Living Resources Committee

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REPORT OF THE

PLANNING GROUP FOR PELAGIC ACOUSTIC SURVEYS IN ICES SUB-AREAS VIII AND IX

La Coruña, Spain
30–31 January 1998

International Council for the Exploration of the Sea
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1 TERMS OF REFERENCE

In the last year, only Spain and Portugal had met in order to co-ordinate the acoustic surveys on sardine. On the other hand, France has routinely performed surveys in the Bay of Biscay. As there is a general coincidence on the main objectives of these surveys, the three countries have agreed to meet and to co-ordinate and standardise (if possible) the methods to be used in these surveys with the main aim of getting a better understanding of the pelagic species in ICES Sub-Areas VIII and IX and their relationship with the oceanographic and environmental factors. Thus, in accordance with C.Res. 1997/2:63, the Planning Group for Pelagic Acoustic Surveys in ICES Sub-Areas VIII and IX (Chairman: Mr P. Carrera, Spain) will meet in La Coruña, Spain for two days at the end of January 1998 to:

a) analyse the results of the 1997 acoustic surveys,

b) review the available information on small pelagic fish (both form the echograms and fishing stations) from the previous surveys;

c) revise the methodologies used by the different member countries, including oceanography and environmental factors;

d) propose improvements in both survey design and data analysis in order to get better understanding of the coastal pelagic ecosystem;

e) co-ordinate the timing of the surveys on Ibero-Atlantic sardine.

In order to get a better organisational structure and taking into account that this is the first time France, Portugal and Spain meet to analyse their acoustic surveys, terms of reference b), c) and d) have been treated first and then terms a) and e) have been reviewed later on.

2 PARTICIPANTS

Pablo Carrera (Chairman)	Spain
Bernard Liorzou	France
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Ramón Muiño	Spain
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*Part-time attendance.

A full list of participant addresses is given in Annex II.

3 REVISION OF THE METHODOLOGIES

The main features of methods used for each country are summarised in Table 1.

3.1 Portugal

Portuguese acoustic surveys are focused on sardine. These surveys are carried out on board R/V "Noruega", a 49 m stern trawler, on the continental shelf, between 20 to 250 m depth. Survey design has been varying between zig/zag and parallel transects, with a distance between peaks or transects of 10 nm. Nevertheless, after the last Planning Group meeting (ICES 1997/H:1) it was decided to standardise the survey design and, in the case of the Portuguese area, surveys will consist in a parallel design with a distance of 8 nm between transects. Surveys were conducted both night

and day as well as the fishing stations to determine species composition and to analyse the length composition. Trawl hauls are made using either pelagic or bottom gears; in both cases polyvalent doors are used.

Surveys have been performed in different periods of the year (February/March in 1986, 1988 and 1996–98; summer in 1985–1988 and 1995–96; and November/December in 1984–87, 1992 and 1997). Since 1996 Portuguese surveys have also covered the the Spanish area, Gulf of Cádiz.

For assessment purposes, acoustic energy has been allocated to fish species according to the known echotraces, corroborated by the fish composition of the surrounding fishing stations. Nevertheless, due to species mixing, it was difficult to use this method in 1997, and the acoustic energy was allocated to species by the species proportion found at the surrounded fishing stations (see Appendix I). Due to this change in species aggregation and composition, survey procedures have been reviewed in 1997. Acoustic records have been collected at night whereas fishing stations have been performed during the day.

Oceanography records (CTD cast) have been collected either directly during the acoustic surveys or they have been gathered from other cruises performed at the same time.

3.2 Spain

Spanish acoustic surveys were focused on sardine. The new Simrad EK-500 has been used since 1991 and the survey area was extended to cover the whole continental shelf, from 20 m to 1000 m where main species are sardine, horse mackerel, mackerel, anchovy and blue whiting. Surveys have been carried out on board R/V "Cornide de Saavedra" but R/V "Ignat Pavliuchenkov" has been used in 1990. In 1997 R/V "Cornide de Saavedra" has been replaced by the new R/V "Thalassa". Until 1993, survey design consisted in a zig/zag grid (except in 1988), and then a parallel grid with a distance of 6 nm between transects has been adopted. Acoustic records were collected both at day and night. Fishing stations were pelagic trawl hauls made with 12 m and 22 m vertical opening gears and Suberkrubb pelagic doors.

As in the Portuguese case, acoustic energy is allocated to species according to the echotraces, which are confirmed by the fishing stations.

CTD stations were always performed at the same cruise over the acoustic tracks.

3.3 France

French acoustic surveys were carried out on board R/V "Thalassa". In 1997 the old "Thalassa" has been replaced by the new one. Main objectives for these surveys have been varying according to research projects, but in general they have been focused on anchovy. Surveys were conducted in spring, generally at the end of the season, when anchovy is spawning.

Both acoustic records and fishing stations are collected during day, whereas the CTD stations are carried out at night. Pelagic trawl hauls are made using gears with a vertical opening of 12, 20 and 30 m with that of 20 m opening being the most used.

For assessment purposes, echo energy is allocated to species using the species proportion found at the fishing stations.

4 REVISION OF THE AVAILABLE INFORMATION ON SMALL PELAGIC FISH

From both echotraces and fishing stations and CTD stations important information on the pelagic coastal system has been collected with an historical perspective. French studies are based on intensive work in small areas as well as extensive work on the continental shelf. Portuguese and Spanish information comes from extensive work done during assessment cruises, mainly focused on sardine in spring.

It seems as if there have been changes in both species composition and fish assemblage along the Iberian Peninsula. These changes coincide with a decrease in the sardine stock and a shrinkage of the distribution area which is clearer in the Spanish Area (ICES Divisions North IXa, VIIIc) than in the Portuguese waters.

