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DISTRIBUTION OF MYCTOPHID FISHES IN THE EASTERN PACIFIC OCEAN OFF NORTHERN CHILE (18°30' TO 30°30'S)*

DISTRIBUCION DE PECES MICTOFIDOS EN EL PACIFICO ORIENTAL NORTE DE CHILE (18°30'-30°30'S)

*Enzo S. Acuña***

ABSTRACT

The juvenile and adult myctophid fishes from two cruises off northern Chile (from 18°30' to 30°30'S) captured with a HPN midwater trawl in oblique tows and a Bongo net in double oblique tows, 0 to 200 m and a CalCOFI net in surface tows, were identified and their distributions plotted. Eleven species were caught during the winter cruise and fourteen during the summer cruise.

Triphoturus mexicanus was the most numerous and widespread species in both cruises. *Diogenichthys atlanticus, D. laternatus, Hygophum bruuni* and *Myctophum nitidulum* were also common. Almost all specimens of all species were caught during night-time sampling, suggesting different day and night vertical distributions. The length-frecuency distribution of most of the species captured is analyzed.

The apparent relationship between northward or southward extensions of the seasonal distributions of several species and the physical parameters recorded during the cruises is discussed.

Key words: Myctophids, Eastern Pacific Ocean, Geographical distribution.

RESUMEN

Se identificaron los juveniles y adultos de peces mictófidos capturados en dos cruceros mar afuera del norte de Chile (desde 18°30' a 30°30'S) con redes de media agua en arrastres oblicuos, con redes Bongos en arrastres oblicuos dobles, de 0 a 200 m, y con una red CalCOFI con arrastres superficiales. Once especies fueron capturadas en el crucero de invierno y catorce durante el crucero de verano. La distribución de las especies identificadas es graficada.

Triphoturus mexicanus fue la especie más abundante y de distribución más amplia en ambos cruceros. *Diogenichthys atlanticus, D. laternatus, Hypophum bruuni* y *Myctophum nitidulum* fueron también comunes. Casi todos los ejemplares y todas las especies fueron capturadas durante los muestreos nocturnos, sugiriendo distribuciones verticales diferentes en el dia y la noche. Se analiza la distribución frecuencia-longitud de muchas de las especies capturadas.

Se discute la relación aparente entre las extensiones hacia el norte y sur de las distribuciones de varias especies y los parámetros físicos registrados.

Palabras claves: Peces mictófidos, Pacífico Oriental, distribución geográfica.

INTRODUCTION

The Myctophidae is a very widespread family of midwater fishes present in all the oceans of the world. A total of 365 species of recent fishes of it are listed under 35 generic and subgeneric categories, and some 225 species are considered valid by Paxton (1979).

Several authors have provided information about the distribution and systematics of myctophid fishes from the southeastern Pacific Ocean off the Chilean coast (Andriashev, 1962; Bussing, 1965; Craddock & Mead, 1970; McGinnis, 1982; Parin, 1971; Parin *et al.*, 1973; Wisner, 1976), but in general their sampling was limited. No systematic sampling of myctophids had been

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completed along the entire Chilean coast until IFOP (Instituto de Fomento Pesquero-Chile) started a series of bio-oceanographic cruises in 1980. This sampling was oriented to capture eggs, larvae, juveniles and prerecruits of species of commercial interest, such as sardine *Sardinops sagax*, anchovy *Engraulis ringens*, jack mackerel *Trachurus symmetricus murphyii*, mackerel *Scomber japonicus* and hake *Merluccius gayi* (Rojas *et al.*, 1983). Sáez (1982) found thirteen myctopid species in samples from the first cruise off northern Chile. Further cruises were completed during 1981 and 1982. The fishes from two of these cruises (winter 1981 and summer 1982) off northern Chile from 18°30′ to 30°30′ S are analyzed in this paper, with special emphasis on the distribution of myctophids.

MATERIAL AND METHODS

The collections were made during cruise IFOP-247 from the R/V Carlos Porter and the F/V Cachagua between August 18 and August 21 and between September 18 to October 4, 1981 respectively; and during cruise IFOP-251 from the R/V ITZUMI between January 31 and March 1, 1982.

Both cruises covered the area between Arica (18°28′S) and Punta Lengua de Vaca (30°30′S) and from the coast to approximately 125 nm (231 km) offshore to the west. The sampling grid had 13 transects, one degree of latitude apart. Each transect had up to seven stations. Samples for micronekton were collected at stations 1, 2, 3 and 5, 30 to 185 km offshore (Fig. 1). The station number, position, maximum sampling depth, date of sampling and sampling time (day or night) of the midwater trawl collections that contained myctophids are presented in Tables (1) and (2).

The samples were collected with and HPN (Hamburger Planktonnetz - Hydro Bios) midwater trawl 11.55 m long, 9.0 m^2 mouth area, with a 0.5 mm mesh net and a 35 kg depressor. Oblique tows were made during day and night (i.e. after sunset) periods from 200 m to the surface. The net was lowered to maximum depth, maintained at it for 60 seconds, and then towed at speed of 3-4 knots, with a wire angle of 60-70° for 10 minutes, while the cable was retrieved. Double oblique tows were also taken with a 60 cm Bongo net, 2.49 m long with 0.3 or 0.5 mm mesh nets. Surface tows were made with a 1-m diameter CalCOFI net, 4.10 m long with 0.3 mm mesh at stations 1 to 7.

The micronektonic fish were preserved in 5% buffered formalin in sea water as soon as they were brought on board. The samples were then sorted into families at the IFOP lab. These samples are kept under cruise and station number at IFOP lab. in Santiago, Chile.

Temperature, salinity, oxygen and chlorophyll content from the surface to a depth of 1,200 to 1,300 m was completed at transects 1, 3, 5, 7, 9, 11 and 13 (Silva & Ramírez, 1982).

To confirm some identifications, specimens were compared with fishes from the cruise MV72 II, Southtow Exped. of the R/V Thomas Washington off Chile that were identified by R.L. Wisner and kept at the National Museum of Natural History (Santiago, Chile).

RESULTS

During IFOP cruise 247, 43.1% of the micronektonic HPN trawl stations yielded samples (90% of them from night time tows). The families Myctophidae and Gonostomatidae accounted for 60.7 and 29.5%, of the specimens caught, respectively. Only two other families comprised more than 1% (Sternoptychidae 3.8 and Carangidae 2.3%). The list of all families and their percentages of the total number of fish is shown in Table (3).

The Myctophidae was present in 77.3% of the samples and was represented by eleven species. The most numerous species were *Triphoturus mexicanus* (34.5%), *Hygophum bruuni* (32.2%) and *Diogenichthys atlanticus* (22.3%). The list of all the species and their percentages is shown in Table (4) which also includes the specimens caught with the Bongo and CalCOFI nets.

During IFOP cruise 251, the percentage of positive micronektonic tows was 69.2%. Myctophidae and Gonostomatidae accounted for 36.4% and 55.6% of the specimens caught, respectively. None of the other eighteen families represented more than 2% of the catch. The list of all the families and their percentages is shown in Table (3).

