorsal fin rays) which are used as diagnostic characters among the species. Alfonsinos (Family Berycidae) are aggregating deep-water fishes and the Splendid alfonsino *Beryx splendens* is normally associated with sea mounts and seen at depths < 500 m. This species was observed only rarely, in a few numbers in the trawl hauls. It is exploited in the Atlantic Ocean using mid water trawls where considering its aggregating behaviour, long life and reproductive characteristics, limits have been set for its exploitation. The Pelican Flounder *Chascanopsetta lugubris* was recorded and incidentally it also occurs as a by-catch in the commercial deep sea shrimp trawl fleet operating on the southwest coast of India. *Sphenanthias whiteheadii* (Family Cepolidae) is distinguished from the similar looking *Owstonia* by having the lateral line portion

in front of the dorsal fin as separate and without loops. Catches were observed only in the Cape region suggesting a restricted distribution or some particular topographical or environmental conditions. Sexual dimorphism as evidenced by males having extra long pelvic fins are observed and this group require more studies.



*Harpadon nudus* captured in Station 12 during cruise 313

## Fishes of the Deep Scattering layer (DSL)

Deep Scattering layer (DSL) DSL has been recorded from all geographical areas in the Indian EEZ at depths between 200–540 m (Menon & Prabha devi, 1990 in *Proceedings of First Workshop on Scientific results of FORV Sagar Sampada*). The authors reported that the biomass of the DSL layers contains about 6% micronekton, which includes a variety of juvenile fishes of certain families such as Myctophidae, Stomiidae, Bregmacerotidae etc. The DSL with its rich constituent of plankton and nekton are an important source of forage for several commercially important food fishes, including tunas. In cruise 313, which was mainly a survey for myctophids, interesting observations were recorded.

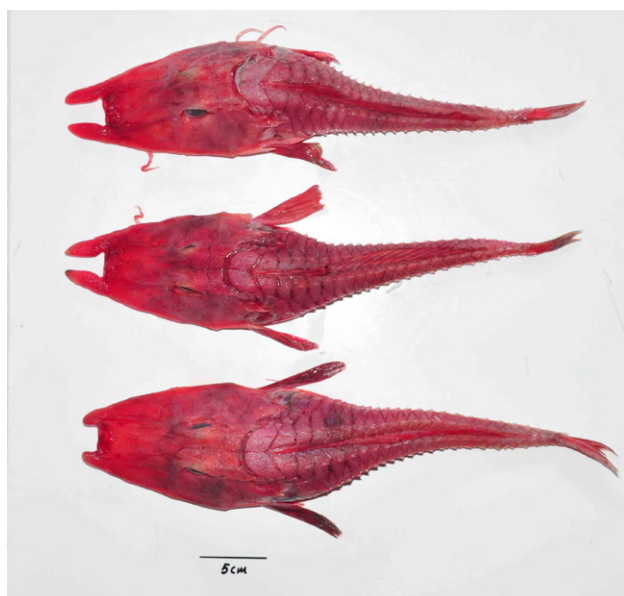


Indian Ruff *Psenopsis cyanea*

Gapers or Crocodile tooth fishes (*Champsodon* spp.),

Table 2 . Species recorded in > 200-<500 m depths during fishing trials

Species	Family	Size range (mm)	Numbers examined (n)
<i>Bathyclupea hoskynii</i>	Bathyclupeidae	135 -190	40
<i>Bembrops caudimacula</i>	Percophidae	110 -315	88
<i>Trichiurus auriga</i>	Trichiuridae	215 -270	31
<i>Chelidoperca investigatoris</i>	Serranidae	115 -180	53
<i>Cubiceps whiteleggi</i>	Nomeidae	110 -215	79
<i>Cubiceps baxteri</i>	Nomeidae	130-195	128
<i>Chascanopsetta lugubris</i>	Cynoglossidae	140-370	25
<i>Chlorophthalmus corniget</i>	Chlorophthalmidae	100 -145	68
<i>Diaphus watasei</i>	Myctophidae		
<i>Harpadon nudus</i> sp.nov.	Synodontidae	130-230	22
<i>Hoplostethus mediterraneus</i>	Trachichthyidae	225-280	8
<i>Beryx splendens</i>	Berycidae	230 -310	19
<i>Psenopsis cyanea</i>	Centrolophidae	105 -210	315
<i>Neopinnula orientalis</i>	Gempylidae	120 - 250	270
<i>Pterygotrigla hemisticta</i>	Triglidae	80-205	119
<i>Satrichthys laticeps</i>	Peristediidae	160 - 460	74
<i>Synagrops hoskynii</i>	Acropomatidae	115 -190	57
<i>Apristurus</i> sp.	Scyliorhinidae	-	
<i>Benthobatis moresbyi</i>	Narcinidae	-	
<i>Eridacnis radcliffei</i>	Scyliorhinidae	-	