In the Portuguese waters sardine used to be the most important fish species. They formed big and thick schools, which allowed sardine to be clearly identified. Close to the coast these schools consisted mostly of small sardine. Other representative fish species were horse mackerel and small mackerel. Sometimes, larger schools of boar fish (*Capros aper*) or longstripe spinefish (*Macroramphosus scolopax*) were also noticed, especially close to the continental shelf break. In the Spanish area there is a distribution pattern of both species composition and species assemblage along the coast (Figures 1a–d show different schematic views along the shelf). Close to the Portuguese border the most important feature is the presence of big estuaries called Rias (Figure 1a). In these, small sardines as well as very few schools of anchovies and sprats are the most representative fish species. Outside, along the continental shelf, horse mackerel and sometimes small mackerel and, close to the shelf break, blue whiting and sometimes *Capros aper* or *Macroramphosus scolopax* are the most important ones. Further north, just in the corner of the Iberian Peninsula, the coast has smaller estuaries and the continental reaches as far as 500 m depth where the slope starts (Figure 1b). Close to the coast, big and thick schools of sardine, whose sizes are bigger than in the southern part, and small horse mackerel are the most representative species whereas big mackerel, horse mackerel and blue whiting characterise the shelf. Close to the slope, a layer of mixed blue whiting and mictophidae is sometimes present. The western part of the Cantabrian Sea is a transition zone between the inner part of the Bay of Biscay and open waters. Here, close to the coast, sardine and bogue are the most important. From here to the shelf break, horse mackerel, both small and big ones, are important together with big schools of mackerel. Mackerel schools are sometimes mixed with those of blue whiting and usually over the horse mackerel layer. The presence of *Trachurus mediterraneus* is also noticed (Figure 1c). In the inner part of the Bay of Biscay (Figure 1d) species diversity increases, with clusters of different species mainly composed of sardine, bogue, horse mackerel (both *T. trachurus* and *T. mediterraneus*), mackerel (*S. scombrus* and *S. japonicus*) and anchovy. On the French coast, this distribution pattern continues and close to the rivers sprat is also an important fish species. It seems that horse mackerel is distributed close to the sea bottom whereas the other fish species remain over this.

According to the intensive work developed by France the oceanographic and climatic conditions have an important influence on the species distribution and distribution pattern. After a change in the weather conditions, both species composition and aggregation pattern varied. Besides, the distribution of the temperature and salinity in water column varied according to data from CTD casts. This work has been done by visiting the same area several times. The Planning Group discussed this kind of work and pointed out the necessity to perform the hydrographic profiles at the same time as the acoustic track in order to avoid misinterpretations when the fish distribution is analysed.

4.1 Changes in Species Aggregation Detected in 1997

As well as this general picture of the species composition and distribution in ICES Divisions VIII and IX, several changes in species composition and distribution have been detected since 1996 in both Portuguese and Spanish waters. These changes were more important in 1997.

In Portugal, sardine has been detected in shallower waters, in dense schools where both juveniles and adults seemed to be mixed. Moreover, big patches of fish assemblages (macro structures, as they have been defined by Petitgas and Levenez (1996), Figure 2) have also been found along the coast. These fish assemblages were composed of several fish species with chub mackerel (*S. japonicus*), small mackerel, anchovy, sardine and bogue (*Boops boops*) as the most important. This change in the aggregation pattern led to a change in the survey strategy and data analysis. Realising the impossibility to allocate the echo energy to known echotraces, it was decided to make the fishing stations during day and the acoustic track at night. Data analyses have been reviewed and the echo energy has been allocated according to species proportion found at the fishing stations. This change will be further analysed in Section 6. Since the beginning of the 1990s, there is a diminution in both sardine abundance and its distribution area in Spanish waters. The number of schools has been decreasing whereas the size of these has been increasing, especially in Cantabrian waters. Since 1997, macro structures have also been detected in this area. The species composition and proportion of these structures varied during the day. Pelagic trawl hauls conducted on these patches at different hours gave different species proportion:

	SPECIES PROPORTION (%)					
HAUL TIME	**Ss**	**Sj**	**Tt**	**Bb**	**Sp**	**Ot**
13:45	21.4	18.7	38.9	19.4	1.6	-
16:30	43.3	-	47.6	8.9	0.1	-
19:45	4.9	0.2	87.7	7.3	-	0.0

Ss: *Scomber scombrus;* Sj: *Scomber japonicus;* Tt: *Trachurus trachurus;* Bb: *Boops boops;* Sp: *Sardina pilchardus;* Ot: Others.

This situation has been discussed by the Planning Group and it was decided that it would be better to perform the fishing stations at the same time as the acoustic track. Moreover, in order to minimise changes is fish proportion, the acoustic track and the fishing stations should be carried out only during day, leaving the night to make the hydrographic stations.

5 SPECIFIC METHODOLOGY TO STUDY THE PELAGIC ECOSYSTEM

The different general objectives which lead the surveys were pointed out. For Portugal and Spain the estimation of the sardine abundance is the main goal, whereas for France the most important is the study of the ecosystem in relation to the anchovy distribution and biology. Besides, Spain and France use the same research vessel and the kind and quality of the records gathered are much the same. Thus the Planning Group decided to clarify the methodology to be used during the next acoustic surveys. This can be divided into two different main activities:

5.1 Extensive Work

Under this topic, activities related to the stock assessment of the pelagic species and distribution area according to the hydrographic and climate conditions are included. Methods and strategies proposed are the following:

a) Survey design: Parallel transects over the area to be covered. In the Spanish area distance between transects should be 6 nm, in the Portuguese area 8 nm and in French waters around 10–12 nm;

b) Acoustic time: Acoustic track should be conducted only at daytime;

c) Fishing stations: The fishing station being the best method to allocate echo energy, it is strongly recommended to perform as many hauls as possible in order to get good information on species composition and their proportion. As in the case of acoustic records, hauls should be made during day;

d) Hydrographic data: CTD casts when possible, should be taken at night using the same R/V;

e) Data recording: Echo traces should be stored on a digital basis. These data should be compatible with the new software MOVIES+ or similar in order to allow data to be replayed with different settings and thresholds;

f) Data analysis: Given the impossibility of allocating the echo energy to species according to the echo traces, this should be made by reference to the species proportion found at the fishing stations (Nakken and Dommasnes, 1975) by using the following agreed table of TS/length relationship:

SPECIES	Name	b_{20}
Sardine	*Sardina pilchardus*	-72.6
Sprat+clupeids	*Sprattus sprattus*	-71.2
Anchovy	*Engraulis encrasicholus*	-71.2
Horse Mackerel	*Trachurus* spp.	-68.7
Mackerel	*Scomber scombrus*	-82
Chub mackerel	*Scomber japonicus*	-68.7
Bogue	*Boops boops*	-67
Blue whiting	*Micromesistius poutassou*	-72.8*
Other gadoids	-	-67

b_{20} means *TS-20*log(L)*

* this correspond to a relationship in which *log L* is multiplied by 21.8.