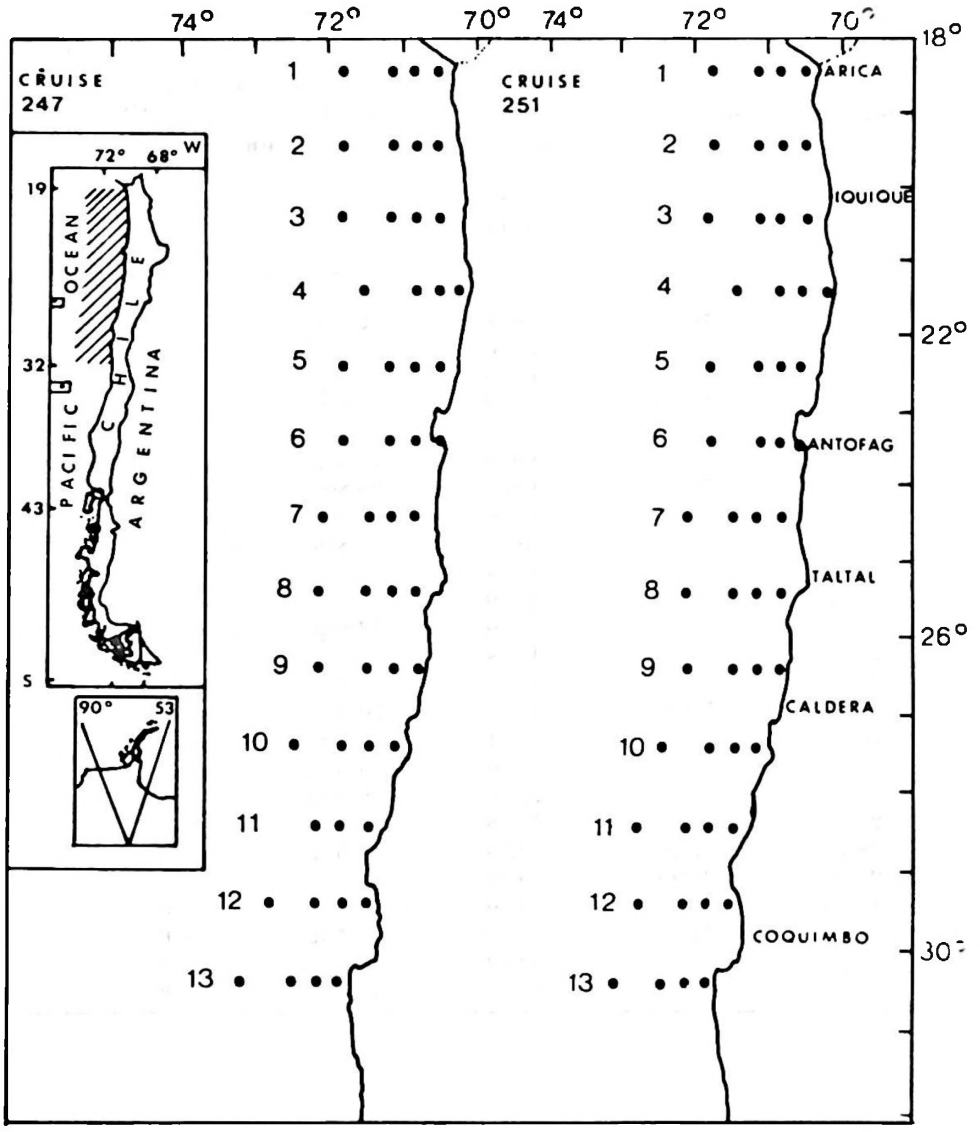

Figure 1. Micronektonic sampling stations occupied during IFOP-247 and 251 cruises off northern Chile. (Modified from Rojas *et al.*, 1983).

The family Myctophidae was present in 72.2% of the samples and was represented by twelve species in the oblique tows. *Triphoturus mexicanus* (50.7%) and *Diogenichthys laternatus* (13.6%) were the most numerous species. *D. atlanticus* (8.3%), *Lampanyctus parvicauda* (8.1%) and *Diaphus hudsoni* (7.9%) were also numerous species. Seven species were captured with the CalCOFI superficial tows, among them *Gonichthys tenuiculus, Myctophum aurolaternatum* and *Symbolophorus boops*?, species that were not captured neither by the HPN nor the Bongo. The list of all species, their numbers and percentages per net or trawl are shown in Table (4).

LATITUDINAL DISTRIBUTIONS

Genera and species are presented alphabetically for easier reference.

Diaphus hudsoni Zurbrigg and Scott, 1976 (Fig. 2A).

Bussing (1965), and later Parin (1971) and Saez (1982) identified specimens of *Diaphus* captured off Chile as *Diaphus theta*. The *Diaphus* collected by Craddock and Mead (1970) off Chile were placed in a *Diaphus* "*theta* complex". Wisner (1976) suggested that this *D.* "*theta* complex" extends across the Southern Atlantic. Zurbrigg and Scott

Table 1
Station numbers, positions, depths, date and tow time of positive midwater trawl collections taken August-October 1981 on cruise 247 of the R/V Carlos Porter (CP) and F/V Cachagua (C). N=night, D=Day. Station 7= ap. 120-125 nm

Station	Position		Depth	Date	Vessel	Tow
	Lat.(S)	Long.(W)	(m)			Time
1-5	18°30′	71°50′	201.5	4 Oct.	C	N
2-1	19°30′	70°30′	186.8	2 Oct.	C	N
2-2	19°30′	70°50′	176.6	2 Oct.	C	N
3-1	20°29′	70°30′	195.0	30 Sep.	C	N
3-5	20°28′	71°50′	197.2	30 Sep.	C	N
4-7*	21°30′	72°10′	212.1	27 Sep.	C	N
5-1	22°30′	70°30′	170.9	25 Sep.	C	N
5-2	22°30′	70°50′	139.6	26 Sep.	C	N
6-2	23°30′	70°50′	174.0	24 Sep.	C	N
6-3	23°30′	71°10′	165.3	24 Sep.	C	N
6-4*	23°32′	71°30′	158.4	23 Sep.	C	N
7-1	24°30′	70°50′	177.9	22 Sep.	C	N
7-4*	24°27′	71°50′	202.0	22 Sep.	C	N
7-5	24°25′	72°10′	192.9	23 Sep.	C	N
8-1	25°30′	70°50′	173.5	21 Sep.	C	N
8-2	25°30′	70°10′	176.0	20 Sep.	C	N
9-2	26°30′	71°10′	141.1	18 Sep.	C	N
10-3	27°29′	71°52′	216.6	29 Aug.	CP	N
10-4*	27°30′	72°10′	211.7	29 Aug.	CP	N
10-5*	27°28′	72°31′	195.8	30 Aug.	CP	N
11-3	28°27′	72°10′	222.0	21 Aug.	CP	N
12-2	29°30′	71°49′	190.0	20 Aug.	CP	N
13-1*	30°29′	71°51′	202.0	18 Aug.	CP	D
13-3	30°30′	72°30′	196.5	18 Aug.	CP	N
13-4*	30°29′	72°50′	240.2	19 Aug.	CP	N
13-7*	30°30′	73°49′	224.2	19 Aug.	CP	N

*Bongo tows.

(1976) described a new *Diaphus* from the South Atlantic, *Diaphus hudsoni* and compared it with *D. subtilis, D. theta* and *D. holti*. Nafpaktitis (1978) described the distribution of *D. hudsoni* as restricted to the southern hemisphere approximately between 30° and 52°S. He also described several differences between *D. hudsoni* and *D. theta* (p. 61-62, fig. 61) and dismissed the possibility of a single species distribution over the known ranges of both species. Hulley (1981) described differences in the PLO-luminous scale morphology and structure between *D. hudsoni, D. theta* and three other *Diaphus* species. He also found differences between *D. hudsoni* and *D. theta* with respect to their anterior profile, eye diameter and length of the upper jaw behind the vertical through the posterior margin of the orbit. Considering all these distinctive characters the *Diaphus* collected during the two IFOP cruises are *Diaphus hudsoni*.

Few specimens of this species were captured during the winter cruise in the area between 23°30′ and 30°30′S. More specimens were taken during the summer cruise, when they extended north to 22°30′S. All the specimens were caught during night-time sampling.

One specimen was captured in a Bongo tow during the summer cruise and none with the CalCOFI net.

Diogenichthys atlanticus
(Taning, 1932) (Fig. 2B).

