ICES C.M. 1993

Paper

C.M. 1993/H:28
Pelagic Fish Committee

ABUNDANDANCE ESTIMATION AND DISTRIBUTION OF SARDINE IN NORTHERN SPAIN (NORTH OF IXa AND VIIIc DIVISIONS)

by

C. Porteiro[1], J. Miquel[2], P. Carrera[3], M. Meixide[1]

and J.M. Cabanas[1]

[1] Instituto Español de Oceanografía, Vigo
Apdo. 1552
36280 Vigo, Spain

[2] Instituto Español de Oceanografía, Baleares
Apdo. 291
07080 Palma de Mallorca

[3] Instituto Español de Oceanografía, A Coruña
Apdo. 130
15080 A Coruña

ABSTRACT

Since 1986, an acoustic survey programme have been carried out for assessment of sardine stock in Atlantic waters of the Iberian Peninsula.

Sardine abundance, estimated by length and age groups and oceanographic conditions in Galician and Cantabrian waters from 1986 to 1993 were studied.

The biomass decreased after 1986 despite the occurrence of two very good year classes 1983 (the strongest ever recorded since 1976) and in 1987. The 1991 recruiting year class seems to be a good one in the 1993 survey.

RESUME

Depuis 1986, un programme de sondage acoustique a été fait pour l'évaluation du stock de sardines dans les eaux atlantiques de la Peninsule Iberique.

L'abondance de sardines, estimée par des groupes de taille et d'âge, et les conditions océanographiques dans les eaux de la Galicie et de la mer Cantabrique a été étudiée depuis 1986 jusqu'à 1993.

La biomasse a diminué après 1986, malgré la présence de deux bonnes années 1983 (la plus forte jamais registrée depuis 1976) et 1987.

INTRODUCTION

Sardine (<u>Sardina pilchardus</u>, Walb.) is the target of an important fishery exploited in common, mainly by Portuguese and Spanish purse-seiner fisheries, in ICES Div. VIIIc and IXa and it is distributed along the Atlantic Iberian coastal waters. Its capture and associated socio-economic infrastructure indicates that it may be one of the most ancient fisheries in this region. In accordance with this economic and social importance, a considerable research effort has been made in order to get relevant scientific information.

For assessment purposes the sardine from Divisions VIIIc and IXa are regarded as one stock unit (Anom 1993) . In order to manage the fishery since 1976, different methods have been applied to assess this stock , tuning of VPA, acoustic and DEPM , (Pestana, 1989; Dias et al., 1989; Porteiro C., 1990; Carrera P. and Meixide M., 1991; García et al., 1991; Dias et al, 1992; Anon., 1993).

Geographically this area lies at the northern limit of the east central Atlantic coastal upwelling system (Wooster et al., 1976), which in these latitudes is seasonal (April to September) and relatively weak (Fraga 1981; Blanton et al., 1984; Fiuza, 1984)

Since 1982 the Instituto Español de Oceanografía (IEO), undertakes sistematic acoustic surveys with the R/V "Cornide de Saavedra" and "Ignat Pavlyuchenkov" and its main aim is to obtain annual estimates of sardine abundance in the Atlantic Coastal waters of the Iberian Peninsula fraction present in the Spanish area.

From 1982 to 1986 a particular emphasis was given to the observation of the annual recruitment to the fishery that occurs during the second half of the year (Pastor et al., 1985a,b.

In order to assess the spawning stock biomass a new acoustic survey series was started in spring 1986 (Pastor et al., 1986b; Porteiro C., 1990; Carrera P. and Meixide M. 1991; Carrera P. and Porteiro C., 1993. In the months of April and May in 1988 and 1990, a simultaneous daily egg production method and acoustic surveys were carried out off the Galician and Cantabrian shelves. (García et al., 1991; Garcia et al., 1992).

This paper provides estimates of sardine abundance obtained on spring cruises during 1986 ,1987, 1988, 1990, 1991, 1992 and 1993. Besides the abundance estimation, in number and biomass by length and age group, the objectives of these surveys also include the distribution of sardine and the observation of the oceanographic conditions.

MATERIAL AND METHODS

The survey execution and the estimates calculations followed the methodologies adopted by the Planning Group for the Acoustic Surveys in ICES Sub-Areas VIII and IX (Anon, 1986).

Table I includes year, Research Vessel, date, acoustic equipment, cruise track, conversion factor ,total miles, degree of coverage (Aglen, 1989), number of fish stations, type of gear and number of CTD station in the period 1986-93.

For each year, the calibration of the acoustic system was done using a copper standard sphere of 60 mm diameter (TS of -33.6 dB) according to the procedures described in Foote et al (1987). The following TS-length relationship for herring (Dengbol et al., 1985), and adopted for the Iberian Sardine stock (Anon., 1986) was used:

$$TS = 20.0 * \log L - 72.6 \text{ (dB)}$$

The survey cover was defined by 20 m isobath as lower limit and the upper one was conditioned to the presence of sardine (200 m isobath), and it was extended further offshore taking into account the egg and CTD stations or to observe the distribution of the main pelagic species in the area. The acoustic signals were integrated over one nautical mile intervals. Figure 1 shows the cruise tracks and fishing stations for each survey.

Pelagic trawl hauls for species identification were decided according to echograms information. Biological sampling of sardine for length (0.5 cm), weight, maturity stages and age were done for each pelagic haul. Nevertheless, due to the presence of commercial fixed fishing gears or fishing boats and in some cases due to the extremely bad weather conditions, it was not possible to make hauls in some areas with significant fish distribution, so market samples in the same place and days were used.

The mean weight were calculated as a mean of grouped weight of length clasess for 1986 to 1991 with an analoge scale which it accuracy was low. In 1992 and 1993 was calculated using individual weight.

The surveys execution and the sardine abundance estimations followed the methodology avovementioned.The abundance estimates were calculated by the Nakken and Dommasnes equations (1975 and 1977). For that purpose the total area was divided into 21 sectors separated out 20 miles and by different depth strata (20-50, 51-100, 101-200, 201-500 and 501-1000 m). The sector and stratum areas were measured with a planimeter in square nautical miles.

For result presentation, the surveyed area was divided into four regions or sub-areas: South Galicia (from 41º50' N to 43º N), North Galicia (from 43º N to 7º W), Western Cantabrian Sea (7º

W to 3º 20' W) and Eastern Cantabrian Sea (3º 20' W to 1º 15' W). The sardine biomass for each region and total was estimated as the sum of the corresponding sectors and strata.

In the surveys, (1987-1993) hydrographic observations were taken using a CTD Neil Brown Smart and Seabird 19. The CTD stations were allocated in the radials perpendiculars to the coast in the survey tracks.

