EPI- AND MESOPELAGIC FISHES, ACOUSTIC DATA, AND SST IMAGES COLLECTED OFF LANZAROTE, FUERTEVENTURA, AND GRAN CANARIA, CANARY ISLANDS, DURING CRUISE "LA BOCAINA 04-97"

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Original entregado en noviembre de 1998

INFORMES TÉCNICOS DEL
INSTITUTO CANARIO DE CIENCIAS MARINAS
Número 5, Telde (Gran Canaria), 1999

RESUMEN

Durante la campaña "La Bocaina 0497", se llevaron a cabo una serie de 14 lances con una red de arrastre pelágico de tipo comercial entre 20 y 700 m de profundidad y una prospección acústica con una ecosonda SIMRAD EK-500 en aguas neríticas y oceánicas adyacentes a Lanzarote, Fuerteventura y Gran Canaria, islas Canarias. Además, se obtuvieron imágenes SST para obtener información de las condiciones hidrológicas en el área de estudio.

De los 14 lances, 10 tuvieron éxito y capturaron un total de 2166 peces pertenecientes a 81 especies, 53 géneros y 28 familias. Se comprueba que diez especies son nuevas citas para el área de las Islas Canarias. La prospección acústica cubrió un total de 2404 mn^2 y permitió obtener una evaluación aproximada de la abundancia y biomasa de los peces.

Tanto los resultados de las pescas como el estudio acústico mostraron que la caballa *Scomber japonicus*, una especie epipelágica de especial interés pesquero, presentaba gran variabilidad espacial en biomasa, con claras variaciones en la superioridad numérica de ciertas clases de edad o talla, entre las diferentes localidades muestreadas. Además, algunos juveniles en el primer año de vida aparecieron en la zona epipelágica oceánica durante la noche junto con peces mesopelágicos de migración vertical. Análisis preliminares del contenido estomacal e intestinal sugieren que estos juveniles se alimentaron cerca del fondo durante el día anterior y que pueden realizar migraciones horizontales entre la plataforma y las aguas oceánicas adyacentes. Se concluye que la gran flexibilidad espacial de esta especie requiere más prospecciones de seguimiento a intervalos regulares para establecer un rendimiento sostenible de la pesquería.

Los datos acústicos junto con los resultados de los arrastres demuestran la existencia de una densa capa profunda de reflexión entre 400 y 700 m de profundidad compuesta por peces mesopelágicos e invertebrados. Se encontraron indicaciones claras de migraciones verticales diurnas en varias especies formando una capa dispersa superficial a menos de 150 m de profundidad durante la noche. Juveniles de tres especies bentopelágicas, que durante su primera fase de vida tienen un comportamiento claramente pelágico, fueron capturadas junto con especies tipicamente mesopelágicas como estomiidos y mictófidos.

Varios individuos de especies mesopelágicas fueron capturados sobre la plataforma, lo que puede reflejar la situación de la frontera ecológica en los bordes oceánicos típicos para las islas oceánicas y montañas submarinas. Algunas especies mesopelágicas recolectadas en este estudio pueden estar estrechamente asociadas con condiciones hidrográficas específicas, como el mictófido *Ceratoscopelus maderensis* que fue encontrado al SE de Fuerteventura en un área de posible afloramiento local. Este descubrimiento apunta la existencia de zonas micro-zoogeográficas en las islas Canarias que deben ser investigadas más profundamente a pequeña escala.

ABSTRACT

During cruise „La Bocaina 0497" a series of 14 tows with a commercial pelagic trawl at depths between 20 and 700 m and an acoustic survey with a SIMRAD EK-500 echosounder were carried out in neritic and adjacent oceanic waters off Lanzarote, Fuerteventura, and Gran Canaria, Canary islands. In addition, SST images were obtained to get some informations on the prevailing hydrological conditions in the study area.

Of the 14 trawl tows ten were successful and resulted in capture of a total of 2166 fishes belonging to 81 species, 53 genera and 28 families. Ten species proved to be new records for the area of the Canary Islands. The acoustic survey covered a total of 2404 nm^2 and allowed to obtain estimates of the abundance and biomass of fishes.

Both the fishing results and the acoustic study revealed considerable spatial variability in biomass of chub mackerel, *Scomber japonicus*, an epipelagic species of particular fisheries interest, showing clear variations in the numerical dominance of certain age- or size classes among different collecting localities. Furthermore, some juveniles in the first year of life occurred in the oceanic epipelagic during night together with vertically migrating mesopelagic fishes. Preliminary analyses of the stomach and intestinal content suggest that these juveniles fed close to the bottom during the day before and hence may undertake diurnal horizontal migrations between the shelf and adjacent oceanic waters. It is concluded that the great spatial flexibility of this species requires further monitoring surveys at regular intervals as a basis for establishing a sustainable fisheries management.

The acoustic data together with the trawling results demonstrate the existence of a dense deep scattering layer at depths between 400 and 700 m which is composed of mesopelagic fishes and invertebrates. Clear indications of diurnal vertical migrations were found in several species with formation of a shallow scattering layer in less than 150 m depth during night. Together with typical mesopelagic species such as stomiids and myctophids also juveniles of three benthopelagic species, which typically undergo a pelagic stage during early life, were collected.

Several individuals of mesopelagic species were collected above the shelf what may reflect the ecological boundary situation at ocean rims typical for oceanic islands and seamounts. Some mesopelagic species collected in this study may be closely associated with distinct hydrological conditions such as the myctophid *Ceratoscopelus maderensis* which was discovered in the SE of Fuerteventura in an area of possible local upwelling. This finding points to the existence of micro-zoogeographic zones within the Canary islands which derserve further investigation using a small-scaled comparative approach.

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1. INTRODUCTION

The epi- and mesopelagic fish fauna in the area of the Canary Islands, Eastern Central Atlantic, deserves increased research efforts both from a fisheries-oriented and a basic ecological viewpoint. During the last years fisheries for economically valuble epipelagic species has significantly increased (BAS et al. 1995, GONZÁLEZ and LOZANO 1996). At the same time, several ecological studies have been carried out aimed at investigating the population dynamics and feeding ecology of two of the most important species, skipjack tuna, *Katsuwonus pelamis* (LINNAEUS 1758), and chub mackerel, *Scomber japonicus* HOUTTUYN 1782 (CASTRO 1993, MORENO and CASTRO 1995, RAMOS et al. 1995). One of these studies clearly showed that young chub mackerel are the preferred food of skipjack (RAMOS et al. 1995). Therefore, chub mackerel has great value as bait for tuna fishing, too. However, young chub mackerels are quite difficult to study, as they are spatially and trophically flexible and may frequently migrate between the coastal shelf and the open sea (CASTRO 1993). This migration activity may be facilitated by the rather narrow shelf, a typical feature for islands of vulcanic origin.

A first detailed study of the mesopelagic fishes from the Canary Islands has been carried out based on material collected during the SOND cruise in 1965 (BADCOCK 1970). This investigation was later followed by another one in adjacent waters off NW Africa (BADCOCK and MERRETT, 1976). In recent years, during several cruises aimed at determining the abundance of epipelagic and benthic fishes with various fishing methods and acoustic devices (BORDES et al. 1987, 1991, 1995), an intense scattering layer was discovered at between 400 and 700 m depth off several islands. Like in other comparable areas, this layer is composed of large densities of micronektonic and planktic organisms, among them also various species of mesopelagic fishes. Many of these organisms show a strong affinity with shallow waters, as they are diurnal migrators which ascend to the surface at sunset, stay there during night, and descend again to deeper, less illuminated levels at sunrise. Hence they may represent also a major food component for epipelagic predators. Lanternfishes (Myctophidae), for instance, are frequently listed as an important trophic source for tunas, chub mackerels, and other epipelagic fishes (e.g., ABRAMS et al. 1997), as well as dolphins (e.g., FIEDLER et al. 1997).

Mesopelagic fishes may vary in species composition among different geographic areas what indicates the existence of important ecological variations or barriers for dispersal. For instance, several studies on myctophids have suggested that the species composition of this group in various parts of the Atlantic represents distinct zoogeographic units (BACKUS et al. 1977, HULLEY 1981). In the area of the Canary Islands, rather complex hydrological conditions prevail with deep-water currents arriving from the North Atlantic, the Mediterranean, and the Antarctic (MITTELSTAEDT 1983). This may have lead to uneven distribution patterns among the different islands, as indicated in the study of BACKUS et al. (1977) on myctophids, who drew a line of zoogeographic separation of the Northern North African

Subtropical Province from the Southern North African Subtropical Province between the two easternmost islands Lanzarote and Fuerteventura and the other five islands of the Canarian archipelago. More recently, ZELCK and KLEIN (1995), in a study of the spatial distribution of the lanternfish *Ceratoscopelus maderensis* (LOWE 1839) off NW Africa, reported a distributional gap in the east of the Canary Islands. They explained this finding by the lack of influence of Mediterranean water with which this species had been observed to be usually associated.

In the present study on epi- and mesopelagic fishes, acoustic data and SST-images collected during a cruise financed by the Viceconsejería de Pesca, Consejería de Agricultura Pesca y Alimentación del Gobierno de Canarias in April 1997, we examined the following questions in particular: (1) Which fish species are the major components of the deep scattering layer and to which extent do they show diurnal vertical migrations? (2) Where and at which abundance do young chub mackerels, an important food resource for tuna accumulate and what are the possible implications for a proper management of this species? (3) Are there any indications of trophic and/or spatial relationships between migratory mesopelagic organisms and epipelagic fishes? (4) Can any further evidence be gathered for the zoogeographic distribution patterns described in earlier studies and to which extent can the distribution of mesopelagic fishes be related to specific hydrological conditions? For this latter purpose two sampling localities of particular ecological interest were included in this cruise: an eddy in the SW off Gran Canaria (HERNANDEZ LEON 1991, ARÍSTIGUI et al. 1994) and an area of possible local upwelling activity in the SE off Fuerteventura (UIBLEIN et al. 1998).

2. MATERIAL AND METHODS

Cruise "La Bocaina 04/97" was carried out from 3 to 12 April 1997. The distance covered was 730 nm. The course of the cruise included a circumnavigation of the islands Lanzarote, Fuerteventura, and Gran Canaria and an eddy SW off Gran Canaria. Fig. 1 shows an overview map of the course with the sampling stations. The zig-zag pattern allowed to investigate a wide area of the shelf with acoustic methods. The research vessel used in this cruise B/E "La Bocaina" (Fig. 2) belongs to the Canarian government and is based at the port of Arrecife, Lanzarote. It has the following characteristics: 29.7 m length, 8 m width, 3.1 m draught, 205 tons registered brutto weight, and the principal motor equipped with 705 H.P. at 1200 r/min.

2.1. Fish sampling

For the fishing operations a comercial trawl was used. The dimensions of the net are shown in Fig. 3. Fourteen trawl tows were performed between the surface and 700 m depth above different bottom depths and during different day- or nighttimes. The duration of the trawl tows which started after the descend and ended before the hauling-in operation was approximately one hour. The characteristics of all fishing operations are shown in Table 1.

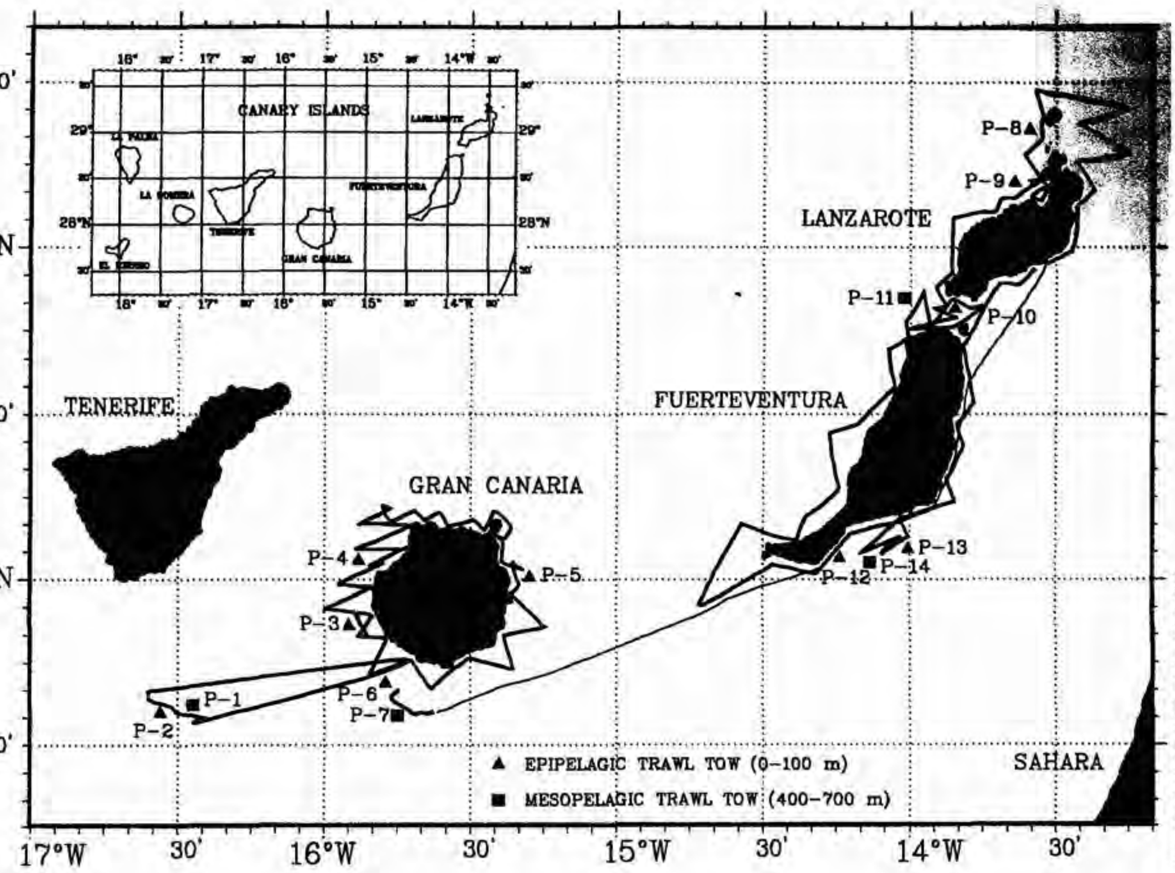


Fig. 1. Overview map of the course of the cruise.

Fig. 2. B/E "La Bocaina".

Table 1. Characteristics of the trawl hauls plus catch per unit effort (CPUE, in kg/h) for the fishes collected.