5.2 Intensive Work

Intensive work refers to the activities to be made in specific areas to develop studies on fish and school behaviour and/or on the overall pelagic ecosystem. This could be done either during a single survey, by repeating transects during a whole day (including night) or on different cruises by repeating the same area with the same strategy. The main goal to achieve with this kind of exercise is to improve the knowledge about diurnal behaviour aspects and migration patterns. In this way Spain and France will cover the south of the Bay of Biscay during their surveys.

6 CO-ORDINATION FOR 1998 ACOUSTIC SURVEYS IN ICES SUB-AREAS VIII AND IX

Since 1995, Spain and Portugal have co-ordinated the acoustic activities focused on sardine and covered the Atlantic and Cantabrian waters of the Iberian Peninsula at the same time. From 1996 this survey has been carried out in March. For this year, there will be a full coverage of an area from the Gulf of Cádiz to the south of the Bay of Biscay (45°N) in March and the French waters will be covered in May (see Figure 3):

Ship	Period	Area
"Noruega"	06/03/98–31/03/98	Miño river to Gulf of Cádiz
"Thalassa"	13/03/98–12/04/98	Miño river to Arcachon
"Thalassa"	20/05/98–7/06/98	Bay of Biscay

7 ANALYSIS AND DISCUSSION OF 1997 PORTUGUESE AND SPANISH RESULTS

As it was pointed out before, during the last few years there seemed to be a change in the distribution pattern of pelagic fish species. This change took place at the same time as the decline in stock biomass of sardine. This change affects several fish species, which tend to form macrostructures of different species as shown in Figure 2. Under such conditions it is not possible to allocate echoenergy to species according to known echotraces. Moreover, this kind of structure is more frequent in the outer part of the main distribution area of sardine which is located at the northern part of Portugal. Fish composition of these structures varied from one area to another. In Cantabrian waters there were almost no sardines, whereas in the Portuguese area, sardine was present according to data from the fishing stations.

A stock size estimate has been made in Portugal using the normal methodology, and the results have been used to perform the assessment (ICES 1998/Assess:6). In Spain, fish species proportion has been used in the areas where it was not possible to allocate echoenergy by echotraces in spite of the fact that the estimated abundance of sardine was low.

Portugal had carried out another acoustic survey off the Portuguese coast in November and the same kind of structures were found. Thus, in order to avoid problems in the allocation of the echoenergy, both survey strategy and data analysis have been changed and the preliminary results of the spring assessment have been reviewed and updated using fish proportion. Main results are shown in Annex I.

The Planning Group has analysed and discussed this document. Since it is very difficult to identify and allocate echotraces, the use of the fish proportion found at the fishing stations is recognised as the best way to split the echoenergy. Thus, the Planning Group has found this new assessment more reliable and therefore it should be used for stock assessment purposes.

8 RECOMMENDATIONS

Considering the changes that have been detected around the Iberian Peninsula, the Planning Group strongly recommends to follow the methods and strategies mentioned in Section 5.

As the best method to allocate the echoenergy is to use the proportion found at the fishing stations, the Planning Group recommends further investigations into the impact of the quality and number of fishing stations on the fish abundance estimations, in terms of both precision and accuracy.

A co-ordinated joint acoustic survey on sardine will be carried out in 1998 along the Atlantic Iberian coast. In order to keep the time series, this should be performed in March.

As well as this co-ordination, the Planning Group recommends to plan common activities in the inner part of the Bay of Biscay between France and Spain in the way described in Section 5. Similar results are expected as both countries use the same research vessel and the same methodology.

9 REFERENCES

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ICES. 1998. Report of Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy, ICES Headquarters, 9–18 September 1997. ICES CM 1998/Assess:6.

Nakken and Dommasnes. 1975. The application for an echo integration system in investigations on the stock strength of the Barents Sea Capelin (*Mallotus villosus*, Müller) 1971–74. ICES CM 1975/H:52 (Mimeo).

Petitgas, P. and J.J. Levenez. 1996. Spatial organisation of pelagic fish: echogram structure, spatio-temporal condition, and biomass in Senegalese waters. *ICES Journal of Marine Science* 53: 147–153.

		PORTUGAL	FRANCE	SPAIN
Echo sounder	**Manufacturer**	Simrad EK500	Ossian 1500	Simrad EK500
	Frequency (kHz)	38	38	38
	Pulse Length	1 ms	1 ms	1 ms
	Ping interval	Automatic	1/2 s	automatic
Transducer	**Mounting**	Hull mounted	Hull mounted	Hull mounted
	Beam	Split beam	Split beam	Split beam
Calibration	**Method**	Standard target	Standard target	Standard target
	Periodicity	Yearly	Yearly	Yearly
Survey	**Design**	Parallel/zigzag	Parallel	Parallel/zigzag
	Time (acoustic sampling)	Day/night-day	Day	Day/night-day
	ESDU	1 nm	1 nm	1 nm
	Species allocation	Echotraces/catches	Catches	Echotraces/catches
Fishing stations	**Haul allocation**	Oportunistic	Oportunistic	Oportunistic
	Gear type	Pelagic/bottom t.	Pelagic trawl	Pelagic trawl
	Time	Day/night	Day	Day/night
Oceanography	**Data**	CTD	CTD/SST/SSS	CTD/SST/SSS

Table 1 General features of the acoustic survey for each country.

