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ASPECTS OF THE DISTRIBUTION OF LANTERNFISHES (PISCES: MYCTOPHIDAE) FROM THE NORTHERN SARGASSO SEA

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ABSTRACT

Sampling in the northern Sargasso Sea using Isaacs-Kidd midwater trawls, neuston and plankton nets resulted in the capture of 4,180 lanternfishes (Pisces: Myctophidae). Sixteen genera and 45 species were identified. Relative abundances, shallowest depths of capture and zoogeographic affinities were determined for the 14 most common species. Sixteen species are recorded for the first time in surface waters at night. Size frequency distribution suggests that species generally associated with tropical waters were advected into the study area via Gulf Stream transport as juveniles. The species list and faunal affiliations are in agreement with earlier zoogeographic accounts. The present study fills an important sampling void in the Northern Sargasso Sea zoogeographic province.

The Sargasso Sea is a subtropical region characterized by high diversity among its pelagic ichthyofauna (Backus et al., 1977) and considerable potential for influence by the Gulf Stream and other large scale hydrographic features such as cyclonic eddies (Wiebe et al., 1976). It is a complex area whose western region has been sampled only sparingly (Nafpaktitis et al., 1977). The northwestern Sargasso Sea has been placed within the North Sargasso Sea Province by Backus et al. (1977) as one of the four provinces comprising the Northern Atlantic Subtropical Region.

The lanternfishes (Myctophidae) are of particular interest in pelagic biogeography because of their circumglobal distribution, high diversity and, with few exceptions, totally pelagic life histories. In this study, myctophids were collected at a series of stations located along the westernmost edge of the Northern Sargasso Sea Province and examined for species composition, relative abundance and shallowest depth of capture. Results are compared to the zoogeographic schemes proposed by Backus et al. (1977) and Hulley (1981).

Methods and Materials

Myctophids were collected during cruise 18-72 of the R/V Eastward in the northwestern Sargasso Sea (22–27 September 1972). A total of 116 net hauls were taken, encompassing 43 stations. Stations were occupied along two transects. The first extended southeastward from 32°05'N, 78°02'W to 29°35'N, 76°10'W, while the second stretched westward from the terminus of the first to 30°04'N, 78°08'W (Fig. 1).

Specimens were collected using a 3.05 m (9.30 m^2 mouth area) Isaacs-Kidd midwater trawl (IKMT) constructed of 6 mm stretch nylon mesh tied off at the cod end, two 1 m × 2 m neuston nets (505 μm mesh), and a 1 m plankton ring net with 333 μm mesh.

All nets were fished open. Surface waters were sampled using neuston nets which were often fished simultaneously from the port and starboard sides of the ship. The plankton net was used to sample to depths less than 200 m. The IKMT was fished from 50 to 750 m. Tow durations and speeds varied. Neuston and plankton net tows generally lasted 30 min and 1 to 1.5 h, respectively, with a ship speed of 3 k, while IKMT hauls ranged from 1.5 to 4.75 h with a ship speed of 3–5 k. Average time at maximum depth for the plankton net was 30 min. Three fishing strategies were used for the IKMT. For oblique trawls (10 stations), the net was dropped to maximum depth at 50 m/min and immediately retrieved at 10 m/min. During discrete-depth hauls (12 stations), the net was dropped to a maximum depth at 50 m/min, fished at depth for an average of 1.75 h, and retrieved at 50 m/min. For stepped oblique tows (4 stations), the net was dropped to maximum depth at 50 m/min, fished for 1 h, brought to a shallower depth at 10 m/min, fished for 1 h, and then retrieved at 50 m/min.