RESULTS

Diferent cruises track were used during this time serie. In table I only miles belonging to the three firsts strata (A from 20 to 50 m, B from 51 to 100 m and C from 101 t o 200 m) and for the total are shown. The zig zag track had a better degree of coverage than perpendicular track design; in 1991 , 1992 and 1993 surveys were very good and for 1988 and 1990 were normal and for the 1986 and 1987 surveys were poor.

Analysing of the degree of coverage , for 1991 , 1992 and 1993 surveys were very good, for 1988 and 1990 were normal and for 1986 and 1987 surveys were poor.

Figure 2 represents the relative distribution of sardine in the surveyed area. The highest concentration of sardine were detected in the Western Cantabrian Sea. In South Galicia sardine was in only few small patches occupying a very small part of the survey area.

The sardine detected was distributed along the continental shelf of the surveyed area (until 200 m isobath). Nevertheless in 1988, 1990 and 1993 in Western Cantabrian, sardine schools were found in offshore waters; in Northern Galicia sardine was located over rocky seabed close to the coast. In 1991 and 1992 sardine seems to be distributed only near the coast in shallower waters.

Table II shows the mean weight by age group. The mean weight at age in 1992 were higher than the values of the previous years for the same ages. Also the mean weight at age in the cacht were higher compared with those of the previous years (Anon, 1993).

Total acoustic biomass estimated by regions for each year is shown in Table III. The highest estimated biomass was in 1988 with 174,016 mt and the lowest in 1992 with 45,016. In South Galicia were always estimated the lowest biomass for each year except 1993 that it was estimated in North Galicia. The highest abundance were found in North Galicia and Western Cantabrian Sea. The biomass calculated in Eastern Cantabrian Sea area remainded very similar (18,5% of the total biomass as a mean), except in 1988 with only a 7,82% and in 1987 with a 44,8% which was the highest biomass assessed for this year.

Figure 3 shows the abundance in number estimated by age group and regions for each year. The age group I was mainly distributed in Southern Galicia and in a minor proportion in Eastern Cantabrian Sea. Fish of four years and older were concentrated mainly in Northern Galicia and in Cantabrian Sea.

The 1983 and 1987 year classes were the most important ones, and in 1993 (with 10 and 7 years old) they still represent the 50% of the total biomass and they can be followed in all areas along the time series. The 1991 recruiting year class seems to be good in the 1992 survey and also 1992 recruiting year class in 1993 survey.

Fig. 4 shows thermal and saline horizontal distributions at 50 m around the Galicia and Cantabrian waters

The coldest water was in 1992, for the period 1987-1993 in all the surveyed area, with highest differentes from the mean in Galicia. The 1990 year was the warmest.

For all the period, the highest salinity was always in Galician waters. In 1990 and 1992 years the salinity was very similar and higher than the salinity in 1987 and 1988 for all the areas.

DISCUSSION

The differences among degrees of coverage are mainly due to the differences in the cruise track (Perp/Para, Zig/Zag), and in the number of integrated miles. The zig-zag track desing are widely employed when the continental shelf is narrow or when the transect are short. Nevertheless, zig/zag desing shows limitations as the non-independence of transects or the higher local sampling intesity per unit area (Simmonds et all,1992). For sardine this survey track seems to be the most appropriate if the track used is narrow. Sardine are mainly distributed between 40-100 m depth and this area are well sampled with this track desing. For 1987, the wide zig/zag track used did not permit a good degree of coverage and the accuracy could be very low (Carrera, 1993).

The sardine distribution in 1990 was offshore, it could be related to the warm waters temperatures present during this survey. On the other hand in 1992 sardine were found in shallower waters, close to the coast, and it could be due to the extremely bad weather and to the cold water temperature (average).

The total biomass and abundance in number assessed in Spanish waters decrease since 1988 to 1992. From analytical assessment (tuning XSA) of sardine in VIIIc and IXa ICES Divisions, the spawning stock biomass shows a decline from 1989 to 1991 to reach a low level similar to that in 1977, which was the minimum in the historical series 1976-1992. The yield has declined since 1986 and the fishing mortality, after an increasin in 1989 and 1990, has subsequently declined (Anon, 1993).

After 1993 not very year classes occured, and the 1987 year class was relatively strong. 1988, 1989 and 1990 were the poorest for this period (1976-1992). 1991 and 1992 years classes appear to be good (Anon, 1993).

The younger sardine distribution (age class I) in South Galicia and the oldest one in Cantabric waters (till age class XII) responds to the different age structure along the VIIIc and IXa ICES Divisions, as it was already observed (Porteiro et al, 1986).

REFERENCES

Aglen, A., 1989 Empirical results on precision effort relationships for acoustic surveys. ICES CM 1989/ B:30

Anon, 1986. Report of the Planning Group for Acoustics Surveys in ICES Sub-Areas VIIIc y IXa . Lisbon, 1-4 april 1986. ICES, Doc. C.M. 1986/H:27

Anon,1993. Working Group on the Assessment of Mackerel, Horse-mackerel, Sardine and Anchovy. C.M. 1993/Asse:

Blanton J., L. Atkinson, F. Castillejo, A. Lavin 1984. Coastal upwelling off the rias Bajas , Galicia, NW Spain . I, Hydrographic studies . Rapp . P.V.Reun. Cons. Int. Explor.Mer. 183, 79-90.

Carrera , P. and Meixide , M . 1991 Acoustic abundance estimation of sardine off Spanish Atlantic Coast. March -April 1991. Working Document (Sardine, Horse Mackerel, and Anchovy ICES Working Group).

Carrera , P. 1993 ,Review of the acoustic abundance estimation of sardine carried out in February - March 1987 in the Spanish Atlantic waters . Working paper presented to the Working Group on the Assessment of Mackerel , Horse Mackerel , Sardinae and Anchovy.

Dias A., Soares.E , Marques 1989.- Acoustic abundance estimation of sardine (Sardina Pilchardus, Walb.) off the Portuguese coast . July-August 1988 . ICES C.M. 1989/H:52

Dias, C.M.A., Marquez, V. and Soares, E. Sardine acoustic surveys off the Portuguese coast September 1991 and January 1992.

Dengbol, P., Lassen, H. and Staehrk.-J. 1985. In situ determination of target strength of herring and sprat at 38 and 120 Khz. Dana, 5, p 45-54

Fiuza 1984.- Hidrologia e dinamica das augas costeiras de Portugal. Tesis Doct. Univ. Lisboa . Portugal .294 p.

Fraga F. 1981.- Upwelling off Galician coast . NW Spain . in Coastal Upwelling . F. Richards (Ed) . Amer. Geophys . Union , Washington D.C. 176-182.

Foote, K.G., Kundsen , H.P., Vestnes, G., MacLennan D. N. and Simmonds, E.J. 1987. Calibration of Acoustic Instruments for Fish Density Estimation: A Practical Guide . Coop . Res. Rep., No. 144. ICES.