The distribution of this species is almost the same during the winter and summer cruises, extending from 23°30′ to 30°30′S. Some specimens were caught north of this latitude during the summer cruise, with the

Table 2
Station numbers, positions, depths, date and tow time of positive midwater trawl collections taken February 1982 on cruise 251 of the R/V ITZUMI. N=night, D=Day. Station 7= ap. 120-125 nm

Station	Position		Depth	Date	Tow
	Lat.(S)	Long.(W)	(m)		Time
1-2	18°30′	70°51′	204.7	21 Feb.	N
1-3	18°30′	71°10′	197.0	21 Feb.	N
1-4*	18°30′	71°30′	203.3	22 Feb.	N
2-1	19°30′	70°30′	203.0	21 Feb.	N
2-2	19°30′	70°50′	197.0	21 Feb.	N
2-3	19°30′	71°10′	200.6	20 Feb.	N
3-1	20°30′	70°30′	208.1	18 Feb.	N
3-2	20°30′	70°51′	201.5	19 Feb.	N
3-6*	20°30′	72°10′	205.9	19 Feb.	N
3-7*	20°30′	72°30′	191.8	20 Feb.	N
4-3	21°30′	70°49′	202.9	18 Feb.	N
4-4*	21°30′	71°10′	194.8	18 Feb.	N
4-5	21°30′	71°30′	206.4	17 Feb.	N
5-1	22°28′	70°31′	168.4	16 Feb.	N
5-5	22°30′	71°50′	204.8	16 Feb.	N
5-6*	22°31′	72°09′	184.9	17 Feb.	N
6-5	23°30′	71°50′	200.0	14 Feb.	N
7-3	24°30′	71°30′	205.1	12 Feb.	N
7-5	24°29′	72°10′	182.4	13 Feb.	N
8-1	25°30′	70°50′	183.9	12 Feb.	N
8-2	25°30′	71°10′	204.0	11 Feb.	N
8-3	25°30′	71°30′	209.0	11 Feb.	N
9-2	26°30′	71°10′	190.2	9 Feb.	N
9-3	26°30′	71°31′	190.0	10 Feb.	N
9-7*	26°30′	72°50′	211.3	10 Feb.	N
10-3	27°30′	71°50′	207.4	9 Feb.	N
11-1	28°30′	71°31′	194.0	7 Feb.	N
11-2	28°30′	71°50′	201.5	7 Feb.	D
11-3	28°30′	72°10′	208.0	7 Feb.	D
12-3	29°30′	72°10′	205.5	6 Feb.	D
12-5	29°30′	72°50′	197.0	5 Feb.	N

*Bongo tows.

highest catches in the area between 24°30′ and 27°30′S. Most specimens were caught during the night-time, and only two specimens were captured during the daytime during the summer cruise.

Five specimens were caught with a Bongo net during the winter cruise and six during the summer cruise, while one specimen was captured with the CalCOFI net in the southern part of the sampling area.

Diogenichthys laternatus
(Garman, 1899) (Fig. 3A).

Three specimens were captured during the winter cruise, all north of 25°S. More individuals were collected during the summer when they were found south to 28°30′S only five specimens were caught south of 24°S. *D. laternatus* was found only in nighttime samples.

One specimen was captured with the Bongo net in the northernmost transect of the summer cruise (Table 4). None was captured with the CalCOFI net.

Gonichthys tenuiculus
(Garman, 1899) (Fig. 3B)

Three specimens of this species were captured with the CalCOFI net at station 5-5

Table 3
Number of specimens/family caught during IFOP cruises 247 and 251 with the HPN midwater trawl off northern Chile

	Cruise 247		Cruise 250	
Family	N	%	N	%
Bathylagidae	6	1.0	23	1.2
Blennidae	—	—	1	0.1
Carangidae	14	2.3	10	0.5
Ceratiidae	—	—	3	0.2
Cheilodactylidae	—	—	1	0.1
Clupeidae	—	—	6	0.3
Engraulidae	—	—	5	0.3
Exocoetidae	—	—	3	0.2
Gigantactinidae	—	—	2	0.1
Gonostomatidae	177	29.5	1,029	55.6
Idiacanthidae	2	0.3	3	0.2
Melamphaidae	3	0.5	4	0.2
Merluccidae	1	0.2	—	—
Myctophidae	364	60.7	674	36.4
Nomeidae	—	—	8	0.4
Paralepididae	1	0.2	1	0.1
Pomacentridae	—	—	2	0.1
Scomberesocidae	—	—	4	0.2
Scopelarchidae	1	0.2	—	—
Scopelosauridae	—	—	1	0.1
Sternoptychidae	23	3.8	31	1.7
Stomiatidae	4	0.7	6	0.3
unidentified	4	0.7	32	1.7
Total	600	100.0	1,849	100.0

(22°30'S, 71°50'W) during the summer cruise.

Hygophum bruuni
(Wisner, 1971) (Fig. 4A)

The most numerous samples of *H. bruuni* were taken during the winter cruise when only 4.6% of the specimens were caught north of 27°S. Three specimens were captured during the summer north of 25°30'S. Only one specimen was captured in upper waters during the daytime.

Eight specimens were caught with the Bongo net during the winter cruise, extending north its distribution. None was captured with the CalCOFI net.

Hygophum reinhardtii
(Lütken, 1892) (Fig. 4B)

Two specimens of this species were captured with the HPN trawl and five with the CalCOFI net in the northern part of the sampling area during the summer cruise, down to 24°30'S.

Lampanyctus achirus
Andriashev, 1962 (Fig. 5A)

Andriashev (1962) described *Lampanyctus achirus* in an area of the southeastern Pacific and southwestern Atlantic Ocean from 58°

Table 4
List of myctophid species, number of specimens and percentage of the total for the HPN and Bongo oblique tows and CalCOFI superficial tows of IFOP cruises 247 and 251 off northern Chile

Trawl/Net	HPN				Bongo				CalCOFI			
Cruise	247		251		247		251		247		251	
Species	N	%	N	%	N	%	N	%	N	%	N	%
Diaphus hudsoni	8	2.2	53	7.9	—	—	1	3.3	—	—	—	—
Diogenichthys atlanticus	81	22.3	56	8.3	5	21.7	6	20.0	—	—	1	1.5
D. laternatus	3	0.8	91	13.6	—	—	1	3.3	—	—	—	—
Gonichthys tenuiculus	—	—	—	—	—	—	—	—	—	—	3	4.6
Hygophum bruuni	117	32.2	3	0.4	8	34.8	—	—	—	—	—	—
H. reinhardtii	—	—	2	0.3	—	—	—	—	—	—	5	7.6
Lampanyctus achirus	3	0.8	4	0.6	—	—	—	—	—	—	—	—
L. idostigma	6	1.7	26	3.9	2	8.7	1	3.3	—	—	—	—
L. iselinoides	19	5.2	4	0.6	—	—	—	—	—	—	—	—
L. parvicauda	—	—	54	8.1	—	—	—	—	—	—	—	—
Myctophum aurolaternatum	—	—	—	—	—	—	—	—	—	—	1	1.5
M. nitidulum	—	—	37	5.5	—	—	1	3.3	—	—	53	80.3
Notolychnus valdiviae	1	0.3	1	0.1	—	—	1	3.3	—	—	—	—
Protomyctophum chilensis	—	—	—	—	2	8.7	—	—	—	—	—	—
Symbolophorus boops?	—	—	—	—	—	—	—	—	1	100	2	3.0
Triphoturus mexicanus	25	34.5	340	50.7	6	26.1	19	63.5	—	—	1	1.5

