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Investigations on Aimed Midwater Trawling for Myctophids in the Arabian Sea

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Abstract

Aimed midwater trawling for lantern fishes (Family: Myctophidae) was attempted in the Arabian Sea onboard FORV *Sagar Sampada* (L_{OA} 72.5 m; 2,285 hp) at the depth range of 372 - 2230 m using a 45 m CIFT myctophid trawl and 49.5 m krill trawl. The vertical opening was between 16.1 and 18.9 m at a trawling speed of 1.8-2.2 kn for the krill trawl and 6.7-9.8 m at 2.3-2.8 kn trawling speed for the myctophid trawl. Total catch obtained during operations was 419.5 kg for a total fishing effort of 33 h 41 min; with an overall mean catch rate of 11.81kg h^{-1}. Myctophid trawl contributed 96.0 kg with a mean CPUE of 8.06±4.17 kg h^{-1} and krill trawl contributed 323.5 kg with a mean CPUE of 14.76±5.06 kg h^{-1}. The total catch comprised of about 40 species including myctophids (24.88%), other finfishes (46.01%), crustaceans (15.21%), jellyfish (13.52%) and cephalopods (0.4%). Myctophids consisted of11 species and it contributed only 25% of the catch. Finfishes belonging to order Stomiformes contributed about 41% of the total catch. Adjustment of the trawl net to the depth of the fish distribution is complex as myctophids migrate vertically in morning and evening at comparatively high speed. The low catch volume realized during the operations, indicate that trawl design and its operation need to be further optimized taking into account the migration behavior in the vicinity of trawl system.

Keywords: Aimed midwater trawling, lantern fishes, myctophid trawl, krill trawl, Arabian Sea

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Introduction

Lantern fishes (Family: Myctophidae) are the key members of mesopelagic communities (FAO, 1997; Catul et al., 2011) and are represented by about 250 species worldwide (Paxton, 1979; Catul et al., 2011) and 137 species in Indian Ocean (Vipin et al., 2011). Mesopelagic fishes in the world oceans was estimated at about 1000 million t by Lam & Pauly (2005). Irigoien et al. (2014), based on acoustic data, estimated median values of mesopelagic fishes biomass between 11 000 and 15 000 million t in the world oceans (40° N and 40° S). Mesopelagic fish biomass in the Arabian Sea has been estimated as 100 million t (GLOBEC, 1993). In spite of its abundance in world oceans, currently only a few commercial myctophid fisheries exist, which include limited operations off South Africa, in the sub-Antarctic, and in the Gulf of Oman (Newman, 1977; Gjosaeter & Kawaguchi, 1980; Hulley, 1996). Global catch of myctophids during 1970-2010, varied between a few tonnes to a maximum of 42 400 t reported during 1973 (FAO, 2012). Though not commercially exploited in India, these resources have been reported as bycatch of deep sea shrimp trawlers operating from southwest coast of India (Boopendranath et al., 2009; Pillai et al., 2009; Sebastine et al., 2013). CMFRI (2013) reported that the annual catch of myctophids during 2010-11 was 2 972 t and the catch was supported mainly by five species *viz*., *Diaphus watasei*, *D. garmani*, *Benthosema fibulatum*, *Myctophum obtusirostre* and *Neoscopilus microchir*. Boopendranath et al. (2012) reported the annual catch of myctophids, caught as bycatch in the deep sea shrimp trawlers operating off southwest coast of India, as 3 676 t, with a catch rate of 19.87 kg h^{-1}.

Midwater trawls have been reported to be appropriate for catching myctophids based on habitat and ecology of the resources (Gjosaeter, 1984; Shilat &

Valinassab, 1998; FAO, 2001). The catch success mainly depends upon the size of the net, mouth opening and the use of sufficiently small mesh size of the netting used for trawl fabrication (Shilat & Valinassab, 1998). Several types of trawls ranging from small micro-nekton nets to large commercial trawls have been used to catch mesopelagic fishes (Gjosaeter & Kawaguchi, 1980; Watanabe & Kawaguchi, 2003; Sassaet al., 2007; Collins et al., 2008; Boopendranath et al., 2012). In the present study, results of aimed midwater trawling using two different designs of trawls, onboard FORV *Sagar Sampada*, for harvesting myctophids in the Arabian Sea is discussed.