Garcia.A, Perez.N, Porteiro.C, Carrera.P. 1991. Estimates of the sardine spawning stock biomass off the Galician and Cantabrian coasts. ICES. C.M. 1991/ H:35

García, A., Pérez, N., Lo, N.C.H., Lago de Lanzós, A. and Solá, A. The Egg Production. Method applied to the spawning biomass estimation of sardine, Sardina pilchardus (Walb), on the Nort Atlantic Spanish coast. (1992. Bol. IEO. Vol. 8, Nº 1. (87-79 pa.).

García, A., Pérez, N., Porteiro, C. and Carrera, P., 1991. Estimates of the sardine spawning stock biomass off the Galician and Cantabrian coast. ICES. Doc. C.M. 1991/H:35.

Hansen B. and S.T. Jákupsstovu. 1992.- Availability of blue Whiting (micromesistius poutassou) in Faroese waters in relation to the hydrography. ICES J. Mar. Symp. 195, xx-xx

Lavín, A., Díaz del Río, G., Cabanas, J.M., Casas, G. 1991. Afloramiento en el noroeste de la península Ibérica. índices de afloramiento para el punto 43ºN 11ºW. Período 1966-1989. Inf. Tec. Inst. Esp. Oceanogr. nº 91

Maillard C. 1986.- Atlas hydrologique de l'Atlantique nord-est. IFREMER

Nakken, O and Dommasnes, A. 1975 . The aplication for an echo integration system in investigations on the stock strength of the Barents Sea capelin (Mallotus villosus , Müller) 1971-74. ICES , Doc . C.M.1975/ B:25

Pastor, X., Porteiro,C. and Lavin, A. 1985. Acoustic Abundance Estimation of pilchard (Sardina pilchardus Walb.) in Galician

Pestana, G. 1989. Manancial Ibero-Atlantico de sardinha (Sardina pilchardus Walb.) sua avaliaçao e medidas de gestao. Unpubl thesis INIP. 192 pp (mimeo in Portuguese).

Porteiro, C., Alvarez, F. and Pereiro, J.A. 1986. Sardine (Sardina pilchardus, Walb.) stock differential distribution by age class in Divisions VIIIc and IXa. ICES. C.M. 1986/H:28.

Porteiro, C., 1990. Campaña Saracus 0490. Unpublished cruise report IEO (mimeo in Spanish).

Simmonds , E.J., Williamson , N.J., Gerlotto, F., Aglen, A.1992. Acoustic survey desing and analysis procedure : a comprehensive review of current practice.

Table I: Main features of acoustic surveys.

YEAR	R/V	DATE	ACOUSTIC EQUIPMENT	CONV. FACTOR	CRUISE TRACK	ST	MILES	I.C.	FIS. STA.	GEAR
1986	C. S.[1]	06/03 19/03	SINGLE BEAM Simrad EK-400 QX+QD	10874120	Perp/Para	A B C TOT	34 214 585 833	1.44 6.29 9.19 10.95	25	SPT[3]
1987	C. S.[1]	20/02 09/03	SPLIT BEAM Simrad EK-400 QX+QD	19915620	Zig/Zag	A B C TOT	64 248 578 890	2.72 7.31 9.16 11.79	26	SPT
1988	C. S.[1]	19/04 04/05	SPLIT BEAM Simrad EK-400 QX+QD	20219890	Perp/Para	A B C TOT	40 250 683 973	1.70 7.38 10.81 12.89	44	SPT
1990	I. P.[2]	19/04 04/05	SPLIT BEAM Simrad EK-400 QX+QD	15573250	Perp/Para	A B C TOT	37 383 530 950	1.57 11.29 8.37 12.59	33	SPT GPT[4]
1991	C. S.[1]	16/03 11/04	SPLIT BEAM Simrad EK-500	1448072	Zig/Zag	A B C TOT	130 285 745 1060	5.53 8.40 11.79 15.37	30	SPT GPT[5]
1992	C. S.[1]	23/04 11/05	SPLIT BEAM Simrad EK-500	1448072	Zig/Zag	A B C TOT	70 262 687 1019	2.98 7.72 10.87 13.50	36	SPT GPT[6] GPT[7]
1993	C. S.[1]	14/04 03/05	SPLIT BEAM Simrad EK-500	1448072	Zig/Zag	A B C TOT	113 315 838 1266	4.81 9.28 13.26 16.77	24	SPT GPT[6]

[1] R/V CORNIDE DE SAAVEDRA
[2] R/V IGNAT PAVLYUCHENKOV
[3] Small Pelagic Trawl (10 m opning)
[4] Great Pelagic Trawl (35 m opening)
[5] Great Pelagic Trawl (22 m opening)
[6] Great Pelagic Trawl (22 m opening)
[7] Great Pelagic Trawl (18 m opening)

	1986	1987	1988	1990	1991	1992	1993
I	26.87	24.85	33.63	42.53	32.97	44.99	41.37
II	48.23	62.95	48.29	66.47	60.52	67.93	60.83
III	62.45	60.16	57.51	78.03	73.51	77.84	68.08
IV	74.44	82.05	68.15	81.67	80.61	87.21	77.34
V	78.16	89.78	88.21	88.31	87.82	92.67	86.71
VI	74.39	83.58	90.66	94.95	97.19	91.28	93.44
VII	82.66	88.30	88.33	94.71	100.08	93.98	92.55
VIII	85.34	101.07	90.23	99.59	96.03	125.88	107.83
IX	91.30	98.00	95.40	99.94	93.55	102.97	110.97
X	104.63	108.68	106.03	102.89	98.91	100.92	106.43
XI	110.62	125.06	120.11	104.04	111.86	105.75	106.43
XII+	-	-	-	103.95	86.91	-	-

Table II: Mean weight by age group and survey.