Tow	Date	Time (h)	Initial position		Final position		Mean	Bottom depth	Number	Weight	CPUE
1	03. Apr 97	18:37-19:37	27°34.6'N	16°26.4'W	27°35.3'N	16°30.7'W	538 m	1258 m	935	667.5	0.78
2	03. Apr 97	21:10-22:00	27°36.5'N	16°31.4'W	27°37.9'N	16°36.3'W	23 m	3400 m	135	149.5	0.18
3	05. Apr 97	13:52-15:00	27°53.3'N	15°53.7'W	27°49.9'N	15°51.4'W	89 m	94 m	0	-	-
4	05. Apr 97	20:35-20:55	28°02.3'N	15°49.8'W	28°04.3'N	15°46.5'W	64 m	79 m	0	-	-
5	07. Apr 97	10:51-11:36	28°02.6'N	15°21.5'W	27°59.6'N	15°20.2'W	40 m	93 m	0	-	-
6	07. Apr 97	23:54-01:35	27°43.7'N	15°46.9'W	27°41.8'N	15°44.5'W	75 m	98 m	219	24007	14.29
7	08. Apr 97	03:00-03:51	27°38.6'N	15°45.9'W	27°36.8'N	15°42.4'W	522 m	986 m	37	169.2	0.21
8	10. Apr 97	05:11-06:05	29°23.3'N	13°32.7'W	29°19.2'N	13°32.9'W	57 m	295 m	102	1517.3	1.67
9	11. Apr 97	10:45-11:50	29°11.9'N	13°33.5'W	29°09.4'N	13°37.6'W	41 m	88 m	0	-	-
10	11. Apr 97	04:57-05:55	28°50.3'N	13°52.2'W	28°47.1'N	13°54.6'W	44 m	115 m	81	1478	1.48
11	11. Apr 97	07:41-08:40	28°51.8'N	13°57.0'W	28°47.2'N	14°00.4'W	624 m	1258 m	195	255.5	0.24
12	12. Apr 97	00:42-01:35	28°08.2'N	14°12.7'W	28°05.2'N	14°15.4'W	36 m	187 m	14	854.7	0.93
13	12. Apr 97	04:42-05:40	28°08.2'N	14°01.2'W	28°06.3'N	14°04.7'W	75 m	1120 m	128	405.7	0.33
14	12. Apr 97	07:48-08:44	28°08.2'N	14°02.2'W	28°06.0'N	14°07.7'W	520 m	1156 m	320	157.1	0.14

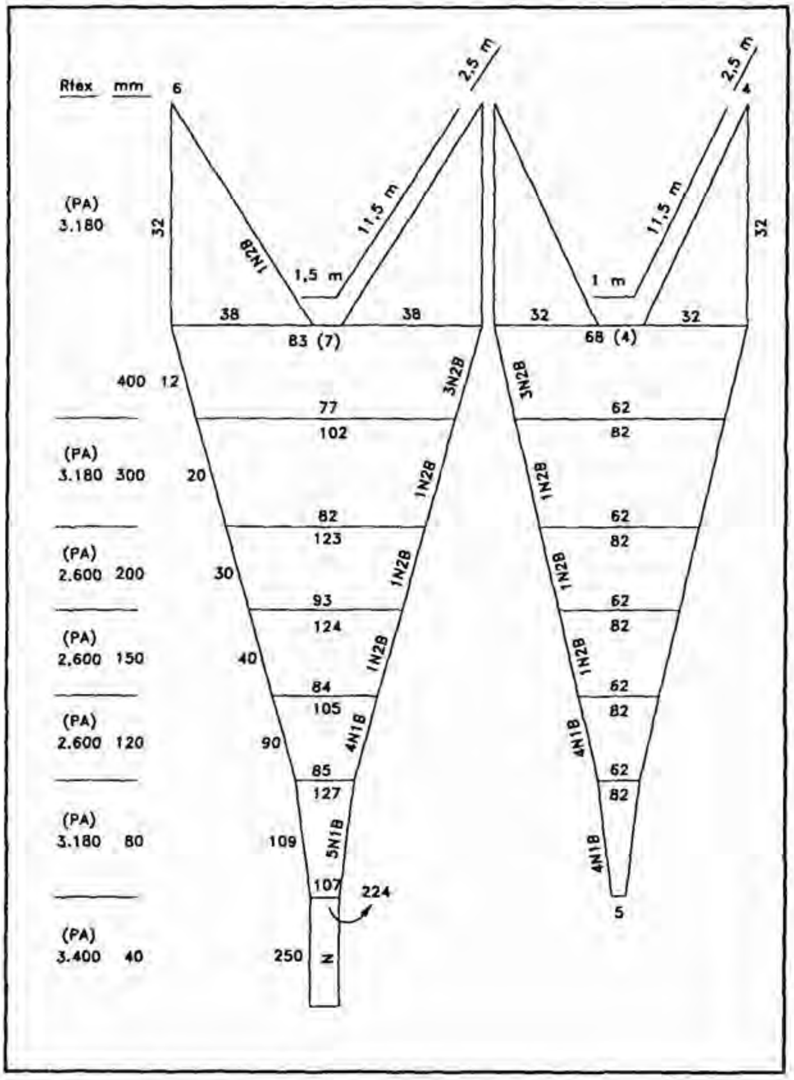


Fig. 3. Dimensions of the net used.

All tows were performed at a speed between 2.4 and 4.1 knots in a distinct depth stratum either between the surface and 100 m or between 400 and 700 m (Figs. 1,4, 5). A netsounder positioned at the mouth of the net during all operations allowed to control the position of the net (Fig. 6). As no opening-closing mechanism was used, the net sounder also served to assure that the aperture of the net was minimal during the descend and ascend of the trawl. The best results in this respect were accomplished by keeping the net in a vertical position during lowering and by folding of the net through an increase of the speed immediately followed by a stopping of the ship, before the hauling-in operation was started. During the towing of the gear, it was repeatedly necessary to adjust the speed of the vessel to keep the net in a distinct depth stratum. To illustrate this, the vertical pathways of two trawl tows and the speed of the vessel are shown in Fig. 5.

Length and weight of the collected fishes were determined. The size measures of common epipelagic fishes such as chub mackerel, round sardinella, *Sardinella aurita* VALENCIENNES 1847, and horse mackerel, *Trachurus picturatus* (T.E. BOWDICH 1825) were carried out on bord immediately after capture. To compare the length distribution among different trawl tows, statistical comparisons of different size classes were performed using G-test with subsequent multiple comparisons (SOKAL and ROHLF 1981).

The mesopelagic fishes were conserved in ethanol for later use in DNA studies. Species identification was based on the following literature: BIGELOW et al. 1964, NAFPAKTITIS et al. 1977, POST 1973, NIELSEN and SMITH 1978, HULLEY 1981, WHITEHEAD et al. 1984-86, MIYA 1994, NELSON 1994, ESCHMEYER 1998.

The stomach and gut contents of several specimens of young chub mackerel were examined. For this diet analysis, the entire digestive tract was removed and dissected. Diet items were assigned to one of several food categories including copepod crustaceans, decapod and bivalve larvae, and fish remains. Non-digested bottom material (e.g., sand grains and large pennate diatoms) was also noted when it occurred.

2.2. Acoustic survey

The acoustic survey covered a total of 2404 nm^2. To obtain proper estimates of fish and plankton densities in this area, a SIMRAD EK-500 split beam acoustic system was used. It was connected to a SUN SPARC 10 station (Fig. 6) into which the acoustic data were entered together with the position and velocity data from a GPS MLR 03 plotter. These data were then processed for each navigated mile. The area was divided into sectors in order to estimate the abundance in homogeneous subareas for each island (north, east, south and west) and these sectors were then subdivided into three subareas with respect to bottom depth. The first subarea ranged from [illegible] bottom depth (shelf), the second from 100 to 500 m (upper slope), and the third from 500 to 1000 m (mid slope).

The total echo density, i.e., the area backscattered (coefficient S_A, see below), expressed in m^2 per nm^2, was split into four different values according to the collecting results of the trawl tows and the type of echoes in the echograms. After further filtering of the echoes and extractions of disturbances and false echos from the bottom, four different types of signals could be distinguished which best correspond with the following groups of organisms: pelagic fishes, epibenthic fishes, benthic fishes, and plankton.

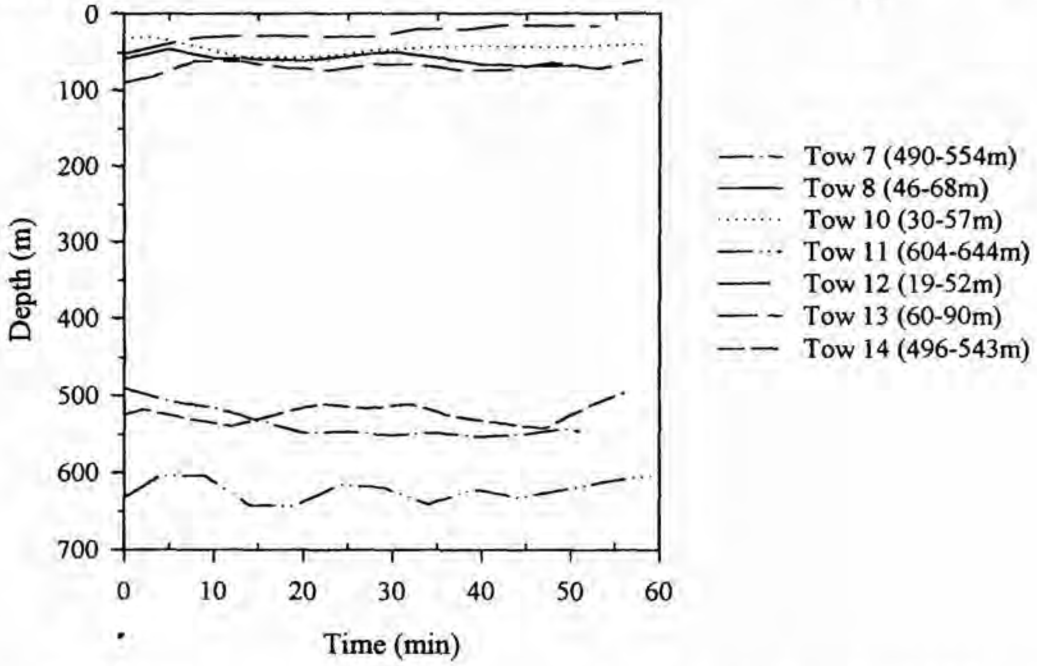


Fig. 4. Pathways of several trawl tows in the epipelagial (0-100 m) and the mesopelagial (400 - 700 m).

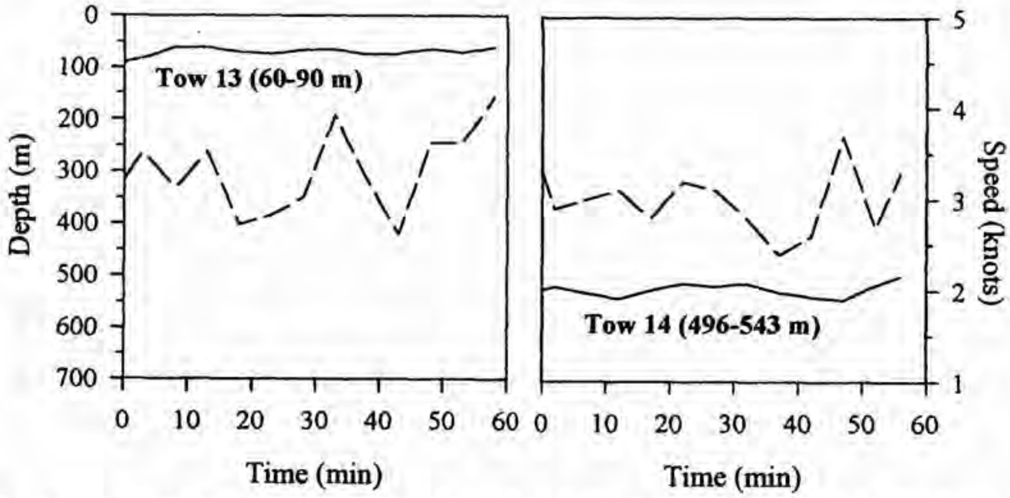


Fig. 5. Pathways of trawl tows nr. 13 and 14 with towing speed (broken lines) indicated.

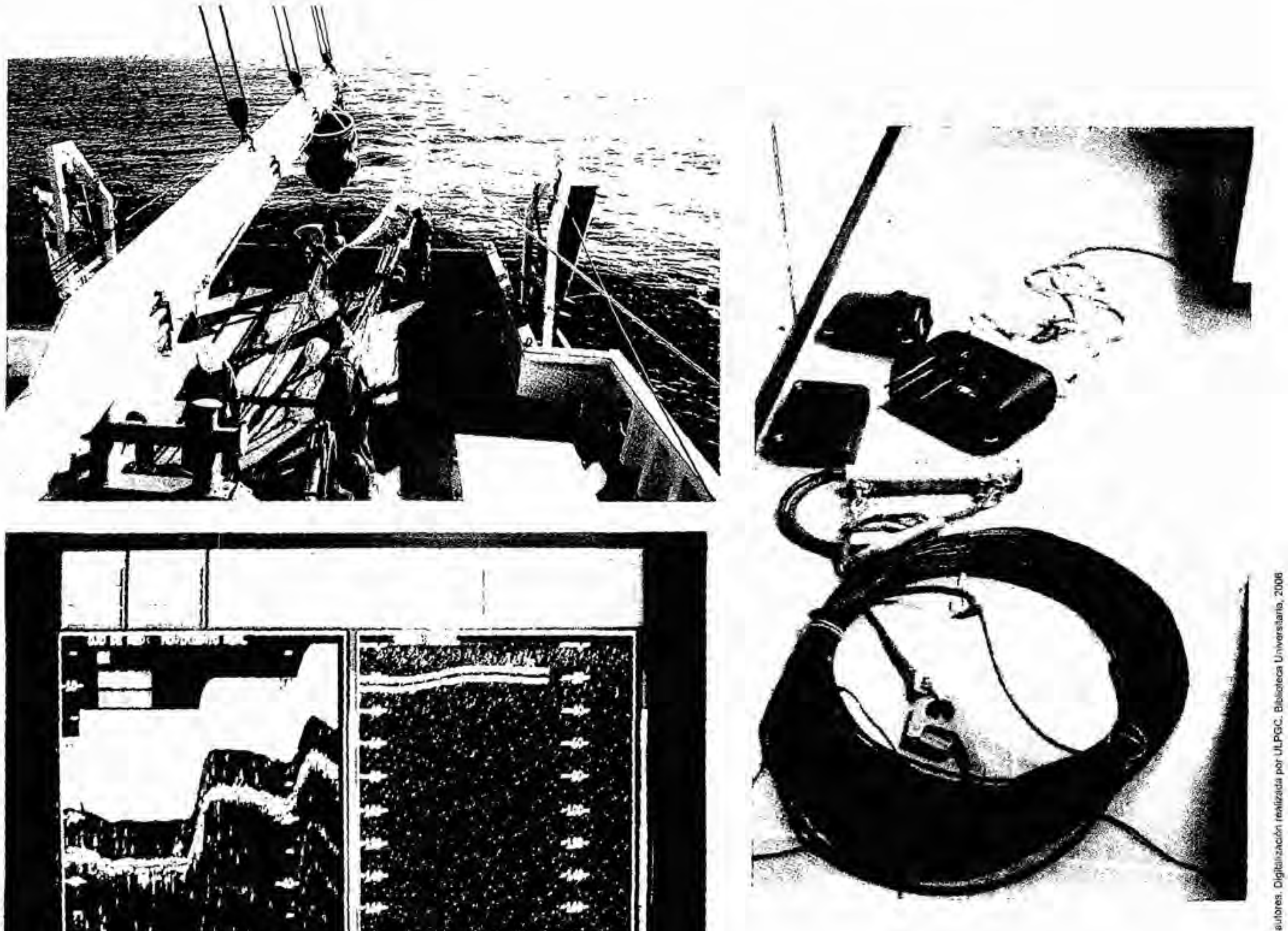


Fig. 6. Top: Photos of a trawling operation, the net sounder, and the image of the net sounder produced on a monitor located at the bridge of "La Bocaina". Bottom: Echointegration system with the SUN SPARC station for acoustic data processing.