Materials and Methods

The study was undertaken onboard FORV *Sagar Sampada* (L_{OA} 72.5 m; 2,285 hp) during cruise number 320 (4 - 15 October 2013), between 8° to 14° N lat and 72° to 77° E long, in the depth range of 372-2230 m, in the Arabian Sea (Fig. 1).

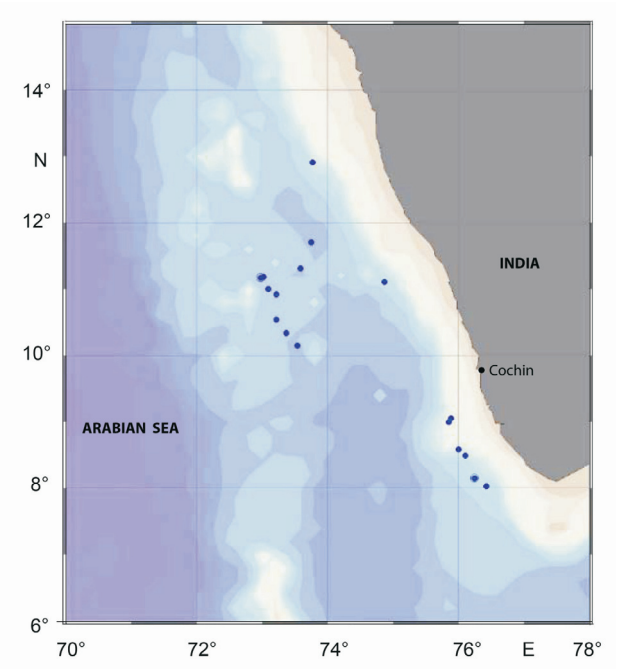

Fig. 1. Trawling stations for the two designs

A 45 m four equal panel myctophid trawl designed at the ICAR - Central Institute of Fisheries Technology (CIFT), Cochin, (Boopendranath et al., 2012) (Fig. 2) and a 49.5 m experimental krill midwater trawl of Danish origin (Cosmos Trawl, Hirtshals, Denmark) (Boopendranath et al., 1998) were used for experimental aimed trawling operations. Codend mesh size was opted as 25 mm to reduce the drag of the trawl and to facilitate the exclusion of juveniles. The trawls were rigged with Thyboron otter boards (Type 7) of 5.57 m^2 each weighing 800 kg, double sweep lines of about 100 m and bunched iron link chain depressor weighing 150 kg were used on both lower legs of the trawl. Trawling was carried out in 16 stations at depths of 84 to 415 m. Myctophid trawl was used at 6 stations and 49.5 m krill trawl at 10 stations. Simrad echosounder EK60 (200, 120 and 38 KHz frequency) was used for detecting Deep Scattering Layer (DSL). Simrad ITI trawl monitoring system was used to measure vertical opening at trawl mouth and to facilitate aimed trawling, after detection of the DSL using echosounder and sonar. The fishes were identified using standard keys (Fischer & Bianchi, 1984; Smith & Heemstra, 1986).

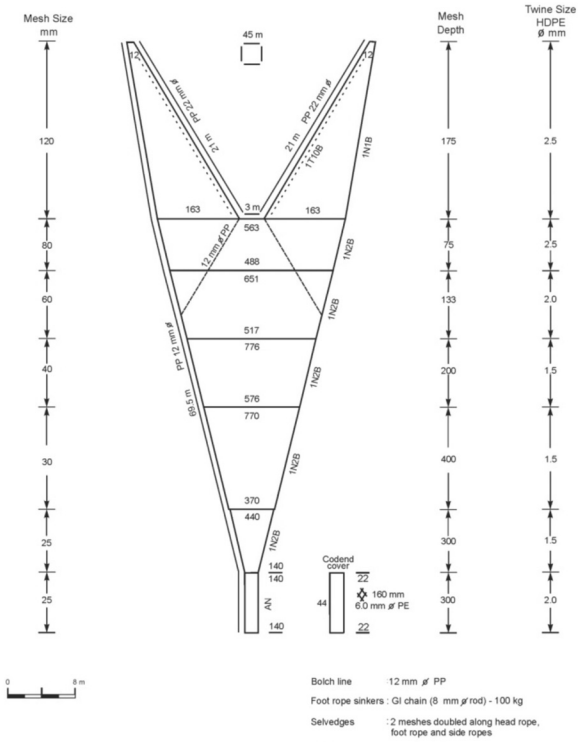

Fig. 2. Design of 45 m four equal panel myctophid trawl

Results and Discussion

Experimental aimed midwater trawling operations were conducted between 8° and 14° N latitudes, in the depth range of 372 - 2230 m, in the Arabian Sea, off west coast of India. Prior to shooting of the net