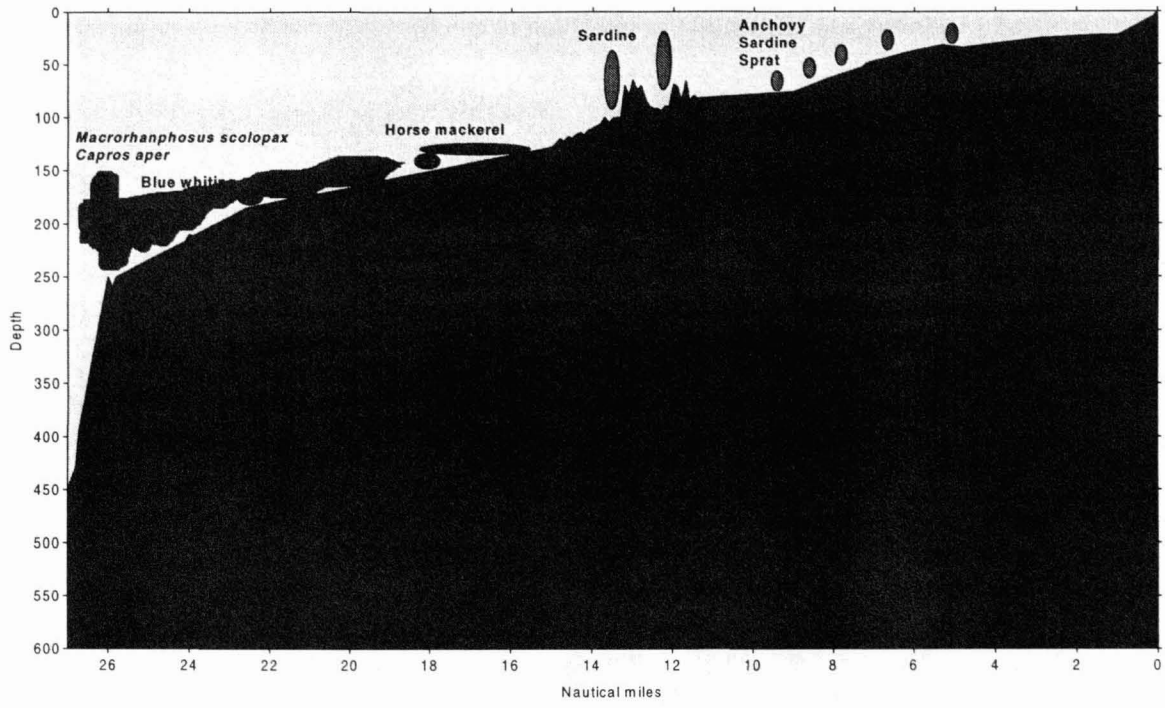

Figure 1a Schematic representation of the species assemblage in South Spain (42° N).

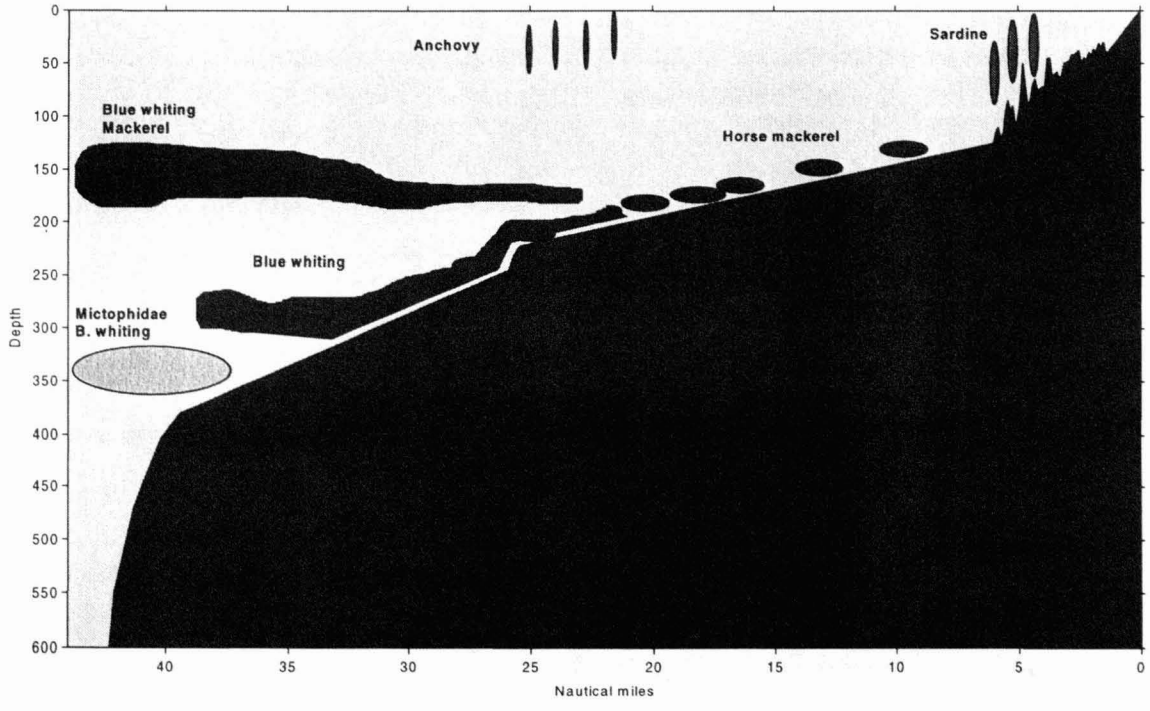

Figure 1b Schematic representation of the species assemblage in North-West corner of Spain (43°15'N).