The software BEI (Bergen Echo Integrator, KNUDSEN 1990) was used to partition the integration data into groups by separating echo recordings horizontally and vertically. Fig. 7 shows two examples of the working sheets produced. For the calculation of abundance of pelagic fishes the model described by DALEN and NAKEN (1983) was adopted. To relate the target strength (*TS*) to fish length (*L*), the equation $TS=20logL-71.2$ (ICES Planning Group CM 1982/H4) was used. The corresponding conversion factor for the calculation of the number of fish was $C_F=1.05*10^6*L^{-2}$. The number of fish in each length frequency group in an area was derived from the formula: $N_i=S_A*A*P_i/_i(P_i/C_{Fi})$, where:

N_i : number of fish in length group i
S_A : mean integrator value in the area
A : area in nm^2
P_i : proportion of fish in length group i in samples from the area
C_{Fi}: fish conversion factor for length group i

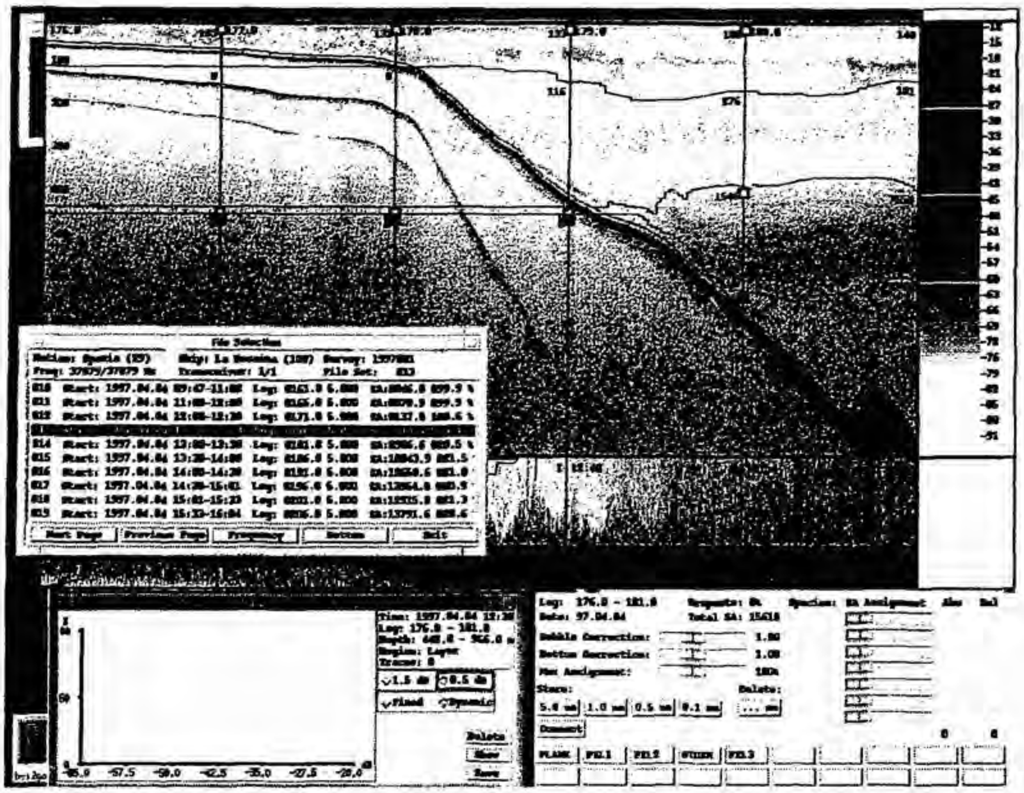
The echosounder was calibrated to provide an echo of -33.7 dB for a 60 mm copper sphere (FOOTE 1982), using the computer program LOBE (SIMRAD 1992). The respective values are shown in Fig. 8. The results of the calibration performed one day before the cruise started, are shown in Table 2.

Table 2. Calibration data for the SIMRAD EK-500 echosounder used in the acoustic survey.

CALIBRATION REPORT EK-500

VESSEL: "La Bocaina" DATE: 2/April/1997
PLACE: Arguineguín. Gran Canaria BOTTOM DEPTH: 25.4 m
SEA TEMP.: 20.6° C SALINITY: 36.3 %
SOUND VELOCITY: 1523 m/seg

Frequency	38 kHz
Absorption coeff.	10 dB//km
Transducer type	ES38B
Angle sensivity	21.9/21.9
Transmission power	NORMAL
Max. Power	2000 w
Pulse duration	MEDIUM
Band width	WIDE
TS of sphere	-33.7 dB
TS transducer gain	26.0 dB
Calibr. TS transducer gain	27.8 dB
Calibrated TS	-33.7 dB
Depth to sphere	13.8 m
Theoretical Sa	12701 m^2/nm^2
Calibrated Sa	12081 m^2/nm^2
Calibrated Sv transd. gain	27.4 dB



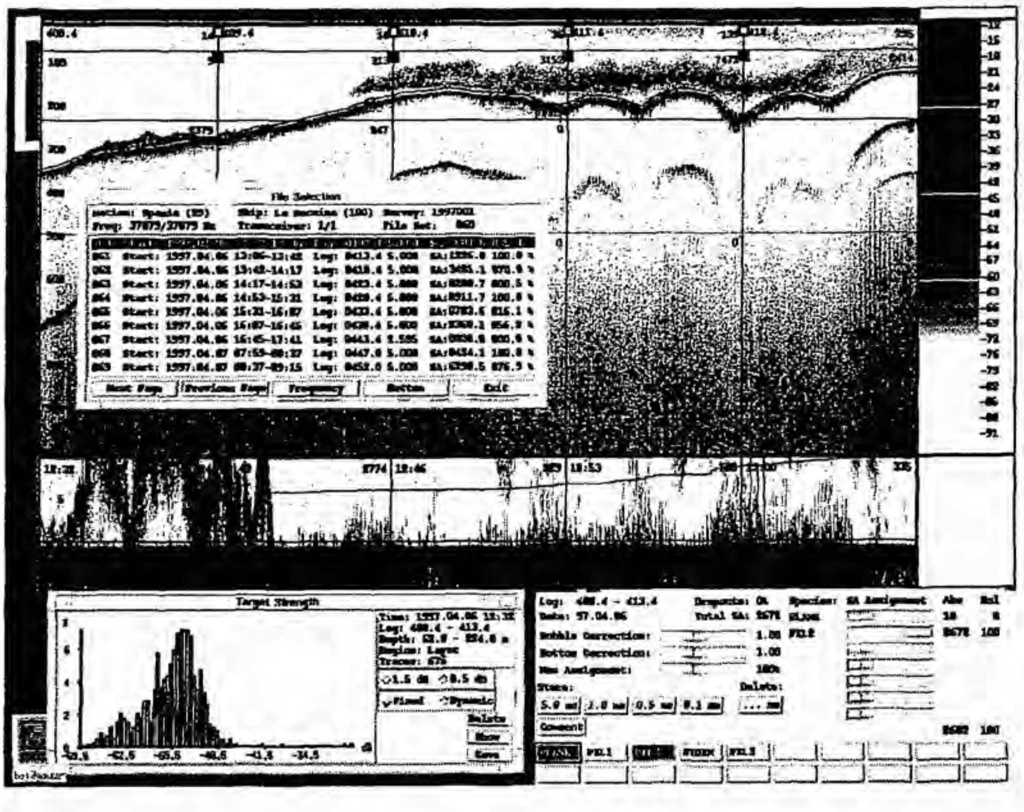
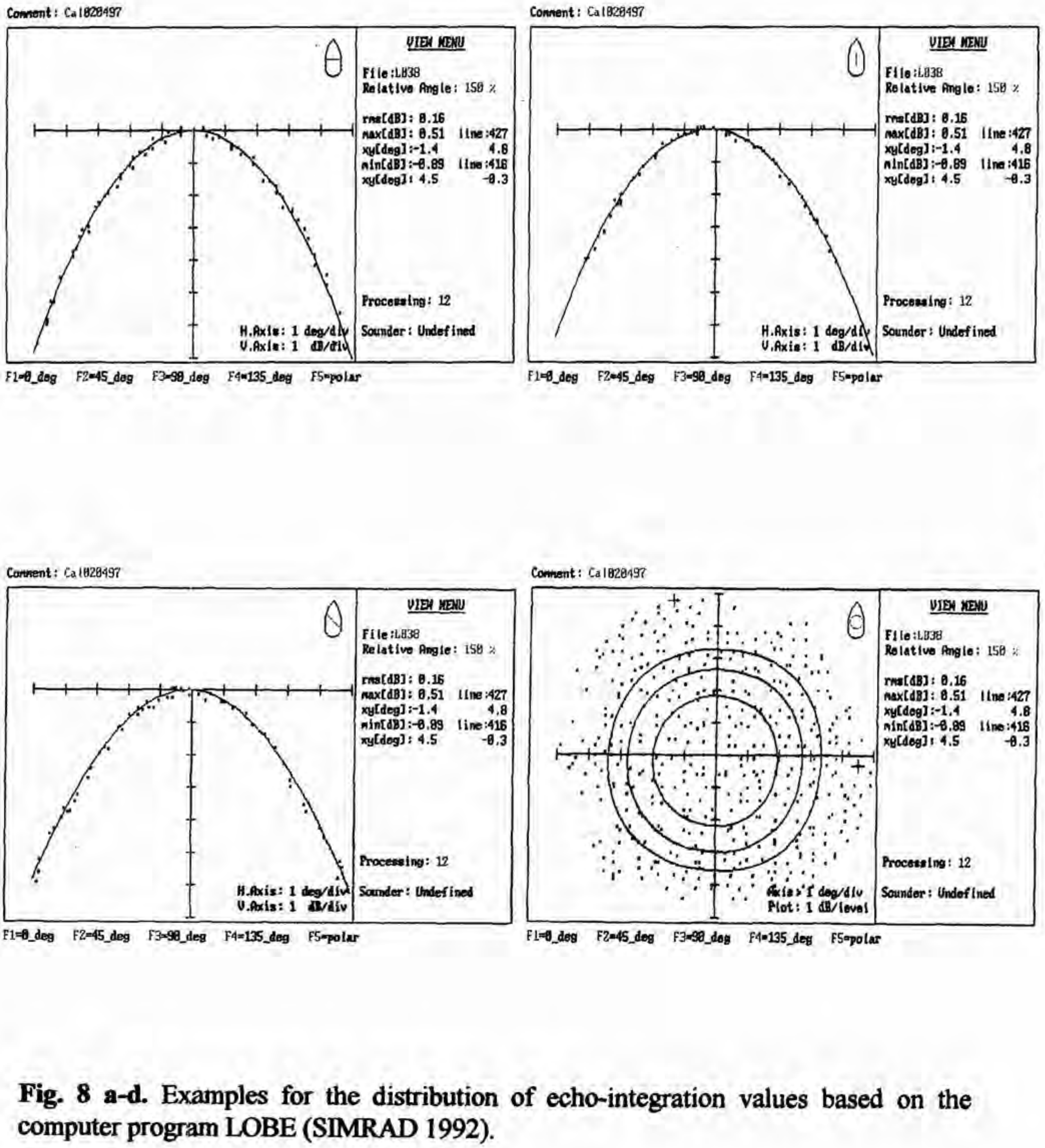


Fig.7. Two examples of the working sheets produced for the processing of acoustic data.



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Comment: Cal020497

VIEW MENU
File:L038
Relative Angle: 150 %

rms[dB]: 0.16
max[dB]: 0.51   line:427
xy[deg]:-1.4         4.8
min[dB]:-0.89   line:416
xy[deg]: 4.5        -0.3

Processing: 12

Sounder: Undefined

H.Axis: 1 deg/div
V.Axis: 1  dB/div

F1=0_deg   F2=45_deg   F3=90_deg   F4=135_deg   F5=polar
```

```
Comment: Cal020497

VIEW MENU
File:L038
Relative Angle: 150 %

rms[dB]: 0.16
max[dB]: 0.51   line:427
xy[deg]:-1.4         4.8
min[dB]:-0.89   line:416
xy[deg]: 4.5        -0.3

Processing: 12

Sounder: Undefined

H.Axis: 1 deg/div
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F1=0_deg   F2=45_deg   F3=90_deg   F4=135_deg   F5=polar
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Processing: 12

Sounder: Undefined

H.Axis: 1 deg/div
V.Axis: 1  dB/div

F1=0_deg   F2=45_deg   F3=90_deg   F4=135_deg   F5=polar
```

```
Comment: Cal020497

VIEW MENU
File:L038
Relative Angle: 150 %

rms[dB]: 0.16
max[dB]: 0.51   line:427
xy[deg]:-1.4         4.8
min[dB]:-0.89   line:416
xy[deg]: 4.5        -0.3