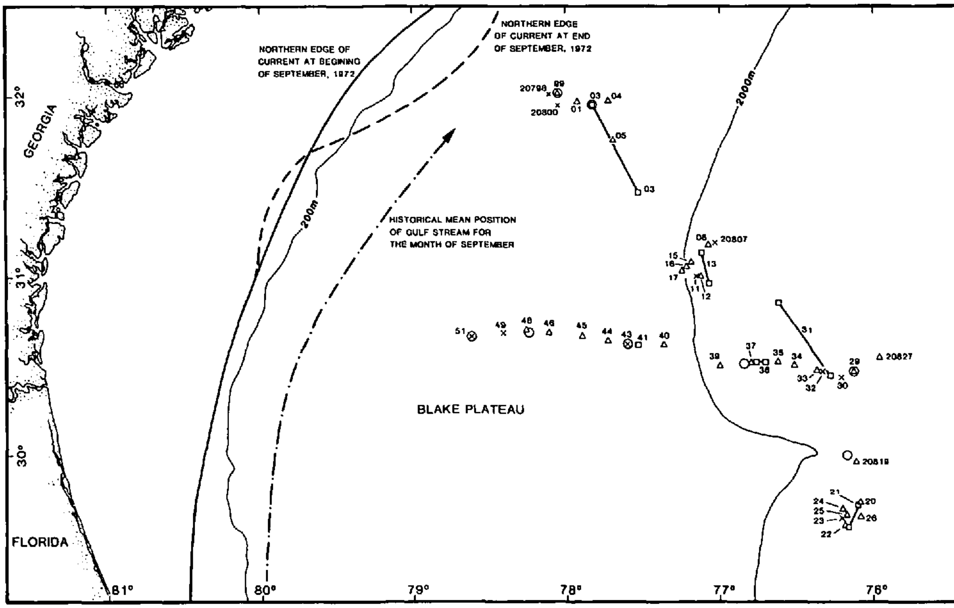

Figure 1. Station locations. Circle—Hydrographic sample; Triangle—3 m IKMT; × —1 m plankton ring net; Square—Neuston net (lines between squares indicate tracks of continuously fished neuston nets).

Expendable bathythermograph (XBT) traces were recorded from eight stations where the IKMT was deployed (Fig. 2). Specimens were fixed at sea in 10% buffered formalin and returned to the laboratory where they were transferred to 70% ethanol or 50% isopropanol, identified to species, counted, measured and archived. The collection was reexamined in 1985 to confirm original identifications.

Results

Hydrography.—Both the XBT data collected during this study (Fig. 2) and extensive temperature records compiled by the U.S. Navy (U.S. Naval Oceanographic Office, 1972) for the location and time of the study suggest that the northernmost stations (20799 to 20803) were influenced by Gulf Stream water. Remaining stations exhibited a typical Sargasso Sea temperature profile. There was no evidence in temperature records for any influence by newly formed or decaying cyclonic eddies (cold-core rings).

Species Captured.—A total of 4,180 specimens were collected, of which 3,677 were reexamined to confirm original identifications (Table 1). Of the 503 specimens that could not be relocated, 397 belonged to three easily identified species: *Centrobranchus nigroocellatus, Ceratoscopelus warmingii,* and *Gonichthys cocco.* These species and the remaining 106 were assumed to have been identified correctly. Specimens that were not rechecked are designated by an asterisk, with totals listed separately in Table 1.

Of the 3,677 specimens reexamined, 42 (1.1%) could not be identified below the family or generic level because of damage. The remaining 3,635 specimens belonged to 16 genera and 45 species (Table 1).

Five species were captured in quantity (>200 specimens per species) and are considered abundant: *Notolychnus valdiviae, Diogenichthys atlanticus,* the con-