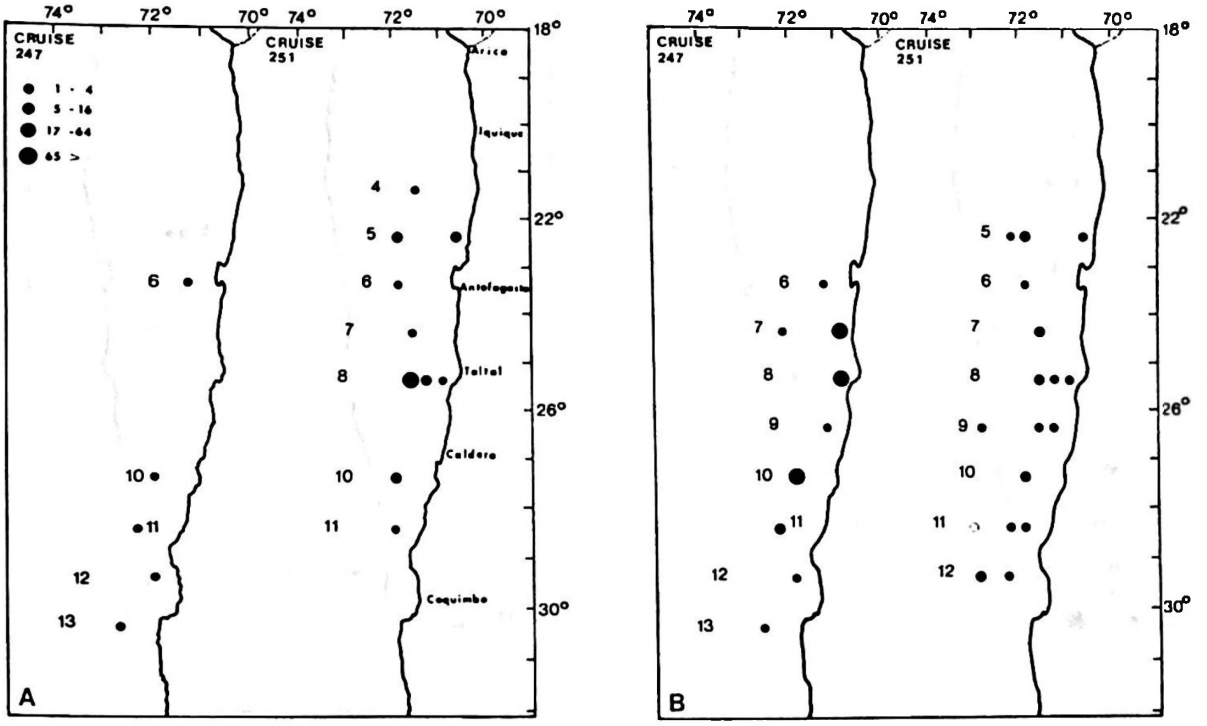

Figure 2. Distribution of A) *Diaphus hudsoni* and B) *Diogenichthys atlanticus* at stations occupied during IFOP cruises off northern Chile. CalCOFI net tows (open circle).

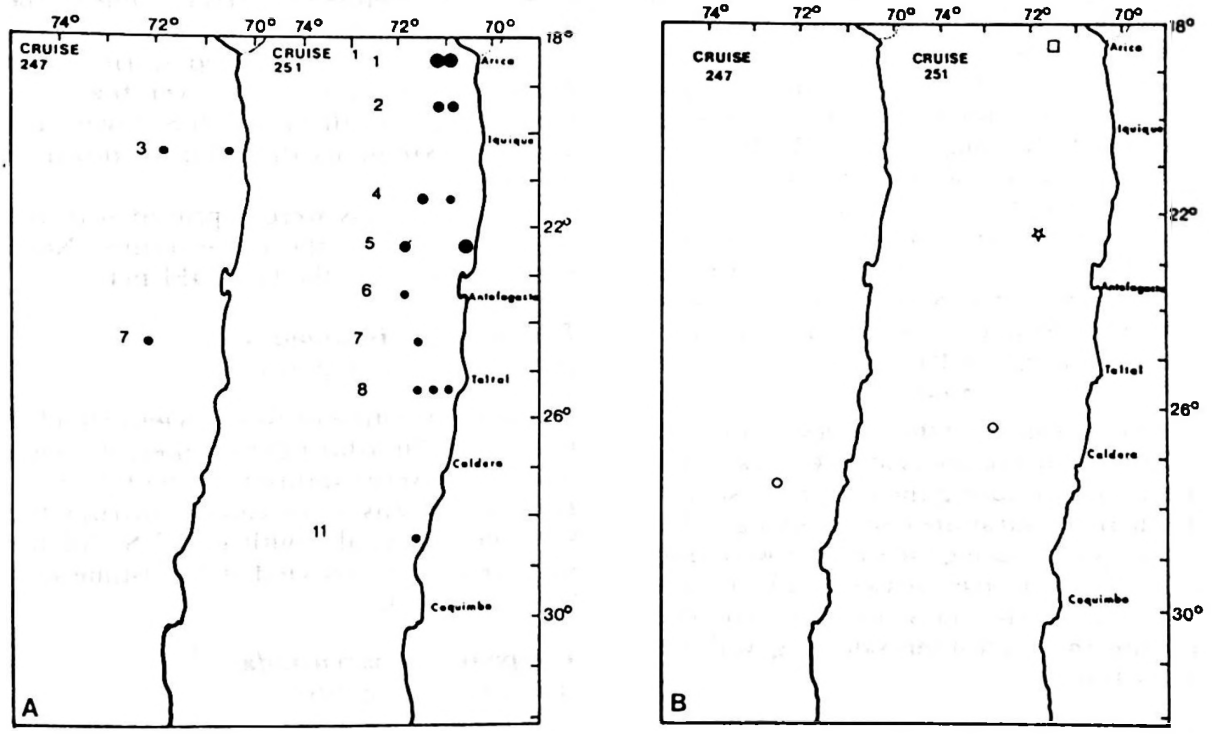

Figure 3. Distribution of A) *Diogenichthys laternatus* and B) *Gonichthys tenuiculus* (☆), *Myctophum aurolaternatum* (□) and *Symbolophorus boops?* (○), at stations occupied during IFOP cruises off northern Chile. Symbol sizes as in Fig. 2.

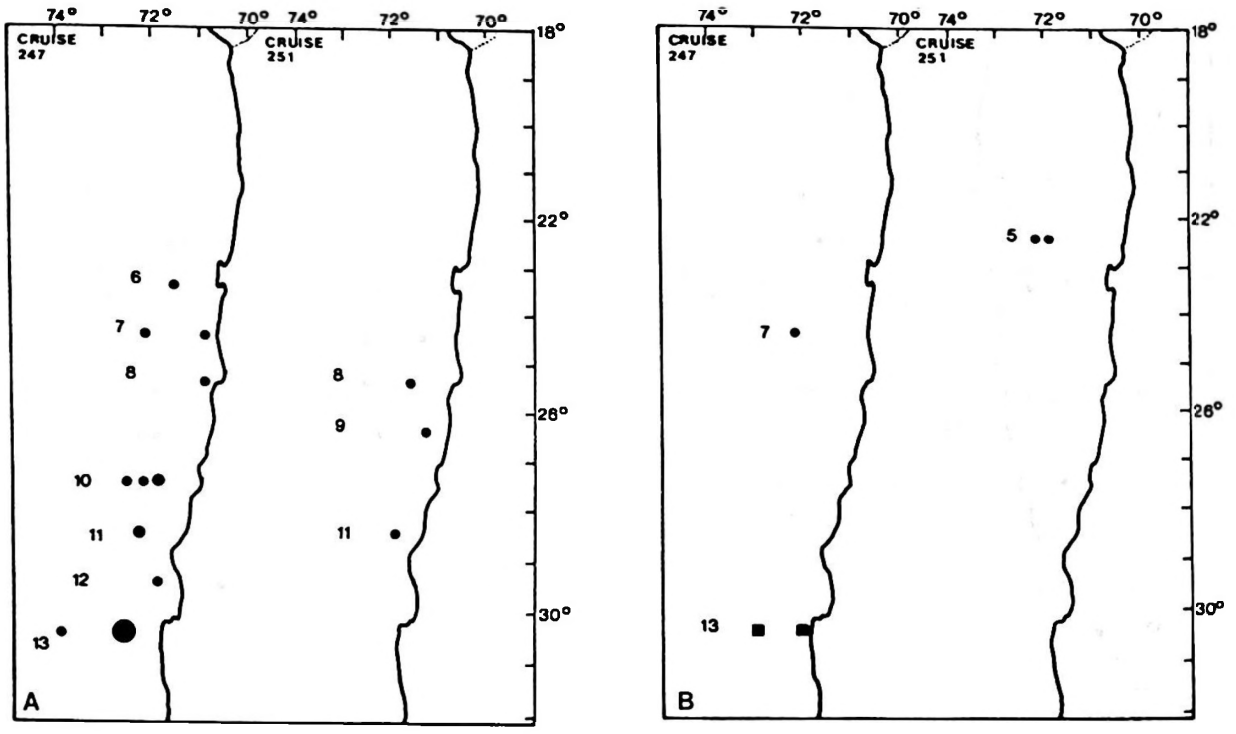

Figure 4. Distribution of A) *Hygophum bruuni* and B) *Hygophum reinhardtii* at stations occupied during IFOP cruises off northern Chile. Symbol sizes as in Fig. 2.

to 64°S, and 61° to 135°W. Wisner (1976) reported that specimens conforming to the diagnosis of *L. achirus* had been taken off Chile and Peru and in the northeastern Pacific between 19° and 27°N, and 118° and 133°W and in the Central Pacific between 19° and 27°N, along about 155°W. However, the specimens captured off northern Chile and assigned to *L. achirus* by Bussing (1965) and Craddock and Mead (1970), both cited by Wisner (1976), are under revision by Zahuranec (1980). But, since his thesis work has not been published, the specimens caught during IFOP cruises will be referred as *Lampanyctus achirus*.