	SOUTH GALICIA	NORTH GALICIA	WESTERN CANTABRIAN	EASTERN CANTABRIAN	TOTAL
1986	5,541	49,553	83,097	22,973	161,164
1987	2,928	7,968	25,242	29,133	65,271
1988	9,873	92,521	58,010	13,612	174,016
1990	7,868	45,457	25,690	17,485	96,500
1991	3,111	10,683	75,711	16,429	105,934
1992	8,409	13,559	11,063	11,987	45,016
1993	18,551	10,872	65,701	31,233	126,356

	SOUTH GALICIA	NORTH GALICIA	WESTERN CANTABRIAN	EASTERN CANTABRIAN
1986	3.44	30.75	51.56	14.25
1987	4.49	12.21	38.67	44.63
1988	5.67	53.17	33.34	7.82
1990	8.15	47.11	26.62	18.12
1991	2.94	10.08	71.47	15.51
1992	18.68	30.12	24.57	26.63
1993	14.68	8.60	52.00	24.72
TOTAL	7.27	29.78	44.50	18.45

__Table III__: Estimated biomass (metric tonnes above, % below) by geographic zone and total for each survey.

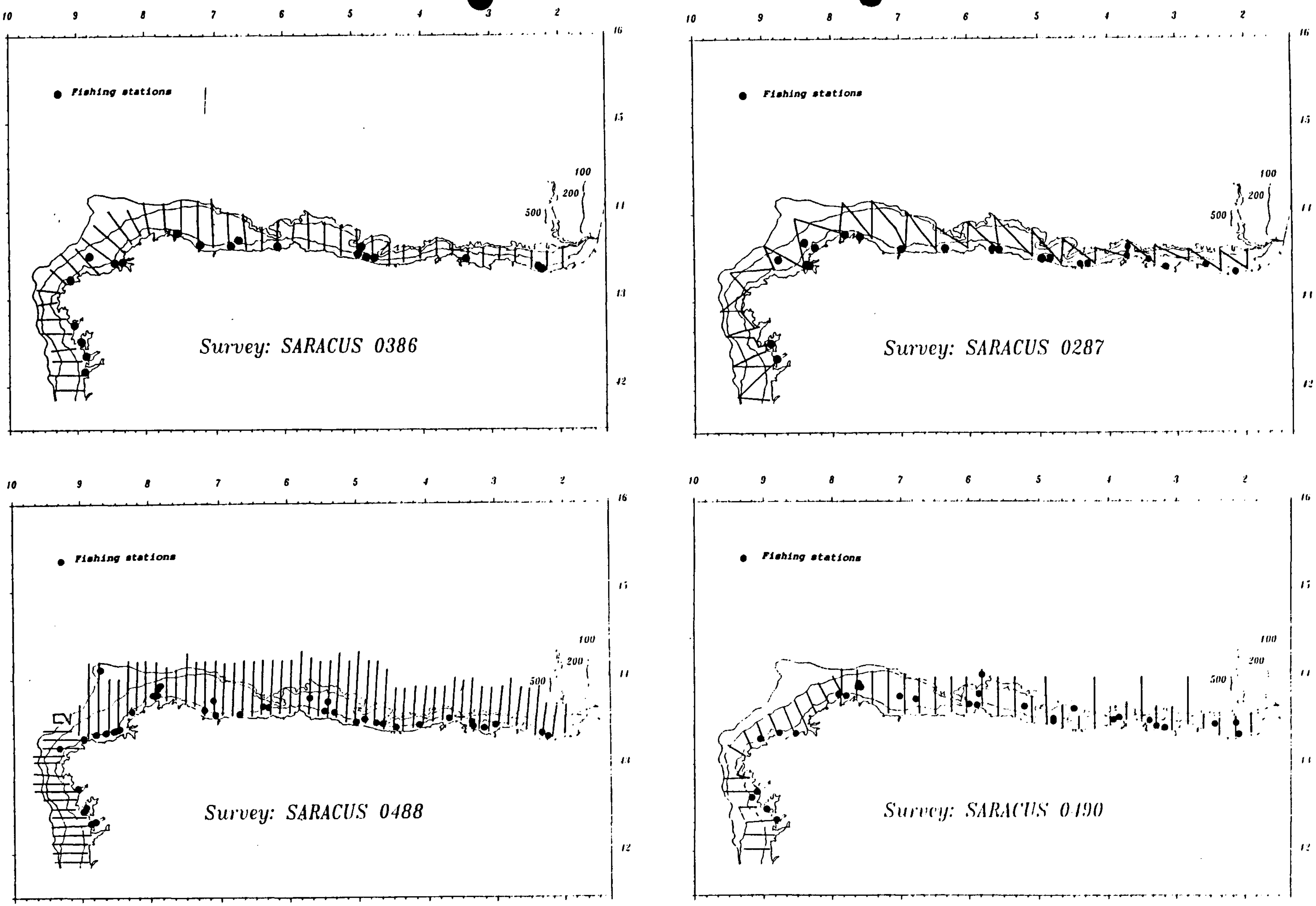


Figure 1: Cruise tracks and fishings stations

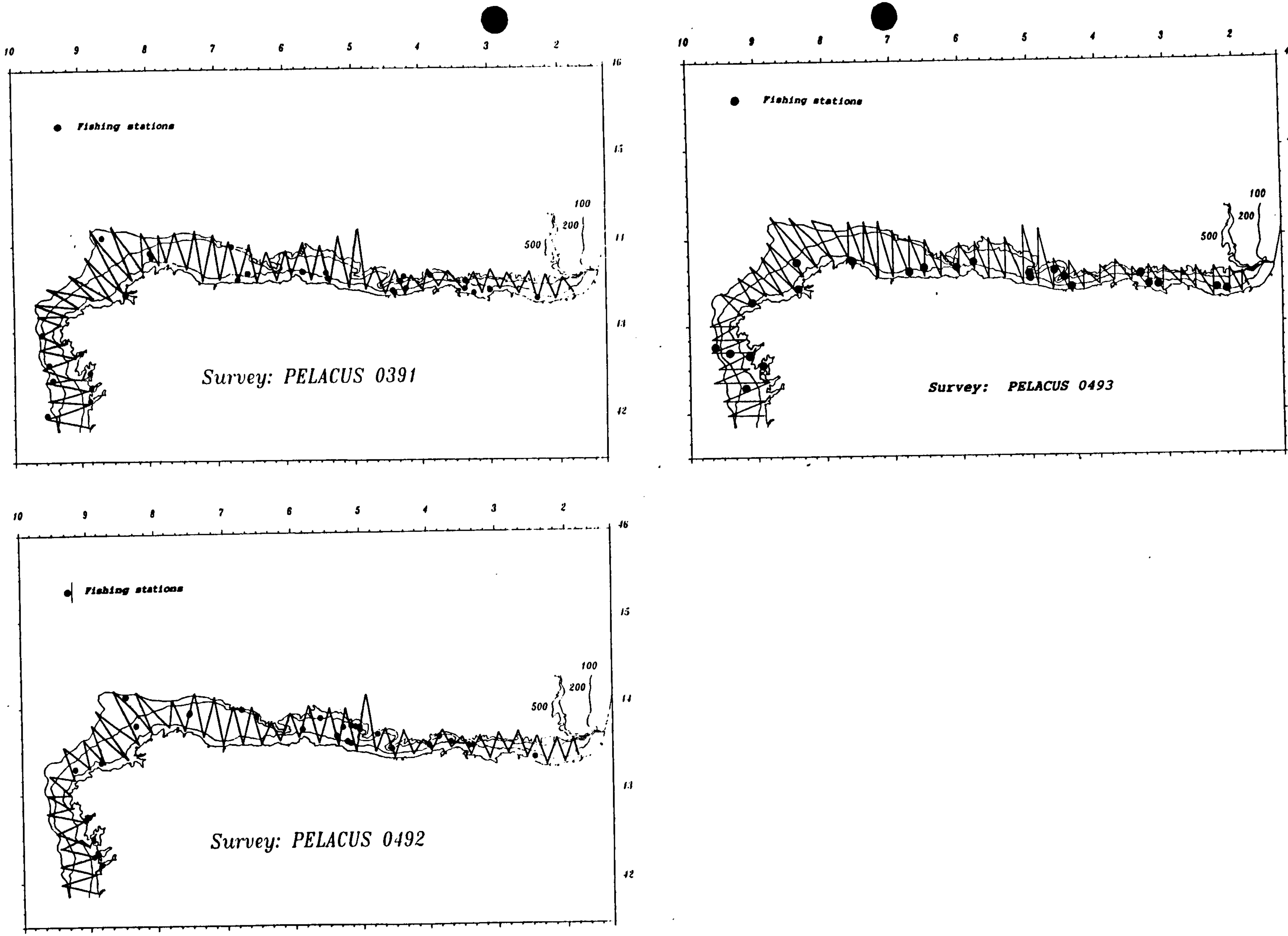


Figure 1: Cont'd

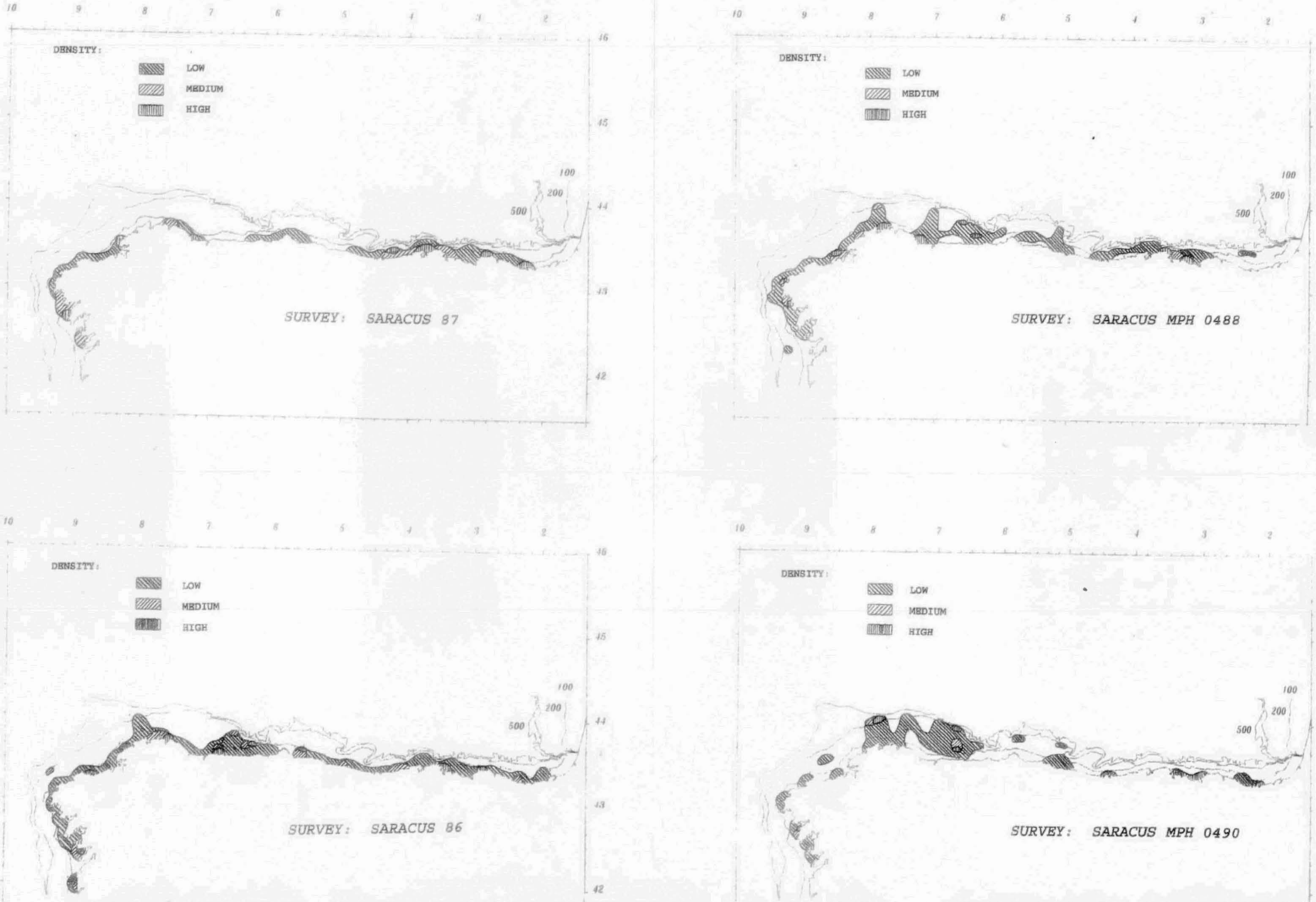
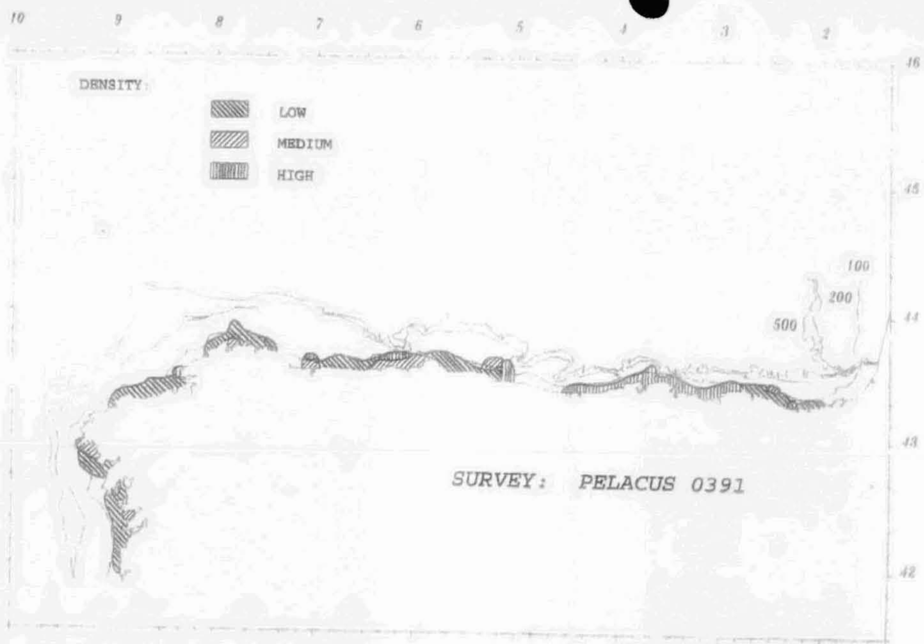
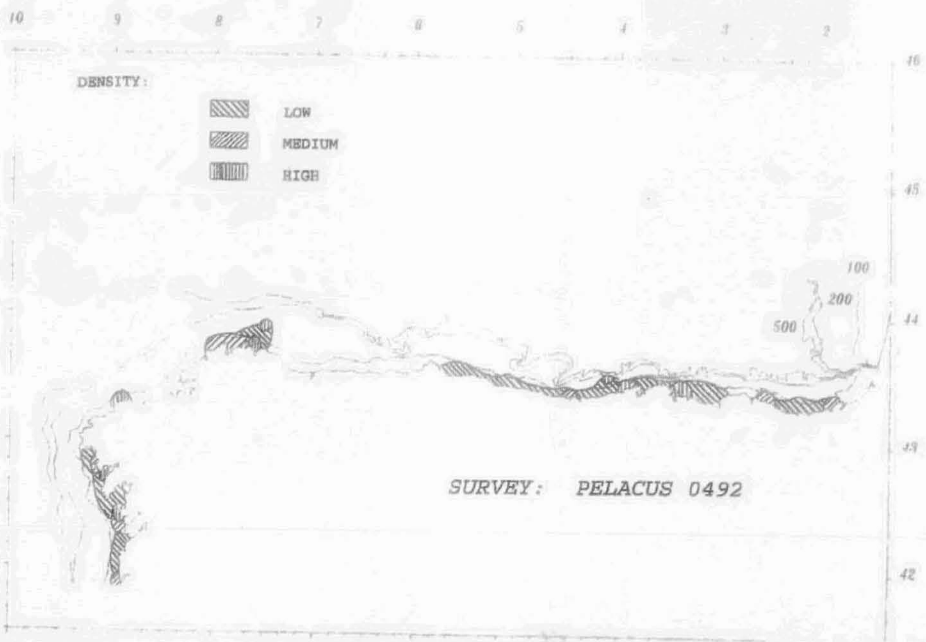