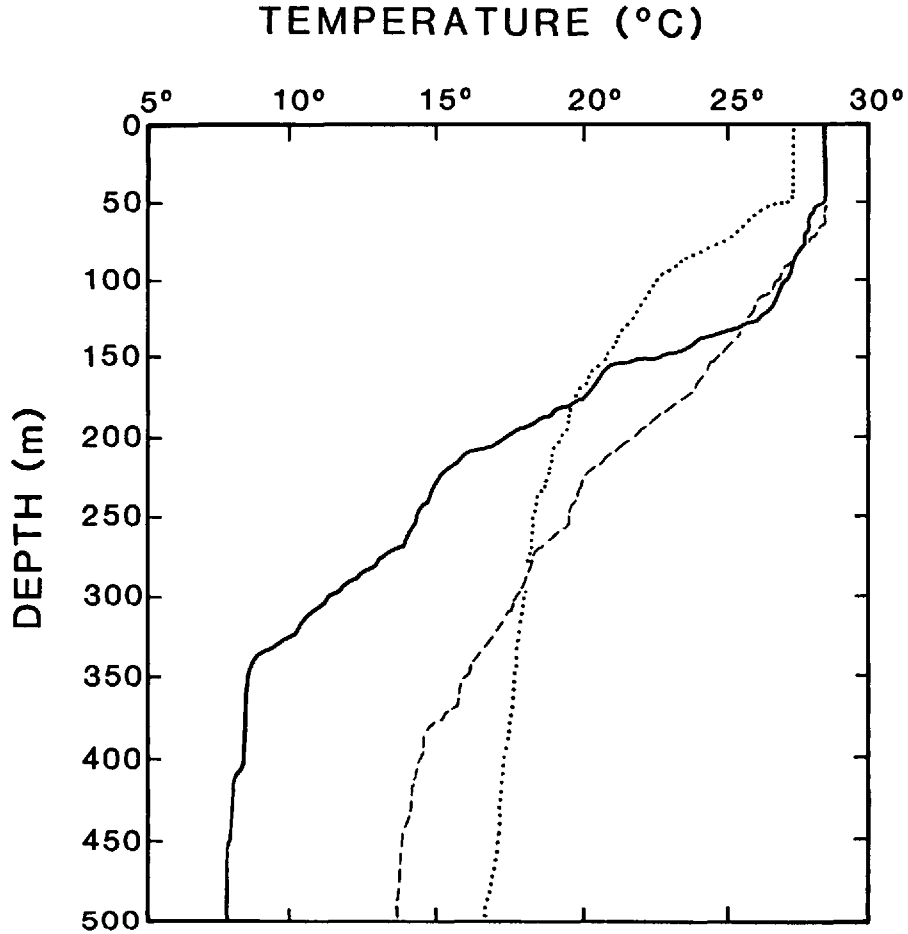

Figure 2. Expendable bathythermograph (XBT) traces from the study area illustrating water types encountered. Solid line—Gulf Stream (St. 20799); Dashed line—Gulf Stream—Sargasso Sea (St. 20803); Dotted line—Sargasso Sea (St. 20819–20851).

geners *Lepidophanes gaussi* and *L. guentheri* and *Hygophum benoiti* (Table 1). These species comprised over 60% of all specimens captured; *Notolychnus valdiviae* alone totalled almost 22%. Six species were considered common (101–200 specimens) in the study area: *Centrobranchus nigroocellatus, Bolinichthys indicus, Gonichthys cocco, Diaphus mollis, Ceratoscopelus warmingii* and *Lampanyctus pusillus. Hygophum taaningi, Benthosema suborbitale* and *Diaphus rafinesquii* were considered intermediate in abundance (51–100 specimens). Although 72 specimens of *Myctophum nitidulum* were captured, 71 were taken in a single tow. This species was excluded from the intermediate group and was considered rare. Fourteen species were uncommon (10–50 specimens), and 17 species were rare (<10 specimens).

With the exception of *Diaphus rafinesquii,* few adult specimens (based on size at sexual maturity) were collected (Table 1). Specimens of >20 mm SL accounted for only 17.8% of the total. Among the abundant species, length frequencies showed that sexually mature adults were collected only for *N. valdiviae* (≥19

Table 1. Myctophid species captured during cruise 18-72, R/V EASTWARD. Abbreviations for nets: I—IKMT; N—Neuston; P—Plankton ring net

Species	Zoogeographic affinity[1]	No. Captured	Size range (mmSL)	Mean size	Size at maturity[2]	Nets I	Nets N	Nets P
Abundant								
Diogenichthys atlanticus	TST	667	7–18	14	20	+		+
Hygophum benoiti	TmpSST	220	7–25	12	40	+		
Lepidophanes gaussi	ST	482	10–43	21	35	+	+	+
*L. guentheri**	T	334 (11)	14–56	19	52	+	+	
Notolychnus valdiviae	TST	903	8–22	13	19	+	+	
Common								
*Bolinichthys indicus**	ST	176 (11)	10–38	15	30	+	+	+
*Centrobranchus nigroocellatus**	TST	19 (171)	13–23 (12–36)	18	34	+	+	+
*Ceratoscopelus warmingii**	TST	44 (85)	13–34 (12–31)	20	55	+		
Diaphus mollis	TST	131	9–41	17	30	+	+	
*Gonichthys cocco**	TST	1 (141)	28 (13–30)	—	38		+	+
Lampanyctus pusillus	TmpSST	108	14–32	22	31	+	+	
Intermediate								
Benthosema suborbitale	TST	62	11–28	16	24	+	+	
Diaphus rafinesquii	TmpSST	53	16–78	63	65	+	+	
*Hygophum taaningi**	ST	43 (24)	6–33	14	40	+		
Uncommon								
Bolinichthys supralateralis	TST	41	12–25	15	90	+	+	+
Diaphus brachycephalus	TSST	17	9–28	16	30	+	+	+
D. dumerilii	T	38	11–29	18	52	+	+	
*D. effulgens**	ST	27 (2)	10–24	13	>100	+	+	
*D. fragilis**	T	9 (4)	11–43	15	65	+		
*D. perspicillatus**	T	10 (1)	10–21	14	50	+	+	
*D. splendidus**	TSST	24 (26)	12–65	23	50	+	+	
Hygophum hygomii	TmpSST	13	17–55	48	>55	+	+	
*H. reinhardtii**	ST	18 (3)	12–18	12	40	+		+
*Lampanyctus alatus**	T	4 (8)	25–43	30	42	+		
L. cuprarius	ST	16	18–67	48	70	+	+	
*L. festivus**	ST	7 (5)	28–64	42	—	+	+	
L. photonotus	TST	22	20–49	24	50	+		
*Lobianchia dofleini**	TmpSST	33 (6)	11–43	25	—	+	+	