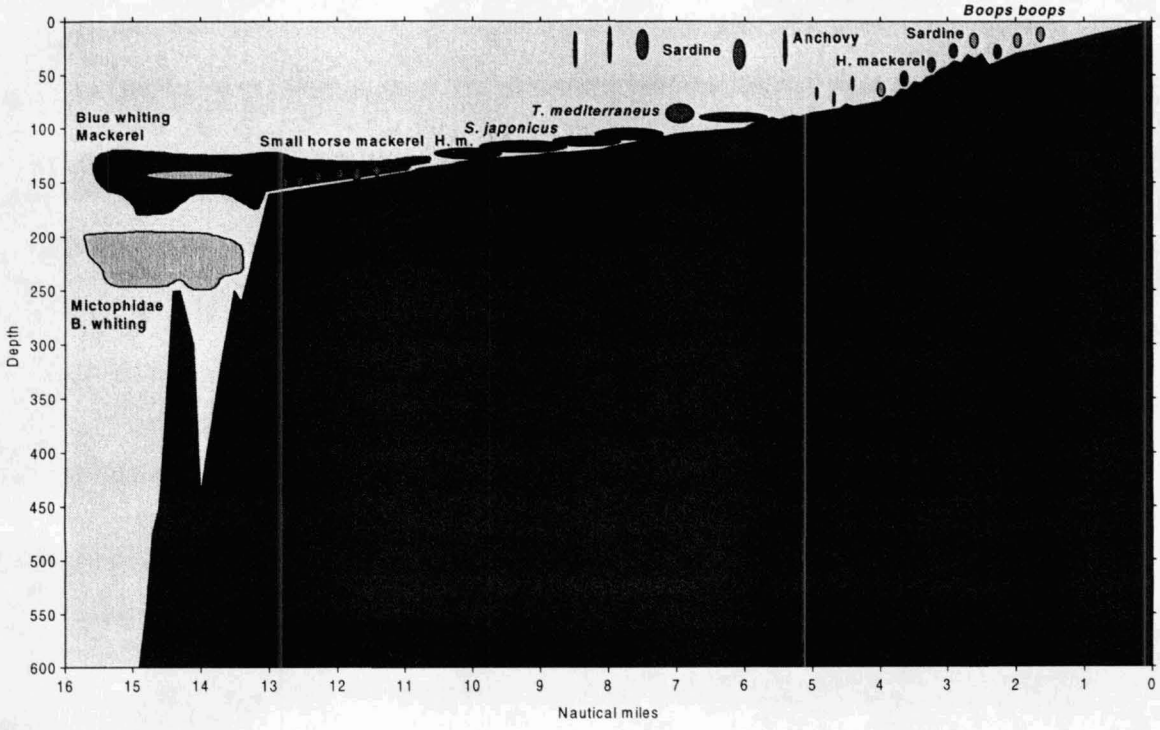

Figure 1c Schematic representation of the species assemblage in the Western part of the Cantabrian Sea (5°W).

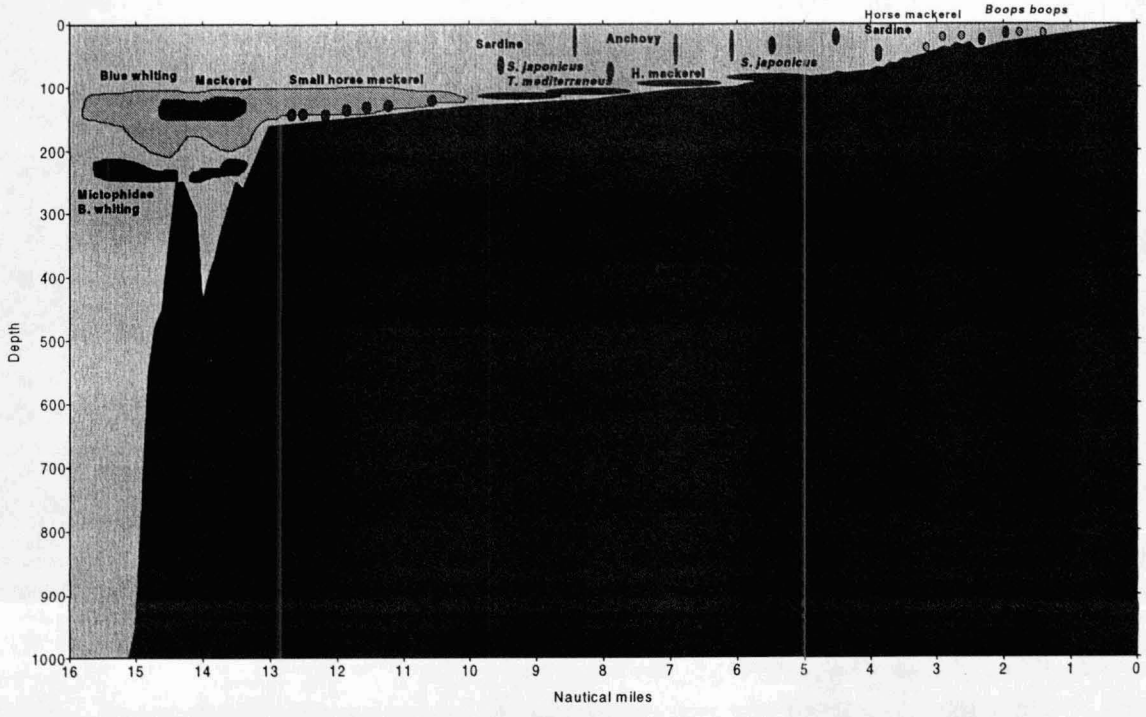

Figure 1d Schematic representation of the species assemblage in the inner part of the Bay of Biscay (1°30'W).

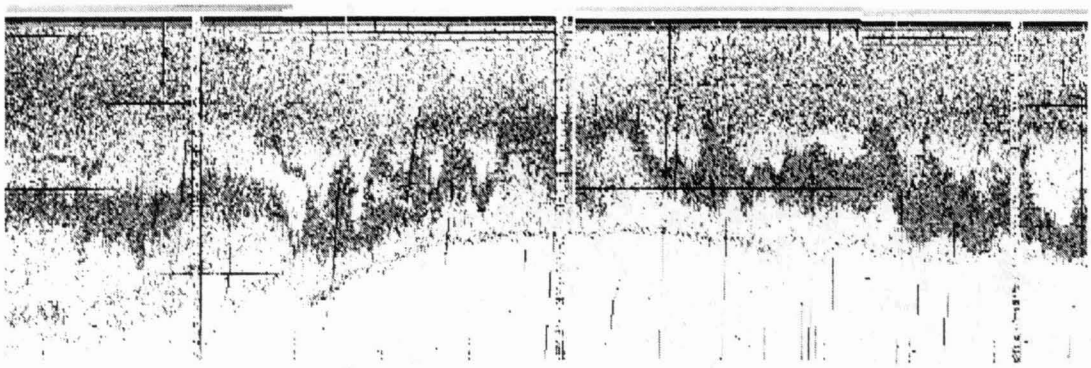

Figure 2 Macrostructure found at 4°W in the Spanish waters at 20:00 UTC, 60 m depth. Total length was approximately 3.5 nautical miles.