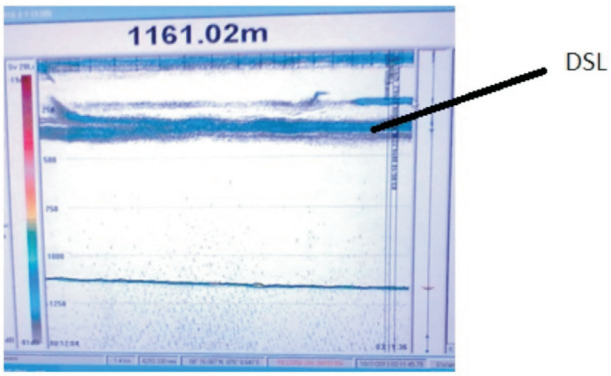

Fig. 3. Echo sounder (Simrad EK60) display of DSL between 250-300 m depth

the depth and movement of DSL was ascertained by scanning the ground using the ecosounder (Fig. 3). Myctophid trawl caught 96 kg against the fishing effort of 11 h 46 min, realizing a CPUE of 8.06±4.17 kg h^{-1}. Krill trawl yielded a total catch of 323.5 kg for trawling duration of 21 h 55 min, realizing a mean CPUE of 14.76±5.06 kg h^{-1}. Details of trawling operations and catch are presented in Table 1 and composition of catch is presented in Fig. 4 and Table 2 and Table 3.

Total catch comprised of 40 species (Table 2) including myctophids (24.88%), other finfishes (46.01%), crustaceans (15.21%), jellyfish (13.52%) and cephalopods (0.4%). Myctophids consisted of *Benthosema fibulatum* (38.5%), followed by *B. pterotum* (22.0%), *Myctophum spinosum* (15.5%), *M. nitidulum* (8.0%), *Diaphus jenseni* (5.2%), *D. watasei* (5.0%), *D. nielseni* (4.6%), *D. garmani* (2.0%), *D. lucidus* (1.0%), *Symbolophorus rufinus* (1.4%) and *S. evermanni* (1.2%) in terms of weight. Average length of *D. watasei* was 120 mm, 60.5 mm for *D. jenseni* where as it was 35.4 mm for *D. nielseni.* According to Vipin et al. (2011) the length of *D. watasei*, the most abundant myctophid landed in the deep sea shrimp trawlers off Kollam, ranged from 100 to 180 mm and weight ranged from 5 to 43 g. The average length was in the range of 42-58 mm for all other myctophids.

Boopendranath et al. (2009; 2012), Pillai et al. (2009) and Sebastine (2013) reported that myctophids are the major component in the bycatch of deep sea shrimp trawlers operating off Kerala. Boopendranath et al. (2012) estimated myctophids to contribute about 32% of the total bycatch of deep sea shrimp trawlers operating off southwest coast of India and *D. watasei* was the most dominant species which formed 13% of the total bycatch.

Fishes belonging to Order Stomiformes contributed about 41% of the total catch, which included *Argyropelecus affinis* (Pacific hatchet fish), *Chauliodus sloani* (Sloane's viperfish), *Polyipnus indicus, Astronesthes indicus* (Black snaggletooth), *A. boulengeri* (Boulenger's snaggletooth) and *A. martensii* (Snaggletooth). Crustaceans consisted of deep sea prawns (*Acanthephyra purpurea* and *Oplophorus typus*)