Table 1. Continued

Species	Zoogeographic affinity[1]	No. Captured	Size range (mmSL)	Mean size	Size at maturity[2]	Nets I	Nets N	Nets P
Rare								
Bolinichthys photothorax	TSST	6	13–57	28	56	+	+	
*Diaphus garmani**	T	3 (1)	18–19	18	40	+		
D. lucidus	T	2	10–21	—	90	+		
D. problematicus	T	5	20–71	45	68	+	+	
D. subtilis	TSST	3	17–26	22	70	+	+	
D. termophilus	T	2	22–23	—	—	+		
Hygophum macrochir	T	1	46	—	45	+		
Lampadena luminosa	TSST	2	17–44	—	>150	+		
L. urophaos atlantica	ST	2	24–39	—	—	+		
Lobianchia gemellarii	TST	4	29–55	32	40	+		
*Myctophum affine**	T	2 (3)	17	—	46	+		+
M. asperum	T	1	17	—	70			+
M. nitidulum	TST	72†	17–60	52	55	+		
M. obtusirostre	T	2	15	—	70	+		
*M. selenops**	TST	2 (1)	13	—	59	+		
Notoscopelus caudispinosus	TST	1	81	—	—	+		
Symbolophorus rufinus	TST	3	22–40	29	70	+		

* Specimens that could not be relocated; number and size ranges in parentheses.
† Single capture of 71 individuals.
[1] According to Backus et al. (1977). Abbreviations as follows: T—Tropical; TST—Tropical-Subtropical; TSST—Tropical-Semisubtropical; ST—Subtropical; TmpSST—Temperate-Semisubtropical.
[2] Data are for minimum sizes reported from Nafpaktitis et al. (1977).

Table 2. The 14 most abundant species: depth range of maximum night-time abundance, and shallowest depth of capture. "S" denotes surface

Group	Species	Depth range of maximum night abundance (m)	Shallowest depth of capture (m)
Abundant	*Notolychnus valdiviae*	50–70	S
	Diogenichthys atlanticus	50–70	50
	Lepidophanes gaussi	50–70	S
	Lepidophanes guentheri	50–70	S
	Hygophum benoiti	50–250	50
Common	*Centrobranchus nigroocellatus*	S–10	S
	Bolinichthys indicus	150–250	S
	Gonichthys cocco	S–10	S
	Diaphus mollis	70–75	S
	Ceratoscopelus warmingii	50–75	S
	Lampanyctus pusillus	S	S
Intermediate	*Hygophum taaningi*	S	S
	Benthosema suborbitale	50–70	S
	Diaphus rafinesquii	200–300	S

mmSL, 2.7% of total) and the two *Lepidophanes* species (*L. gaussi* adults ≥35 mmSL, 4.7%; *L. guentheri* adults ≥52 mmSL, 1.5%).

Net Comparisons.—The combined fishing effort of all nets was 125.25 hours. Of this, the IKMT accounted for 57.9% of the fishing effort, the neuston net, 21.5% and the ring net, 10.6%. The percentage of specimens collected by each net (catch per unit effort) was proportional to mouth area. The IKMT captured 93.8% of the total number of specimens, the neuston net, 5.5% and the ring net, 0.7%.