Few specimens of this species were caught during both cruises (Table 4). The specimens caught during the winter cruise were from the central area of sampling, while those caught during the summer were from the northern area between 21°30′ and 24°30′S. All the specimens were collected during the night-time sampling with the HPN trawl.

Lampanyctus idostigma
(Parr, 1931) (Fig. 5B)

The generic status of this species is under revision by Zahuranec (1980), but for the reason stated before the current name will be used in this paper.

The species was captured during both cruises in a similar area. However, few specimens caught south of 25°30′S during the summer extend its distribution down to 26°30′S.

Two specimens were captured with the Bongo net during the winter cruise. None was captured with the CalCOFI net.

Lampanyctus iselinoides
(Bussing, 1965) (Fig. 6A)

The distribution of this species extended north to 24°30′S during the winter, although only 10.5% were captured north of 27°30′S. Four specimens were caught during the summer cruise, all south of 27°S. All the specimens were collected at night-time with the HPN trawl.

Lampanyctus parvicauda
(Parr, 1931) (Fig. 6B).

This species was only captured during the summer cruise in the northern part of the sampling area, north of 26°S, with the HPN trawl.

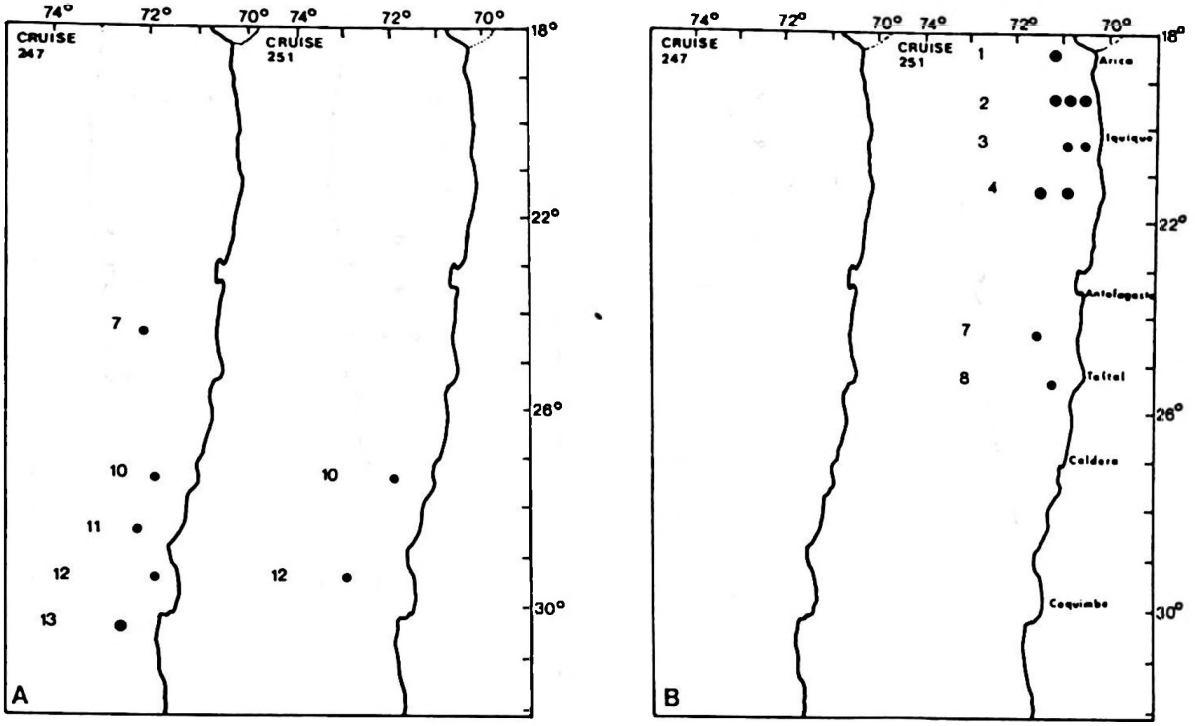

Figure 5. **Distribution of A) *Lampanyctus achirus* and B) *Lampanyctus idostigma* at stations occupied during IFOP cruises off northern Chile. Symbol sizes as in Fig. 2.**

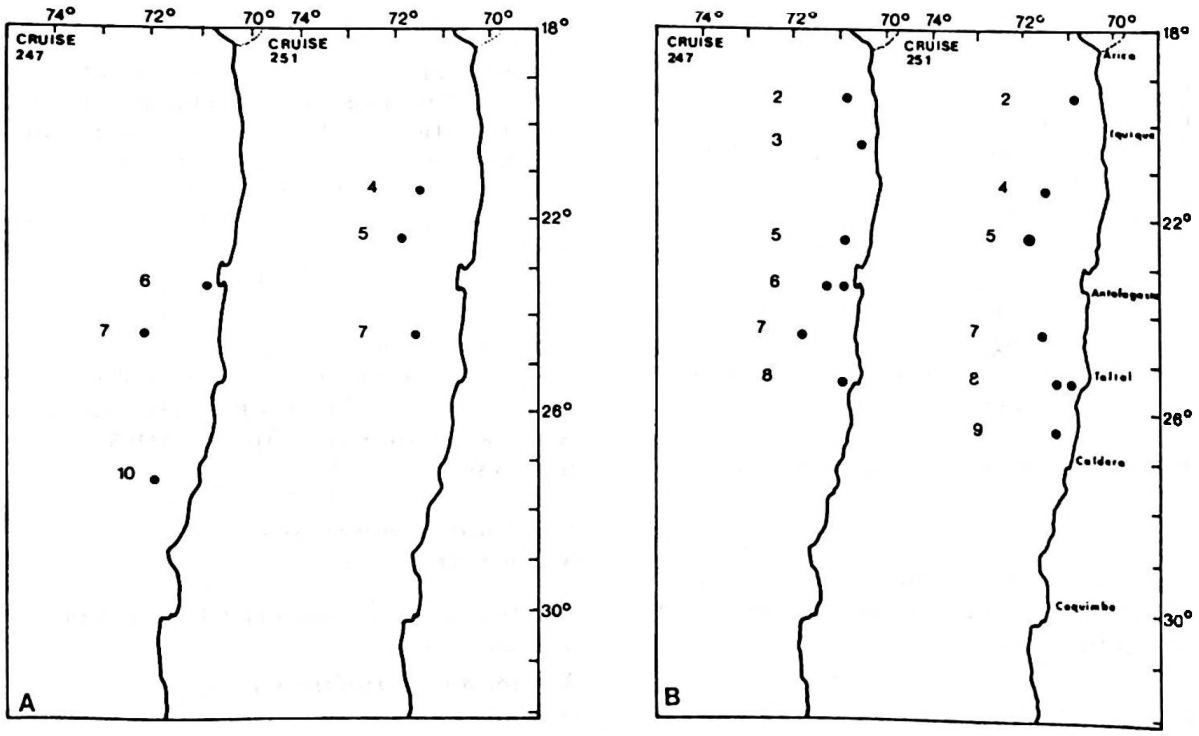

Figure 6. **Distribution of A) *Lampanyctus iselinoides* and B) *Lampanyctus parvicauda* at stations occupied during IFOP cruises off northern Chile. Symbol sizes as in Fig. 2.**