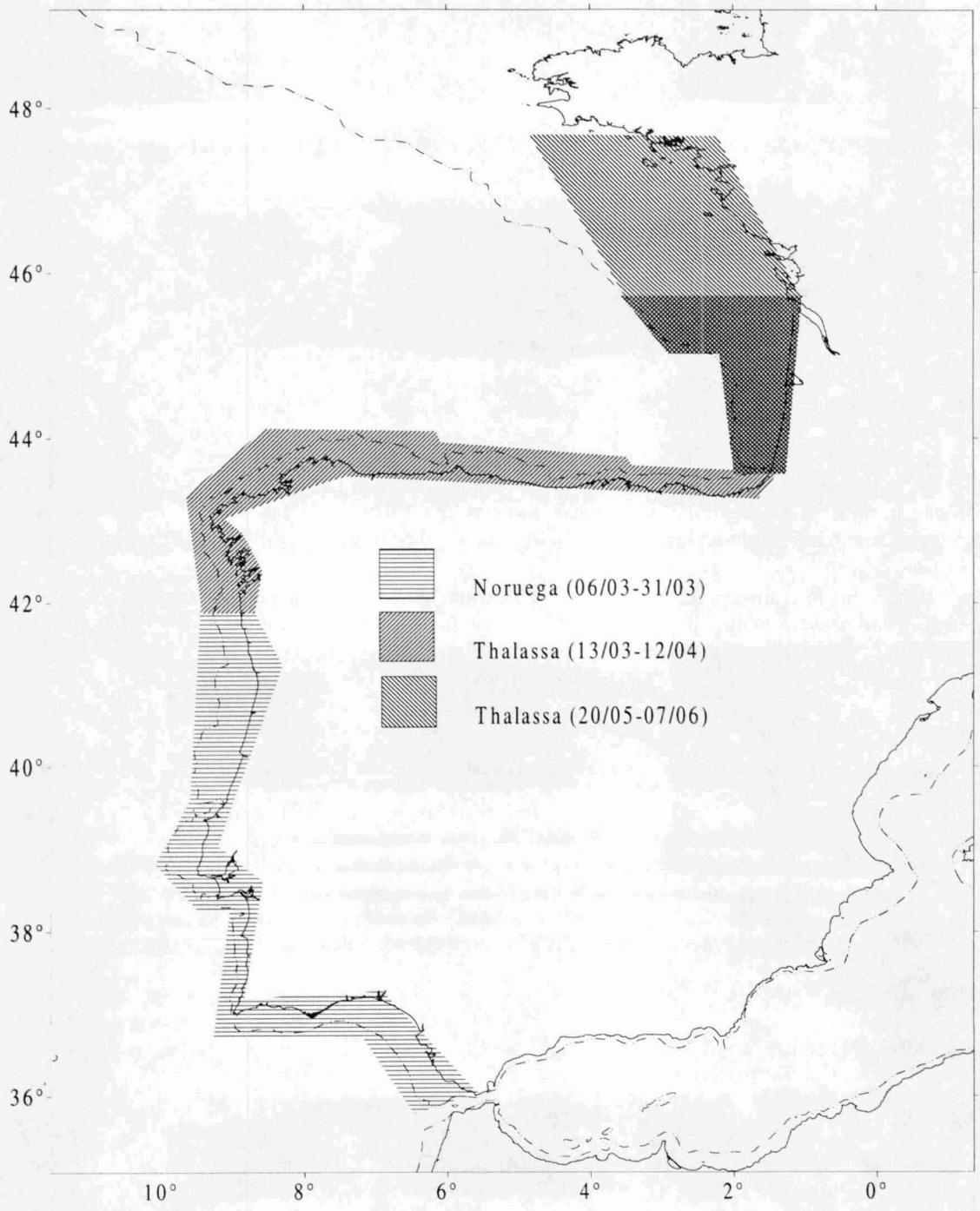

Figure 3 Area and date to be covered for each vessel.

ANNEX I

REVISION AND UPDATE OF THE 1997 SPRING ACOUSTIC SURVEY

by

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For the earlier acoustic surveys carried out in the Portuguese waters, allocation of the echo-energy was made according to the knowledge of the acoustic traces for the different fish species. Inspection of pelagic hauls data sheets indicate that species identification appears to be quite realistic, when sardine are caught by the pelagic gear they are the either the only species caught or accompanied by single specimens of mackerel, horse mackerel or anchovies. There are almost no Chub mackerel found in these years. Nevertheless in 1997 it was difficult to identify the acoustic records to species level. Dense echo-traces which have been found along the coast, seemed to be formed by different fish species

For this reason, the first estimation of the sardine abundance, done using the traditional methodology, has been reviewed and a new estimation has been made using the method proposed by Nakken and Dommasnes (1975) which was recommended for the ICES for splitting acoustic records by species proportion.

Material and methods

According to the methodology proposed by Nakken and Dommasnes (op.cit) the following TS/length relationship have been used:

Sardine	20 log L – 72.6
Chub mackerel	20 log L – 68.7
Bogue	20 log L – 67.0
Horse mackerel	20 log L – 68.7
Anchovy	20 log L – 71.2
Atlantic mackerel	20 log L – 82.0

Where TS is id dB/individual and L is length in cm

Results and discussion

Figure 1 shows the cruise track design and location of trawl station. In Figure 2 the sardine distribution is represented according to the allocated echo-energy. Table 1 represents the basic acoustic data by sectors and Table 2 shows the differences between the old and the new assessment by age group and area.

Major changes are related to southern areas where the species mixtures were higher. In these areas, big echo-traces have been found and they seemed to be composed by several fish species. On the other hand, in the north part they were no found this kind of macro-structures, thus there were only a change of a 4% in number between the new and the old assessment whereas the old assessment gave an overestimation of the sardine abundance Occidental South, Algarve and Cadiz. As in these areas, age groups 2 and older were the most important, major changes are related to the estimated size of the spawning stock biomass which has been reduced in 15% in number.