All species except *Gonichthys cocco* and *Myctophum asperum* were represented in IKMT collections, 23 species were identified from neuston nets, and 10 were identified from the plankton net captures (Table 1).

Distribution.—Because open nets were employed, analyses of vertical distribution patterns were restricted to determinations of shallowest depths of capture for the 14 abundant, common and intermediate species. Only five daytime tows (three at 530 m, one each at 600 and 700) reached depths overlapping the bathymetric ranges typical of those 14 species (350–800 m). In addition, two samples were collected at 200 m during the day. However, a good vertical profile was obtained at night with one sample each being collected from 10, 50, 70, 75, 100, 150, 200, 310, 340, and 450 m, two samples from 300 m, three from 250 m, and 79 neuston samples from surface waters. Samples taken within 1 h before or after sunrise and sunset were not included because of the migratory activities of myctophids at these times.

During the day, only *Bolinichthys indicus* occurred in the 200 m samples. All 14 species were captured at the 530 m station, none were captured at the 600 m station and only two (*B. indicus* and *Diaphus rafinesquii*) were captured at the 700 m station.

Several patterns were apparent at night (Table 2). Among the abundant species, *Notolychnus valdiviae* and both species of *Lepidophanes* were quite similar in that captures of all three species occurred as shallow as the surface but with the greatest percentage (66% *N. valdiviae*; 73% *L. gaussi*; 72% *L. guentheri*) captured in nets fished to 50 and 70 m. *Diogenichthys atlanticus* and *Hygophum benoiti* occurred no shallower than 50 m, but 75% of the *D. atlanticus* species were captured in net hauls to 50 and 70 m, whereas all but eight of 163 specimens of *H. benoiti* were captured in roughly equivalent numbers between 50 and 250 m.

Table 3. Zoogeographic affinities. Total number of species, number of dominant species and number of species with maximum size <75% or ≥75% of adult length for each distribution pattern

Distribution pattern	Total number of species	No. of dominant species	No. of species <75% adult length	No. of species ≥75% adult length
Backus et al. (1977)				
Temperate-semisubtropical	5	1	1	4
Subtropical	8	1	4	4
Tropical-subtropical	14	2	3	11
Tropical-semisubtropical	5	0	2	3
Tropical	13	1	9	4
Hulley (1981)				
Widespread	3	2	0	3
Temperate-subtropical	2	1	1	1
Subtropical	9	1	4	5
Broadly tropical	19	0	7	12
Tropical	11	1	7	4

Some individuals of all nine common and intermediate species were captured at the surface at night. *Centrobranchus nigroocellatus* and *Gonichthys cocco* were captured almost exclusively between the surface and 10 m (91% and 96% of total night-time catch, respectively). Similarly, most *Lampanyctus pusillus* (61%) captures occurred at the surface. The distribution of *Benthosema suborbitale* resembled that of most of the dominant species in that 67% of night time captures were from nets fished at 50 and 70 m. The distribution peak for *Diaphus mollis* (60% of captured specimens) occurred slightly deeper at 70–75 m. Most of the specimens of *Bolinchthys indicus* and *D. rafinesquii* were obtained from nets fished deeper at night, 57% at 150 and 250 m and 73% at 200 and 300 m, respectively. *Ceratoscopelus warmingii* had a fairly even distribution to 450 m with peak abundance (25% of total) at 50–75 m. *Hygophum taaningi* had a bimodal distribution, being found most often in surface waters (0–50 m; 43%) and between 150 and 200 m (39%).

Discussion

The study area is several hundred miles west of the location within the Northern Sargasso Sea province (sensu Backus et al., 1977) that has received the most intensive sampling efforts (Nafpaktitis et al., 1977; Hulley and Krefft, 1985; Karnella, 1987) and is subject to greater influence by the Gulf Stream and cyclonic eddies. Nevertheless, our species list generally conforms to the zoogeographic groups as defined by Backus et al. (1977) and Hulley (1981), while our list of dominant species is quite similar to that reported by Backus et al. (1977).

Five zoogeographic distribution patterns defined by Backus et al. (1977) were represented among the 45 species identified (Table 3). Eighty-nine percent of the species were warm water forms; only five species had cooler water affinities (temperate-semisubtropical) according to this scheme. When compared with the zoogeographic affinities outlined by Hulley (1983), the results are virtually identical; 39 of 44 species (Hulley considered *D. garmani* pseudooceanic, Backus et al. did not) have tropical and subtropical affiliations (Table 3).