Processing: 12

Sounder: Undefined

Axis: 1 deg/div
Plot: 1 dB/level

F1=0_deg   F2=45_deg   F3=90_deg   F4=135_deg   F5=polar
```

Fig. 8 a-d. Examples for the distribution of echo-integration values based on the computer program LOBE (SIMRAD 1992).

2.3. Satellite data

For the period of the cruise and the remaining days of April 1997, satellite imagery of Advanced Very High Resolution Radiometer (AVHRR/NOAA) was received from a ground station (UTIS-ULPGC) and processed. Radiance values of channels 4 (10.5-11.3 nm) and 5 (11.5-12.5 nm) were converted to sea-surface temperatures and corrected for atmospheric effects using a multichannel algorithm. SST maps were then geometrically corrected using orbital parameters and fixed points on the ground and completed with a legend.

3. RESULTS

3.1. Fish samples

Ten of the 14 trawl tows were successful and resulted in capture of fishes. All four unsuccessful tows were carried during daylight or in the early evening near the surface and above the shelf. The catch per unit effort (CPUE; in kg fish per trawling hour) of each successful trawling operation is shown in Table 1. Total 2166 individuals belonging to 81 species, 53 genera and 28 families were collected. A complete list of the species collected is provided in Table 3. Photos of selected species are shown in the Appendix on Plates I-IV.

Apart from epipelagic fishes, a large number of mesopelagic fishes as well as juveniles of the benthopelagic trichiurids *Lepidopus caudatus* and *Aphanopus intermedius* and the epibenthic *Capros aper* were caught. With exception of *Bathylagus*, a small syngnathid specimen, and the leptocephali, all species could be accurately determined. Several pelagic invertebrates were also collected including pyrosomid tunicates, several crustaceans, one mollusc and 13 cephalopod species (cf. BORDES et al. 1997).

Three different types of trawl tows with clearly distinguishable trawling and bottom depth were performed: neritic epipelagic tows (20-100 m) above shallow bottoms (90 - 300 m), oceanic epipelagic tows above deep bottoms (> 950 m), and mesopelagic tows (400 - 700 m) above bottoms of more than 950 m depth. Quite different results were gained with respect to these three tow types: neritic epipelagic tows resulted in the capture of mainly epipelagic fishes of the families Carangidae and Scombridae (Tab. 4) with chub mackerel being the most abundant species (Tab. 5). A few clupeids, myctophids, one serrivomerid, and one juvenile trichiurid, *Lepidopus caudatus*, were also collected.

The two oceanic epipelagic tows were performed during night and resulted in capture of both epi- and mesopelagic fishes of several families, partly at high abundances (Tab. 4). The most abundant myctophids were *Ceratoscopelus warm*[illegible] and *Lampanyctus alatus* (Table 5).

Table 3. List of the families and species collected during cruise "La Bocaina 0497" indicating tow number, number of individuals (n), and standard length (SL)

Family or Order	Species	Tow nr.	n	SL (mm)
Nemichthyidae	*Nemichthys curvirostris* (STRÖMMAN 1896)	2, 11, 13, 14	7	274-788
	Nemichthys scolopaceus RICHARDSON 1848	14	1	206
Serrivomeridae	*Serrivomer beani* GILL and RYDER 1884	1, 2, 11, 12, 14	52	133-388
Clupeidae	*Sardinella aurita* VALENCIENNES 1847	12, 13	9	161-222
Bathylagidae	*Bathylagus* sp.	2, 11	3	31-56
Gonostomatidae	*Cyclothone braueri* JESPERSEN and TÅNING 1926	1, 11, 14	543	12-28
	Cyclothone pallida BRAUER 1902	11	1	28
	Cyclothone pseudopallida MUKHACHEVA 1964	1, 11	41	20-33
	Diplophos taenia GÜNTHER 1873	1	3	88-107
	Gonostoma denudatum RAFINESQUE 1810	1,11, 13	7	22-120
	Gonostoma elongatum GÜNTHER 1878	1, 2, 7, 11, 14	258	17-115
	Margrethia obtusirostra JESPERSEN and TÅNING 1919	1	1	47
Sternoptychidae	*Argyropelecus aculeatus* VALENCIENNES 1850	1, 7, 11	5	53-74
	Argyropelecus gigas NORMAN 1930	1	4	64-111
	Argyropelecus hemigymnus COCCO 1829	1, 7, 11, 14	28	17-33
	Argyropelecus olfersi CUVIER 1829	14	1	18
	Sternoptyx diaphana HERMANN 1781	7	1	27
Phosichthyidae	*Vinciguerria nimbaria* (JORDAN and WILLIAMS 1895)	2, 13	5	24-33
Stomiidae (Astronesthinae)	*Astronesthes gemmifer* GOODE and BEAN 1896	1, 13, 14	7	26-65
	Astronesthes indicus BRAUER 1902	1	2	26-30
	Astronesthes macropogon GOODYEAR and GIBBS 1970	1	1	32
	Astronesthes micropogon GOODYEAR and GIBBS 1970	1	3	21-38
	Astronesthes neopogon REGAN and TREWAVAS 1929	13	1	73
	Rhadinesthes decimus (ZUGMAYER 1911)	11	1	46
Stomiidae (Stomiinae)	*Chauliodus danae* REGAN and TREWAVAS 1929	1, 2, 7, 11, 13, 14	57	45-132
	Chauliodus sloani BLOCH and SCHNEIDER 1801	7, 11, 14	13	46-238
	Stomias boa (RISSO 1810)	1, 2, 7, 11, 13, 14	138	26-230
Stomiidae (Melanostomiinae)	*Bathophilus vaillanti* (ZUGMAYER 1911)	1, 7, 14	7	83-126
	Chirostomias pliopterus REGAN and TREWAVAS 1930	1, 14	4	39-54
	Eustomias obscurus VAILLANT 1884	2, 7, 13	13	124-214
	Eustomias tetranema ZUGMAYER 1913	11	2	126
	Flagellostomias boureei (ZUGMAYER 1913)	11	1	70
	Grammatostomias flagellibarba HOLT and BRYNE 1910	11	1	97
	Leptostomias gladiator (ZUGMAYER 1911)	14	1	143
	Melanostomias biseriatus REGAN and TREWAVAS 1930	1, 14	2	64-84
	Melanostomias tentaculatus (REGAN and TREWAVAS 1930)	1, 7, 14	7	62-138
	Photonectes braueri (ZUGMAYER 1913)	1	1	37
Stomiidae (Idiacanthinae)	*Idiacanthus fasciola* PETERS 1877	1, 7, 11, 13, 14	90	41-276
Stomiidae (Malacosteinae)	*Aristostomias lunifer* REGAN and TREWAVAS 1930	1	1	72
	Photostomias guernei COLLETT 1889	1, 7, 11, 14	106	31-118
Notosudidae	*Ahliesaurus berryi* BERTELSEN, KREFT and MARSHALL 1976	1	2	36-38
	Scopelosaurus argenteus (MAUL 1954)	1	3	32-39
Paralepididae	*Macroparalepis nigra* (MAUL 1965)	2	1	172
Myctophidae	*Benthosema suborbitale* (GILBERT 1913)	1, 2	2	28,4
	Bolinichthys indicus (NAFPAKTITIS and NAFPAKTITIS 1969)	1	2	36 - 38,9
	Ceratoscopelus maderensis (LOWE 1839)	2, 8, 13	11	52 - 58
	Ceratoscopelus warmingii (LÜTKEN 1892)	2, 7, 13	42	24 - 62
	Diaphus adenomus GILBERT 1905	11	1	104
	Diaphus metopoclampus (COCCO 1829)	1, 14	39	53 - 78
	Diaphus mollis TÅNING 1928	2	3	39 - 46
	Diaphus perspicillatus (OGILBY 1898)	14, 2	8	48 - 58
	Diaphus rafinesquii (COCCO 1838)	1, 7, 11, 14	19	60 - 83
	Hygophum benoiti (COCCO 1838)	2	1	44
	Hygophum hygomi (LÜTKEN 1892)	1, 2, 13	13	29 - 63
	Hygophum reinhardti (LÜTKEN 1892)	2	1	45
	Lampadena urophaos atlantica MAUL 1969	1, 14	4	92 - 125
	Lampanyctus alatus GOODE and BEAN 1896	1, 7, 13, 14	48	19 - 51
	Lampanyctus ater TÅNING 1928	11, 14	4	25 - 57
	Lampanyctus festivus TÅNING 1928	11	1	63
	Lampanyctus lineatus TÅNING 1928	11	1	41
	Lampanyctus photonotus PARR 1928	13, 14	4	21 - 62
	Lampanyctus pusillus (JOHNSON 1890)	1, 13, 14	7	25 - 35
	Lepidophanes gaussi (BRAUER 1906)	1, 2, 11	19	20 - 42
	Lobianchia dofleini (ZUGMAYER 1911)	1, 2, 13	13	22 - 58
	Lobianchia gemellarii (COCCO 1838)	1, 7, 11, 14	5	50 - 76
	Notolychnus valdiviae (BRAUER 1904)	11	1	22
	Notoscopelus caudispinosus (JOHNSON 1863)	2	1	31
	Notoscopelus resplendens (RICHARDSON 1845)	2, 8, 13	11	27 - 75
	Symbolophorus veranyi (MOREAU 1888)	13	1	96
Melanocetidae	*Melanocetus johnsoni* GÜNTHER 1864	7	1	44
Diretmidae	*Diretmus argenteus* JOHNSON 1864	1, 7	2	63-67
Caproidae	*Capros aper* (LINNAEUS 1758)	1, 11	3	24-29
Syngnathidae	? *Syngnathus* sp.	13	1	77
Carangidae	*Trachurus picturatus* (T.E. BOWDICH 1825)	6, 8	13	210-280