Figure 2: Relative abundance of sardine





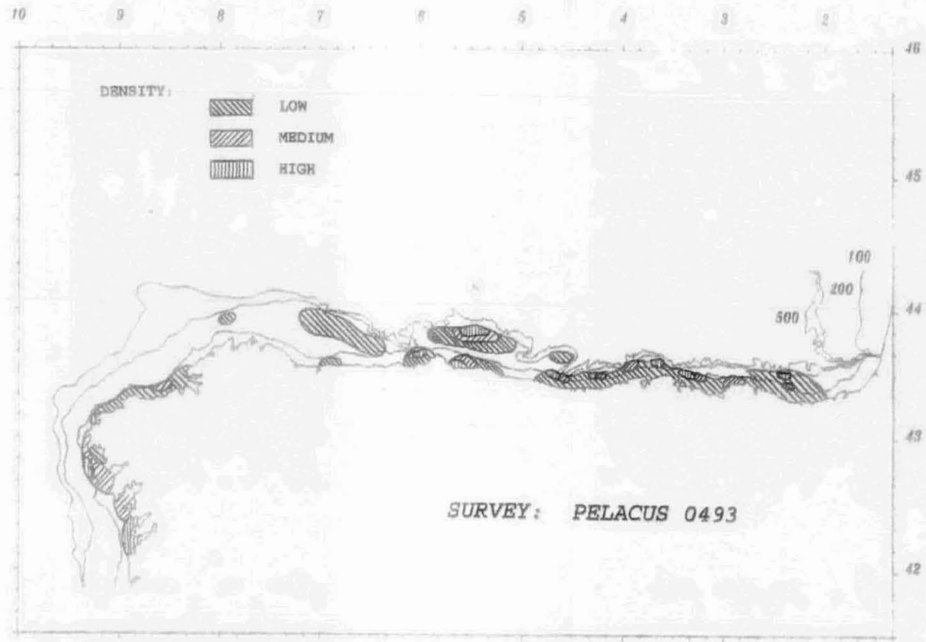


Figure 2: Cont'd

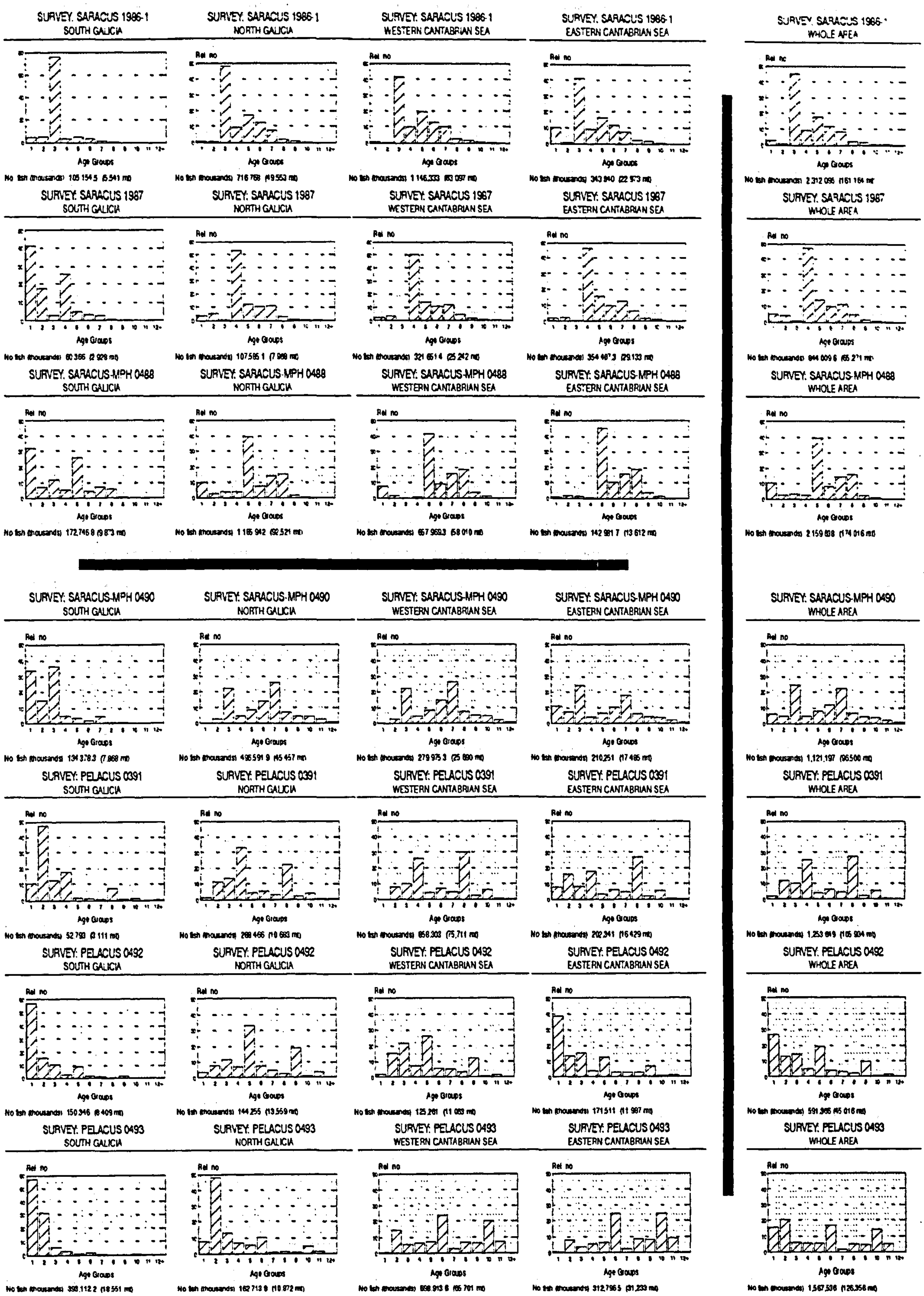


Figure 3: Estimated abundance by age group and geographic zone and total for each survey

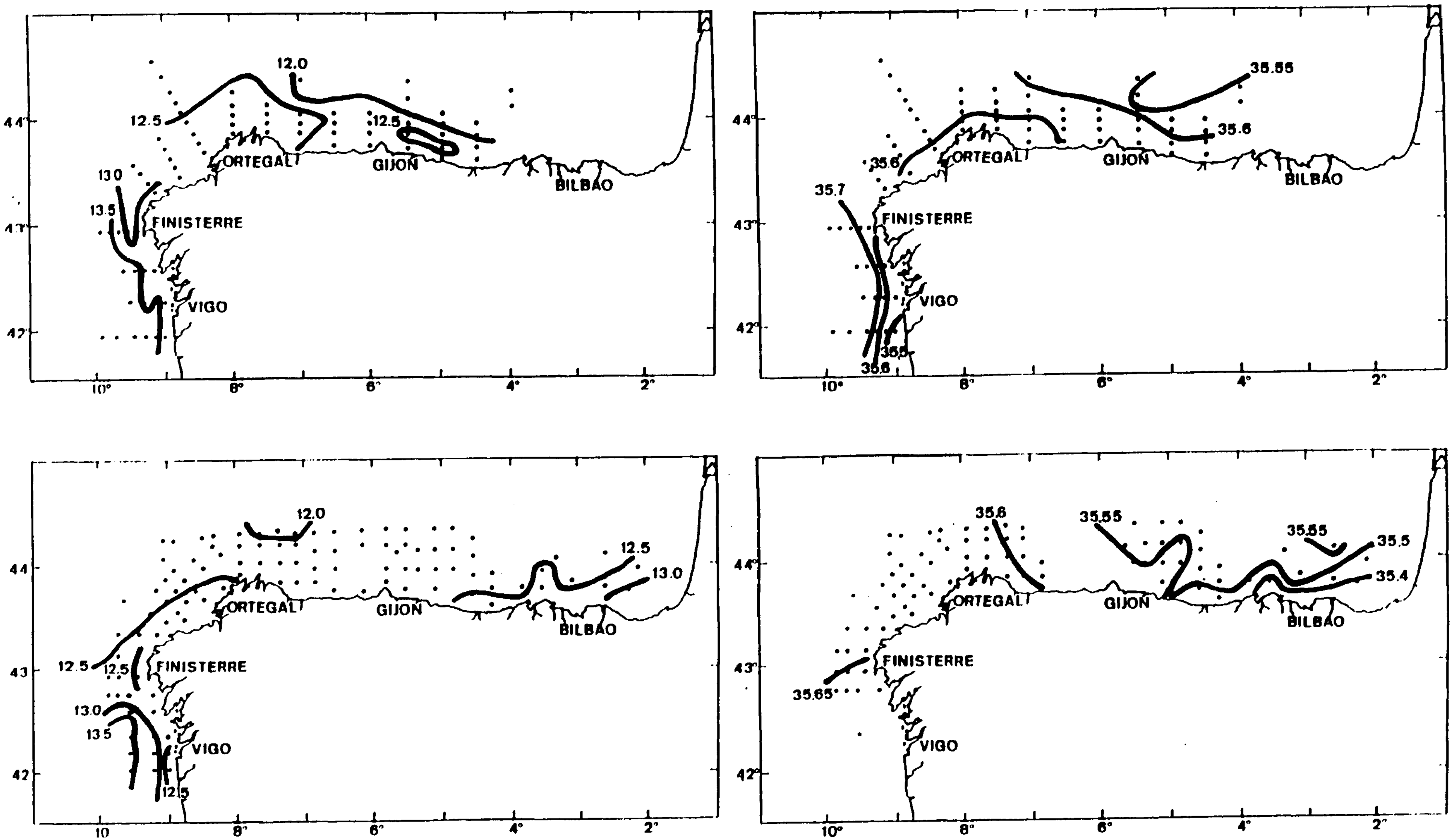


Figure 4: Termal and salinity distribution for 1987 (above) and 1988 (below)