AREA	SECTOR	OLD Area	OLD Average	NEW Area	NEW Average
	Caminha	32.1	64	28.9	64.0
	Porto			151	641.0
OCN	Aveiro	406.6	1435.0	240.2	1794.0
	Figueira	218.8	2056.0	115.4	3721.0
	Nazare			110.2	510.0
	Total	**657.5**	**1554.4**	**645.7**	**1469**
	Peniche 1	334.4	1514	54.6	3655.0
	Peniche 2			213.9	983.0
OCS	Lisboa	135.1	1790.0	186	1681.0
	Setúbal			61	2018.0
	Sines 1	195.2	1774.0	82	476.0
	Sines 2			135	155.0
	Arrifana	197.6	727.0	93.8	358.0
	Total	**862.3**	**1431.1**	**826.3**	**1090**
	Sagres			131.9	2232.0
	Lagos	328.6	1859	113.4	925.0
	Albufeira			119.9	767.0
ALGARVE	Faro	187	890.0	57.4	386.0
	Vila Real			73.5	62.0
	Total	**515.6**	**1550.1**	**496.1**	**1169**
PORTUGAL	**Total**	**2035.4**	**1315.5**	**1968.1**	**1219**
	Cádiz 1	590.7	931	190.6	411.0
	Cádiz 2	498.6	650.0	140.1	302.0
CADIZ	Cádiz 3			275.2	1419.0
	Cádiz 4			207.9	885.0
	Cádiz 5			238.7	193.0
	Total	**1089.3**	**799.7**	**1052.5**	**661**
TOTAL	**Total**	**3124.7**	**1394**	**3020.6**	**1071**

Table 1 Basic acoustic data by sectors and evaluation.

AREA	AGE GROUP	OLD Number	%	NEW Number	%	Difference Number	%
	0						
	1	2791	61.2	3127	65.7	-336	89.3
OCN	2	234	5.1	274	5.8	-40	85.4
	3	736	16.1	816	17.1	-80	90.2
	4	536	11.8	405	8.5	131	132.3
	5	263	5.8	137	2.9	126	192.0
	6						
	7+						
	Total	**4560**		**4759**		**-199**	**95.8**
	0						
	1	1397	29.1	1217	32.6	180	114.8
OCS	2	1393	29.1	1131	30.3	262	123.2
	3	464	9.7	268	7.2	196	173.1
	4	707	14.7	478	12.8	229	147.9
	5	723	15.1	544	14.6	179	132.9
	6	110	2.3	96	2.6	14	
	7+						
	Total	**4794**		**3734**		**1060**	**128.4**
	0						
	1	111	4.1	37	1.9	74	300.0
ALGARVE	2	810	29.6	479	25.2	331	169.1
	3	355	13.0	259	13.6	96	137.1
	4	482	17.6	349	18.3	133	138.1
	5	850	31.1	674	35.4	176	126.1
	6	129	4.7	106	5.6	23	
	7+						
	Total	**2737**		**1904**		**833**	**143.8**
	0						
	1	4299	35.6	4381	42.1	-82	98.1
PORTUGAL	2	2437	20.2	1884	18.1	553	129.4
	3	1555	12.9	1343	12.9	212	115.8
	4	1725	14.3	1232	11.8	493	140.0
	5	1836	15.2	1355	13.0	481	135.5
	6	239	2.0	202	1.9	37	
	7+						
	Total	**12091**		**10397**		**1694**	**116.3**
	0						
	1	2033	50.2	1962	55.1	71	103.6
CADIZ	2	1627	40.1	1355	38.1	272	120.1
	3	319	7.9	208	5.8	111	153.4
	4	58	1.4	27	0.8	31	214.8
	5	16	0.4	6	0.2	10	266.7
	6						
	7+						
	Total	**4053**		**3558**		**495**	**113.9**
	0						
	1	6332	39.2	6343	45.5	-11	99.8
TOTAL AREA	2	4064	25.2	3239	23.2	825	125.5
	3	1874	11.6	1551	11.1	323	120.8
	4	1783	11.0	1259	9.0	524	141.6
	5	1852	11.5	1361	9.8	491	136.1
	6	239	1.5	202	1.4		
	7+						
	Total	**16144**		**13955**		**2152**	**115.7**

Table 2 Estimated abundance (million fish) by age group and area.