*Satrichthys* spp. species diversity recorded (station 5 cruise 322)

mesopelagic fishes exhibiting diurnal , vertical migration were caught at depths of 280 -390 m in stations sampled between 19 and 21 N latitudes in the north east Arabian Sea. Species identification is done by a combination of characters such as scale pattern, especially on the breast (triangular area anterior to pelvic fin base) and chin (ventral region between dentaries'); arrangement and number of dorsal sensory papillae and gill raker counts on first arch. *C. nudivittis*, *C. snyderii* and *C. vorax* (Family Champsodontidae) were recorded in the catch with *C. nudivittis* being the



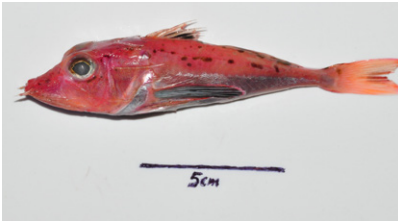
*Chlorophthalmus corniget*

most numerically abundant in the catch. The presence of a sizeable self-regenerating population of *C. nudivittis* in the northern Arabian Sea comprising of reproductively active, mature fish, believed to be absent so far, was evident from the samples. Since the species exhibits strong vertical movements related to the diurnal cycle, it will be desirable to formulate a special sampling protocol to understand the species mix, potential biomass and other biological details of the fishes found in this special zone known as the DSL.

*Astronesthes* spp. (Family Stomiidae) is another mesopelagic group found in tropical waters of high productivity. Species diversity is high and they are superficially, very similar among themselves. The luminous patches on the head and body of the adult are the primary species specific recognition characters. In certain species, sexual dimorphism in the chin barbel structure is observed, which may be an indication of their function in reproductive behaviour. Photophore pattern on the body is another character used in taxonomic studies. In cruise 313, a few numbers of fishes identified as *A. indopacificus* were obtained. Species being very small and delicate, they are easily damaged in the trawl nets, and better quality specimens with little damage, preferably collected with smaller nets like the Isaacs -Kidd Midwater trawl (IKMT) is preferred for studies on taxonomy and the species diversity of this group in the Indian EEZ.

Lantern bellies (Family Acropomatidae) were recorded commonly consisting of *Synagrops* sp. They have a





*Pterygotrigla hemisticta*



*Chelidoperca investigatoris*



*Beryx* sp.



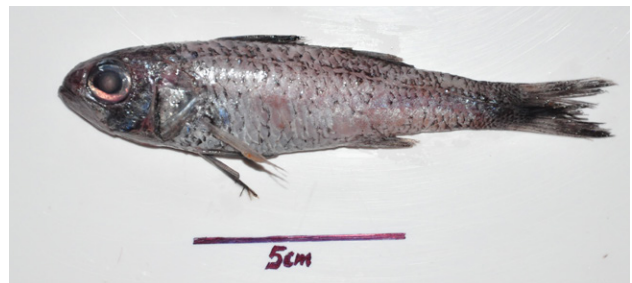
*Chascanopsetta lugubris*



*Sphenanthias whiteheadii*



*Champsodon nudivittis*



*Synagrops* sp

characteristically elongate body with large scales and 3-6 large canine like teeth on the lateral side of the lower jaw. Recently, catches of these species as by-catch in trawl nets operated for deep sea shrimps which was utilised for fish meal preparation has been reported in the media. Bathyclupeids or Deep sea scaly fins represented by *Bathyclupea hoskynii* Alcock, 1891 (Family bathyclupeidae) commonly called the Indian deep sea herring was also recorded.