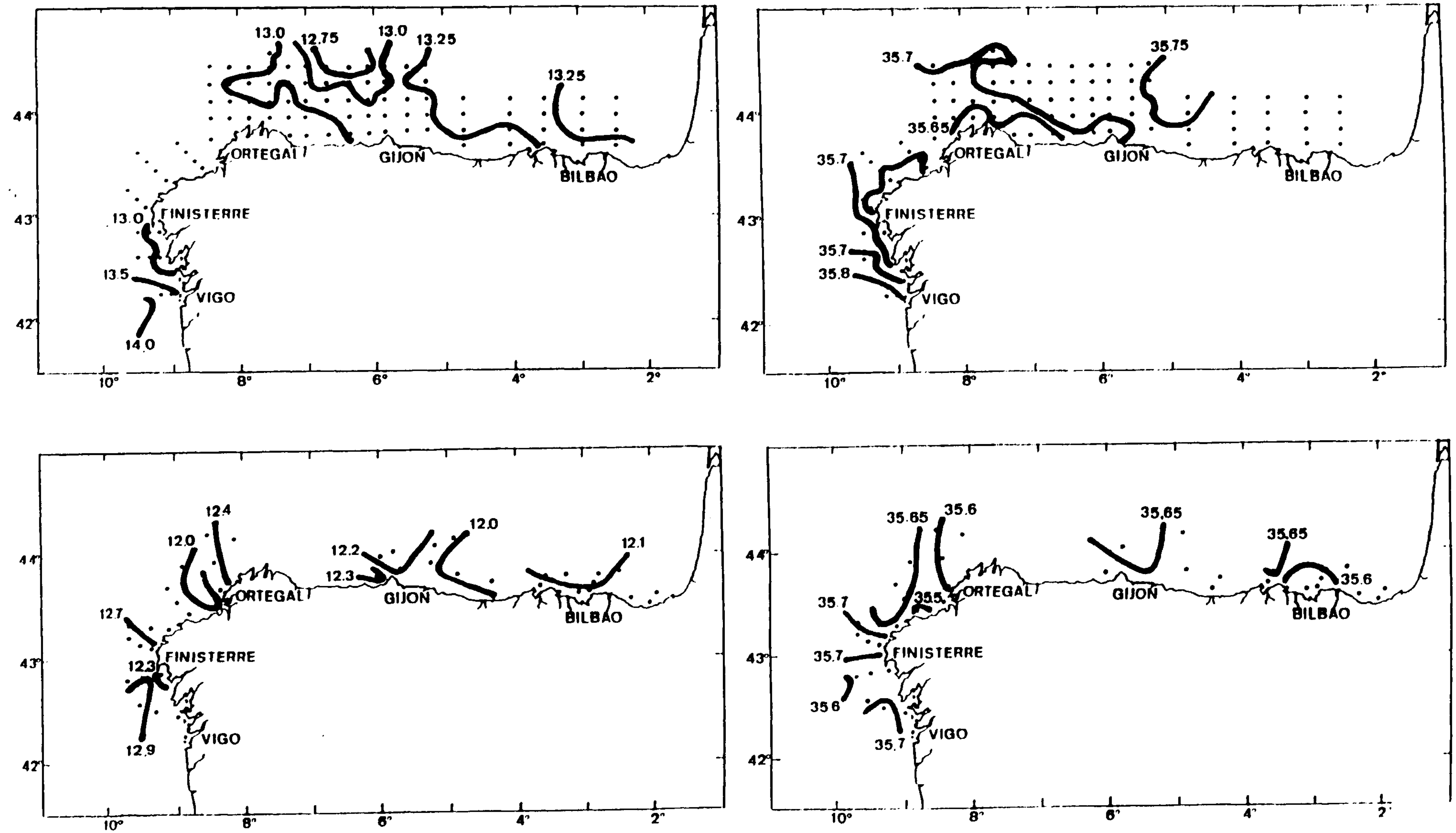


Figure 4: Termal and salinity distribution for 1990 (above) and 1991 (below)

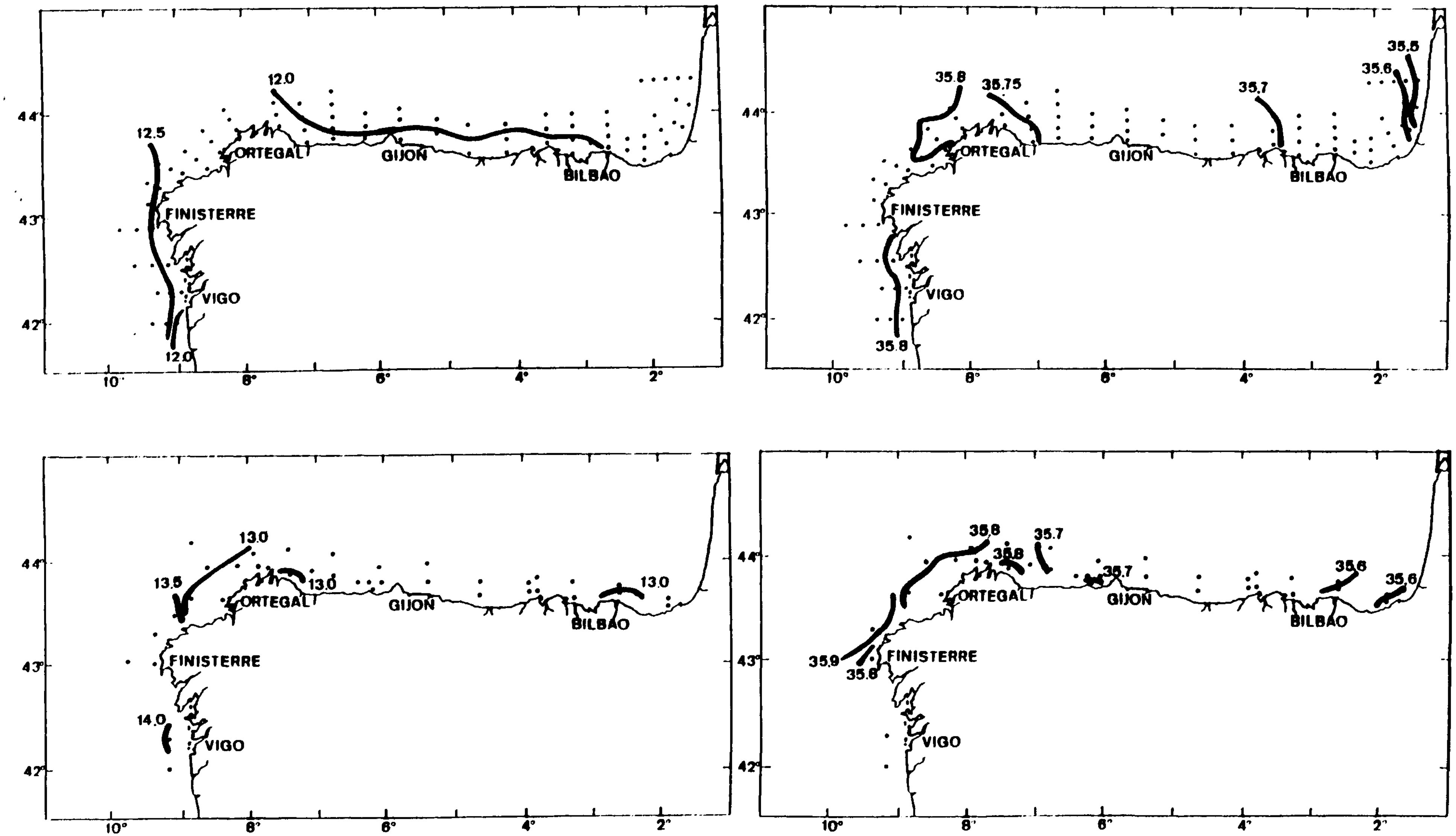


Figure 4: Termal and salinity distribution for 1992 (above) and 1993 (below)