Gempylidae	*Diplospinus multistriatus* MAUL 1948	1, 14	2	101-161
Trichiuridae	*Aphanopus intermedius* PARIN 1983	1	1	154
Trichiuridae	*Lepidopus caudatus* (EUPHRASEN 1788)	12	1	70
Scombridae	*Scomber japonicus* HOUTTUYN 1782	6, 8, 10, 12, 13	417	72-318
Anguilliformes	various genera	1, 2	28	33-194
	Total		2166	

With tow 13 a considerable number of young chub mackerels and one round sardinella were collected, too (Tab. 5). With tow 2, which was located in the area of the eddy, several leptocephali were collected.

The mesopelagic tows resulted in capture of high numbers of mesopelagic fishes. The most numerous mesopelagic species collected was *Cyclothone braueri*, followed by *Gonostoma elongatum*, both belonging to the family Gonostomatidae (Tab. 4, 5). Quite abundant were also the stomiids *Stomias boa*, *Idiacanthus fasciola*, *Photostomias guernei*, and *Chauliodus danae*. Among the myctophids, *Diaphus metapoclampus* and *D. rafinesquii* occurred most frequently. Quite common were also serrivomerid eels of the species *Serrivomer beani* and the sternoptychid *Argyropelecus hemigymnus*. In the area of the eddy (tow 1), several leptocephali occured together with a juvenile of the benthopelagic trichiurid *Aphanopus intermedius* and two small juveniles of *Capros aper*.

The length distribution of 368 chub mackerel, the most common epipelagic species in the samples, is shown in Fig. 9a. While in tow 6 mainly adult specimens were collected, only juveniles occurred in the other tows. There were significant differences in size distribution of chub mackerel between tow 6 and all other tows ($G=538.3$, $df=48$, $p<0.001$). Furthermore, specimens caught by tow 13 were significantly smaller than those caught by tow 8 and 10, repectively ($G=132.6$, $df=12$, $p<0.001$). The specimens caught with tow 12 ($n=4$; 107-125 mm TL) were excluded from this analysis due to the small sample size. The length-weight relationship of 365 mackerels caught by tows 6, 8, 10, 12, and 13 is shown in Fig. 9b.

Table 4. Results of each trawl tow with the number of individuals of each family indicated. The three different types of trawl tows, neritic epipelagic, oceanic epipelagic, and oceanic mesopelagic are shown separated with further indications of time of day, towing depth range and bottom depth range.

Tow nr.	6	8	10	12	2	13	1	7	11	14
Time of day	N	N	N	N	N	N	D	N	D	D
Towing depth	20-100 m						400-700 m			
Bottom depth	90-300 m				950-3400 m					
Nemichthvidae					1	2			2	3
Serrivomeridae				1	6		40		3	2
Clupeidae				8		1				
Bathylagidae					2				1	
Gonostomatidae					4	4	534	3	79	230
Sternoptychidae							10	14	2	13
Phosichthyidae					1	4				
Stomiidae					20	15	262	14	98	50
Notosudidae							5			
Paralepididae					1					
Myctophidae		5			85	72	66	4	9	21
Melanocetidae								1		
Diretmidae							1	1		
Caproidae							2		1	
Syngnathidae						1				
Carangidae	12	1								
Gempylidae							1			1
Trichiuridae				1			1			
Scombridae	207	96	81	4		29				
Anguilliformes					15		13			
Total	219	102	81	14	135	128	935	37	195	320

Table 5. Species collected ordered according to trawl tow type and ecological group (I=epipelagic species, II=mesopelagic species, III=juveniles of benthopelagic species).

	Tow nr.	6	8	10	12	2	13	1	7	11	14
	Time of day	N	N	N	N	N	N	D	N	D	D
	Towing depth	20 - 100 m						400 - 700m			
	Bottom depth	90 - 300 m				950 - 3400 m					
I	*Sardinella aurita*										
	Trachurus picturatus	12	1								
	Scomber japonicus	207	96	81	4		29				
II	*Nemichthys curvirostris*					1	2			2	2
	Nemichthys scolopaceus										1
	Serrivomer beani				1	6		40		3	2
	Bathylagus sp.					2				1	
	Cyclothone braueri							273		44	226
	Cyclothone pallida									1	
	Cyclothone pseudopallida							10		31	
	Diplophos taenia							3			
	Gonostoma denudatum						4	2		1	
	Gonostoma elongatum					4		245	3	2	4
	Margrethia obtusirostra							1			
	Argyropelecus aculeatus							2	2	1	
	Argyropelecus gigas							4			
	Argyropelecus hemigymnus							4	11	1	12
	Argyropelecus olfersi										1
	Sternoptyx diaphana								1		
	Vinciguerria nimbaria					1	4				
	Astronesthes gemmifer						2	2			3
	Astronesthes indicus							2			
	Astronesthes macropogon							1			
	Astronesthes micropogon							3			
	Astronesthes neopogon						1				
	Rhadinesthes decimus									1	
	Chauliodus danae					3	1	44	2	2	5
	Chauliodus sloani								2	8	3
	Stomias boa					7	6	104	1	10	10
	Bathophilus vaillanti							3	3		1
	Chirostomias pliopterus							3			1
	Eustomias obscurus					10	2		1		
	Eustomias tetranema									2	
	Flagellostomias boureei									1	
	Grammatostomias flagellibarba									1	
	Leptostomias gladiator										1
	Melanostomias biseriatus							1			1
	Melanostomias tentaculatus							4	1		2
	Photonectes braueri							1			
	Idiacanthus fasciola						3	65	2	12	8
	Aristostomias lunifer							1			
	Photostomias guernei							28	2	61	15
	Ahliesaurus berryi							2			
	Scopelosaurus argenteus							3			
	Macroparalepis nigra					1					
	Benthosema suborbitale					1		1			
	Bolinichthys indicus							2			
	Ceratoscopelus maderensis		3			1	7				
	Ceratoscopelus warmingii					38	3		1		
	Diaphus adenomus									1	
	Diaphus metapoclampus							37			2
	Diaphus mollis					3					
	Diaphus perspicillatus					7					1
	Diaphus rafinesquii							15	1	1	2
	Hygophum benoiti					1					
	Hygophum hygomi					11	1	1			
	Hygophum reinhardti					1					
	Lampadena urophaos atlantica							1			3
	Lampanyctus alatus						38	5	1		4
	Lampanyctus ater									2	2
	Lampanyctus festivus									1	
	Lampanyctus lineatus									1	
	Lampanyctus photonotus						3				1
	Lampanyctus pusillus						2	1			4
	Lepidophanes gaussi					17		1		1	
	Lobianchia dofleini					1	11	1			
	Lobianchia gemellarii							1	1	1	2
	Notolychnus valdiviae									1	
	Notoscopelus caudispinosus					1					
	Notoscopelus resplendens		2			3	6				
	Symbolophorus veranyi						1				
	Melanocetus johnsoni								1		
	Diretmus argenteus							1	1		
	? *Syngnathus* sp.						1				
	Diplospinus multistriatus							1			1
	Anguilliformes (Leptocephali)					15		13			
III	*Capros aper*							2		1	
	Aphanopus intermedius							1			
	Lepidopus caudatus				1						

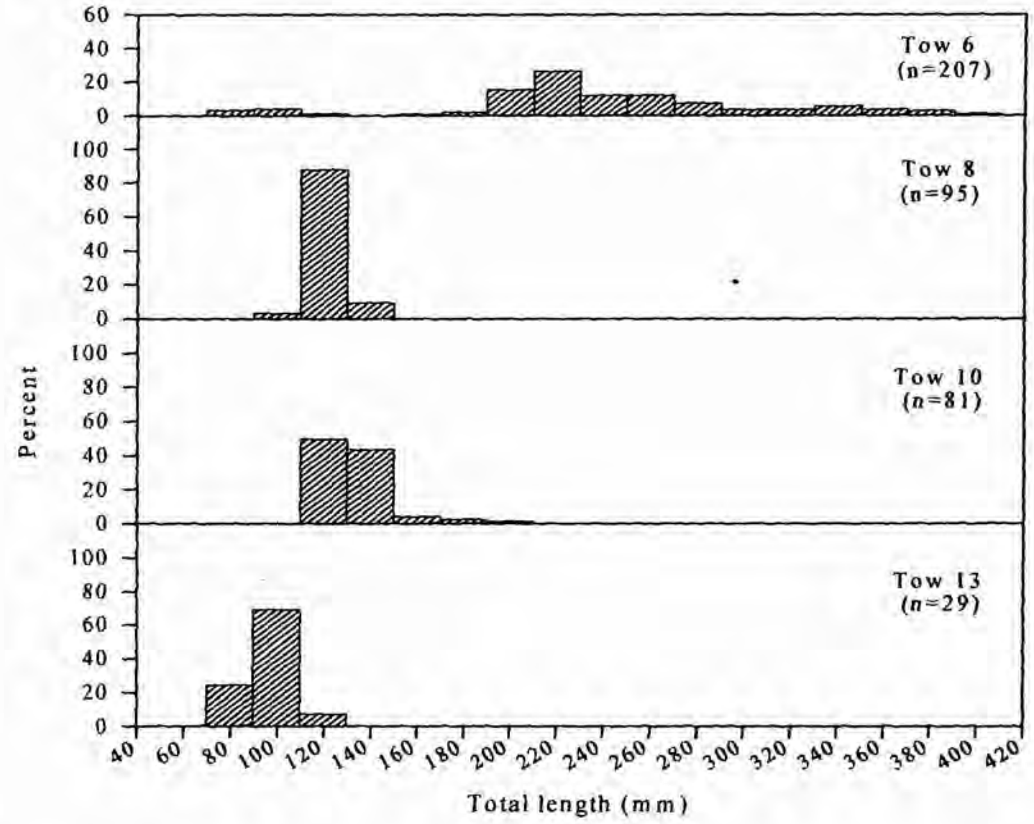

Fig. 9.a. Length distribution of chub mackerel with the tow number indicated.

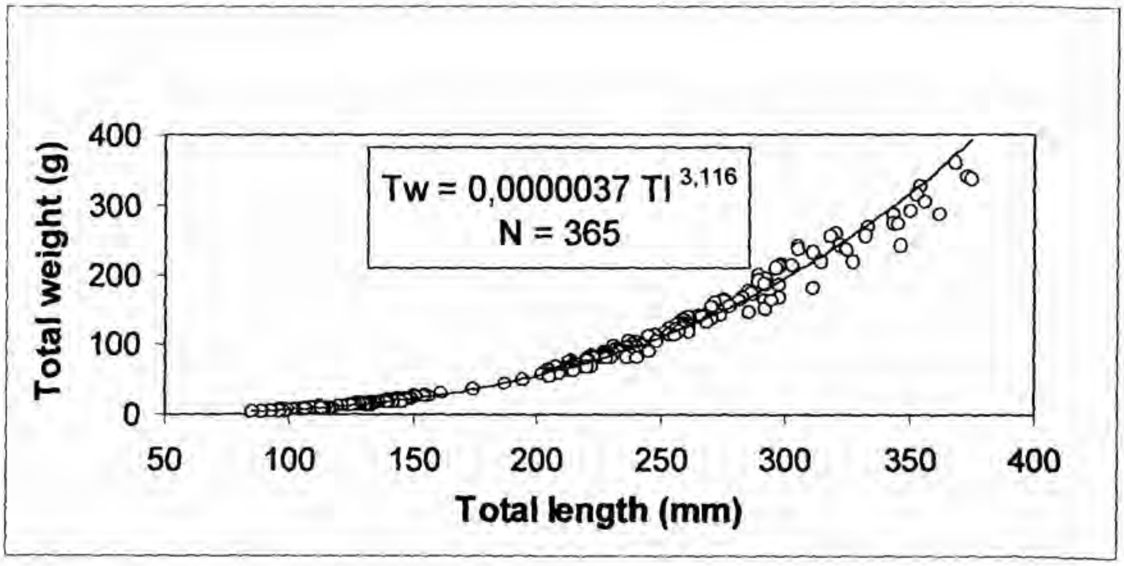

Fig. 9.b. Length-weight relationship in chub mackerel.

Among the ten juvenile chub mackerels (93-135 mm TL; four from tow 12 and six from tow 13) examined for their stomach and gut contents, five did not show any food or other remains. In the other five specimens, the stomachs were mostly empty and only the intestines were filled. The latter contained numerous prey items, among them copepods belonging to the genera *Candacia*, *Corycaeus*, *Microsetella*, *Oncaea*, and *Pleuromamma* (Appendix, Plate V). Especially *Oncaea* and *Microsetella* occurred at high frequencies of between 100 to 10000 specimens per gut. In addition, decapod and bivalve larvae, fish eggs, and - in one case - a small fish bone were found. In addition, sand grains and pennate diatoms were found in two individuals collected with tow 13. Size measures of the gut remains indicate that small copepods of a mean metasome length of about 60 microns were the dominant prey category.

3.2. Acoustic data