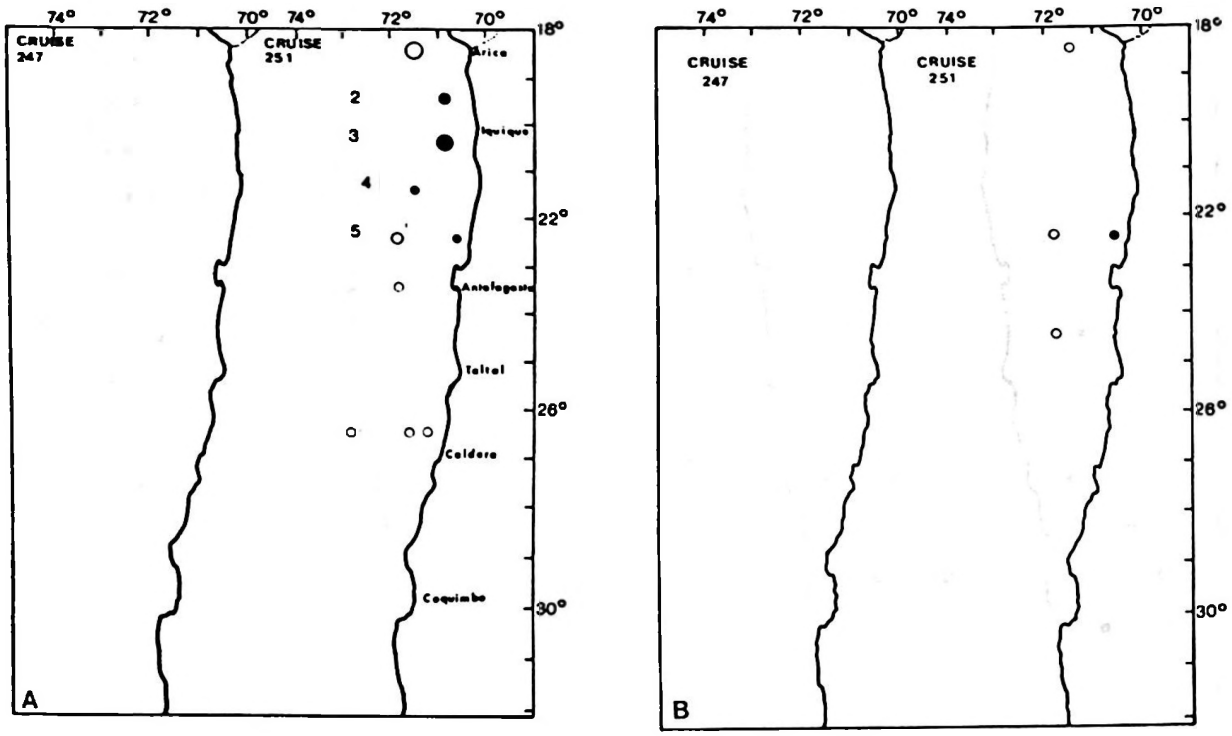

Figure 7. Distribution of A) *Myctophum nitidulum* and B) *Notolychnus valdiviae* (solid circles) and *Protomyctophum chilensis* (solid squares) at stations occupied during IFOP cruises off northern Chile. Symbol sizes as in Fig. 2.

Notolychnus valdiviae
(Brauer, 1904) (Fig. 7B)

As Wisner (1976) indicated, *N. valdiviae* is a very fragile species. The specimens captured had only a few photophores, and one of them had no skin. However, the characteristic supracaudal gland and the median transparent dome in the frontal region allowed the identification of this species.

Two specimens were caught in the sampling area during the summer cruise, one with the HPN and one with the Bongo net, and one during the winter cruise between 22°30' and 24°30'S. None was captured with the CalCOFI net.

Protomyctophum (Hierops) chilensis
(Wisner, 1971) (Fig. 7B)

Two specimens of this species were caught in the sampling area with a Bongo net during the winter cruise in the southernmost transect of the area.

Symbolophorus boops?
(Richardson, 1844) (Fig. 3B)

According to Wisner (1976) there are at least three forms in the *S. boops* "southern" species group, and their relationships are not clear. The principal differences are the structure and arrangement of the caudal luminous glands. The specimens collected during IFOP cruises correspond to the form which has two small, closely spaced, but distinctly separate scales, both in the supra and infracaudal glands of the males. Wisner (1976) suggests that it could tentatively be considered a new species know from off southern Peru and northern Chile.

One specimen was captured during the winter cruise (St. 10-5) and two were caught during the summer cruise (St. 9-7), all of them with the CalCOFI superficial tow. None was captured with the HPN or the Bongo net.

Triphoturus mexicanus
(Gilbert, 1890) (Fig. 8)

Moser and Ahlstrom (1970) based on the

Myctophum aurolaternatum
(Garman, 1899) (Fig. 3B)

One specimen of this species was captured in a superficial CalCOFI net tow in the

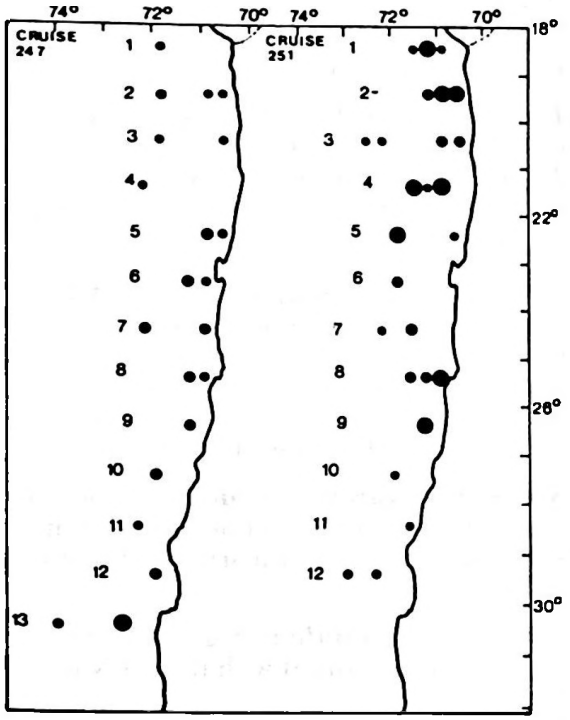

Figure 8. **Distribution of *Triphoturus mexicanus* at stations occupied during IFOP cruises off northern Chile. Symbol sizes as in Fig. 2.**

northernmost transect of the sampling area during the summer cruise.

Myctophum nitidulum (Garman, 1899) (Fig. 7A)

This species was also captured only during the summer cruise in the northern part of the sampling area, north of 23°S with the HPN trawl. However, specimens were captured with the CalCOFI net down to 26°30'S. Only one specimen was captured with the Bongo net at station 2-2.

distinctiviness of the larvae suggested that the southern hemisphere form of this species was referrable to *Triphoturus oculeus* (Garman, 1899). However, Hulley (1986), in a recent taxonomic review of the genus, determined that *Triphoturus* comprise only two species, *T. nigrescens* and *T. mexicanus*, the latter with a "northern" and a "southern" population. Furthermore, as Hulley (1986) and others suggest for several myctophid larvae, a high degree of variation has been observed in *T. mexicanus* larvae captured in chilean waters. Therefore, considering Hulley's results the species present in Chilean waters is *T. mexicanus*.

This species is the most numerous and widespread myctophid along the coast off northern Chile. It shows similar latitudinal pattern of distribution during the winter and summer. It is found in the entire sampling area during both seasons. The largest numbers were collected during the summer cruise. All the specimens were caught during the night-time sampling.

Six specimens were captured with the Bongo net during the winter cruise and nineteen during the summer cruise, and one was caught with the CalCOFI net during the summer.

LENGTH-FREQUENCY DISTRIBUTIONS

The length-frequency distributions of the species captured were analyzed to indirectly determine the efectiveness of the HPN midwater trawl in capturing the different sizes of fishes.

Diaphus hudsoni (Fig. 9). Nafpaktitis (1978) reports a maximum size of 75 mm for this species. The specimens captured ranges in size from 11 to 47 mm Standard Length (SL). However, 89.7% of them were between 11 and 24 mm SL.

Diogenichthys atlanticus and ***D. laternatus*** (Fig. 9). Wisner (1976) reported a maximum size for both species of 25 mm SL. Considering this, the full known size range was captured by the HPN. Five *D. laternatus* of more than 25 mm SL were also captured, extending the maximum size for this species to 29 mm SL.