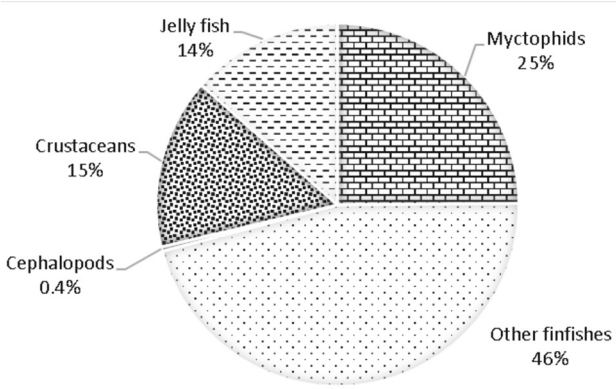

Fig. 4. Percentage composition of major catch categories

Table 1. Details of trawling operations

Gear	Fishing depth (m)	No. of hauls	Towing speed (kn)	Vertical opening at trawl mouth (m)	Fishing effort (h:min)	Total catch(kg)	Mean CPUE±SD, (kg h^{-1})
45 m myctophid trawl	84-370	6	2.3-2.8	6.7- 9.8	11:46	96.00	8.06±4.17
49.5 m krill trawl	223-415	10	1.8-2.2	16.1 - 18.9	21:55	323.50	14.76±5.06

Table 2. Percentage composition of total catch in 45 m myctophid trawl

Species	kg	%
Myctophids		
Benthosema fibulatum	2.1	2.2
B. pterotum	0.6	0.63
Diaphus garmani	1.2	1.25
D. watasei	5.0	5.20
D. jenseni	0.6	0.63
Myctophum spinosum	1.0	1.04
M. nitidulum	0.4	0.42
Other finfishes		
Chauliodus sloani	15.9	16.56
Astronesthes boulengeri	3.9	4.06
Trichiurus lepturus	1.1	1.14
T. auriga	0.1	0.10
Argyropelecus affinis	26.5	27.61
Astronesthes martensii	0.4	0.41
Mene maculata	1.1	1.14
Crustaceans		
Acanthephyra purpurea	0.5	0.52
Oplophorus typus	11.5	11.98
Charybdis longicollis	9.1	9.48
Others		
Jellyfish	15.0	15.63
Total	96.0	100

and crabs (*Charybdis longicollis*). Cephalopods consisted of squid *Ancistrocheirus lesueurii* and *Asperoteuthis acanthoderma,* and the later the first record from Indian waters (Joseph et. al. 2015).

Midwater trawls have been reported to be appropriate for catching myctophids (Gjosaeter, 1984; Shilat & Valinassab, 1998; FAO, 2001). Main design requirements for midwater trawls are high stability, large mouth opening, low turbulence and low drag and fast towing speed (Scharfe, 1969; McNeely, 1971; Parrish, 1975; Hameed & Boopendranath, 2000). In the Gulf of Oman, mesopelagic trawl net with a length of 98 m, circumference 170 m, mouth area 381 m^2 and opening height 23 m was used for catching lantern fishes (Shilat & Valinassab, 1998). International Young Gadoid Pelagic Trawl (IYGPT) with a mouth dimension of 12x7 m, and 10 mm mesh size

Table 3. Percentage composition of total catch in 49.5 m krill trawl

Species	kg	%
Myctophids		
Benthosema fibulatum	36.4	11.25
B. pterotum	21.4	6.62
Diaphus garmani	0.8	0.25
D. jenseni	4.6	1.42
D. lucidus	1.0	0.30
D. nielseni	4.6	1.43
Myctophum spinosum	14.5	4.49
M. nitidulum	7.6	2.35
Symbolophorus rufinus	1.38	0.42
S. evermanni	1.2	0.37
Other finfishes		
Chauliodus sloani	16.7	5.16
Astronesthes boulengeri	1.3	0.40
A. martensii	1.8	0.56
A. indicus	16.8	5.20
Argyropelecu saffinis	96.3	29.77
Aluterus monoceros	0.6	0.19
Cubiceps caeruleus	2.6	0.80
Nemichthys scolopaceus	3.5	1.08
Stemonosudis macrura	1.6	0.49
Zenopsis conchifer	0.2	0.06
Cyttopsis roseus	0.2	0.06
Macrorhamphosodes uradoi	0.5	0.15
Neoscopelus microchir	0.2	0.06
Bathyclupea elongata	0.5	0.15
Coccorella atlantica	5.5	1.70
Caristius sp.	0.6	0.18
Cubiceps baxteri	1.72	0.53
Laeops nigromaculatus	0.1	0.03
Cephalopods		
Ancistrocheiru slesueurii	0.8	0.25
Asperoteuthis acanthoderma	0.8	0.25
Crustaceans		
Oplophorus typus	27.0	8.35
Charybdis longicollis	15.7	4.86
Others		
Jellyfish	35.0	10.82
Total	**323.5**	**100**