Estimates of the abundance and biomass of pelagic fishes calculated by the echo-integration method are provided in Table 6. For the three islands a total of 61546 tons was calculated with much higher abundance, density, and biomass values for Lanzarote and Fuerteventura. Within the shelf area (0-100 m) a high spatial variability of acoustic signal patterns occurred with particularly dense concentrations in the NW of Lanzarote, in the "La Bocaina" strait between Lanzarote and Fuerteventura, and off Puerto de Mogan in the south of Gran Canaria (Fig. 10). Two examples of echograms indicating aggregations of epipelagic and epibenthic fishes are provided in Fig. 11.

Table 6. Estimates of total abundance and biomass of pelagic fishes calculated by the echo-integration analysis.

	GRAN CANARIA	**FUERTEVENTURA**	**LANZAROTE**	**TOTAL**
Surveyed nautical miles	198	215	210	623
Covered area (0-1000 m) *(nm^2)*	626,0	949,9	826,9	2403,8
Mean integration value *(m^2/nm^2)*	55,0	486,5	282,8	302,9
Mean fish length *(cm)*	24,5	12,7	13,2	16,8
Abundance *(n° of fish)*	$55,9 \times 10^6$	$2326,3 \times 10^6$	$1658,6 \times 10^6$	$4040,8 \times 10^6$
Density *(n° of fish/ nm^2)*	$0,1 \times 10^6$	$3,2 \times 10^6$	$1,7 \times 10^6$	$1,7 \times 10^6$
Biomass *(tons)* (%)	5753 (9,35%)	30925 (50,25%)	24868 (40,41%)	61546 (100%)

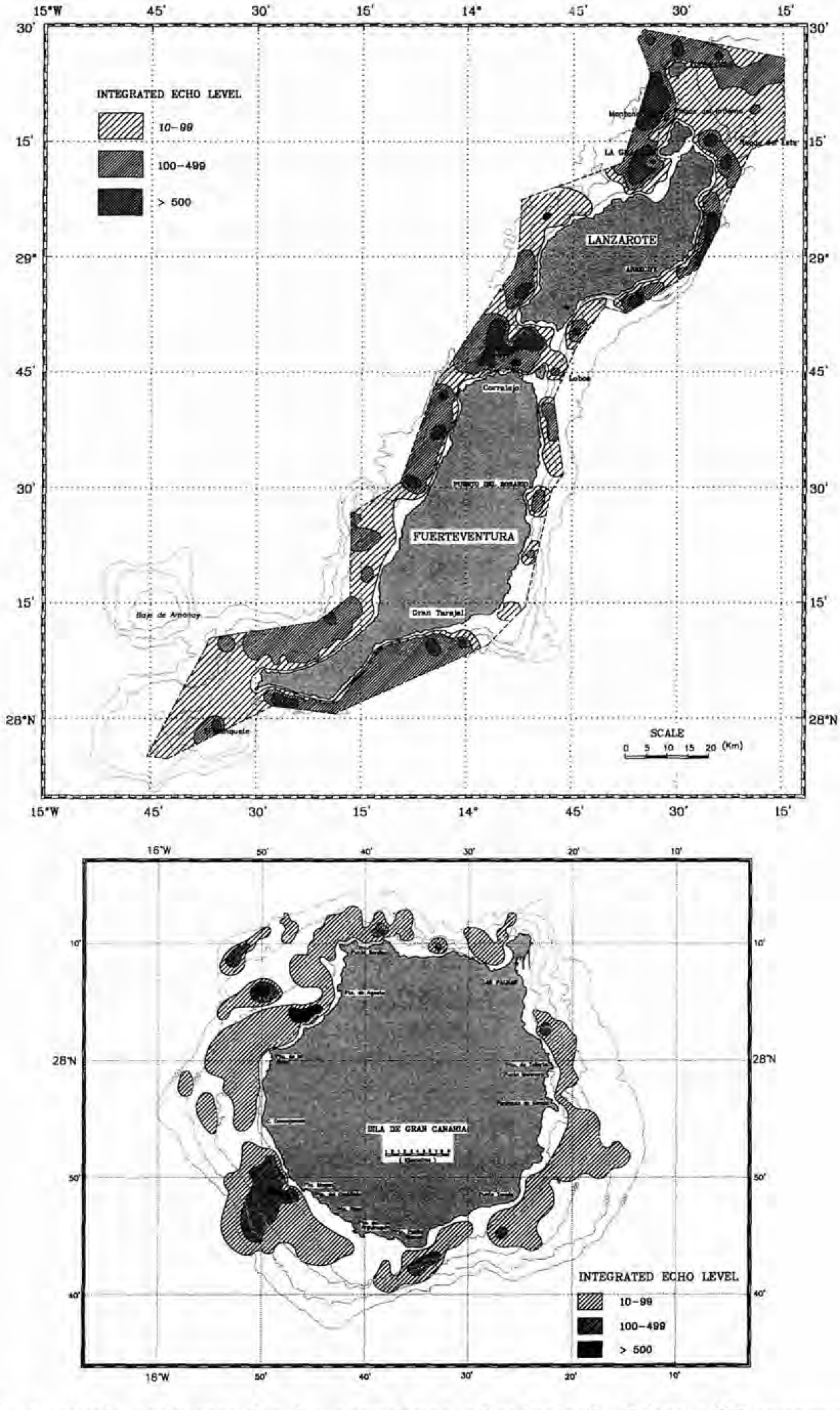

Fig. 10. Acoustic estimates for the abundance of epipelagic fishes off Lanzarote and Fuerteventura (on top), and Gran Canaria (bottom).

For the epipelagic neritic tow 6 (Fig. 12) which resulted in the capture of a considerable number of epipelagic fishes, biomass calculations with respect to chub mackerel and horse mackerel were carried out based on mean total lengths of 25.1 cm and 24.5 cm, for each of the two species, respectively. The mean integrator value during the four miles towing distance was 168 m^2/nm^2. Chub mackerel had an estimated biomass of 28.5 tons/nm^2 and a mean density of 276959 fish/nm^2 or 0.06 fish/m^2. In comparison, horse mackerel occured at a much lower density of estimated 0.003 fish/m^2.

Clear evidence for diurnal vertical migration of mesopelagic fishes comes from the results of an echogram produced during the night of 11 to 12 April and the following morning in combination with the collecting data. Parallel to this echogram tows 13 and 14 were carried out successively at the surface during late night and in midwater during the morning (see Fig. 5). The echogram gathered during and between these tows is shown in Fig. 13. In the transect carried out the contours of the shelf and slope, the nocturnal formation of the deep and shallow scattering layers at 400-700 m and at less than 150 m depth, respectively, and the downwards migration towards the deep scattering layer in the morning can be clearly recognized. The descent of the migrating mesopelagic fauna started with the sunrise at about 6:30 a.m. just after tow 13 had been hauled in. Tow 14 started at 7:48 a.m. when the descending process was already considerably advanced. One nemichthyid (*Nemichthys curvirostris*), four stomiids (*Astronesthes gemmifer*, *Chauliodus danae*, *Stomias boa*, *Idiacanthus fasciola*), and three myctophid species (*Lampanyctus alatus*, *L. photonotus*, *L. pusillus*) co-occurred in the collections of both tows (Table 5).

3.3. SST images

Sea-surface temperature (SST) images taken during the cruise from 7th to 12th April and immediately afterwards for the periods from 14th to 15th and from 27th to 30th April are shown in the Appendix (Plates VI, VII). During the period of the cruise, surface temperatures of 19 to 21 °C prevailed in the study area with warmer water between Tenerife and Gran Canaria and in the south of both islands. Later, water temperature increased in the northern area of the Canary Islands, too, with maximum values of 24.5 °C in the centre of warm-water pockets. These pockets moved from the north to south along the east of Lanzarote, Fuerteventura, and Gran Canaria or were formed in the southwest of Gran Canaria and Tenerife. At the same time, with the general increase in surface temperature, the upwelling activity off NE Africa becomes evident. In one case, on 29th April, a cooler water mass appears off the southeastern coast of Fuerteventura which is surrounded by two warm-water pockets towards the south and southeast. On the next day, this situation has completely changed with another warm-water body arriving in the east. Between 27th and 30th April, weak anticyclonic displacements of surface waters can be observed in the southwest or south of Gran Canaria close to the location of the eddy (ARÍSTEGUI et al. 1994).

Fig. 11. Examples of echograms showing accumulations of epipelagic and epibenthic fishes. West of Fuerteventura; 11 April 1997.

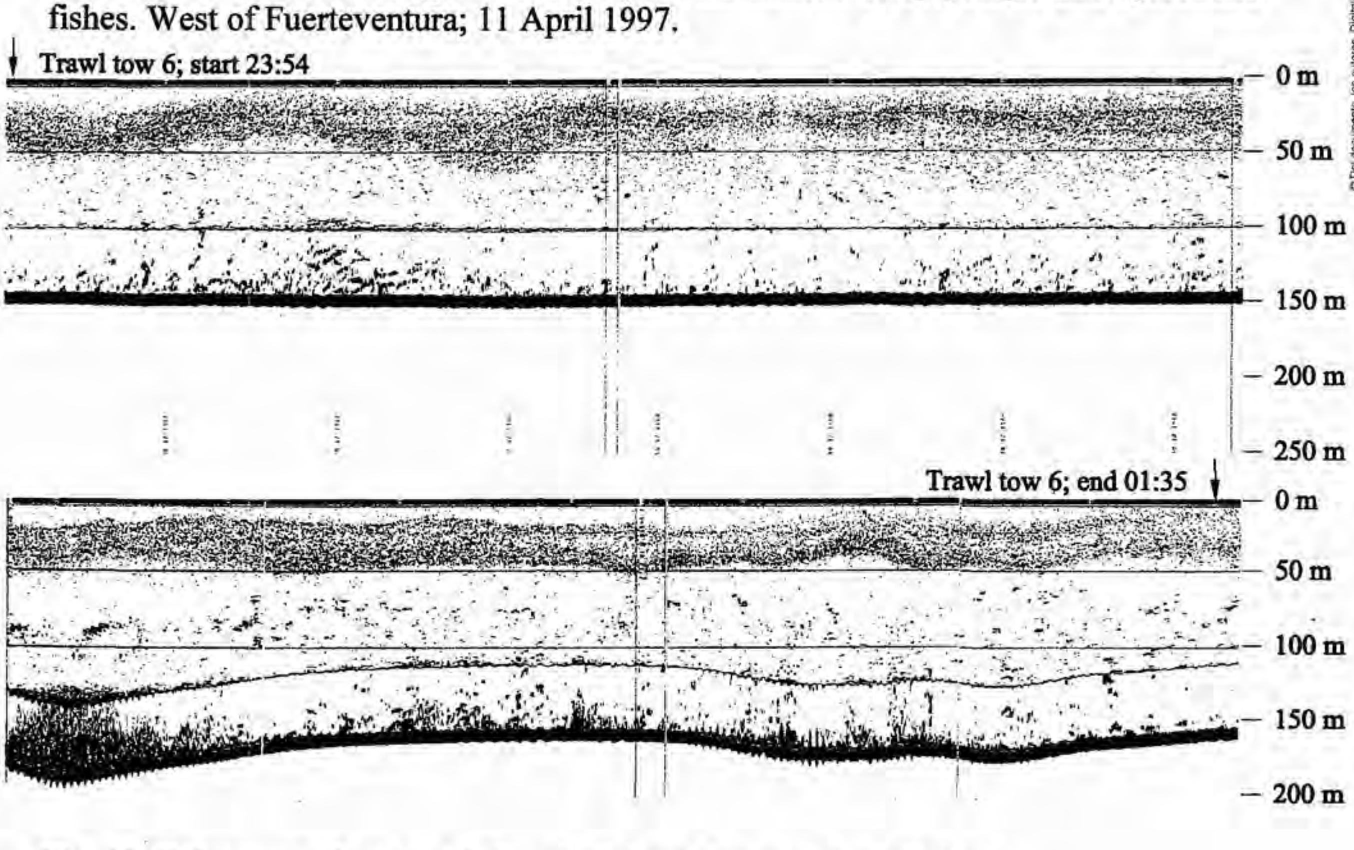

Fig. 12: Echogram of tow nr. 6. South of Gran Canaria; 8 April 1997.

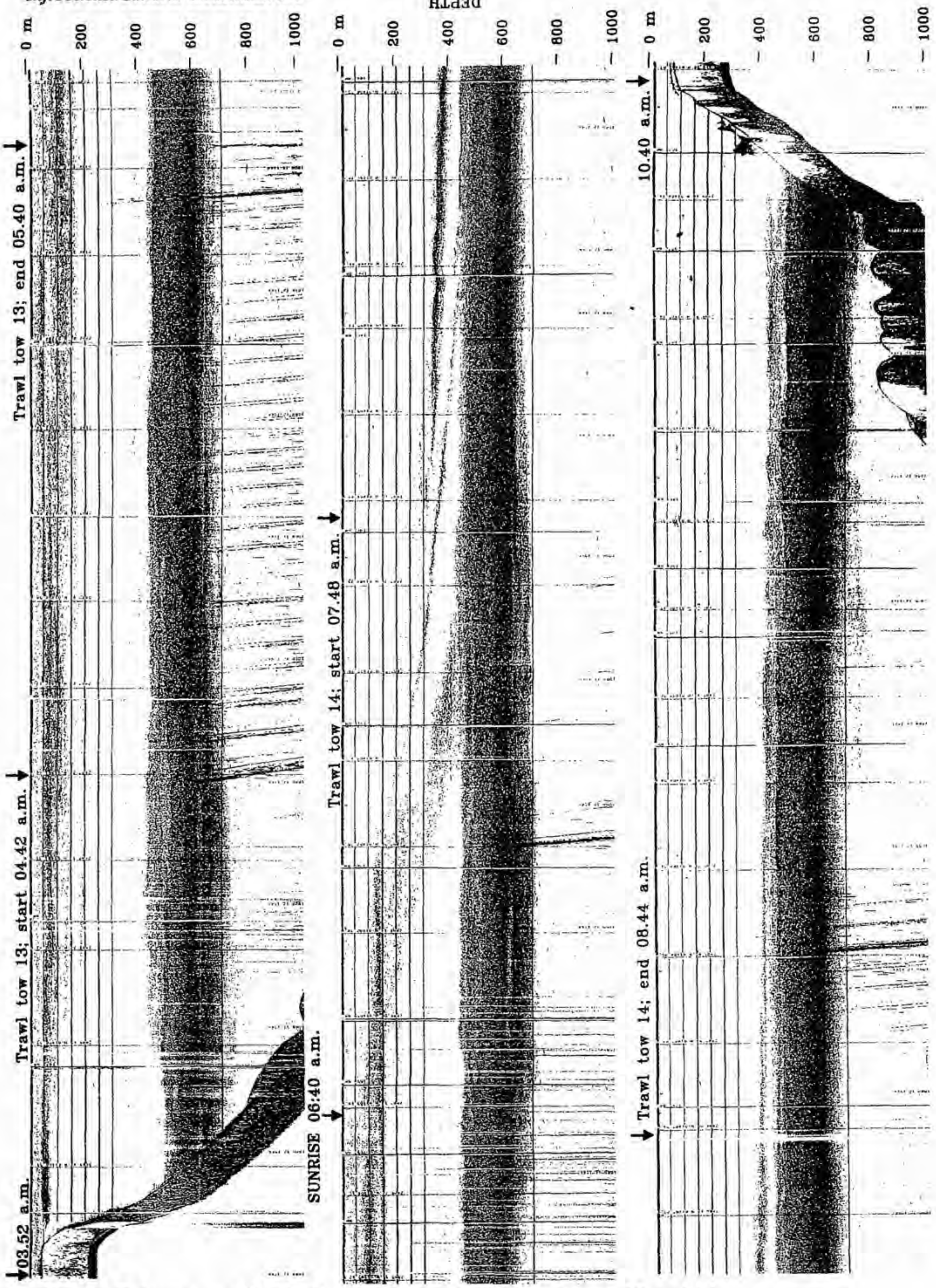

Fig. 13. Echograms taken before, during and after trawl tows 13 and 14.

4. DISCUSSION

All epipelagic trawl tows carried out in daylight or dawn were without fishing success. This result may be due to active, visually mediated avoidance of vessels and/or fishing gears by epipelagic fishes and/or too slow trawling speed (e.g., WARDLE 1993). During night, with the same gear and speed, epipelagic as well as mesopelagic fishes were collected, partly at high numbers. Mesopelagic tows were successful both during day and night.

The following ten species have not been cited in the most recent species catalogue of the fish fauna of the Canary archipelago (BRITO 1991) or in any other relevant zoogeographic account (e.g., BADCOCK 1965, KOTTHAUS 1972, QUERO et al. 1990), and hence can be regarded as new records for this area: *Astronesthes macropogon*, *Astronesthes micropogon*, *Astronesthes neopogon*, *Grammatostomias flagellibarba*, *Melanostomias tentaculatus* (all Stomiidae), *Ahliesaurus berryi* (Notosudidae), *Macroparalapis nigra* (Paralepididae), *Diaphus adenomus* (Myctophidae), *Diplospinus multistriatus* (Gempylidae), and *Aphanopus intermedius* (Trichiuridae). The latter species probably co-occurs with *A. carbo* in the study area (cf. UIBLEIN et al. 1998). However, further taxonomic studies on comparative material are required to examine this assumption. Another interesting aspect of this finding is that only few juveniles of the genus *Aphanopus* have been collected in this and adjacent areas. Off Madeira, for instance, only two specimens of 60 and 100 mm SL were caught at about 400 - 450 m depth in the open water (KOTTHAUS 1972). For the Canaries, our record is the first for a juvenile of this genus.

Some of the dominant stomiiform and myctophid species in the study area occur at particular high frequencies also in other regions, such as, for instance, *Cyclothone braueri* off the NW African coast (BADCOCK and MERRETT 1976) and *Lampanyctus alatus* and *Ceratoscopelus warmingii* in the Gulf of Mexico (GARTNER et al. 1987). In the earlier study off Lanzarote and Fuerteventura by BADCOCK (1970), *Cyclothone braueri*, *Ceratoscopelus warmingii*, *Lobianchia dofleini*, and *Argyropelecus hemigymnus* occurred at the highest frequencies in the catches. Numeric dominance of *Cyclothone* species in mesopelagic layers has been observed at a worldwide scale. This genus is said to include the most abundant vertebrates on earth (MIYA and NISHIDA 1997).