Hygophum bruuni (Fig. 9) and *H. reinhardtii*. Wisner (1976) reported sizes of 53 and 55

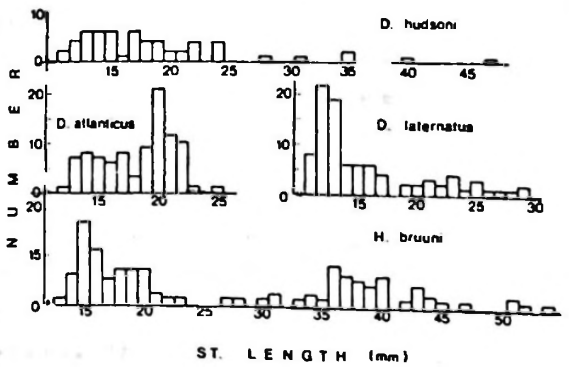

Figure 9. **Length-frequency distribution of four species of myctophids captured with the HPN trawl during IFO-247 and 251 cruises of northern Chile.**

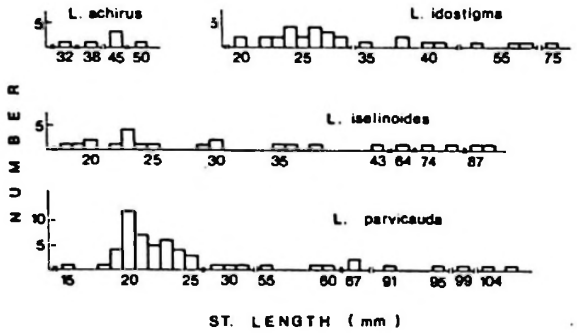

Figure 10. **Length-frequency distributions of four species of the genus *Lampanyctus* captured with the HPN trawl during IFOP 247 and 251 cruises off northern Chile.**

mm SL, respectively. The samples taken with the HPN cover the whole size range of both species. Two *H. reinhardtii* of 63 and 65 mm SL were also captured with the CalCOFI net, extending the largest size caught to 65 mm SL for this species.

Lampanyctus achirus (Fig. 10). The largest specimen captured was 50 mm SL. The largest ones recorded in the literature have up to 155 mm (Wisner, 1976). Hulley (1981) reported that 69.5% of the *L. achirus* caught in the South Atlantic were taken in net fished to below 1,000 m and 24.4% in nets fished between 500 and 1,000 m. Therefore, this could be a case of accesibility more than vulnerability and of ontogenetic migration, being only the youngest specimens in near surface waters and the adults at deeper regions.

Lampanyctus idostigma (Fig. 10). Wisner (1976) reported a size up to 90 mm SL for this species. The largest specimen caught during IFOP cruises, 75 mm SL, is the only larger than 57 mm.

Lampanyctus iselinoides (Fig. 10). A 21.7% of the specimens captured were larger than 43 mm SL. The largest was 88 mm SL. The largest known size recorded is about 115 mm SL (Bussing, 1965).

Lampanyctus parvicauda (Fig. 10). A 12.5% of the specimens captured were larger than 60 mm SL, and 17.8% larger than 31 mm SL. However, two specimens of 104 and 106 mm SL are very near the largest size recorded in the literature (110 mm SL) (Wisner, 1976).

Myctophum aurolaternatum. The specimen caught with the CalCOFI net has 81 mm SL, while the largest known size is 105 mm SL (Wisner, 1976).

Muctophum nitidulum (Fig. 11). The largest specimen captured with the HPN has 75 mm SL, also a 85 mm SL one was captured with the CalCOFI net. The largest size recorded for the species is 75 mm SL (Wisner, 1976), therefore the specimen captured with the CalCOFI net is the new largest size recorded.

Notolychnus valdiviae. The specimens caught fall within the known range of size of the species.

Protomyctophum chilensis. The two specimens caught with the Bongo net fall within the known size range of the species.

Symbolophorus boops? The three specimens caught with the CalCOFI net fall with-

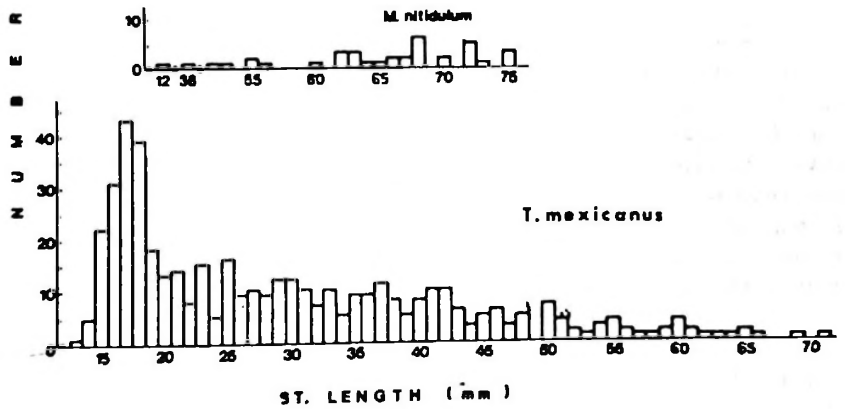

Figure 11. **Length-frequency distributions of *M. nitidulum* and *T. mexicanus* captured with the HPN trawl during IFOP-247 and 251 cruises off northern Chile.**

in the known size range for the *Symbolophorus* spp.

Triphoturus mexicanus (Fig. 11), Wisner (1976) reports a maximum size of about 70 mm SL for this species. The whole known size range was captured, the largest one being 71 mm SL. The captures of *T. mexicanus* made with an IKMT with an 8 mm mesh in its anterior part and 0.5 mm mesh in the posterior part and analyzed by Saez (1982) were compared with the captures from the summer cruise (IFOP-251) during the same months and in the same area, and taken with the HPN midwater trawl (Table 5). Both trawls collected the whole known size range of the species, but the number captured per size range is different. While the size range 10-20 mm is the most numerous in the HPN samples, the size range 41-50 mm is the most numerous for the IKMT samples. Although part of the difference at smaller sizes could be explained by extrusion of smaller fish through the 8 mm mesh of the anterior part of the IKMT, the cumulative percentage shows that the smaller sizes were captured relatively better by the HPN trawl while the medium and larger sizes were captured better by the IKMT.

Table 5
Size composition of *Triphoturus mexicanus* captures made with IKMT and HPN trawls off northern Chile during the summer of 1980 and 1982 respectively

	IKMT (Saez, 1982)			HPN IFO - 251		
Size Range	N	%	cum. %	N	%	cum. %
10-20	1	0.7	0.7	163	48.4	48.4
20-30	22	15.7	16.4	43	12.8	61.2
30-40	30	21.4	37.8	55	16.3	77.5
40-50	46	32.9	70.7	49	14.5	92.0
50-60	31	22.2	92.7	18	5.3	97.3
60-70	10	7.1	100	9	2.7	100
Total	140	100	100	337	100	100

DISCUSSION

The new data generated by the analysis of the two IFOP cruises off northern Chile modifies the distributional range of several myctophid species off the Chilean coast.

Nafpaktitis (1978) cites the occurrence of *Diaphus hudsoni* off Chile between 30° and 52°S. The specimens reported in this study extend the northern limit of distribution of *D. hudsoni* to 22°30'S.

Wisner (1976) reported that *Diogenichthys atlanticus* has a disjunct distribution in the eastern Pacific Ocean and was not taken close to shore off Chile, citing the findings of Craddock and Mead (1970) who captured 87 specimens from 18 stations between 33° to 34°S and 73° to 90°W. All specimens of this species from IFOP cruises were captured east of 73°W along the northern Chilean coast from approximately 22°30' to 30°30'S, extending the distribution reported by Wisner to coastal waters off Chile. Although Wisner (1976) reported the distribution of *Diogenichthys laternatus* down to about 33°S, few specimens were caught south of 24°S, being 28°30'S the southermost limit. According two this, the distributions of both *Diogenichthys* species have a small area of overlap, apparently forming a replacement series, as the one described for them by Hartmann and Clarke (1975) in the Central Equatorial Pacific. These authors found that closely related species seem to be frequently separated geographically.

Wisner (1976) reports the distribution of *Gonichthys tenuiculus* to be principally in tropical waters but also near the Americas to about 32°N and 22°S. The three specimens of this species reported in this study were collected near the southern limit of distribution at 22°30' during the summer.