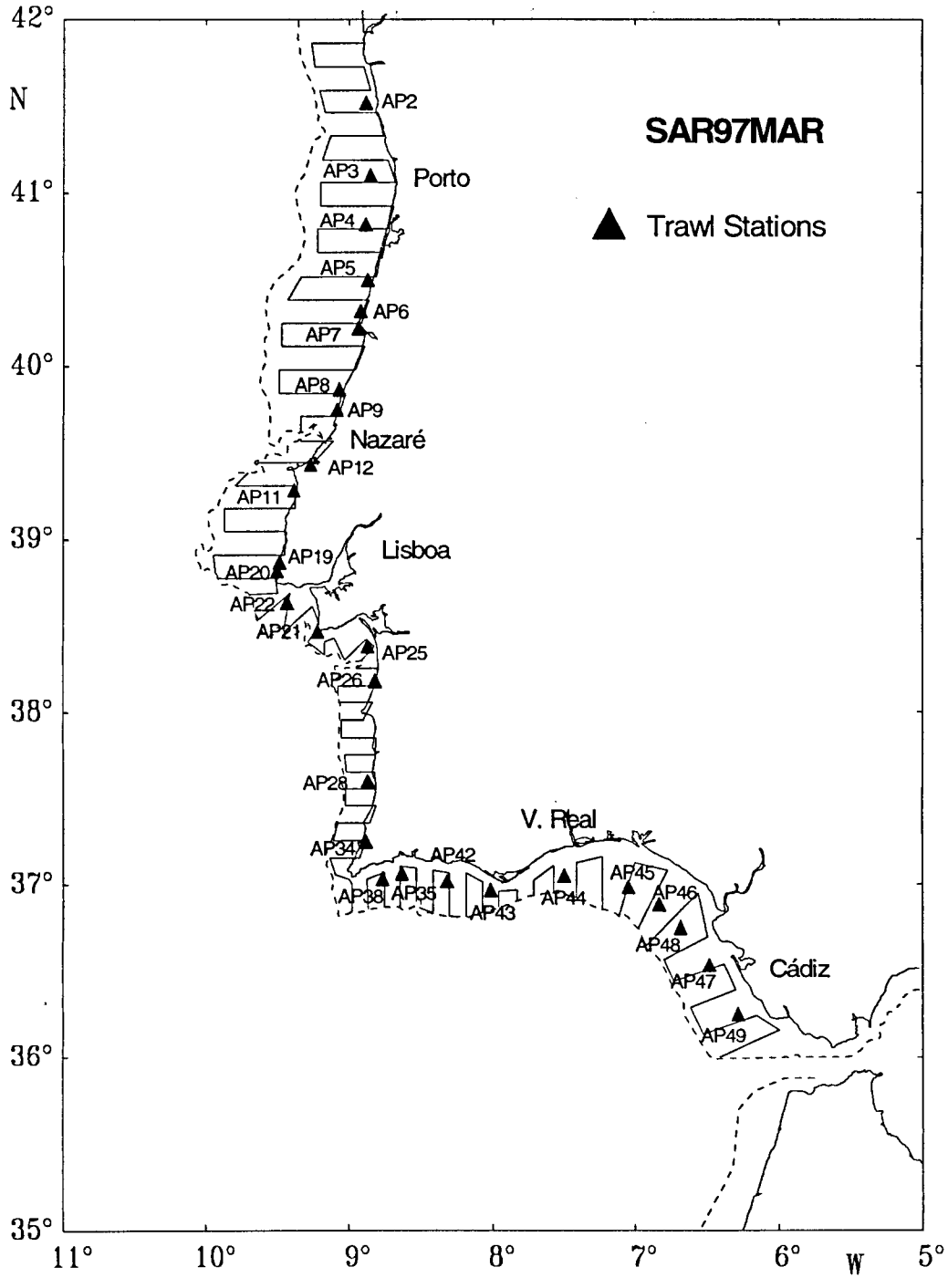

Figure 1 Cruise track design and location of trawl station.

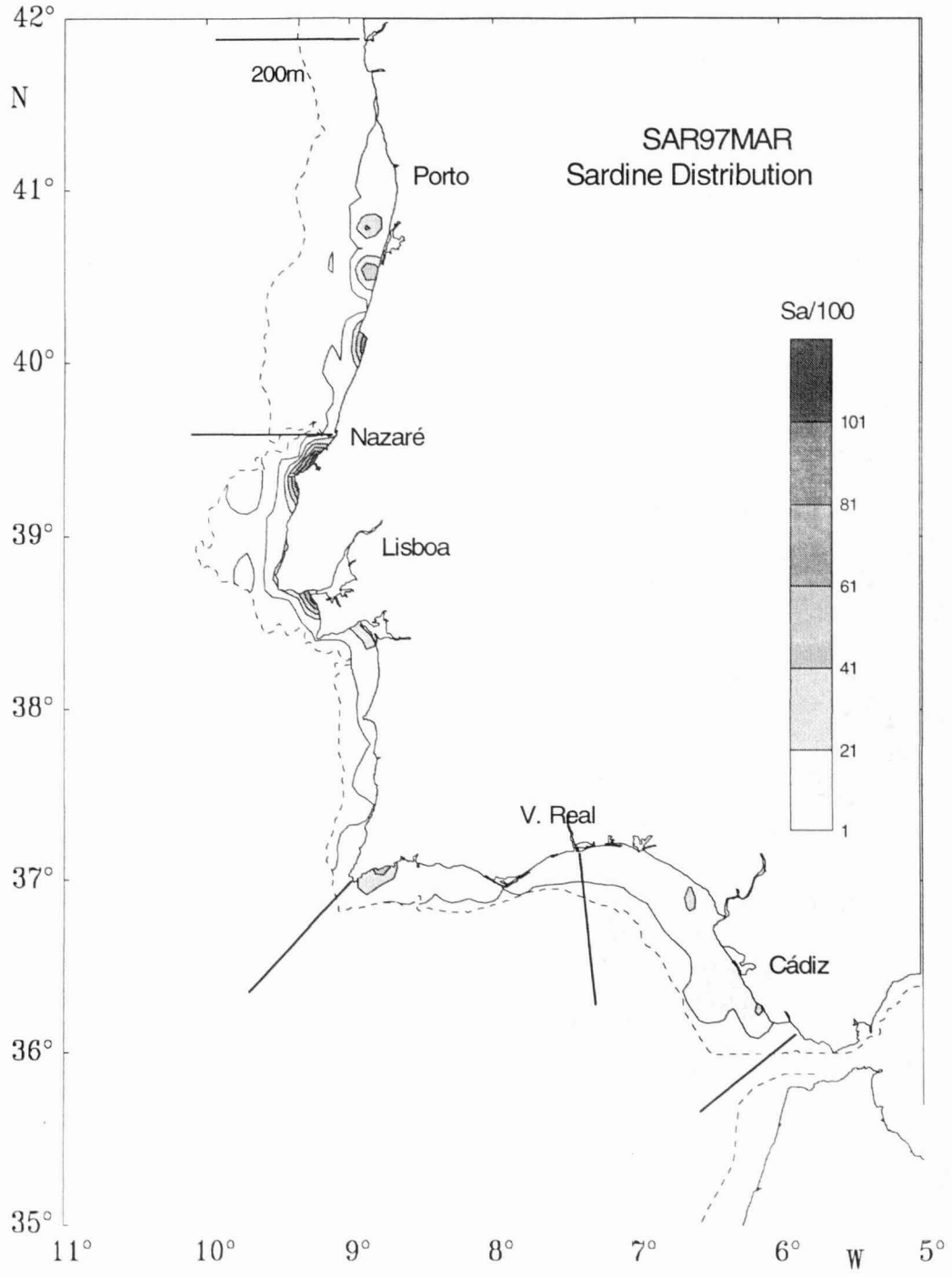

Figure 2 Contour map of sardine density (s_a - $m^2\ mn^{-2}$).

ANNEX II

Full address of the participants:

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