## Deep sea fishes of the continental slope > 500 m depths

Alepocephalids (Family: Alepocephalidae) commonly known as slick heads are a group of deep-sea fishes with high oil content. Four species were commonly recorded in the deep sea trawling exploratory surveys conducted on board FORV *Sagar Sampada*. 4 genera, *Alepocephalus*, *Bathytroctes*, *Narctes* and *Talismania* were recorded. While species such as *Talismania longifilis*, *Rouleina attrita* and *Narctes lloydi* were available only at around 1000 m depths, *Alepocephalus bicolor* was caught from the 500m

depth zone. *A. bicolor* is occasionally landed as by-catch in shrimp trawlers operating in deeper waters but more often discarded at sea itself due to its soft flesh having high oil content and lack of avenues for oil extraction as is done for squalene rich deep-sea sharks. The surveys revealed that numerically *Alepocephalus* is the most dominant (50-95%) genera followed by *Rouleina* (12 -50%) and *Narctes* (8-15%). While *T. longifilis* was more abundant in the 8 N latitude, *Rouleina* was more in the 11 N latitude and *Alepocephalus* had a wider, more uniform distribution between 8-11° N latitudes. Further studies on the taxonomic characters based species identification of species available in the Indian EEZ and the techno-economic prospects of tapping the oil content of this group of fishes which are caught as by-catch in the deep-sea shrimp trawls operated at 300 -500 m depths requires attention. DNA barcode data of *A. bicolor* (Alcock, 1891) and *A. longiceps* (Lloyd, 1909) were deposited in Barcode of Life Database (BOLD). Tripod fishes (Family Ipnopidae) were recorded during cruise 322. These fishes were from *Bathypterois* genus and temperature is reported to be the primary factor governing its vertical and horizontal distribution in the sea. In the deep



***Narcetes lloydii***

Dorsal fin origin well in advance of anal fin origin  
Teeth in jaw multi serial  
premaxilla and maxilla toothed  
Upper jaw extends notably behind posterior margin of orbit



***Alepocephalus longiceps*?**

Dorsal and anal fin subequal and opposite  
( Expt *A. bicolor* with anal fin longer than dorsal fin)  
Palatine teeth present  
2 supra maxillae, no supra pre opercle

***Alepocephalus longiceps***- Posterior end of anal fin base just below or slightly behind posterior end of dorsal fin base , Analfin rays less than 25



***Bathytroctes sp.*?**

Anal fin with more than 13 -17 rays



***Talismania longifilis***

Dorsal and anal fin subequal and opposite  
Teeth on maxilla (small)  
Pectoral fins from moderately long to very long  
( with elongated thread like first ray).



***Alepocephalus bicolor***

Anal fin longer than dorsal fin  
Anal fin rays more than 25  
Eyes small



***Rouleina sp.***

Body completely scale less or  
in some sp. tubular scales present in lateral line only  
Anus close to anal fin origin.

Alepocephalid diversity in Indian EEZ and taxonomic issues to be resolved



*Bathytroctes atricolor*



*Bathytroctes guentherii*

sea environment, *Bathytroctes atricolor* is considered to be an extremely eurythermal (2.5- 10°C) and eurybenthic (250 – 5100 m) form while *B. guentherii* has a narrow range of 4-7°C and 700 -1000 m depth range (Sulak, 1977).

Table 3. Species recorded in > 500 m fishing trials

Species	Family	Size range	Numbers examined (n)
<i>Alepocephalus bicolor</i>	Alepocephalidae	350 -490	13
<i>Narcetes lloydii</i>	Alepocephalidae	460 -600	14
<i>Rouleina attrita</i>	Alepocephalidae	130 -310	59
<i>Talismania longifilis</i>	Alepocephalidae	155 -225	28
<i>Bathytroctes sp.</i>	Ipnopidae	110 -180	21
<i>Coryphaenoides sp.</i>	Macrouridae	-	
<i>Dicrolene multifilis</i>	Ophidiidae	-	
<i>Lamprogrammus niger</i>	Ophidiidae	-	

## Deep sea elasmobranchs

The Pygmy ribbontail catshark, *Eridacnis radcliffei* (Family Proscyllidae) was one of the most common sharks in the surveys. A small sized shark species, it matures at 18 cm total length. It exhibits aplacental viviparity (ovoviviparous) where it gives birth to one or two live pups, with no direct connection between embryos and mother during development. It feeds

on deep sea crustaceans and small fishes. The deep water skate *Dipturus* sp. and the Indian ringed skate *Orbiraja powelli* (Family Rajiidae), and the Blind electric ray *Benthobatis moresbyii* were also recorded.

## Conclusion

The scientific informations collected during the cruises gave



*Orbiraja powelli*



*Dipturus* sp.



*Eridacnis radcliffei*



*Benthobatis moresbyii*



valuable insights on deep sea trawling operations, inherent risks and future possibilities. The exploratory surveys yield valuable databases on the fisheries resources, their biology and scope for tapping their fishery potential. A critical appraisal of available information and filling knowledge gaps with appropriate research programmes will help in the assessment of the deep-sea fishery potential in the Indian EEZ.

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