The distribution of *Hygophum bruuni* was

described by Wisner (1971) as rather restricted to the southeastern Pacific Ocean off Central Chile between 30° to 33°S and 72° to 92°W, and as restricted to the waters off Chile between 30° and 50°S by McGinnis (1982). The captures of this species during IFOP cruises extend its distribution northward to 22°30'S during the winter, although very few specimens were caught north of 27°S, and eastward to about 70°30'W. *Hygophum reinhardtii* is found in warmer waters of the eastern Pacific Ocean between about 30°N and 30°S except fot a hiatus of about 20° of latitude north of the Eastern Equatorial region (Wisner, 1976). The specimens collected during IFOP cruises were present in the area only during the summer and all north of 25°S. The distributions of these two *Hygophum* spp. are very similar to the distributions stated before for the two *Diogenichthys*, and also suggest a replacement series.

The distribution of *Lampanyctus idostigma* was described by Wisner (1976) as apparently confined to the east of about 135°W, from San Diego, California to Antofagasta, Chile. This species was captured off northern Chile during the summer and winter down to 26°30'S, extending the southern limit of its distribution to this latitude. *Lampanyctus parvicauda* has a distribution very similar to *L. idostigma* although it is present in the area only during the summer. The new southern limit of its distribution considering the captures reported in this study is 25°30'S, although Saez (1982) reported one specimen from 27°30'S, also caught during the summer.

Myctophum aurolaternatum is widely distributed, commonly taken from about 25°N to 17°S in the Eastern Pacific and to about 170°W (Wisner, 1976). The specimen caught in the northernmost transect of the sampling area extends its distribution to 18°30'S, at least during the summer. The distribution of *Myctophum nitidulum* was discussed by Wisner (1976, Fig. 58) indicating localities between 20° and 25°S and citing the report of two adults from 30°59'S by Craddock and Mead (1970). Specimens of *M. nitidulum* were captured in the area between 18°30' and 26°30'S during IFOP summer cruise, confirming the presence of the species, at least during this season, in the coastal area off northern Chile between 70°30' and 73°W. This finding confirms Hulley's (1981) classification of this species as having a thermophilic eurytropical pattern of distribution.

Moser and Ahlstrom (1970, p. 114) stated that *Triphoturus oculeus* (= *T. mexicanus* (Hulley, 1986)) ranged from Panama to Peru. However, Wisner (1976) considered that this species ranges somewhat farther north and much farther south, citing the findings of Bussing (1965) near Valparaiso, Chile and Craddock and Mead (1970) from there and westward to about 76°W, between 31° and 33°S. *T. mexicanus* was the most numerous and widespread species caught off northern Chile between 18°30' and 30°30' during both the winter and summer IFOP cruises, confirming Wisner's suggestion. Furthermore, Acuña (1986) reported the presence of this species down to 39°S.

The distributional patterns of myctophid fishes off northern Chile (18°30' to 30°30'S) fall into three different categories according to the season of the year:

1. Species present in the area during both winter and summer: *Diogenichthys laternatus* and *Lampanyctus idostigma* are present in the northern part of the area. *Lampanyctus achirus* and *Notolychnus valdiviae* are present in the central part of the area. *Diaphus hudsoni, Diogenichthys atlanticus, Hygophum bruuni, Lampanyctus iselinoides* and *Symbolophorus boops?* are present in the southern part of the area. Finally, *Triphoturus mexicanus* is found in the whole area during both winter and summer.

2. Species present in the northern part of the sampling area (from about 24° to 27°S) only during the summer: *Gonichthys tenuiculus, Hygophum reinhardtii, Lampanyctus parvicauda, Myctophum aurolaternatum* and *M. nitidulum*.

3. Species present in the southern part of the sampling area during the winter and up to about 30°S: *Protomyctophum chilensis*. Although Wisner (1976) cites the distribution of this species up to 21°S, it was not captured north of 30°S during IFOP cruises.

These patterns suggest the presence of a zoogeographical boundary around 24°S. It is more clearly delimited during the winter between 23° and 24°S, and tends to shift south during the summer to around 26° to 27°S. This boundary has been previously reported by Antezana (1981) for euphausiids and Fagetti (1968) for two species of chaetognaths. Bussing (1965) noted that the

mesopelagic fishes *Chaulodius barbatus* and *C. sloani* and *Idiacanthus austronomus* and *I. niger* formed replacement series at that latitude. Antezana (1981) proposed the division of the "Peru-Chilean" Province into four districts: "Peru-Nordchilensis" (3° to 24°S), "Atacamensis" (24° to 30°S), "Centro-Chilensis" (30° to 38°S) and "Valdiviensis" (38° to 42°S). The distributional patterns described above for the myctophid fishes of northern Chile seem to fit quite well to the proposed regions. Therefore, *Diogenichthys laternatus, Gonichthys tenuiculus, Hygophum reinhardtii, Lampanyctus idostigma, L. parvicauda, Myctophum aurolaternatum* and *M. nitidulum* can be considered as species of the "Peru-Nordchilensis" zoogeographical district. *Lampanyctus achirus* and *Notolychnus valdiviae* can be assigned to the "Atacamensis" district. Although *Diaphus hudsoni, Diogenichthys atlanticus, Hygophum bruuni, Lampanyctus iselinoides* and *Symbolophorus boops?* are also present in the "Atacamensis" district during both winter and summer, some of their distributions extend farther south into the "Centro-Chilensis" district or even the "Valdiviensis" in the case of *H. bruuni* and *L. iselinoides* (Acuña, 1986). Therefore, the real existence of the "Atacamensis" district for myctophids is not yet clearly established, since its only true representatives at this time, *L. achirus* and *N. valdiviae*, with very few specimens captured, could be present further south, considering that *N. valdiviae* has a widespread pattern of distribution (Hulley, 1981). Finally, *P. chilensis* is found near the northern limit of the "Centro-Chilensis" district during the winter.

Ebeling (1962), Backus *et al.* (1969) and Hartmann and Clarke (1975) have reported the existence of subpatterns of abundance and distribution of mesopelagic fishes within water masses. While Backus *et al.* (1969) related these to shallow thermal fronts, Ebeling (1962) and Hartmann and Clarke (1975) related them to variation in primary productivity in the surface layers. Wisner (1976) suggested that the area of low oxygen (1 ml/l and less) that dominates the subsurface of the Eastern Pacific or a tongue of submerged warm water present along the coast at a depth of about 300 m to as far as 40°S could explain the distributions of some myctophid fishes off the Chilean coast. Paxton (1967) in his study of the San Pedro Basin myctophids considered temperature to be the most important factor influencing distribution.

The only oceanographic factor that seems to remain more or less constant during the winter and summer cruises is the oxygen minimum layer (OML), The thermal and salinity structure and therefore the water masses present in the area, varies with season (Silva and Ramirez, 1982). This change in water masses could explain the southward and northward movements of the boundaries of distribution of several species. *Hygophum bruuni, Lampanyctus iselinoides* and *Protomyctophum chilensis* extend their distributions farther north during the winter, *Diogenichthys laternatus, Hygophum reinhardtii, Lampanyctus idostigma, L. parvicauda, Gonichthys tenuiculus, Myctophum aurolaternatum* and *M. nitidulum* extend their distributions farther south during the summer. These movements may be associated with the presence farther north of the subantarctic water mass during the winter and the penetration farther south of the subtropical water mass during the summer. These penetrations have been described by Silva and Ramirez (1982) for the cruises analyzed and also by Bernal *et al.* (1982). Silva and Fonseca (1983) analyzing information from several cruises done in the area between the coast and approximately 73°W off northern Chile, within the sampling area of IFOP cruises, determined that the geostrophic velocity at 0, 100, 200 and 600 m had a predominantly northward flow during the winter and a southward flow during the summer. These flows could provide a good transport mechanism for myctophids as it has been suggested for some currents in the Atlantic by Krefft (1974) and Hulley (1981). These results reinforce the idea that there are seasonal displacements of the distributions of several myctophids related to the seasonal changes in the oceanographic regime in the area off northern Chile.

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