in the codend, was successfully used for sampling mesopelagic fish in the Southern Ocean (Duhamel et al., 2000). In the Kuroshio–Oyashio Transition Zone, myctophid samples were collected by using a trawl net with a mouth opening area of approximately 480 m^2, mesh sizes of 57–1000 mm and 8 mm mesh codend, towed at a speed of 3.8-4.7 kn (Yatsu et al., 2005). In the slope waters of King George Island, the mesopelagic fishes were sampled with a pelagic trawl PT-1088, with an estimated mouth opening of 200 m^2 (width 20 m; height: 10-12 m) and a codend mesh size of 12 mm (Pusch et al., 2004). Valdemarsen (2004) has suggested that a trawl for efficient myctophid capture should have an opening that is relatively large with a minimum of 20 m vertical opening, 1000 mm mesh sizes in the front part, and less than 30 mm behind the belly section with a diameter of around 8 m and codend mesh size less than 10 mm. Shilat & Valinassab (1998) has suggested a towing speed of about 2.5 kn, as the myctophids are small in size with low swimming speed. Catching efficiency is maximized when the vertical opening of the trawl mouth coincides with the vertical range of the layer of maximum fish abundance (Shilat & Valinassab, 1998; Boopendranath, 2009).

The vertical opening at trawl mouth was between 16.1 and 18.9 m at a trawling speed of 1.8-2.2 kn for the krill trawl and 6.7- 9.8 m at 2.3-2.8 kn trawling speed for the myctophid trawl. Mean CPUE for krill trawl was 74% higher than myctophid trawl. The lower catch in myctophid trawl can be attributable to (i) differences in trawl size, which is 9% lower in CIFT myctophid trawl, in terms of headline length, (ii) lower vertical opening at trawl mouth (6.7-9.8 m at 2.3-2.8 kn trawling speed) compared to krill trawl (16.1-18.9m) and (iii) relatively larger mesh sizes in the trawl body and codend in the case of myctophid trawl. Krill trawl is provided with an inner lining of polyamide netting in the belly sections from square to codend with mesh size ranging from 31.4 to 19.6 mm and codend mesh size of 10 mm while belly sections of CIFT trawl ranges in mesh size from 60 to 25 mm with a codend mesh size of 25 mm (Boopendranath et al., 1998; 2012), which would have excluded smaller sized catch (Remesan et al., 2013). The estimated drag of CIFT myctophid trawl ranges from 4.9 to 7.3 t at 2-3 kn trawling speed (Boopendranath et al., 2012) and it is much more for krill trawl as evidenced by the lower trawling speed achieved, in spite of favourable tidal current.

There is a paucity of information on commercial harvesting systems for myctophids, even though there is a large potential for developing the fishery, particularly in the Arabian Sea, where high concentrations of myctophid resources are available. The four equal panel 45 m CIFT myctophid trawl has been designed to attain large mouth area, smoothly tapering trawl body with small meshes in belly and codend, which can be towed at about 2.5 kn, and the trawl geometry was found to be working in accordance to design. Adjustment of the trawl net to the depth of the fish distribution is complex as myctophids migrate vertically at comparatively high speed, in morning and evening, which would have affected the catch volume. Catching efficiency may also vary during day time, since reaction distance, and escape behaviour in myctophids might change with light intensity. Positioning and towing the net within the DSL continuously based on the ecosounder display is the real challenge for the successful operation, especially when the mouth opening of the trawl is low. The low catch volume realized during the present investigations also indicate that trawl design, rigging and its operation need to be further optimized based on additional information on fish behavior in the vicinity of trawl system and codend mesh selectivity studies in order to optimize the mesh sizes; diel migration and association with DSL and Oxygen Minimum Zone (OMZ), in respect of myctophid species in the Arabian Sea.

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