Ten species, which comprised over 80% of the total number of myctophids caught, made up the ranking group (as defined by Nafpaktitis et al., 1977) in the present study (Table 4). Despite the great potential for variability, this list com-

Table 4. Comparison of ranking species in the present study vs. those reported in Backus et al., 1977

Present study			Backus et al., 1977*		
Rank	Species	Total % catch	Rank	Species	Total % catch
1	*Notolychnus valdiviae*	21.8	1	*Notolychnus valdiviae*	18.5
2	*Diogenichthys atlanticus*	16.1	2	*Diogenichthys atlanticus*	13.8
3	*Lepidophanes gaussi*	11.6	3	*Ceratoscopelus warmingii*	10.5
4	*Lepidophanes guentheri*	8.3	4	*Bolinichthys indicus*	7.2
5	*Hygophum benoiti*	5.3	5	*Lobianchia dofleini*	7.2
6	*Centrobranchus nigroocellatus*	4.6	6	*Lampanyctus pusillus*	6.8
7	*Bolinichthys indicus*	4.5	7	*Benthosema suborbitale*	5.5
8	*Gonichthys cocco*	3.4	8	*Lampanyctus photonotus*	3.3
9	*Diaphus mollis*	3.2	9	*Lepidophanes gaussi*	3.1
10	*Ceratoscopelus warmingii*	3.1	10	*Diaphus mollis*	3.1
			11	*Lampanyctus alatus*	2.6

* Based on IKMT collections in the upper 200 m at night in both Northern and Southern Sargasso Sea provinces.

pares well with the 11 ranking species reported for the North Atlantic Subtropical Region by Backus et al. (1977). In fact, the ranks of our two most abundant species, *Notolychnus valdiviae* and *Diogenichthys atlanticus*, are identical. Altogether, both lists share six species.

Although the order of ranks differs somewhat between the two studies, distributional affinities among ranking species do not. Six of the ranking species from Backus et al. (1977) are tropical-subtropical, compared to five in the present study. In both studies, two ranking species are subtropical, two are temperate-semisubtropical and one is a tropical species.

When the largest specimen of each species was compared with its distribution pattern (Table 3), it was noted that most specimens of tropical or tropical-semisubtropical affinities as defined by Backus et al. (1977) were immature. Only five of the 18 species exhibiting these distribution patterns had specimens in the subadult to adult size range; of these, three species were represented by only a single specimen ≥75% adult length. This suggests that the presence in the study area of species with more tropical affinities is due primarily to the northward advection of larvae and juveniles by the Gulf Stream.

Although the proportion of specimens captured by the different nets was not unexpected, owing to the differing types of gear and sampling regimes, the composition of the catches from neuston nets was somewhat surprising. Vertical distribution patterns of most species are all within ranges reported by Nafpaktitis et al. (1977). However, among 11 of the 14 most common species (Table 2), at least a fraction of the population reached the surface at night, although in most of these, the centers of distribution were usually at or below the 50 m thermocline.

Only a few studies have included neustonic collections as part of sampling for myctophids (Gorelova, 1977; Nafpaktitis et al., 1977; Gartner et al., 1987). In those and other studies where near-surface (≤10 m) collections have been made (Clarke, 1973; Karnella, 1987) members of the genera *Centrobranchus, Gonichthys, Hygophum, Myctophum* and *Symbolophorus* were the only myctophids recorded from the neuston at night. Data from our neuston collections show representatives from an additional seven genera and 19 species (Table 1). Of these, Nafpaktitis et al. (1977) have also noted *Diaphus perspicillatus* and *D. mollis* from surface waters, while Karnella (1987) reported *Lobianchia dofleini* from as shallow as one meter. The other 16 species have not heretofore been reported from the surface at night.

Many of the neustonic captures were juveniles, but in seven species sub-adult and sexually mature adult specimens were also captured. In *Diaphus dumerilii*, *D. mollis*, *Lampanyctus cuprarius* and *L. pusillus*, neustonic captures accounted for ≥15% of the total number of specimens collected. These data further support the regional variability of vertical distribution patterns and indicate that neustonic collections should be a requisite portion of nighttime collection efforts in distributional studies involving myctophids.

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