The species of the genus *Cyclothone* do not show diurnal vertical migrations and remain in deep layers during night. Similar to the observations made by BADCOCK and MERRETT (1976), *Cyclothone* specimens clinged in the mesh of the net and could not be completely removed after each mesopelagic tow. Therefore, if the trawl was towed in the epipelagic immediately afterwards, *Cyclothone* specimens appeared in the net as "pollution".

The vertical migrations observed covered considerable depth ranges. For instance, the eight species collected before sunrise in the epipelagic and immediately afterwards in deeper layers migrate vertically over distances of more than 400 m. Such extensive vertical migrations can be observed in many mesopelagic fish species of the Canary Islands or other areas of the Atlantic (e.g., BADCOCK 1970, GARTNER et al. 1987, MAGNÚSSON 1996). They proceed at a considerable speed and thus may represent an important means of quick energy transfer between the productive surface layers and the deep sea.

Epipelagic fishes were caught exclusively during night with trawling tows in the epipelagic. Chub mackerel were collected at higher numbers in the South of Gran Canaria, between Lanzarote and Fuerteventura, and in the North of Lanzarote. Pronounced differences in size composition among the different stations occurred. While specimens with more than 20 cm total length belong to age classes 1 or 2, the smaller individuals all belong to age class 0 and are juveniles in their first year of life. Only a few small juveniles were caught in the south of Gran Canaria where older age classes obviously occurred at a considerable density. At the other three sites, however, only the smaller and no older specimens were collected. Moreover, these juvenile chub mackerels of age class 0 showed clear differences in size distributions. This may reflect the existence of spatially separated cohorts which stem from different reproductive events. Chub mackerel is known to show a particularly long spawning season in the Canary Islands which usually lasts from December to April (LORENZO 1992). The existence of considerable spatial variability in the abundance of chub mackerel is also demonstrated by the acoustic study. For establishing a sustainable fisheries management such spatial fluctuations among different sites will have to be studied more closely. Especially the questions, if certain size classes of chub mackerel show preferred habitats and if this preference undergoes seasonal changes, require a continuation of the present line of research over a longer period with further sampling and acoustic monitoring at regular intervals.

With one epipelagic tow young chub mackerels and round sardinella were collected offshore above ca. 1000 m bottom depth and at about 1.5-4 miles off the shelf and 4-6.5 miles off the coast together with mesopelagic fishes, especially myctophids. Similarly, PASTOR and DELGADO DE MOLINA (1985) caught a great number of small juvenile sardine, *Sardina pilchardus* (WALBAUM 1792) in the late evening five miles off the coast of northern Tenerife at 20 m trawling depth and at above 1000 m bottom depth. Therefore, nocturnal offshore migration into adjacent oceanic waters may be a feature not uncommon in juvenile epipelagic fishes in the Canary Islands area. The narrow shelf typical for islands of vulcanic origin certainly facilitates these horizontal migration activities. Several factors may account for the entering of the open water during night including changes in food availability and predation pressure. Other possibilities are that the mackerels encounter optimal temperatures, salinity or current conditions, or some combination of these factors (cf. WALSH et al. 1995). An increase in food availability may be the most probable reason, as vertically migrating fish and invertebrate prey organisms aggregate near the surface at night.

The diet analyses of young chub mackerels showed that the faunal composition of the primary prey category, Copepoda, was comprised mainly of high salinity oceanic forms (OWRE and FOYO, 1967). The small average prey size of the juvenile chub mackerel examined in our study may suggest passive straining in clouds of plankton rather than particulate feeding with selection of individual food items as the primary feeding strategy. However, in earlier studies on the food selection of juvenile chub mackerel in the Canary Islands (CASTRO 1991, 1993), particulate feeding on large prey organisms including fishes was observed, too. The fish bone found in one of the guts may confirm these earlier findings.

The contribution of cyclopoid and harpacticoid copepods relative to calanoid copepods in the diets is in contrast to the usual pattern of similar-sized planktivorous oceanic micronekton including many myctophid and stomiid species, which strongly select calanoids (HOPKINS et al. 1996, HOPKINS and SUTTON 1998). Since all specimens in this study were captured at night, a detailed feeding chronology was not possible. The lack of filled stomachs in all specimens examined suggests that these fish had been feeding mostly during daytime. The presence of bottom-related particles in the guts of two individuals which had been collected in oceanic water suggests that foraging had occurred at another site closer to the bottom. Therefore, it may be hypothesized that at least some of the juvenile chub mackerels encountered off the shelf during night did not forage there, but fed close to the bottom of the shelf on the day before.

Several copepod species identified in the mackerel stomachs perform vertical migrations over several hundred metres in the Canary Island area such as *Candacia* and *Pleuromamma* (RUDJAKOV 1979). These two species as well as *Oncaea* are frequently preyed upon by mesopelagic fish, too, such as *Argyropelecus hemigymnus* and *Lampanyctus alatus* (ROE and BADCOCK 1984, HOPKINS and BAIRD 1985). *Ceratoscopelus maderensis*, which was also caught together with the mackerels with tow 13 feeds on *Pleuromamma* and *Candacia* as well as on the cyclopoid copepod *Oncaea* (WÖRNER 1979). These oceanic copepods may be „trapped“ at the shelf due to horizontal drift. Such phenomena occur frequently near steep slopes where upwards migrating mesopelagic zooplankton is drifted by currents or local upwelling towards shallow plateau-like bottoms where it is trapped during downwards migration (HESTHAGEN 1970). There it can be used by fishes as an additional food source (see also, UIBLEIN et al. 1999).

In earlier studies of chub mackerel feeding behaviour in the Canary Islands large amounts of copepods have been found in the digestive tract of juveniles together with small fish and other prey items (CASTRO 1991, CASTRO 1993, LORENZO and CASTRO 1996). With increasing age and size, a shift in diet from copepods to a higher percentage of mysids and fish was observed. Adults feed frequently on juveniles of the snipefish *Macroramphosus scolopax* (LINNAEUS 1758).

Our study suggests that spatial or trophic interactions between mesopelagic fishes and juvenile chub mackerels may occur both at the shelf, where a few mesopelagic fishes where collected, as well as in oceanic waters. At ocean rims, such as above steep slopes close to the shelf of oceanic islands or in the surroundings of seamounts (UIBLEIN et al. 1999), mesopelagic fish may interact not only with epipelagic fishes, but also with demersal fishes. Intense trophic relationships have been found with benthopelagic fishes especially in depth zones, where the mesopelagic fauna impinges on the slope (GORDON et al. 1995). In such zones, lanternfishes may form an important diet component of benthopelagic fishes such as silver roughy, *Hoplostethus mediterraneus* CUVIER 1829 (KERSTAN 1989). In a detailed study of the diets of demersal fishes of the Rockall Trough (MAUCHLINE and GORDON 1991, and references therein) it was shown that between 800 and 1300 m depth over 80 % of these fish had consumed pelagic prey. MERRETT (1986) found reports of 24 different species of meso- and bathypelagic fishes in the stomachs of 34 species of demersal fishes in the Atlantic. The finding of juvenile trichiurids with *Lepidopus caudatus* occurring in the epipelagic and *Aphanopus intermedius* in the mesopelagic zone are another example for the existence of important ecological links. During later ontogeny these two species occur near the slope, where they switch to a benthopelagic lifestyle. Similarly, small juveniles of *Capros aper* were found in the mesopelagic. Adults often occur above deep bottoms (UIBLEIN et al. 1999).

Based on their own and earlier findings on the geographical distribution of the lanternfish *Ceratoscopelus maderensis* in the Atlantic, ZELCK and KLEIN (1995) hypothesized that both larvae and adults of this species are associated with high salinity water of Mediterranean origin which may not exist in the east of Fuerteventura. The new collecting locality is situated in an area of particular ecological interest. For instance, preliminary indications of a seasonally limited, local upwelling activity between April and September have been discovered based on the examination of SST images (UIBLEIN et al. 1998). The SST image of 29th April supports this assumption. Furthermore, at 850 to about 1000 m depth, an important spawning site of the demersal deep-sea cod *Mora moro* (Risso 1810) has been found in this area (UIBLEIN et al. 1996, 1998). To more closely examine, whether *Ceratoscopelus maderensis* or other species occurring at high frequency at this site are associated with particular ecological conditions or if they have a broader distribution range in the east of Fuerteventura and Lanzarote, further sampling in adjacent areas combined with detailed studies of the hydrological conditions at greater depths are required.

The satellite data collected in April 1997 provide only limited evidence for the existence of the eddy in the SW off Gran Canaria (HERNANDEZ LEON 1991, ARÍSTIGUI et al. 1994). During the period of the cruise, however, the surface water temperatures were still quite low. After the cruise, when these temperatures increased, some indications for the existence of this hydrographic feature were found. Support comes also from the fish samples, as several larvae and juveniles occurred in this area, including all leptocephali which were collected during this cruise, the single *Aphanopus intermedius*, and two *Capros aper* specimens.

In conclusion, the results of cruise "La Bocaina 0497" presented here provide preliminary evidence that there is considerable variation in the species composition and spatial distribution of epipelagic and mesopelagic fishes among the different collecting sites. This indicates the existence of "micro-zoogeographic" zones within the Canary archipelago which require to be studied separated from each other in a comparative context. Such small-scaled comparisons will be required not only to be able to detect interrelationships between local ecological conditions and patterns of species composition and assemblage structure, but also to define the adequate area for stock assessment and management of commercially important fishes (HAEDRICH 1995).

5. ACKNOWLEDGEMENTS

The cruise "La Bocaina 04-97" was financed by the Viceconsejería de Pesca, Consejería de Agricultura Pesca y Alimentación del Gobierno de Canarias (Canary Government). We thank the captain and the crew of RV "La Bocaina" for their assistance. Dr. Jørgen G. NIELSEN, Copenhagen, Prof. Nik PARIN, Moscow, Prof. Horst WILKENS, Hamburg kindly helped in species identification and/or transfer of specimens. F.U. thanks Prof. Mutsumi NISHIDA, Fukui Prefectural University, Obama, for his hospitality during a research stay in Japan, and Prof. Hjalmar THIEL, Hamburg, for organizing a stay at the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, for literature search. F.U. received travel fundings from the Österreichische Forschungsgemeinschaft, project 06/4724, and the Stiftungs- und Förderungsgesellschaft der Paris-Lodron-Universität Salzburg.

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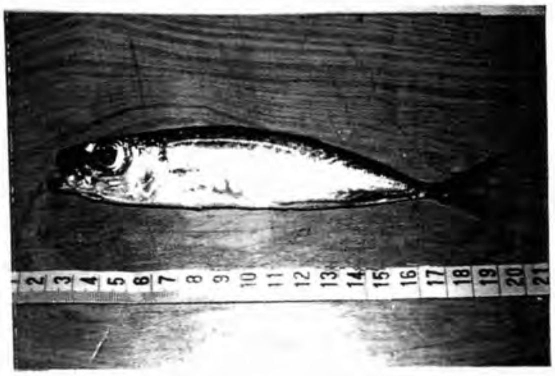
APPENDIX

Plates I-IV. Photos of species collected during cruise "La Bocaina 0497".

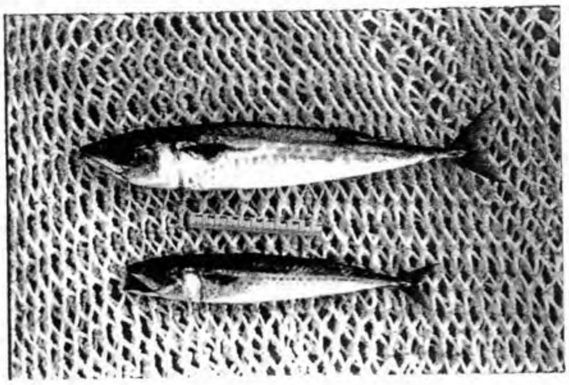
Plate V. Photos of the remains of food items found in the stomachs of juvenile chub mackerels. Top (from left to right): *Candacia* pereiopod, *Microsetalla* sp. Bottom (from left to right): *Oncaea* sp., *Corycaeus* sp.

Plates VI, VII: SST images collected in April 1997 during and after cruise "La Bocaina 0497".

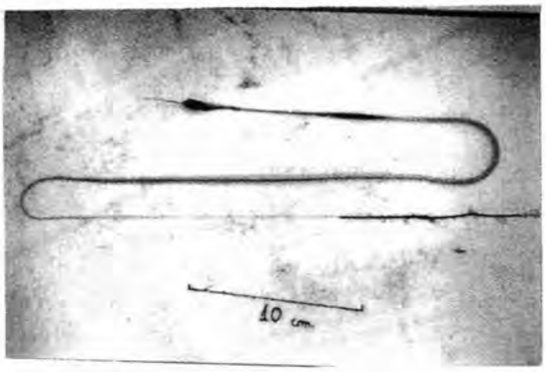
Plate I



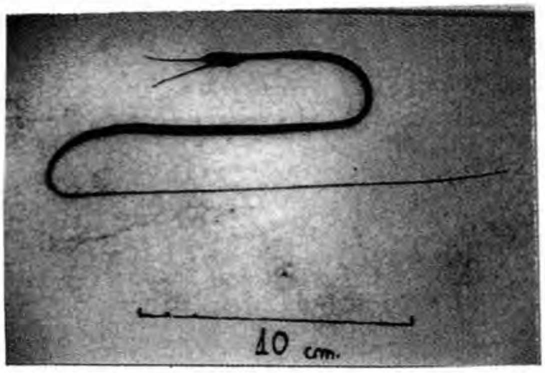
Trachurus picturatus



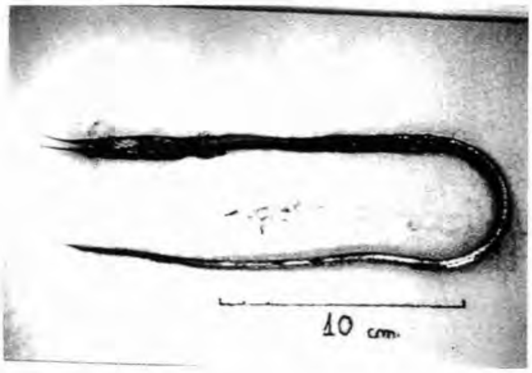
Scomber japonicus



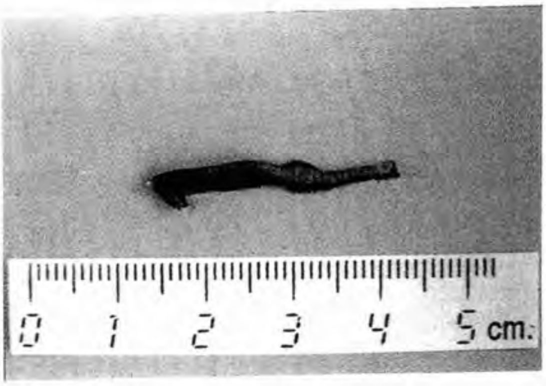
Nemichthys curvirostris



Nemichthys scolopaceus



Serrivomer beani

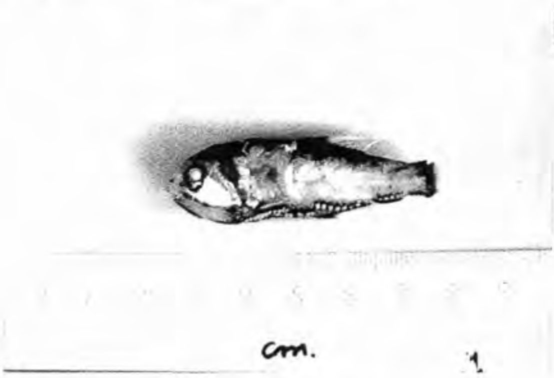


Cyclothone pseudopallida

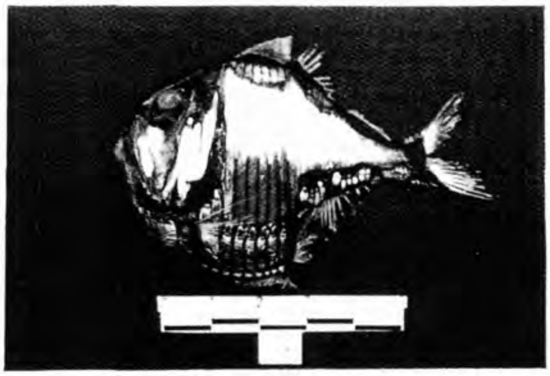
Diplophos taenia

Gonostoma elongatum

Plate II

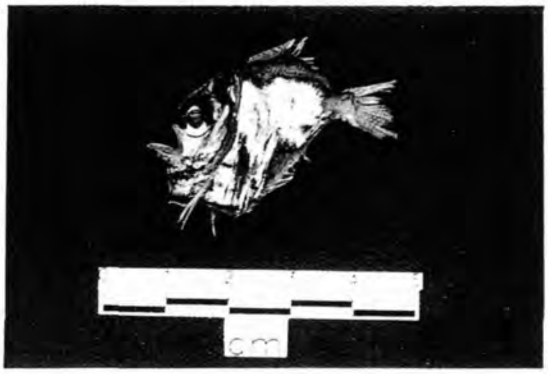


Margrethia obtusirostra

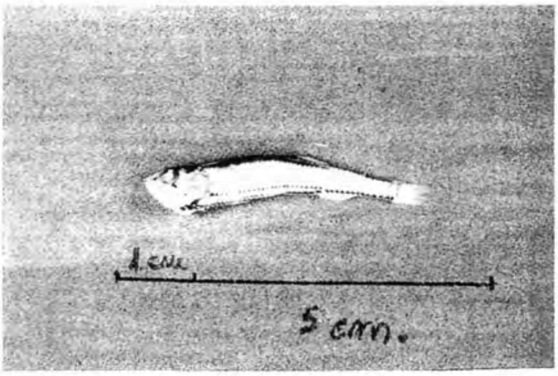


Argyropelecus aculeatus

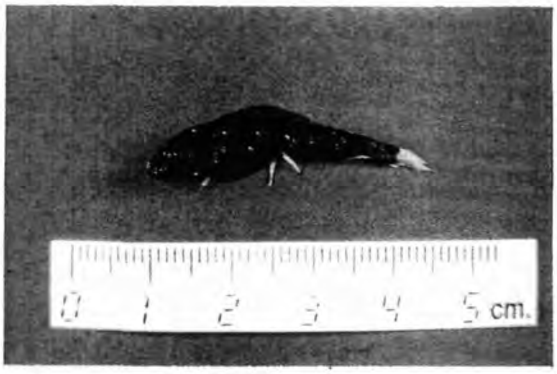
Argyropelecus hemigymnus



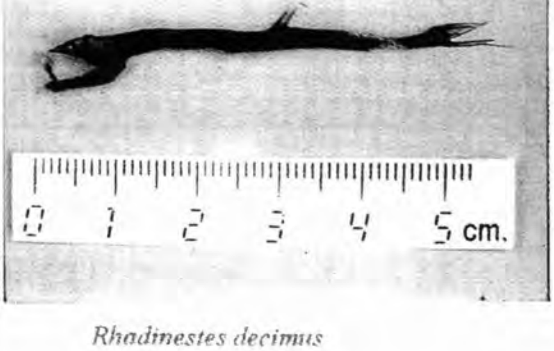
Sternoptyx diaphana



Vinciguerria nimbaria



Astronesthes macropogon



Rhadinestes decimus

Chauliodus danae

Plate III

Stomias boa

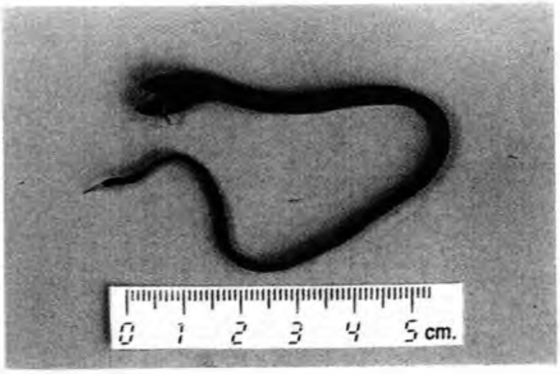
Bathophilus vaillanti

Eustomias tetranema

Grammatostomias flagellibarba

Leptostomias gladiator

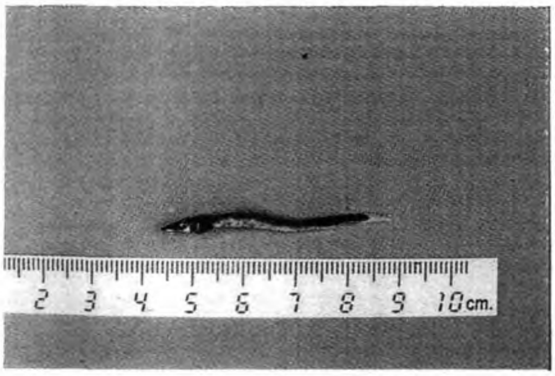
Melanostomias tentaculatus



Idiacanthus fasciola

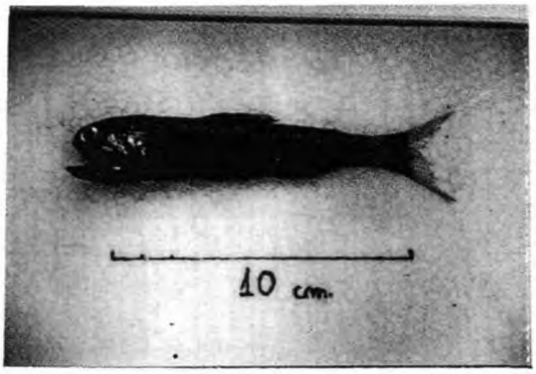
Photostomias guernei

Plate IV

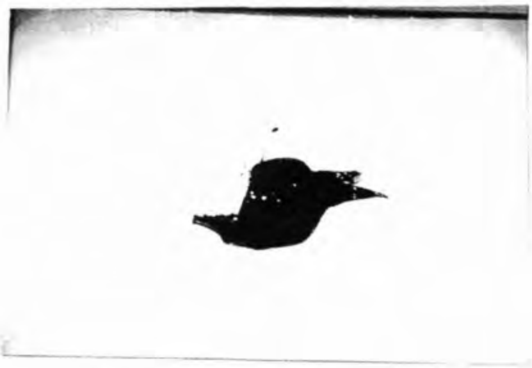


Scopelosaurus argenteus

Macroparalepis nigra



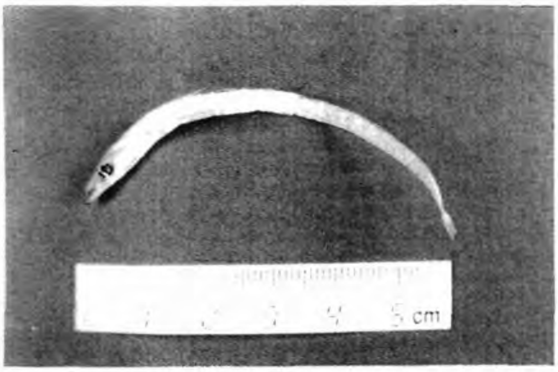
Diaphus adenomus



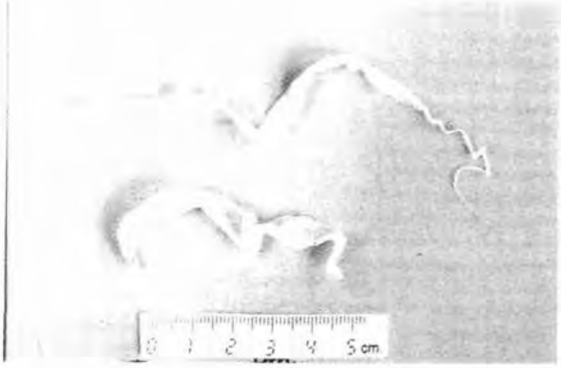
Melanocetus johnsoni

Diretmus argenteus

Capros aper



Lepidopus caudatus



Leptocephali

Plate V

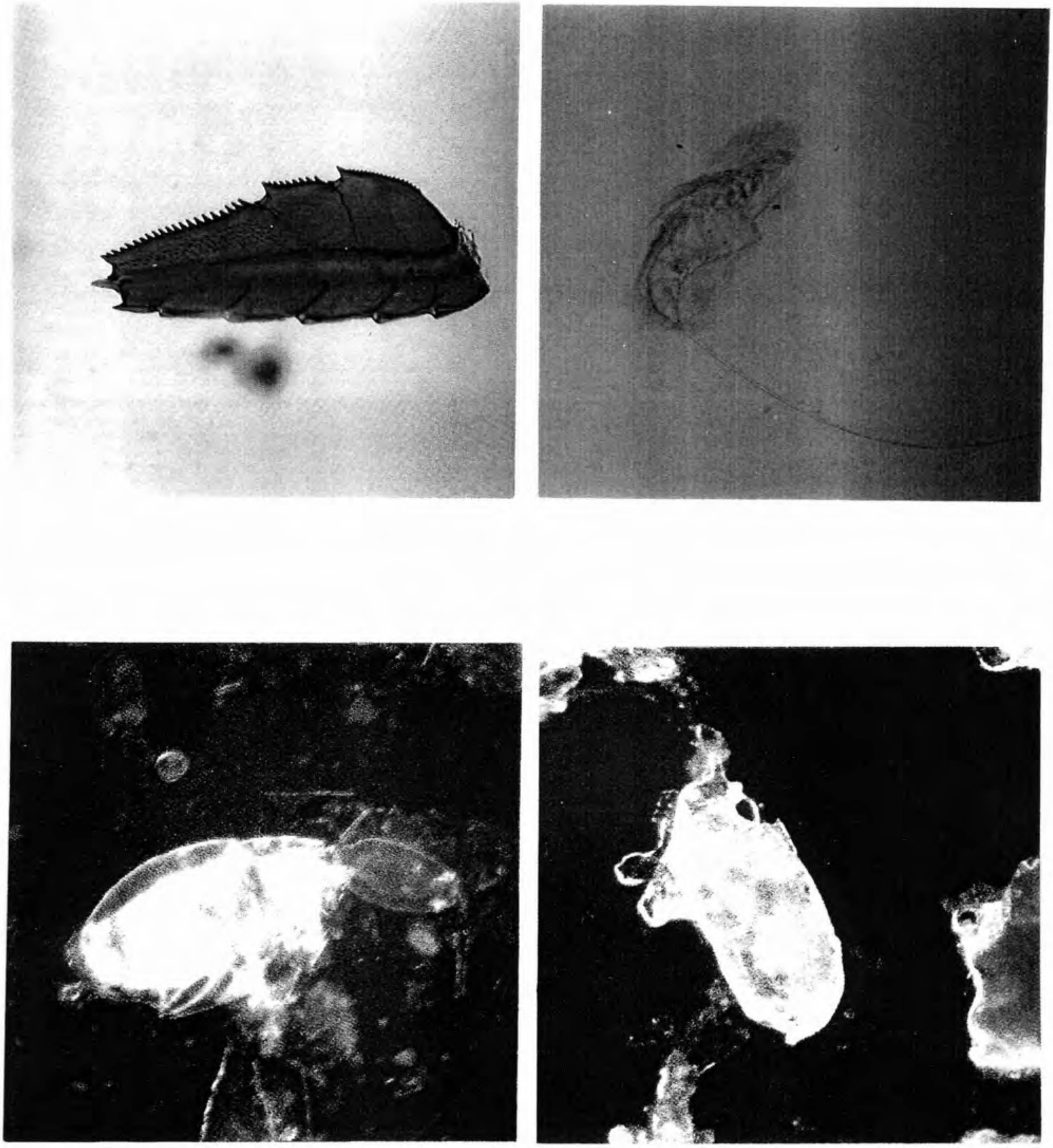
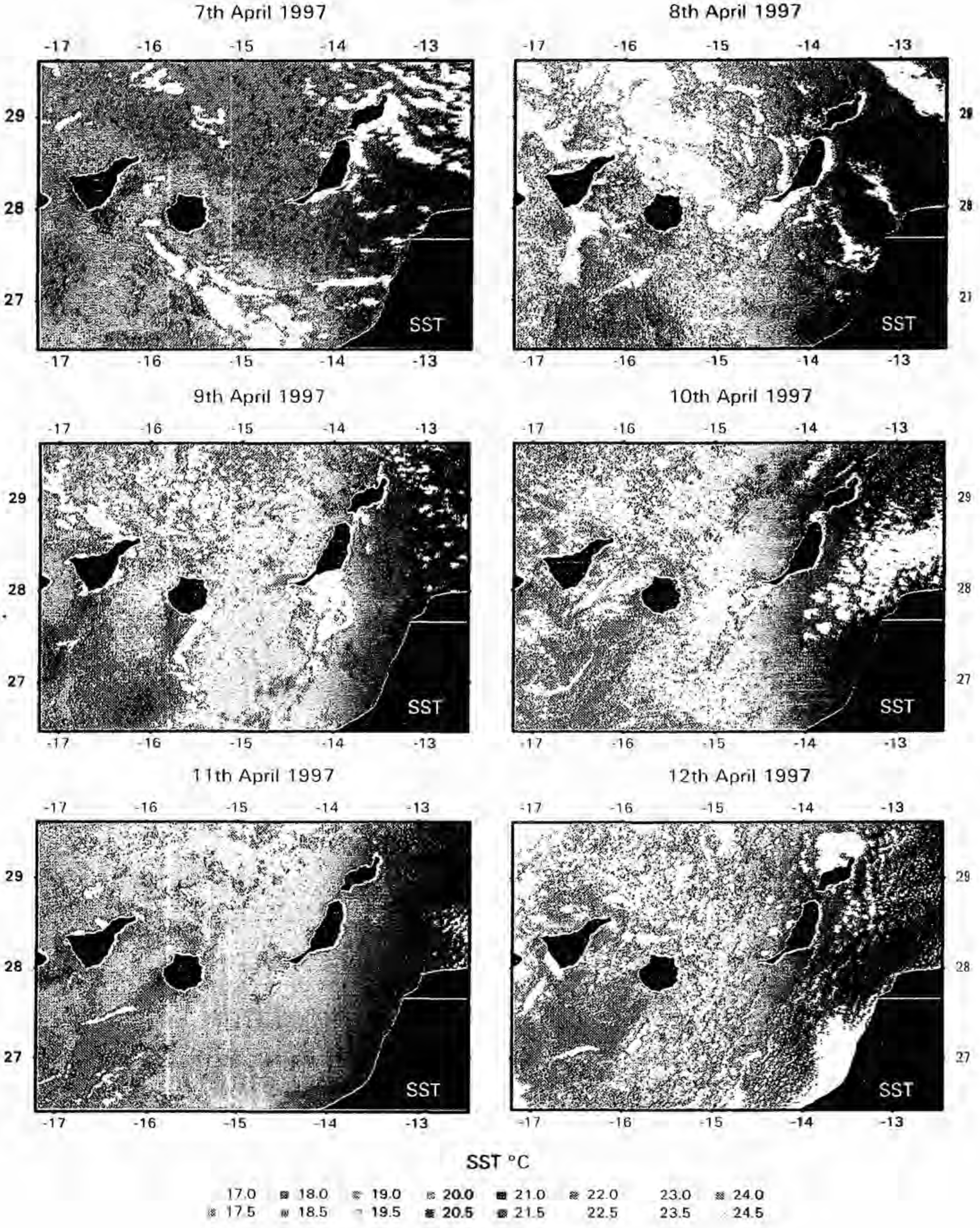


Plate VI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SST
SST °C
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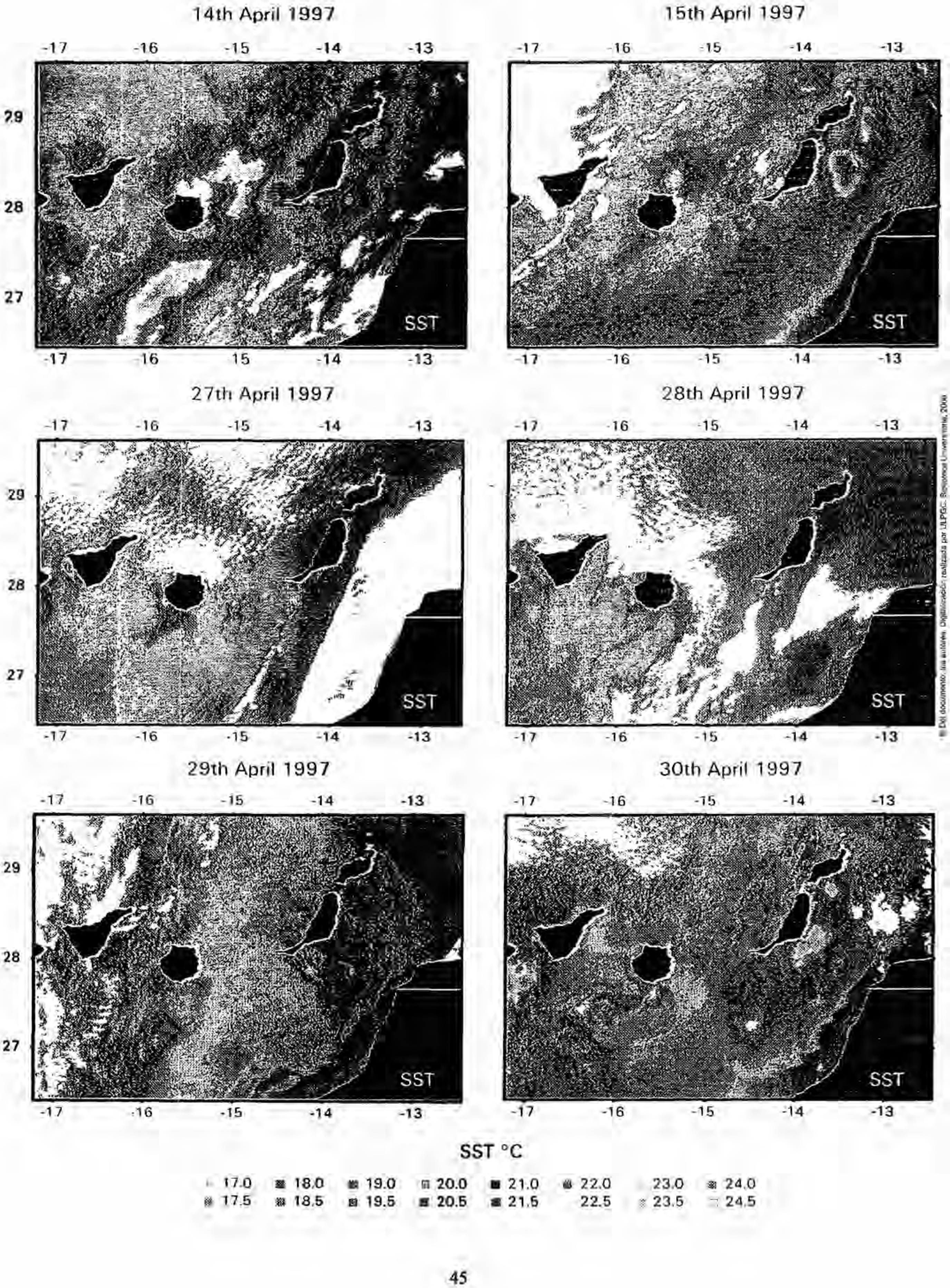
Plate VII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